DEVELOPMENT PERMIT

NO. **DP- 2018-14**

TO: [redacted]

ADDRESS: [redacted]
(Permittee)

1) This Development Permit is issued subject to compliance with all of the Bylaws of the Town of Gibsons applicable thereto, except those specifically varied or supplemented by this Permit.

2) The Development Permit applies to those "lands" within the Town of Gibsons described below:

Parcel Identifier: **007-973-063**

Legal Description: **Lot 1, Block D, District Lot 685, Plan 7714**

Civic Address: **340 Cochrane Road**

3) These lands are within Development Permit Area('s) of the Town of Gibsons Official Community Plan (Bylaw 985, 2005). This permit applies to the following Development Permit Area:

- Development Permit Area No. 1 (Geotechnical Hazard Area) for the purpose of protection of development from hazardous conditions.

4) The "land" described herein shall be developed strictly in accordance with the terms and conditions and provisions of this Permit, and any plans and specifications attached to this Permit which shall form a part thereof; specifically:

- Geotechnical Assessment by Arya Engineering Inc., stamped by Ben Tomasz, dated 2018-09-05

5) All requirements of the plan(s) are to be followed.

6) Minor changes to the aforesaid drawings that do not affect the intent of this Development Permit are permitted only with the approval of the Town of Gibsons and Geotechnical Engineer.

7) If the Permittee does not commence the development permitted by this Permit within twenty four months of the date of this Permit, this Permit shall lapse.

8) This Permit is NOT a Building Permit.

ISSUED THIS 6TH DAY OF SEPTEMBER, 2018.

Lesley-Ann Staats, RPP
Director of Planning

Copy of permit to the Geotechnical Engineer

ARYA
Engineering Inc.

Lower Mainland Office
212-980 West 1st Street
North Vancouver, BC V7P 3N4
t 604.842.3734

Sunshine Coast Office
103-938 Gibsons Way
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e info@aryaeng.ca
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[redacted]

September 5, 2018
File: 18-167-SC

Re: Geotechnical Assessment: Proposed Demolition and Residential Development
340 Cochrane Road, Gibsons, British Columbia

Arya Engineering Inc. (Arya) presents the following report providing the results of a geotechnical assessment recently performed for the proposed demolition of an existing residential structure and the proposed redevelopment of a single-family residential dwelling to be located at 340 Cochrane Road in Gibsons, British Columbia. The intent of this document is to provide the client with the information required for the issuance of a development permit. It is also the intention of this report to provide the contractor and additional key stakeholders with preliminary geotechnical information needed to guide the geotechnical aspects of the proposed works.

We trust this report contains the relevant information required for project continuation at this time. Should additional information be required, please do not hesitate to contact our office.

Sincerely,
Arya Engineering Inc.

Ben Tomasz, B.Eng., P.Eng.
Principal | Senior Geotechnical Engineer

EXECUTIVE SUMMARY

Based on the findings of this assessment and provided that all of the recommendations presented herein are implemented, there are no reasonably conceivable geotechnical issues that would preclude the safe development of the proposed works on the subject site, consisting of both the demolition of the existing structures on the property, and the redevelopment of a new single-family residential structure. The land can be considered safe for the use intended considering the recommendations in this report are adhered to. It is important to note that the term safe as presented in the above statement should be understood in terms of tolerable risk and does not constitute a guarantee. In this context, the land can be considered within the limits of tolerable geotechnical risk, as defined by society and related in applicable building codes, national design standards, professional practice guidelines, and design and construction policies presented in the Smart Plan – Gibsons' Official Community Plan (OCP) adopted in March 2015, including development permit criteria.

The subject site falls within Development Permit Areas (DPA) 1 and 9, defined as Geotechnical Hazard Development Permit Area and Gibsons' Aquifer Development Permit Area by the OCP, respectively. The site is situated within a "Low Geotech Hazard" area for DPA 1, as specified on Schedule C of the OCP. Based on conversations with the Town of Gibsons' planning department, it is our understanding that this qualitative hazard rating has been applied to the area due to potential flooding hazard posed by nearby Charman Creek. Additionally, the site lies within the boundaries of Lower Gibsons Subarea for DPA 9.

Based on the results of this assessment, it is expected that the proposed development can be considered outside the influence of reasonably conceivable flooding hazard, as detailed in this report. In addition, based on the results of the subsurface investigation conducted as part of this assessment, as well as a review of the clients design objectives, excavation beyond 1.5 m below existing ground surface is not expected as part of the proposed works. Therefore, it is not expected that a development permit for DPA 9 will be required for the proposed works, and no further screening for Gibsons Aquifer related influence was conducted as part of this assessment.

Continuous concrete strip footings are the recommended foundation type for the proposed development. Strip footings should be sized with a minimum width of 450 mm. A minimum width of 600 mm should be used for pad footings. Provided these recommendations are adhered to an allowable bearing pressure of 75 kPa (SLS) can be used for foundation elements placed directly on either approved, undisturbed subgrade material, or on approved, compacted engineered fill.

1.0 INTRODUCTION

Arya Engineering Inc. (Arya) has conducted a geotechnical assessment of 340 Cochrane Road in Gibsons, British Columbia at the request of the clients, Monika Melvin and Christiaan Mantel. The scope of work performed for this assessment included the following:

1. A site investigation to observe current conditions of the site, including the observations of subsurface soils through the excavation of test pits, and observations of topography, vegetation and surface water conditions.
2. A desktop review of relevant background information including related subsurface information, published hydrological information for Charman Creek and nearby watersheds, and satellite imagery.
3. Geotechnical engineering analysis and evaluation of the collected data.
4. Preparation of this summary geotechnical report to present the relevant findings and recommendations.

An Arya representative conducted the site investigation on August 21, 2018 utilizing visual observation and manual probing methods to evaluate geotechnical conditions of the lot. In addition, a subsurface investigation through the advancement of two test pits was conducted on this date, to more comprehensively evaluate the subsurface conditions that will influence the geotechnical aspects of this project. The following sections summarize the observations and results of the geotechnical investigation.

The scope of this assessment did not include items related to other disciplines, and the site investigation did not include any evaluation of environmental hazards or contamination that may be present on or near the site. No testing or evaluation for the presence of corrosive materials or corrosive conditions was completed.

2.0 SITE ASSESSMENT

2.1 Site Layout and Topography

The subject site is located at 340 Cochrane Road in Gibsons, British Columbia. The property is approximately trapezoidal in shape measuring approximately 40 m on the longest edge running east-west and averaging approximately 30 m wide in the north-south direction. The subject site encompasses a total area of approximately 0.1 ha. A developed residential parcel bounds the property to the south, with Cochrane Road adjacent to the western property boundary and Trueman Road adjacent to the northern property boundary. The eastern property line is bordered by Arrowhead Park. The lot can be accessed directly from either Trueman Road or Cochrane Road.

Ground inclinations and topographic characteristics were developed from LIDAR data available on the Sunshine Coast Regional District's (SCRD) web mapping tool, in combination with on site measurements.

The subject site is located in an area of planar to gently sloping terrain that generally decreases in elevation from the west to the east. The lot itself decreases in elevation from west to east at an average gradient of 17H:1V (horizontal to vertical).

2.2 Existing Structures and Proposed Development

Existing structures were observed to consist of a primary dwelling located roughly mid-lot and a garage located north of the primary dwelling, adjacent to Trueman Road. A shed was also observed immediately east of the dwelling. Visual observations conducted of the foundation and chimney of the primary dwelling did not provide indications of geotechnical related issues.

Based on conversations with the client, the proposed works will primarily consist of the demolition of existing structures, and the construction of a single-family residential dwelling to be situated approximately mid-lot, in addition to a secondary structure consisting of a garage and carriage house. No project plans were available at the time of the site investigation.

2.3 Vegetation

The vegetation on the subject site was observed to consist of low growth vegetation, including native and non-native species such as grass, moss, ferns, hedges, and various woody stemmed plants and landscaping varieties. Canopy vegetation was also observed around the perimeter of the lot, including second growth coniferous trees with occasional juvenile trees.

Moss was prevalent in the area of Test Pit 2 (see test pit location map in Appendix A) advanced at a location southeast of the existing dwelling. This condition coincided with very moist, organic surface soils and indications of transient groundwater conditions on this portion of the lot (Section 3.3). Apart from this condition, no irregular growth patterns or other vegetation indicators suggesting geotechnical related issues were observed during the site investigation.

2.4 Surface Water and Runoff

No surface water was observed directly onsite during the site investigation. Charman Creek is located in excess of 100 m northwest of the property.

In consideration of the plain to gently sloping topographic gradients characterizing the parcel, in addition to the granular surface soils encountered, infiltration of surface water through these granular soils is expected during precipitation events. In the event of heavy, prolonged precipitation, the subgrade soils infiltration capacity may be exceeded and ponding could occur across portions of the lot.

3.0 SUBSURFACE CONDITIONS

The subsurface conditions at the subject site were investigated through the excavation of two test pits to a maximum depth of 1.5 m, to comply with excavation restrictions posed by the Town of Gibsons' OCP for the Lower Gibsons sub-area. Both test pits were terminated in undisturbed soils. It was determined that excavation beyond 1.5 m was not needed for preliminary design purposes due to the compact materials encountered at depth, in conjunction with our understanding of the stratigraphy of the parcel. The subsurface investigation was conducted on August 21, 2018. Manual probing methods and visual observations taken at the time of the investigation were also used to generate an understanding of the subsurface conditions that characterize the lot.

Soils samples were gathered during subsurface exploration at target depths to classify the subsurface materials, and the test pits were backfilled at the end of the day. A summary of the results of the subsurface investigation is presented in the subsequent sections of this report. Test pit logs containing comprehensive descriptions of the materials encountered are provided in Appendix B, in addition to a test pit location map in Appendix A indicating the approximate test pit locations.

3.1 Soil Stratigraphy

A local surficial geology map (McCammon, 1977) indicates that the site is located at the contact of granular material consisting of gravel, sand and cobbles, as part of the Capilano Sediments, and pre-Vashon sediments consisting of gravel, sand and silt. The Capilano Sediments present in the area are marine and glacio-marine in origin, and may contain a fines fraction including silt and clay sized particles. These deposits are known to vary in depth and are generally underlain by Vashon Stade lodgement till (Gibson Aquitard).

During the subsurface investigation, test pit (TP) TP-01 revealed soils consistent with Capilano Sediments (predominantly granular soils with trace fines) to the maximum depth explored, and TP-02 also revealed soils consistent with Capilano Sediments underlain by glacial till at 1.5 m. These results corroborate the findings of McCammon for the area.

Undisturbed soils were typically compact at a depth ranging from 0.8 m to 1.5 m. In addition, a thickness of approximately 0.5 m of deleterious overburden, consisting of fill/disturbed ground can be expected across portions of the lot.

3.2 Bedrock

Bedrock was not observed during the investigation and it not expected at a depth necessary to influence the proposed works. Based on an aquifer mapping study conducted for the Town of Gibsons, bedrock is expected to be located beyond a 50 m depth below surface at the project location (Waterline, 2013).

3.3 Groundwater

Groundwater was not encountered during the site investigation. However, it is expected that during periods of prolonged precipitation, surface water may infiltrate to the interface of the granular surficial soils and the underlying, less permeable, glacial till on the site. This condition is also expected in areas uphill of the subject site, forming perched groundwater condition that is locally known as the Capilano Aquifer. The Capilano Aquifer is expected across the site during the wetter winter months and during periods of prolonged precipitation.

In addition, an oxidation profile was observed in the test pit sidewalls indicating periods of elevated groundwater level. Based on these observations a maximum groundwater level of 0.5 m below existing ground surface is expected across the parcel.

4.0 SEISMIC ANALYSIS

The proposed structure should be designed under the seismic provisions of the 2012 British Columbia Building Code (BCBC) and the National Building Code of Canada (NBCC). Horizontal PGA and 5% damped spectral response acceleration values $S_a(T)$ for four different periods (0.2, 0.5, 1.0 and 2.0 seconds) are outlined below for the subject site for a seismic event with a 2 % probability of exceedance within 50 years (1 in 2,475 year event). In consideration of the material encountered during the site investigation, these values have been interpolated according to Site Class 'D' – Stiff Soil.

As interpolated from the 2010 National Building Code Seismic Hazard Calculation, the following criteria apply for this location (Latitude 49.3956° N, Longitude -123.5086°W):

Peak ground acceleration and spectral acceleration response values should be referenced as follows:

PGA = 0.435 g

Spectral Acceleration Response Values: S_a (0.2)=0.893g, S_a (0.5)=0.625g, S_a (1.0)=0.329g, S_a (2.0)=0.171g

Site Coefficients: F_a = 1.1, F_v = 1.2

5.0 GEOTECHNICAL HAZARD ASSESSMENT

According to the Town of Gibsons' OCP, the subject site is located within Development Permit Area (DPA) 1 and is designated as a "Low Geotech Hazard" area per Schedule C of the OCP. Conversations with the Town's planning department indicate that this hazard rating has been adopted for the property due to proximity to nearby Charman Creek. As a result, a document review and screening for flood related hazard on the property was undertaken as part of this assessment.

Based on the results of this assessment, it is anticipated that competent soils capable of bearing the loads of a single-family residential structure are located within the top 1.5 m of the ground surface, and

therefore no additional screening was undertaken pertaining to influence of the proposed works on the Gibsons Aquifer.

5.1 Clearwater Flood Hazard Screening

The outlet of Charman Creek into the oceanic waters of Shoal Channel (Gibsons' Marina) is located approximately 300 m northeast of the subject site. The creek channel immediately upstream of Lower Gibsons can be characterized as a moderately to deeply incised corridor. Beginning approximately 400 m west of the subject site and extending east across Lower Gibsons, Charman Creek's channel is only mildly incised, and has likely been restricted in further incision due to dense, Vashon Stade lodgement till in the area, resulting in relatively low channel confinement throughout Lower Gibsons. The creek channel is located approximately 125 m northwest of the subject site at its closest point.

In consideration of the low channel confinement characteristic of the creek throughout Lower Gibsons, in addition to development permit criteria dictated by the Town of Gibsons' planning department, the property was screened for susceptibility to clearwater flooding that could result on the property during a peak discharge event (1 in 200 year return period).

A sensitivity analysis was undertaken to establish the peak discharge condition approximately 400 m west of the site during the design level event. Using the rational method for small basins and limited analysis areas (less than 25 km^2), extreme peak flow runoff accounting for both existing and future conditions (increased development and impermeable land area) were generated through modifying the watersheds runoff coefficient. The runoff coefficient for the watershed was further adjusted to account for a rain-on-snow event, which would result in higher peak flow. Peak flows were estimated according to a 1 in 200 year event based on published climatic data and IDF curves generated for Gibsons (Environment Canada, 2014). As an analysis verification measure, results were compared to 1 in 200 year peak discharge estimates for local watersheds on the Sunshine Coast that share similar characteristics to Charman Creek (Delcan, 2009).

As estimated from the above methodology, a peak discharge of less than 10 m^3/s is expected during the design level event. Based on this estimation, in addition to topographic characteristics in the vicinity of the site, and as there were no subsurface indications of historic flooding observed during test pitting, clearwater flood hazard resulting from low channel confinement and peak discharge is expected to be low for the subject site.

6.0 RECOMMENDATIONS AND CONCLUSIONS

6.1 Suitable Building Sites

In consideration of the results of this assessment, no siting criteria for the proposed structures are warranted at this time. Provided the recommendations contained herein are adhered to, the property can be considered safe for the use intended.

6.2 Site Preparation and Foundations

Given the compact, undisturbed soils observed within 0.8 m to 1.5 m of the existing ground surface, excavation beyond 1.5 m is not expected to be required as part of the proposed works. Based on the findings of the subsurface investigation, an excavation depth of between 0.8 m and 1.5 m is expected to uncover competent soils for footing placement.

Continuous concrete strip footings are the recommended foundation type for the proposed development. Strip footings should be designed with a minimum footing width of 450 mm. A minimum width of 600 mm should be used where pad/column footings are needed for design purposes.

In accordance with the 2010 NBCC, the foundation recommendations included in this report are based on limit state design (LSD) methodology. Factored ultimate limit state (ULSf) bearing capacity values for the site's soils have been determined and are provided in Table 1 below. Serviceability Limit States (SLS) design criteria have also been provided in Table 1, reflecting the allowable bearing pressures appropriate for the foundation specifications presented in this report.

Table 1 – Recommended Bearing Capacities and Allowable Bearing Pressures

Material	Geotechnical Resistance Factor (ϕ)	Factored ULS	SLS
Compact Undisturbed Soils	0.5	110	75
Engineered Fill	0.5	110	75

All footings should be placed on competent undisturbed soils which have been approved by this office or on engineered fill approved by and compacted to the satisfaction of this office. Construction surfaces and footing subgrades should be flat, thoroughly cleared of disturbed, loose, or softened material or deleterious materials that may be present in the proposed building envelope prior to forming and the pouring of concrete. **Special conditions should be approved by the geotechnical engineer.**

Footings should be placed a minimum of 450 mm below final grade for frost protection requirements and to satisfy the bearing capacity and allowable bearing pressures presented herein. Strip footings and pad footings seated on approved, undisturbed soils or compacted engineered fill can be designed for an allowable bearing pressure of 75 kPa. This value represents SLS resistance based on a reasonable subsidence in the proposed structure of less than 25 mm over a 6.25 m length (CFEM, 2006).

It is important to note that the construction recommendations for foundation design are preliminary. Suitability of the specifications presented in this assessment will be confirmed by a member of this office upon demolition of the existing dwelling and excavation. The recommendations provided above may be subject to change contingent upon site specific conditions encountered during construction.

Adjacent footings situated on approved soils, and at different elevations, should be stepped at no steeper than 2H:1V. If this is not possible, footings situated at the lower elevation should be designed to carry the loads associated with the footing at the higher elevation. In addition, surcharge loading on the lower foundation wall should be considered as part of structural design.

If engineered fill is required, this material should be compacted on approved undisturbed soils. Engineered fill is generally described as clean sand to sand and gravel, of particles less than 75 mm in diameter, and containing silt and clay less than 5% by weight. Engineered fill should be implemented in loose, 300 mm lifts and compacted to 100% standard proctor maximum dry density (SPMDD) within 2% of optimum moisture content. Backfill utilized for foundation walls, retaining walls and utilities should be compacted to 98% SPMDD within 2% of optimum moisture content. **This office should be retained to approve fill material prior to compaction.**

To minimize the chance of undesirable floor wetness, the required import fill beneath all nonstructural, interior slab-on-grade components should consist of a minimum of 150 mm thick layer of 19 mm clear free draining gravel that serves as a capillary barrier between the subgrade material and the slab. An impermeable membrane should be placed over the gravel such as 6 mil polypropylene sheeting or an approved equivalent. The membrane may be covered with 50 mm of sand to protect it during construction and to mitigate undesirable effects that the membrane may have on the curing properties of the concrete.

6.3 Site Drainage

The need for site drainage controls should be determined based on the final design elevation of underside of footings. As transient, elevated groundwater conditions are expected throughout the year at a depth of 0.5 m below existing ground surface, footings placed in proximity to this elevation should utilize perimeter drains corresponding to the following specifications:

A minimum 300 mm wide trench should be implemented adjacent to strip-footing elements for placement of perimeter drains. The trench should then be lined with a non-woven geotextile fabric, a 50 mm bedding layer of 19 mm diameter, clear open graded drain rock should be implemented in the trench, followed by the placement of the drain pipe (100 mm diameter, rigid, perforated drain pipe, set with perforations facing downward). The drain pipe should be set as close as practical to the heel of footing elements at the bottom of the trench, and backfilled with drain rock as described above. It is recommended that drain rock extend to within 150 mm of the ground surface, and the entire rock/pipe unit should then be fully surrounded by the non-woven geotextile fabric.

The high end of the system and all 90° bends of the perimeter drain pipe should be connected to vertical risers consisting of closed 100 mm diameter pipes which extend to the surface and act as cleanouts. The use of cleanouts at 90° bends can be reduced by using either double 45° elbows, or sweep 90° elbows. The drain pipes should be sloped at 2% gradients to promote positive drainage all

perforated pipes should lead to non-perforated (solid wall) pipes that should be conveyed to appropriate discharge facilities.

All rainwater collected on the roof of the buildings should also be conveyed though gutters, downspouts, and closed pipes leading to appropriate discharge facilities. **The perimeter drain system and the rainwater collection and conveyance system should remain independent systems, to prevent overloading of either system that could otherwise occur.**

If it is desired to place footings below the anticipated transient groundwater elevation, consideration should be given to a permanent groundwater management strategy. Alternatively, the foundation may be waterproofed ("tanked"), by incorporating an appropriate admixture into the concrete. This office is available to provide additional design commentary regarding these items upon request.

6.4 Excavation, Trenching and Retaining Walls

Although extensive excavation is not expected to be required for this project, WorkSafe BC guidelines for stable excavations should be followed for excavations in excess of 1.2 m. WorkSafe BC guidelines for excavations should be adhered to in accordance with Section 20 (20.78 - 20.95) of the Occupational Health and Safety Regulation. For excavations in granular material less than 1.2 m, a 2H:1V slope angle should be maintained to promote excavation stability during construction.

Per WorkSafe BC guidelines, a qualified professional must be retained to conduct a WorkSafe BC Excavation Review in that case that excavation in excess of 1.2 m is required for the project. This document should specify instructions to promote excavation stability during construction, and may include such items as sloping and shoring requirements. This office is available to provide WorkSafe BC Excavation Reviews upon request, or as needed to satisfy WorkSafe BC criteria. Trenching, utility installation, and backfilling should be carried out in accordance with local municipal specifications.

Retaining walls over 1.2 m in height require an engineered design. Lateral earth pressures for foundation walls or other retaining structures have been provided in Section 6.5. In addition, Arya is available to provide design recommendations and permitting documents for engineered walls that may be required for this development upon request.

6.5 Lateral Earth Pressures

Below grade walls, foundations and grade beams should be adequately designed to resist the lateral earth pressures acting on them and any additional loads caused by surcharge loads on the adjoining ground surface. Lateral loading coefficients on these elements have been provided for a number of situations. Coefficients have been provided for At-Rest Pressure (K_O) and Active Pressure (K_A) conditions. Coulomb's theory was used to calculate the active pressures while the Mononobe-Okabe method was used to calculate an earthquake induced active pressure coefficient (K_{AE}). The PGA value

detailed in Section 4.0 of this report was utilized in calculating the earthquake induced active pressure coefficient.

These coefficients have provided in accordance with the 4th edition of the Canadian Engineering Foundation Manual (2013). Table 2 below provides the lateral earth pressure coefficients that should be used for applicable below grade elements.

Table 2 – Lateral Earth Pressure Coefficients

Pressure Condition	Coefficient Symbol	Coefficient Value
At-Rest Pressure	K_O	0.43
Active Pressure	K_A	0.27
Active Pressure (Including Seismic Effects)	K_{AE}	0.30

Lateral earth pressure coefficients were determined assuming a level, free draining backfill corresponding to the material specifications, and compaction specifications provided in Section 6.2. A unit weight of 19 kN/m^3 and an internal angle of friction of 35° were used in the development of these values. **It is assumed that free draining backfill will extend horizontally from the top of below grade elements, to a lateral distance equivalent to the elements height. In the case that a level backfill is not achievable, higher earth pressures can be expected and this office should be retained to provide updated design values.**

The at-rest and active pressure condition can be designed according to a triangular pressure distribution. For seismic earth pressures, the effects of earthquake shaking can be assumed to add an additional, inverse triangular pressure distribution.

The need to design for the hydrostatic loading condition should be determined prior to construction, and will be contingent upon the elevation of footings and the drainage strategy undertaken. This office is available to provide design consultation for this confition as needed.

6.6 Construction Field Reviews

The preceding conclusions constitute preliminary geotechnical recommendations for the development of the proposed residential dwelling and related works. It is essential that all stakeholders including all contractors and consultants working on this project review the results of this assessment prior to commencement of final design and construction activities. This office will require review of the final project plans prior to the construction process and prior to the issuance of a Schedule B, to ensure conformance to the recommendations provided in this report. It is also recommended that this office be provided the opportunity to provide design consultation when required to ensure that our intentions have been effectively conveyed.

For conditions in this report to be considered valid, this office must be provided the opportunity to conduct field reviews during construction. Arya should be informed 48 hours in advance prior to the following inspections:

1. Site preparation, excavation and subgrade review;
2. Drainage installation prior to backfilling;
3. Approval and compaction of engineered fill and backfill;
4. Closure review (prior to Schedule C-B issuance).

Failure to engage the geotechnical engineer in the construction field review process may result in the non-issuance of a Schedule C-B.

7.0 CLOSURE

This report has been prepared for the exclusive use of Monika Melvin and Christiaan Mantel for the development activities proposed on the subject site at the time this assessment was conducted. The recommendations provided in this document reflect Arya's best judgment based on the information available to Arya at the time of preparation of this document. If conditions other than those are noted during subsequent phases of development, Arya should be notified immediately and given the opportunity to review and revise the current recommendations, if necessary.

This report remains the property of Arya Engineering Inc., and Arya does not accept damages caused by the unauthorized third-party use of the information contained herein. The information in this assessment can be considered valid for a period of 2 years, after which this office should be retained to review site conditions and verify the adequacy of the information contained herein. The assessment was conducted in accordance with current geotechnical engineering practice and principles.

We trust this report provides you with the information required at this time, and we appreciate the opportunity to be of service on this project. If you have any questions regarding the report, please do not hesitate to contact us.

Best Regards,
Arya Engineering Inc.

PROFESSIONAL
PROVINCE OF
B. A. TOMASZ
193313
BRITISH COLUMBIA
ENGINEER

Elvis Lu, B.ESc., EIT
Geotechnical Engineer-in-Training

Ben Tomasz, B.Eng., P.Eng.
Principal | Senior Geotechnical Engineer

2018-09-05

8.0 BIBLIOGRAPHY

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APPENDIX A – Figures

ARYA ENGINEERING	PROPERTY REPORT		
	340 COCHRANE ROAD, GIBSONS, BC		
	PROJECT ID	DATE	FIGURE NUMBER
	18-167-SC	9/5/18	Figure 1

SCRD Maps

Property Report

340 COCHRANE RD 8/15/2018

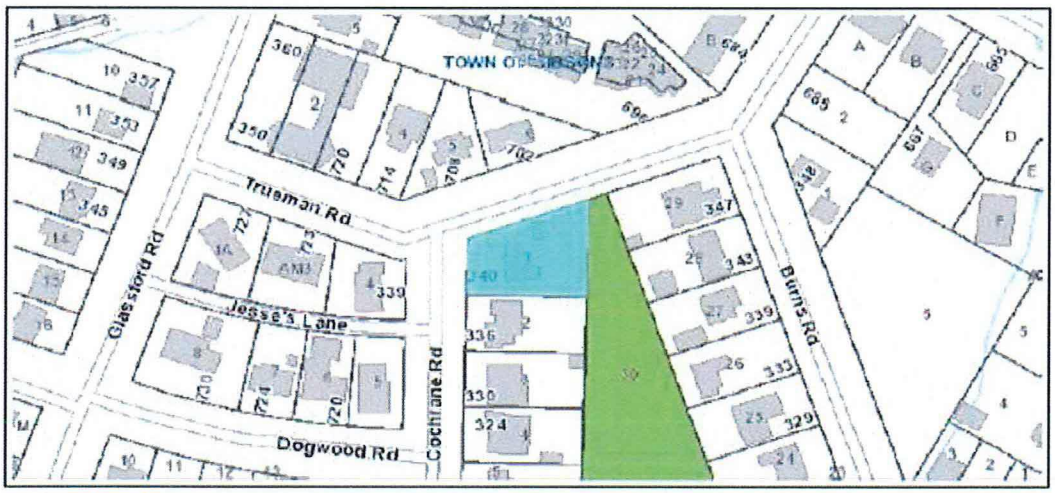
Folio: 524.00160.000 PID: 007-973-063

Address: 340 COCHRANE RD Jurisdiction: Gibsons

Lot: 1 Block: D Plan: VAP7714 District Lot: 685

2018 Assessed Value: 566100 Land Value: 473000 Improvement Value: 93100

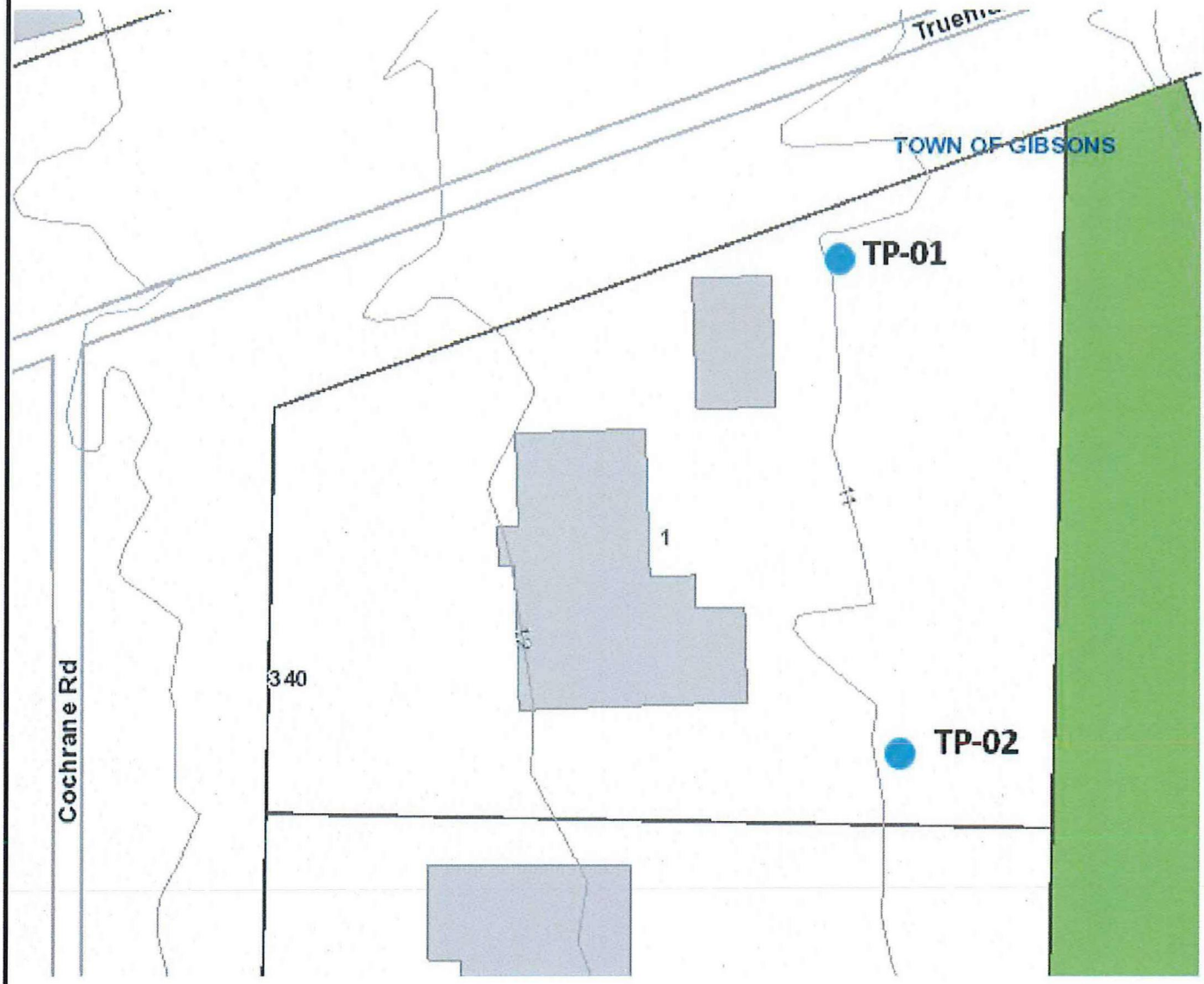
Approximate Lot Size (BC Assessment): 11576 SQUARE FEET



This information has been compiled by the Sunshine Coast Regional District (SCRD) using data derived from a number of sources with varying levels of accuracy. The SCRD disclaims all responsibility for the accuracy or completeness of this information.

- Compiled through utilization of the Sunshine Coast Regional District's (SCRD) web-based property viewer application

ARYA ENGINEERING	TEST PIT LOCATION MAP		
	340 COCHRANE ROAD, GIBSONS, BC		
	PROJECT ID	DATE	FIGURE NUMBER
	18-167-SC	9/5/18	Figure 2



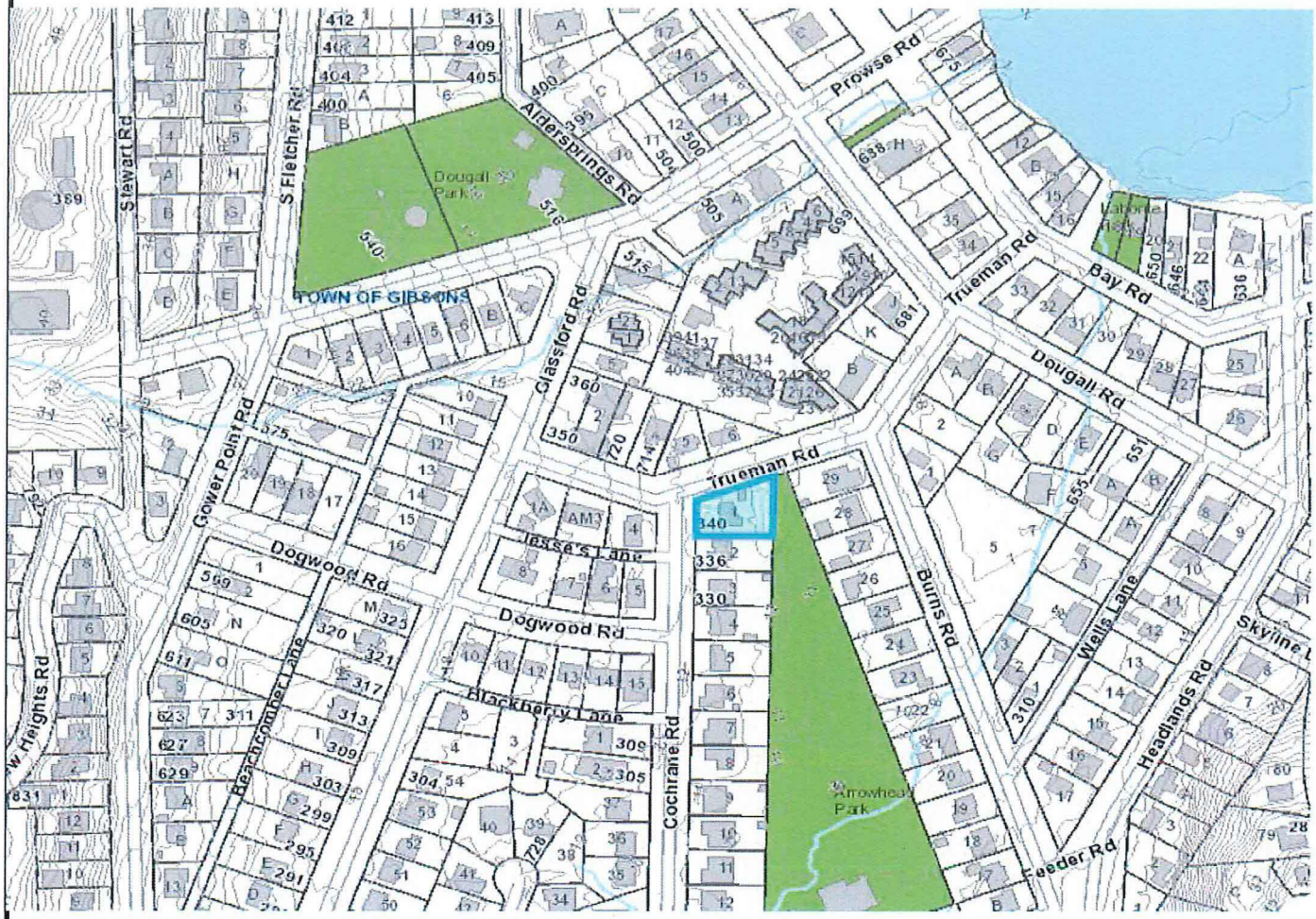
- Compiled through utilization of the Sunshine Coast Regional District's (SCRD) web-based property viewer application

ARYA ENGINEERING

VICINITY MAP

340 COCHRANE ROAD, GIBSONS, BC

PROJECT ID	DATE	FIGURE NUMBER
18-167-SC	9/5/18	Figure 3



- Compiled through utilization of the Sunshine Coast Regional District's (SCRD) web-based property viewer application

ARYA ENGINEERING	NCBBC SEISMIC HAZARD		
	340 COCHRANE ROAD, GIBSONS, BC		
	PROJECT ID	DATE	FIGURE NUMBER
	18-167-SC	9/5/18	Figure 4

2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: , August 15, 2018

Site Coordinates: 49.3956 North 123.5086 West

User File Reference:

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.893	0.625	0.329	0.171	0.435

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.*** Warning: You are in a region which considers the hazard from a deterministic Cascadia subduction event for the National Building Code. Values determined for high probabilities (0.01 per annum) in this region do not consider the hazard from this type of earthquake.

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.218	0.469	0.639
Sa(0.5)	0.149	0.322	0.441
Sa(1.0)	0.077	0.169	0.231
Sa(2.0)	0.039	0.086	0.119
PGA	0.111	0.233	0.314

References

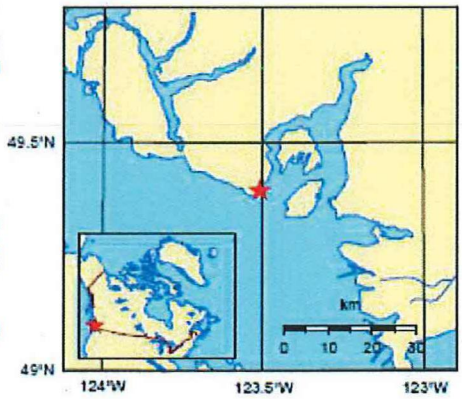
National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



Natural Resources Canada Ressources naturelles Canada Canada

- Compiled through utilization of The Department of Natural resources (operating under the FIP applied title Natural Resources Canada) and the 2010 National Building Code of Canada web-based seiesmic hazard calculator

APPENDIX B – Test Pit Logs

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KEY TO SUBSURFACE EXPLORATION LOGS

*Unified Soil Classification System (ASTM D-2487)

PRIMARY DIVISIONS			GROUP SYMBOL	SECONDARY DIVISIONS
COARSE GRAINED SOILS MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	**GRAVELS:** MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GRAVEL WITH FINES	GM	Silty gravels, gravel-sand mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS: MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	SW	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands or gravelly sands, little or no fines
		SANDS WITH FINES	SM	Silty sands, sand silt mixtures, non-plastic fines
			SC	Clayey sands, sand-silt mixture, plastic fines
FINE GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	**SILTS AND CLAYS:** LIQUID LIMIT IS LESS THAN 50%		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS: LIQUID LIMIT IS GREATER THAN 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils

DEFINITION OF TERMS

U.S. STANDARD SERIES SIEVE — CLEAR SQUARE SIEVE OPENINGS

200	40	10	4	3/4"	3"	12"
SILTS AND CLAYS	SAND		GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE	

GRAIN SIZES

SANDS AND GRAVELS	BLOWS/FOOT+	SILTS AND CLAYS	STRENGTH*	BLOWS/FOOT+
		VERY SOFT	0 - 0.25	0 - 2
VERY LOOSE	0 - 4	SOFT	0.25 - 0.50	2 - 4
LOOSE	4 - 10	FIRM	0.50 - 1.0	4 - 8
COMPACT	10 - 30	STIFF	1.0 - 2.0	8 - 16
DENSE	30 - 50	VERY STIFF	2.0 - 4.0	16 - 32
VERY DENSE	OVER 50	HARD	OVER 4.0	OVER 32
RELATIVE DENSITY		CONSISTENCY		

+ Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1-3/8 inch I.D.) split spoon 12 inches (ASTM D - 1586)

* Unconfined compressive strength in tons per square foot, as determined by laboratory testing or approximated by the standard penetration test (ASTM D - 1586), pocket penetrometer, torvane, or visual observation

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SUBSURFACE EXPLORATION LOG

340 COCHRANE ROAD, GIBSONS, BC

PROJECT ID	LOCATION ID	DATE LOGGED
18-167-SC	TP-01	2018-08-21

EXPLORATION METHOD:	EXCAVATOR	SURFACE ELEVATION (m):	11 m MSL	LOGGED BY:	EL
TEST PIT DIMENSIONS:	1 m (L) X 2.5 m (W)	GROUNDWATER DEPTH (m):	N/A	CHECKED BY:	BT

SOIL CLASSIFICATION	DEPTH (m)	SOIL TYPE	SAMPLE ID	WATER CONTENT (%)	OTHER TESTS
SAND: VAR GRAIN, TRACE TO SOME SILT, TRACE GRAVEL, MED BROWN, SLIGHTLY MOIST LOOSE -NUMEROUS FINE WOODY ROOTS -CONSISTENT WITH DISTURBED GROUND/FILL	-	SM			
SAND: VAR GRAIN, SOME SILT, TRACE GRAVEL, DARK BROWN, SLIGHTLY MOIST, LOOSE -NUMEROUS WOODY ROOTS FOUND AT 0.5 M, CONSISTENT WITH PODZOL	0.5	SM			
SAND: VAR GRAIN, TRACE TO SOME SILT AND GRAVEL, TRACE COBBLE, STRONG BROWN MOIST, LOOSE TO COMPACT -OXIDATION OBSERVED, CONSISTENT WITH COLLUVIUM	-	SW-SM			
SAND: FINE TO MED GRAIN, TRACE SILT, GREY, COMPACT, MOIST TO VERY MOIST, COMPACT -CONSISTENT WITH UNDISTURBED GLACIO-MARINE DEPOSITS	1.0	SM			
SAND: VAR GRAIN, TRACE TO SOME SILT AND GRAVEL, TRACE COBBLE, STRONG BROWN VERY MOIST TO WET, COMPACT TO DENSE, SLIGHTLY CEMENTED -MORE COMPACT THAN 0.9 M - 1.2 M COLLUVIUM LAYER -OXIDATION OBSERVED, CONSISTENT WITH COLLUVIUM	-	SW-SM			
NOTES: 1) NO GW FOUND 2) TP-01 BACKFILLED AT END OF DAY 3) MAXIMUM DEPTH OF 1.5 M	1.5				
	2.0				
	2.5				
	3.0				
	3.5				
	4.0				
	4.5				
	5.0				

SUBSURFACE EXPLORATION LOG

ARYA ENGINEERING

340 COCHRANE ROAD, GIBSONS, BC

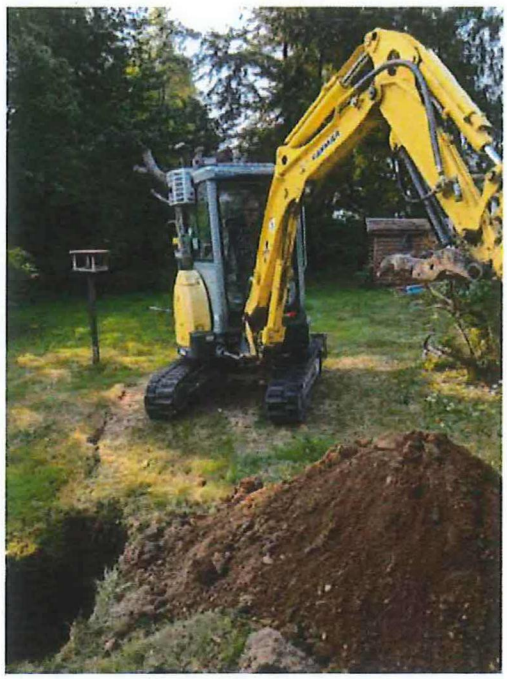
PROJECT ID	LOCATION ID	DATE LOGGED
18-167-SC	TP-02	2018-08-21

EXPLORATION METHOD:	EXCAVATOR	SURFACE ELEVATION (m):	11 m MSL	LOGGED BY:	EL
TEST PIT DIMENSIONS:	1 m (L) X 2.5 m (W)	GROUNDWATER DEPTH (m):	N/A	CHECKED BY:	BT

SOIL CLASSIFICATION	DEPTH (m)	SOIL TYPE	SAMPLE ID	WATER CONTENT (%)	OTHER TESTS
SAND: VAR GRAIN, TRACE TO SOME SILT, TRACE CLAY, VAR COLOUR, MOIST, LOOSE		SM			
-NUMEROUS FINE WOODY ROOTS					
-CONSISTENT WITH DISTURBED GROUND/FILL					
SAND: VAR GRAIN, TRACE TO SOME SILT, TRACE GRAVEL, DARK BROWN, MOIST, LOOSE	0.5	SM			
-NUMEROUS WOODY ROOTS FOUND AT 0.5 M, CONSISTENT WITH PODZOL					
SAND: VAR GRAIN, TRACE TO SOME SILT AND GRAVEL, TRACE COBBLE, STRONG BROWN MOIST, LOOSE TO COMPACT		SW-SM			
-OXIDATION OBSERVED, CONSISTENT WITH COLLUVIUM					
SAND: VAR GRAIN, TRACE TO SOME SILT AND GRAVEL, TRACE COBBLE, VAR BROWN, MOIST, LOOSE TO COMPACT	1.0				
SAND: VAR GRAIN, TRACE SILT AND GRAVEL, GREY, VERY MOIST TO WET, COMPACT TO DENSE, CEMENTED		SM			
-CONSISTENT WITH GLACIAL TILL					
NOTES:	1.5				
1) NO GW FOUND					
2) TP-01 BACKFILLED AT END OF DAY					
3) MAXIMUM DEPTH OF 1.4 M					
	2.0				
	2.5				
	3.0				
	3.5				
	4.0				
	4.5				
	5.0				

APPENDIX C – Photographs

Photograph 1 – Compact to Dense Undisturbed Soil Observed Within TP-01



Photograph 2 – Excavator used for Subsurface Investigation

Photograph 3 – Glacial Till found in TP-02

Photograph 4 – Planar Terrain Observed on Lot