



DEVELOPMENT PERMIT

NO. DP-2019-25

TO: [REDACTED]

ADDRESS: [REDACTED]
[REDACTED] [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: 030-971-462

Legal Description: Lot 1 Blocks 4 and 9 District Lot 685 Group 1 New Westminster District Plan EPP98128

Civic Address: 438-444 Gower Point 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. 9 (Gibsons Aquifer) for the purpose of the protection of the Gibsons Aquifer.

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 – Proposed Auxiliary Structure (Greenhouse), dated August 9, 2019., stamped by Benjamin Tomaz, P.Eng #48432, and the subsequent memos listed below:

Memo. 1 – Construction Field Review – Subgrade Preparation and Compaction of Engineered Fill Construction Monitoring, dated August 22, 2019;

Memo. 2 – Construction Field Review – Site Consultation, dated August 22, 2019; and,

Memo. 3 – Construction Field Review – Construction Monitoring, dated September 13, 2019.

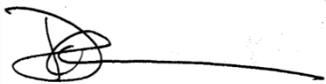
Memo. 4 – Development Permit Area 9 Review – Gibsons Aquifer, dated March 3, 2020.

5) All requirements of the plan(s) are to be followed. On site monitoring by the Geotechnical Engineer during construction as outlined in the plan(s) is required.

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 27TH DAY OF APRIL, 2020.



Dave Newman, AScT
Director of Infrastructure Services



Lesley-Anne Staats, MCIP, RPP
Director of Planning

Copy of permit to the Geotechnical Engineer



Element Landscape Group
805 Marine Drive
Gibsons, British Columbia
t: 604.741.3528 e: info@elementgardens.ca

August 9, 2019
File: 19-231-SC

Attention: Bill Marshall

**Re: Geotechnical Assessment: Proposed Auxiliary Structure (Greenhouse)
438 Gower Point Road, Gibsons, British Columbia**

Arya Engineering Inc. (Arya) presents the following report providing the results of a geotechnical assessment recently performed for the proposed development of a greenhouse and associated unpaved parking areas to be located at the above-listed address. The intent of this document is to provide the client, the contractor and additional key stakeholders with preliminary geotechnical information required to guide 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.

Benjamin Tomasz, P.Eng.
Principal | Senior Geotechnical Engineer



1.0 INTRODUCTION

Arya Engineering Inc. (Arya) has conducted a geotechnical assessment of 438 Gower Point Road in Gibsons, British Columbia at the request of the client, Element Landscape Group. The scope of work performed for this assessment included the following tasks:

1. A geotechnical site investigation to observe current conditions of the site, including observations of surficial soils, topographic conditions, vegetation, and drainage conditions. The site investigation included a subsurface exploration program consisting of the excavation of five exploratory test pits to characterize subsurface conditions, in addition to three additional site visits to measure groundwater seepage in an existing exposed test hole and drainage swales on the property.
2. A desktop review of relevant background information including existing well log data and a local aquifer mapping study, and related published subsurface information, 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.

The geotechnical site investigation and subsurface exploration program was conducted on July 18, 2019. The site visits conducted to evaluate groundwater conditions took place on July 25, 2019, July 26, 2019 and August 8, 2019.

The scope of this assessment did not include items related to other disciplines.

2.0 SITE DESCRIPTION

The property is approximately rectangular in shape and averages approximately 35 m in length (east-west) and 30 m in width (north-south), encompassing a total area of approximately 0.11 ha. The property is bordered by developed residential parcels to the north and west, and by a developed commercial parcel to the south (C-5 downtown commercial designation), and by Gower Point Road to the east. The site can be accessed from an unpaved driveway extending from Gower Point Road on the northern extent of the property.

The property is relatively level with a slight decrease in elevation from west to east at an approximate gradient of 15H:1V (horizontal to vertical). There were no permanent structures on the site at the time of the geotechnical site investigation. A rectangular, concrete culvert was observed approximately mid-lot. Based on conversations with the client, the client expects that this feature constitutes infrastructure for a groundwater well that may be present in this area; however, the desktop study conducted by this office provided no indications of existing wells or springs on the property (further discussed in Section 3.2 of this report).

Based on conversations with the client, it is our understanding that the proposed works will consist of the development of a greenhouse building, unpaved parking areas and landscaping across the parcel. We understand from a site plan provided by the client, dated May 2019 and titled *Barefoot Gecko Restaurant, 444 Gower Point Gibsons BC, Master Plan* that development of the subject property is to provide



conveyance and parking for the commercial property located immediately adjacent and to the south, and the greenhouse facility will be associated with the adjacent restaurant. We understand that development of the southern commercial lot, including all drainage works, filling and earthworks, have been completed prior to Arya's project involvement. Arya was not retained to provide any geotechnical commentary or otherwise on this adjacent lot, including design, site preparation or construction recommendations, and was not involved in construction field review during development of the adjacent lot.

Vegetation across the site was largely observed to consist of a dense understory of herbaceous (non-woody) hydrophilic vegetation. Several second growth conifers were observed near the northern property boundary. It is our experience in the area that the hydrophilic vegetation observed on the site is locally encountered in anaerobic soil environments associated with prolonged (year-round), very moist to wet surficial soil conditions, and suggests the potential for transient or permanent shallow groundwater conditions across the site.

At the time of the geotechnical site investigation, very moist surface soils were observed across the parcel. Surface water in the form of localized ponding was observed on the western extent of the parcel in a drainage ditch that had been excavated in this area prior to our site investigation. The drainage ditch was observed to convey concentrated surface water from south to north along the western property boundary to another drainage swale that was observed to extend approximately mid-lot from west to east, conveying water in this direction. The swale exhibited a depth of approximately 0.6 m, and a width ranging from 1.2 m to 1.5 m. At the time of the site investigation, the swale was measured to contain approximately 100 mm of standing water.

3.0 SUBSURFACE INVESTIGATION

The subsurface conditions at the subject site were evaluated through machine test pitting, hand probing methods and visual observation methods conducted on July 18, 2019. Five exploratory test pits (TP19-01 – TP19-05) were excavated to evaluate subsurface conditions that characterize the parcel. Pocket penetrometer readings were taken on August 8, 2019 to evaluate the consistency of fine-grained soils that were encountered across the western drainage ditch (consistent with materials encountered at depth during test pitting operations).

Test pits were excavated to a maximum depth of 1.2 m below existing grade. All test pits were advanced into compact to dense, undisturbed soils and were backfilled at end of day.

A summary of the results of the subsurface conditions encountered are presented below. Test Pit Logs in Appendix B can be referenced for more detailed descriptions of the subsurface conditions encountered. The approximate location of TP19-01 to TP19-05 can be found on the Test Pit Location Map in Appendix A.



3.1 Soil Stratigraphy

A surficial geology map of the Sunshine Coast prepared by J.W. McCammon in 1977 (McCammon, 1977) indicates that the subject site is located at the contact of Salish Sediments consisting of shore, deltaic, fluvial and swamp deposits (gravel, sand, clay, peat) and Capilano Sediments comprised of marine and glacio-marine deposits (varied gravelly, sandy, stoney, clay, and clay veneer over till). A surficial geology map published by Waterline Resources Inc. in 2013 (Waterline, 2013) suggests that the subject site is characterized by Capilano Sediments located at surface.

The subsurface conditions encountered across the site during test pitting and site traversal were generally observed to corroborate the findings of the surficial geology maps referenced herein. Arya's experience in subsurface exploration on nearby project sites further corroborates published surficial geologic information for the area. The stratigraphic profile encountered across the parcel was generally observed to consist of the following: an organic laden sand/silt deposit with trace gravel and some deleterious materials consistent with topsoil and/or disturbed ground (0.3 m to 0.9 m in thickness), underlain (in discrete areas) by an undisturbed, loose to compact gravelly sand deposit (0.2 m to 0.4 m in thickness), further underlain by compact to dense silty sand (inferred to be either a Basal Capilano deposit or Vashon Till deposit). The compact to dense silty sand deposit was encountered at all test pit locations within 0.3 m to 1.2 m of ground surface. Typically, the uppermost 0.1 m to 0.3 m of this deposit was observed to be loose/soft and very moist to wet, below which the deposit was observed to be compact to dense and moist.

Pocket penetrometer readings were also taken on August 8, 2019. Undisturbed soils consistent with the silty sand deposit encountered during subsurface exploration program, were exposed through manual excavation on the northern extent of the drainage swale. Pocket penetrometer readings ranging from 95 kPa to 200 kPa were measured.

Bedrock was not encountered at the time of the geotechnical site investigation and is not expected at depths such that it will influence geotechnical components of the proposed works.

3.2 Groundwater

A published aquifer mapping study completed for the Town of Gibsons (Waterline, 2013) indicates that the Capilano Sediments expected in this area contain a "shallow, perched aquifer". Locally, in Upper Gibsons, this condition is known as the Capilano Aquifer, and an evaluation of water levels of this aquifer has illustrated rapid response to precipitation (and lack of precipitation), suggesting recharge connection to the surface (Waterline, 2013).

Test pitting, and subsequent groundwater elevation monitoring in an open pit and drainage swales on the property (advanced by others), were conducted after several weeks of minimal, local precipitation. During Arya's site investigation, each test pit advanced revealed indications of groundwater at the contact of the compact to dense silty sand deposits encountered. The uppermost 0.1 m to 0.3 m of silty sand encountered was observed to be loose/soft and very moist to wet. Test pits were left open during



excavation, and less than 10 mm of standing water was observed in each test pit location after a 1 hour period.

Subsequent groundwater monitoring in existing swales and in the open pit (conducted on July 25, July 26, and August 8), showed a decrease of up to 100 mm of standing water over a two-week monitoring period.

Based on our experience in the area, review of published documentation of surficial soils and aquifer conditions, in addition to the results of test pitting, groundwater conditions across the subject site are expected to consist of an unconfined, transient aquifer which is limited in downward mobility by the low permeable, dense silty sand deposit observed during test pitting (basal aquitard). We expect that this aquifer is active during the wetter, winter months and during periods of prolonged precipitation, and is minimal or not present during the summer months, and after prolonged, dry periods. The hydrophilic vegetation discussed in Section 2.0 of this report further supports the presence of a transient, unconfined aquifer on the property. It is expected that this aquifer is charged by infiltration of precipitation on the subject site itself and in granular surface soils mapped in uphill areas.

As no distinct oxidation profile was observed in the undisturbed sand and gravel deposit encountered above the aquitard, however an oxidation profile was observed in the silty sand deposit, it is considered unlikely that the aquifer seasonally fluctuates to a depth less than 0.5 m below existing ground surface across the parcel. Maximum expected groundwater level is therefore considered at a depth of 0.5 m below existing ground surface across the parcel.

Published well log data for the area (iMap BC), in addition to review of the aforementioned local aquifer mapping study (Waterline, 2013), and Arya's experience in subsurface exploration on nearby parcels suggests that the low permeable, dense silty sand deposit encountered (Basal Capilano deposit and/or Vashon Stade lodgement till) is both the basal aquitard of the transient aquifer expected across the property, and also serves as an overlying aquitard to the underlying Gibsons Aquifer. The dense, silty sand deposit encountered (Gibsons Aquitard) is expected to be at least 6 m in thickness in the vicinity of the subject site.

It should be noted that the desktop study completed by this office could not corroborate the expectation that the existing rectangular, concrete culvert observed approximately mid lot comprises water well infrastructure. No published water wells or natural springs on the parcel were verified by this office during site traversal, test pitting, or completion of the desktop study. It is recommended that the client contact a suitably qualified professional to evaluate this feature prior to the commencement of site preparation activities for the proposed development, to determine any implications that this feature may have on the proposed development.

4.0 SEISMIC ANALYSIS

Any proposed structure to be located on the subject site should be designed under the seismic provisions of the 2018 British Columbia Building Code (BCBC) and the National Building Code of Canada 2015



(NBCC). Horizontal peak ground acceleration (PGA) and 5% damped spectral response acceleration values $S_a(T)$ for seven different periods (0.2, 0.3, 0.5, 1.0, 2.0, 5.0 and 10.0 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 2015 National Building Code Seismic Hazard Calculation, the following criteria apply for this location (Latitude 49.3986° N, Longitude -123.5093° W):

$$PGA_{ref} = PGA = 0.369 \text{ g}$$

$$PGV = 0.559 \text{ m/s}$$

$$\text{Spectral Acceleration Response Values: } S_a(0.2)=0.846\text{g, } S_a(0.3)=0.854\text{g, } S_a(0.5)=0.759, S_a(1.0)=0.432\text{g, } S_a(2.0)=0.262\text{g, } S_a(5.0)=0.084\text{g, } S_a(10.0)=0.03\text{g}$$

$$\text{Site Coefficients: } F(0.2) = 0.98, F(0.5) = 1.18, F(1.0) = 1.29, F(2.0) = 1.34, F(5.0) = 1.39, F(10.0) = 1.36, F(PGA) = 0.97, F(PGV) = 1.18$$

$$F_s = 1.6$$

$$F_a = F(0.2)$$

$$F_v = F(1.0)$$

5.0 GEOTECHNICAL HAZARD SCREENING

Based on site topography and the subsurface conditions encountered at the time of the geotechnical site investigation, the lot is not considered to be susceptible to reasonably conceivable geotechnical hazards provided the design and construction recommendations provided in this report are adhered to.

6.0 RECOMMENDATIONS AND CONCLUSIONS

6.1 Site Preparation

Based on conversations with the client, a conventional shallow foundation through open excavation is the preferred foundation type and construction strategy for the proposed building. Structural loading criteria for footings (including bearing capacity, allowable bearing pressure requirements and settlement tolerances) were not available at the time of preparation of this assessment.

It is expected that excavation could be successfully implemented in the summer months (dry season) and would require an excavation on the order of 1.5 m to remove loose, saturated soils and to uncover undisturbed, compact to dense, silty sand material. Based on the minimal groundwater seepage rates encountered during test pitting, sequential excavation and immediate implementation and compaction of engineered fill (angular, clean, open graded gravel), may be a suitable site preparation strategy without the need for additional temporary groundwater management.



This strategy is expected to consist of the sequential excavation of discrete areas of the subject site, to compact to dense, undisturbed, silty sand subgrade (1.5 m maximum depth expected), followed by immediate placement of non-woven geotextile fabric directly atop the subgrade (Nilex 4545 or approved equivalent, 300 mm minimum lap length). Placement of the non-woven geotextile (in each sequence) should be followed by placement of clear, open graded 19 mm gravel (clear crush gravel), to be consecutively placed in loose, 300 mm lifts, and compacted via vibratory methods to within 0.5 m of existing ground surface (expected maximum groundwater elevation). The entire clear crush, gravel system should be wrapped in non-woven geotextile fabric (blanket drain). Engineered fill comprised of sand and gravel (less than 5% fines) can be implemented above this elevation to the desired grade. Additional compaction and material specifications for engineered fill are provided in Section 6.2 of this report.

It is recommended that the client retain a qualified arborist or landscape professional prior to site preparation to assess the implications of excavation on the health of the second growth conifers observed on-site and on adjacent parcels. Such services are beyond the scope of our assessment.

It should be considered that the above-mentioned site preparation strategy should be considered with a reasonable contingency for the possibility of unforeseen ground conditions, due to variations inherent in soil deposition processes. Actual ground conditions, including subsurface soils and groundwater conditions, as evaluated during site preparation works may dictate the need for a temporary groundwater management or dewatering plan. Temporary groundwater management may include, but may not be limited to, an excavation grading plan, the implementation of filtered drains and swales within the excavation, and internal or external excavation pumping. A sediment control plan (sediment tank, silt trap, or similar) may also be required prior to discharge of collected waters into the Town of Gibsons' municipal stormwater system. Contingency on construction progress and scheduling, and variations in climatic conditions, a temporary winterization plan to protect the competency of subgrade materials may also be required.

It is also important to note that the subject site is in the Town of Gibsons' Development Permit Area (DPA) 9 – Gibsons Aquifer. While not expected to be required at this time based on the results of the subsurface exploration program, development permit criteria pertaining to DPA 9 may need to be addressed if excavation in excess of 1.5 m is required on the property based on actual ground conditions encountered. An appropriate scheduling contingency should be considered accordingly.

6.2 Foundation Design and Proposed Structure Drainage

Construction surfaces and footing subgrades should be flat, thoroughly cleared of disturbed, loose, moist and softened material or deleterious materials in the proposed building envelope prior to forming and pouring of concrete. It is anticipated that a subgrade of engineered fill will be utilized for underside of footings based on the site preparation commentary provided herein.



Continuous concrete strip footings are the recommended foundation type for the proposed structure. 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.

In accordance with the 2015 NBCC and the BCBC 2018, the foundation recommendations 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	Recommended Bearing Capacities and Bearing Pressures (kPa)		
	Geotechnical Resistance Factor (ϕ)	Factored ULSf	SLS
Engineered Fill	0.5	75	50

All footings should be placed on compacted engineered fill, underlain by clear crush gravel (blanket drain), further underlain by approved undisturbed, compact to dense silty sand. All subgrade areas should be approved by the geotechnical engineer during excavation and fill monitoring. Clear crush gravel and engineered fill material should be approved by and compacted to the satisfaction of this office.

Engineered fill generally consists of clean sand to sand and gravel, of particles less than 75 mm in diameter, and containing silt and clay less than 5% by weight. All engineered fill material, including that to comprise the blanket drain, should be implemented in loose, 300 mm lifts and compacted to 100% Standard Proctor Maximum Dry Density (SPMDD) at a moisture content that is within 2% of optimum. Backfill utilized for retaining walls and utilities should be compacted to 98% SPMDD at a moisture content that is within 2% of optimum.

Footings should be placed a minimum of 450 mm below final grade for frost protection requirements and to satisfy the bearing capacity criteria and allowable bearing pressures presented herein. Strip footings and pad footings seated on engineered fill that is positioned atop an approved subgrade can be designed for an allowable bearing pressure of 50 kPa associated with a maximum settlement of 25 mm of a 6.25 m span.

Adjacent footings at different elevations should be stepped at no steeper than 2H:1V to prevent potential surcharge loading. Otherwise, subgrade soils, footings, and foundation walls situated at the lower elevation should be designed to accommodate the loads induced by the footing at the higher elevation.

To minimize the chance of undesirable floor wetness, the recommended import fill beneath all nonstructural, interior slab-on-grade components should also consist of a minimum of 150 mm thick, clear crush layer 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 should 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.

Drainage for the structure should consist of individual perimeter drains comprised of 100 mm diameter perforated pipe set with perforations set faced downwards, set adjacent to footing elements. A minimum 300 mm wide trench should be implemented adjacent to footing elements for placement of perimeter drains. The trench should be lined with an approved non-woven geotextile fabric (Nilex 4545 or approved equivalent). Subsequently, a 50 mm bedding layer of 19 mm diameter clear crush gravel should be implemented in the trench, followed by the placement of the drainpipe (100 mm diameter, rigid, perforated drainpipe). The drainpipe should be set as close as practical to the heel of footing elements at the bottom of the trench and backfilled with clear crush gravel. The clear crush gravel should extend to within 150 mm of the ground surface, and the entire gravel/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 drainpipe should be connected to vertical risers consisting of closed 100 mm diameter pipes which extend to the surface and act as cleanouts. The drainpipes should be sloped at minimum 2% gradients. Final lift of backfill should be sloped at minimum 2% gradient away from the proposed structure to promote positive drainage away from the foundations. All perforated pipes should lead to non-perforated (solid wall) pipes that should be conveyed to appropriate discharge facilities. It is recommended that perimeter drains be discharged into the Town of Gibsons' municipal stormwater system in conformance to municipal requirements.

All rainwater collected on the roof of the building should also be conveyed through gutters, downspouts, and closed pipes leading to the municipal stormwater system. 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.

6.3 Construction Field Reviews

Prior to issuance of a Schedule B, our office will require a review of structural and architectural plans Issued for Building Permit (BP), and prior to conducting field reviews, our office will require a review of structural and architectural plans Issued for Construction (IFC). The following field reviews are expected to be required by this office prior to issuance of a Schedule CB. It is important to note that the required number of, and extent of construction field review activities is subject to change based on site conditions encountered during site preparation. Arya should be informed 48 hours in advance prior to the following inspections for:

1. Site consultation with the general contractor and client prior to site preparation;
2. Full time monitoring of excavation and placement and compaction of engineered fill;
3. Backfill review;
4. Drainage installation review;
5. Closure review prior to the issuance of a Schedule CB.



7.0 CLOSURE AND LIMITATIONS

It is important to note that the intent of this document is to provide preliminary design and construction recommendations for site preparation works and foundation construction, from a geotechnical perspective. The information provided herein pertains to the proposed development as we understand it at this time, as specified in this report. While the southern adjacent lot is associated with the proposed development project, this office was not retained to provide any services in support of the development of this adjacent parcel, including geotechnical engineering and design, drainage control, construction field review, or otherwise.

This office provides no assurance for works completed on the southern adjacent parcel and assumes no responsibility for failures caused directly or indirectly by works on adjacent parcels. It is the responsibility of the general contractor to identify property boundaries, and to locate underground services and utilities prior to commencement of site work. The general contractor is responsible for the location of, and connection to the municipal stormwater system.

The recommendations in this report are subject to change based on site conditions encountered during site preparation. The number of construction field reviews, and the extent of construction field reviews and engineering design work to be conducted during construction, will be contingent upon site conditions uncovered during site preparation. At this time, it is expected that full-time monitoring for subgrade review and compaction of engineered fill lifts will be required. For the commentary in this report to be considered valid, our office requires a pre-construction meeting with relevant project stakeholders, including the client and contractor, prior to commencement of excavation.

This report has been prepared for the exclusive use of Element Landscape Group 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 noted herein are encountered 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 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. This 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.

Emir Hot, B.ASc., EIT
Geotechnical Project Engineer

Benjamin Tomasz, P.Eng. **2019-08-09**
Principal | Senior Geotechnical Engineer





8.0 BIBLIOGRAPHY

Province of British Columbia. (2018). British Columbia Building Code.

Natural Resources Canada. (2015). Determine 2015 National Building Code of Canada seismic hazard values .

McCammon, J. (1977). Surficial Geology and Sand and Gravel Deposits of Sunshine Coast, Powell River, and Campbell River Areas. Bulletin 65. Province of British Columbia: Ministry of Mines and Petroleum Resources.

Society, C. G. (2013). Canadian Foundation Engineering Manual. 4th Edition. Richmond: BiTech Publisher Ltd.

Waterline Resources Inc. (2013). Aquifer Mapping Study – Town of Gibsons, British Columbia

*Geographic Data & Services – iMapBC (August 9 , 2019), Retrieved from:
<https://maps.gov.bc.ca/ess/hm/imap4m/>*



APPENDIX A – Figures



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



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

2015 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

Site: 49.399N 123.509W

2019-08-08 19:07 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.450	0.312	0.223	0.097
Sa (0.1)	0.685	0.476	0.342	0.148
Sa (0.2)	0.846	0.595	0.430	0.186
Sa (0.3)	0.854	0.604	0.436	0.186
Sa (0.5)	0.759	0.531	0.379	0.154
Sa (1.0)	0.432	0.295	0.203	0.077
Sa (2.0)	0.262	0.174	0.116	0.042
Sa (5.0)	0.084	0.049	0.029	0.009
Sa (10.0)	0.030	0.017	0.010	0.004
PGA (g)	0.369	0.260	0.187	0.080
PGV (m/s)	0.559	0.379	0.261	0.095

Notes: Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. 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 directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
 Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

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



APPENDIX B – Test Pit Logs



ARYA
ENGINEERING INC.

SUBSURFACE EXPLORATION LOG

438 Gower Point Road, Gibsons, British Columbia

PROJECT ID LOCATION ID DATE LOGGED

19-231-SC TP19-01 2019-07-18

EXPLORATION METHOD: EXCAVATOR SURFACE ELEVATION (m): 8 m MSL LOGGED BY: EH
 TEST PIT DIMENSIONS: 2.0 m (L) X 2.0 m (W) GROUNDWATER DEPTH (m): 0.9 m CHECKED BY: BT

SOIL CLASSIFICATION	DEPTH (m)	SOIL TYPE	SAMPLE ID	BLOW COUNT (N60)	WATER CONTENT (%)	DRY DENSITY (kg/m ³)	STRENGTH TESTS (kPa)	OTHER TESTS
SAND/SILT: VARIABLE GRAIN SIZE, TRACE GRAVEL, BLACKISH BROWN, MOIST TO VERY MOIST, LOOSE - CONTAINS ORGANICS	-	SM/ML						
	0.5							
SAND: FINE TO MEDIUM GRAIN SIZE, SILTY, TRACE GRAVEL, VARIABLE GREY, VERY MOIST TO WET, COMPACT TO DENSE - UPPERMOST 0.3 m OF DEPOSIT WAS NOTED TO BE LOOSE	1.0	SM/ML			▼			
NOTES: 1) TEST PIT BACKFILLED AT END OF DAY 2) EXCAVATION HALTED AT 1.4 m DEPTH 3) GROUNDWATER ENCOUNTERED AT 0.9 m 4) DEPOSIT ENCOUNTERED FROM 0.0 m TO 0.9 m WAS OBSERVED TO BE CONSISTENT WITH TOPSOIL/DISTURBED GROUND 5) DEPOSIT ENCOUNTERED FROM 0.9 m TO 1.4 m WAS OBSERVED TO BE CONSISTENT WITH A BASAL CAPILANO DESPOIT OR A VASHON TILL DEPOSIT	1.5							
	2.0							
	2.5							
	3.0							
	3.5							
	4.0							
	4.5							
	5.0							



ARYA
ENGINEERING INC.

SUBSURFACE EXPLORATION LOG

438 Gower Point Road, Gibsons, British Columbia

PROJECT ID

LOCATION ID

DATE LOGGED

19-231-SC

TP19-02

2019-07-18

EXPLORATION METHOD: EXCAVATOR

SURFACE ELEVATION (m): 8 m MSL

LOGGED BY: EH

TEST PIT DIMENSIONS: 2.0 m (L) X 2.0 m (W)

GROUNDWATER DEPTH (m): 0.5 m

CHECKED BY: BT

SOIL CLASSIFICATION	DEPTH (m)	SOIL TYPE	SAMPLE ID	BLOW COUNT (N60)	WATER CONTENT (%)	DRY DENSITY (kg/m ³)	STRENGTH TESTS (kPa)	OTHER TESTS
SAND: VARIABLE GRAIN SIZE, TRACE TO SOME GRAVEL, TRACE COBBLES, TRACE BOULDERS VARIABLE GREY, MOIST TO VERY MOIST, LOOSE	-	SW/GW						
SAND: FINE TO MEDIUM GRAIN SIZE, SILTY, TRACE GRAVEL, VARIABLE GREY, VERY MOIST TO WET, COMPACT TO DENSE - UPPERMOST 0.2 m OF DEPOSIT WAS NOTED TO BE LOOSE	0.5	SM			▼			
NOTES: 1) TEST PIT BACKFILLED AT END OF DAY 2) EXCAVATION HALTED AT 0.6 m DEPTH 3) GROUNDWATER ENCOUNTERED AT 0.5 m 4) DEPOSIT ENCOUNTERED FROM 0.0 TO 0.3 m WAS CONSISTENT WITH FILL/DISTRUBED GROUND 5) DEPOSIT ENCOUNTERED FROM 0.3 m TO 0.6 m WAS OBSERVED TO BE CONSISTENT WITH A BASAL CAPILANO DESPOIT OR A VASHON TILL DEPOSIT	-							
	1.0							
	1.5							
	2.0							
	2.5							
	3.0							
	3.5							
	4.0							
	4.5							
	5.0							



ARYA
ENGINEERING INC.

SUBSURFACE EXPLORATION LOG

438 Gower Point Road, Gibsons, British Columbia

PROJECT ID	LOCATION ID	DATE LOGGED
------------	-------------	-------------

19-231-SC	TP19-03	2019-07-18
-----------	---------	------------

EXPLORATION METHOD:	EXCAVATOR	SURFACE ELEVATION (m):	7 m MSL	LOGGED BY:	EH
TEST PIT DIMENSIONS:	2.0 m (L) X 2.0 m (W)	GROUNDWATER DEPTH (m):	0.9 m	CHECKED BY:	BT

SOIL CLASSIFICATION	DEPTH (m)	SOIL TYPE	SAMPLE ID	BLOW COUNT (N60)	WATER CONTENT (%)	DRY DENSITY (kg/m ³)	STRENGTH TESTS (kPa)	OTHER TESTS
SAND: VARIABLE GRAIN SIZE, TRACE SILT, TRACE TO SOME GRAVEL, VARIABLE BROWN, MOIST TO VERY MOIST, LOOSE - CONTAINS ORGANICS - DELETERIOUS MATERIALS AND DEBRIS ENCOUNTERED	-	SW						
	0.5							
SAND: VARIABLE GRAIN SIZE, GRAVELLY, VARIABLE GREY, VERY MOIST, COMPACT	1.0	SW/GW			▼			
SAND: FINE TO MEDIUM GRAIN SIZE, SILTY, TRACE GRAVEL, VARIABLE GREY, VERY MOIST TO WET, COMPACT TO DENSE	1.5	SM						
NOTES 1) EXCAVATION HALTED AT 1.3 m 2) GROUNDWATER ENCOUNTERED AT 0.8 m 3) TEST PIT BACKFILLED AT END OF DAY 4) DEPOSIT ENCOUNTERED FROM 0.0 m TO 0.8 m WAS OBSERVED TO BE CONSISTENT WITH FILL/DISTURBED GROUND 5) DEPOSIT ENCOUNTERED FROM 0.8 m TO 1.2 m WAS OBSERVED TO BE CONSISTENT WITH UNDISTURBED GROUND 6) DEPOSIT ENCOUNTERED FROM 1.2 m TO 1.3 m WAS OBSERVED TO BE CONSISTENT WITH A BASAL CAPILANO DESPOIT OR A VASHON TILL DEPOSIT	2.0							
	2.5							
	3.0							
	3.5							
	4.0							
	4.5							
	5.0							



ARYA
ENGINEERING INC.

SUBSURFACE EXPLORATION LOG

438 Gower Point Road, Gibsons, British Columbia

PROJECT ID LOCATION ID DATE LOGGED

19-231-SC TP19-04 2019-07-18

EXPLORATION METHOD: EXCAVATOR SURFACE ELEVATION (m): 8 m MSL LOGGED BY: EH
 TEST PIT DIMENSIONS: 2.0 m (L) X 2.0 m (W) GROUNDWATER DEPTH (m): 0.7 m CHECKED BY: BT

SOIL CLASSIFICATION	DEPTH (m)	SOIL TYPE	SAMPLE ID	BLOW COUNT (N60)	WATER CONTENT (%)	DRY DENSITY (kg/m ³)	STRENGTH TESTS (kPa)	OTHER TESTS
SAND/SILT: VARIABLE GRAIN SIZE, TRACE GRAVEL, BLACKISH BROWN, MOIST TO VERY MOIST, LOOSE - CONTAINS ORGANICS	-	SM/ML						
	0.5							
SAND: VARIABLE GRAIN SIZE, GRAVELLY, VARIABLE GREY, VERY MOIST, COMPACT	-	SW/GW			▼			
SAND: FINE TO MEDIUM GRAIN SIZE, SILTY, TRACE GRAVEL, VARIABLE GREY, VERY MOIST TO WET, COMPACT TO DENSE - UPPERMOST 0.1 m OF DEPOSIT WAS NOTED TO BE LOOSE	1.0	SM/ML						
NOTES 1) EXCAVATION HALTED AT 1.2 m 2) GROUNDWATER ENCOUNTERED AT 0.7 m 3) TEST PIT BACKFILLED AT END OF DAY 4) DEPOSIT ENCOUNTERED FROM 0.0 m TO 0.7 m WAS OBSERVED TO BE CONSISTENT WITH TOPSOIL/DISTRUBED GROUND 5) DEPOSIT ENCOUNTERED FROM 0.7 m TO 0.9 m WAS OBSERVED TO BE CONSISTENT WITH UNDISTURBED GROUND 6) DEPOSIT ENCOUNTERED FROM 0.9 m TO 1.2 m WAS OBSERVED TO BE CONSISTENT WITH A BASAL CAPILANO DESPOIT OR A VASHON TILL DEPOSIT	1.5							
	2.0							
	2.5							
	3.0							
	3.5							
	4.0							
	4.5							
	5.0							



ARYA
ENGINEERING INC.

SUBSURFACE EXPLORATION LOG

438 Gower Point Road, Gibsons, British Columbia

PROJECT ID	LOCATION ID	DATE LOGGED
------------	-------------	-------------

19-231-SC	TP19-05	2019-07-18
-----------	---------	------------

EXPLORATION METHOD:	EXCAVATOR	SURFACE ELEVATION (m):	8 m MSL	LOGGED BY:	EH
TEST PIT DIMENSIONS:	2.0 m (L) X 2.0 m (W)	GROUNDWATER DEPTH (m):	0.5 m	CHECKED BY:	BT

SOIL CLASSIFICATION	DEPTH (m)	SOIL TYPE	SAMPLE ID	BLOW COUNT (N60)	WATER CONTENT (%)	DRY DENSITY (kg/m ³)	STRENGTH TESTS (kPa)	OTHER TESTS
SAND/SILT: VARIABLE GRAIN SIZE, TRACE GRAVEL, BLACKISH BROWN, MOIST TO VERY MOIST, LOOSE - CONTAINS ORGANICS	-	SM/ML						
SAND: VARIABLE GRAIN SIZE, GRAVELLY, VARIABLE GREY, VERY MOIST, COMPACT	0.5	SW/GW			▼			
SAND: FINE TO MEDIUM GRAIN SIZE, SILTY, TRACE GRAVEL, VARIABLE GREY, VERY MOIST TO WET, COMPACT TO DENSE - UPPERMOST 0.1 M OF DEPOSIT WAS NOTED TO BE LOOSE	-	SM/ML						
NOTES 1) EXCAVATION HALTED AT 0.8 m 2) GROUNDWATER ENCOUNTERED AT 0.5 m 3) TEST PIT BACKFILLED AT END OF DAY 4) DEPOSIT ENCOUNTERED FROM 0.0 m TO 0.3 m WAS OBSERVED TO BE CONSISTENT WITH TOPSOIL/DISTURBED GROUND 5) DEPOSIT ENCOUNTERED FROM 0.3 m TO 0.5 m WAS OBSERVED TO BE CONSISTENT WITH UNDISTURBED GROUND 6) DEPOSIT ENCOUNTERED FROM 0.5 m TO 0.8 m WAS OBSERVED TO BE CONSISTENT WITH A BASAL CAPILANO DESPOIT OR A VASHON TILL DEPOSIT	1.0							
	-							
	-							
	-							
	1.5							
	-							
	-							
	-							
	2.0							
	-							
-								
-								
-								
3.0								
-								
-								
-								
3.5								
-								
-								
-								
4.0								
-								
-								
-								
4.5								
-								
-								
-								
5.0								



ARYA
ENGINEERING INC.

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
		GRAVEL WITH FINES	GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
			GM	Silty gravels, gravel-sand mixtures, non-plastic fines
		SANDS: MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	GC
	SW			Well graded sands, gravelly sands, little or no fines
	SANDS WITH FINES		SP	Poorly graded sands or gravelly sands, little or no fines
			SM	Silty sands, sand silt mixtures, non-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%	SC	SC
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
SILTS AND CLAYS: LIQUID LIMIT IS GREATER THAN 50%		OH	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 LOOSE	0 - 4	VERY SOFT	0 - 0.25	0 - 2
LOOSE	4 - 10	SOFT	0.25 - 0.50	2 - 4
COMPACT	10 - 30	FIRM	0.50 - 1.0	4 - 8
DENSE	30 - 50	STIFF	1.0 - 2.0	8 - 16
VERY DENSE	OVER 50	VERY STIFF	2.0 - 4.0	16 - 32
		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



APPENDIX C – Site Photographs



Photograph 1 – TP19-01 at Maximum Depth



**Photograph 2 – Groundwater Encountered in
TP19-05**



Photograph 3 – Drainage Swale

Memorandum

File No.:	19-231-SC	Date:	August 22, 2019
To:	Element Landscape Group		
Email:	info@elementgardens.ca	Phone:	604.741.3528
From:	Emir Hot, EIT; Ben Tomasz, P.Eng.	CC:	kjscontracting@gmail.com
Subject:	Memo. 1 – Construction Field Review – Subgrade Preparation and Compaction of Engineered Fill – Construction Monitoring 438 Gower Point Road, Gibsons, British Columbia		

An Arya Engineering Inc. (Arya) representative was on-site on August 20th, 2019 to review subgrade preparation and monitor placement and compaction of engineered fill across the subgrade as needed to elevate grade for the proposed auxiliary structure (greenhouse) and related works. Site conditions at the time of the review were assessed through visual observation methods, manual probing methods, pocket penetrometer readings, and soil density gauge readings. This document presents a summary of the observations taken at the time of the review and provides additional recommendations that should be adhered to.

- During the site visit, the subgrade was sequentially exposed on the southeastern extent of the site (approximately 25% of the subgrade for the property was exposed during construction monitoring).
- The excavation on the southeastern extent of the site extended to a maximum approximate depth of 1.2 m below grade to a subgrade comprised of undisturbed, gravelly sand with trace to some cobbles.
- The subgrade was generally observed to be compact. Localized sections of the subgrade were observed to be loose to an approximate depth ranging from 150 mm to 300 mm. These areas generally coincided with those portions of the subgrade where saturated soils and ponding (10 mm to 25 mm) of surface water was encountered. The general contractor was instructed to remove loose material and surface water in these areas as needed to uncover a compact subgrade prior to the placement of geotextile fabric (Nilex 4545).
- Based on the results of Arya’s subsurface exploration program, the silty sand (consistent with a basal Capilano deposit or Vashon Till) underlies the gravelly sand at a relatively shallow depth. This material was observed at localized locations of exposed soil cuts across the excavation side walls and at localized areas of the subgrade. Pocket penetrometer readings of the silty sand across exposed soils cuts were observed to range from 50 kPa to 150 kPa.



- Upon exposure of suitable subgrade material, non-woven geotextile fabric (Nilex 4545) was placed directly atop the subgrade. Adjacent sections of the fabric were placed with a 300 mm overlap.
- 19 mm, clear, open-graded gravel was placed in loose, 200 mm to 300 mm lifts that were compacted, and moisture conditioned upon placement.
- The first three lifts were implemented on the southeastern corner of the site during the site visit.
- Generally, the engineered fill material met compaction specifications throughout the course of construction monitoring as measured with a soil density gauge.

The following commentary was relayed to the general contractor and client on-site. The following information should be considered, and recommendations adhered to:

- To prevent saturation and loosening of subgrade materials the general contractor was instructed to backfill areas of exposed subgrade at end of day.
- It is important to note that contingent upon groundwater levels encountered during excavation and contingent upon subgrade conditions and the amount of precipitation anticipated during construction, additional groundwater management and/or dewatering recommendations may be warranted.
- Our office should be contacted upon construction continuation to continue to assess subgrade conditions and engineered fill placement compaction.

We trust that the observations and recommendations presented herein meet the current development requirements. Should any questions or concerns arise, please do not hesitate to contact our office.

Sincerely,

Arya Engineering Inc.

Emir Hot, EIT
Geotechnical Project Engineer

Benjamin Tomasz, P.Eng.
Principal | Senior Geotechnical Engineer



2019-08-22



Photograph 1 – Southeastern Extent of Exposed Subgrade



Photograph 2 – Compacted Engineered Fill and Stockpile

Memorandum

File No.:	19-231-SC	Date:	August 22, 2019
To:	Element Landscape Group		
Email:	info@elementgardens.ca	Phone:	604.741.3528
From:	Emir Hot, EIT; Ben Tomasz, P.Eng.	CC:	kjscontracting@gmail.com
Subject:	Memo. 2 – Construction Field Review – Site Consultation 438 Gower Point Road, Gibsons, British Columbia		

An Arya Engineering Inc. (Arya) representative was on-site on August 21th, 2019 to review site conditions after a period of precipitation for the proposed auxiliary structure (greenhouse) and related works. Site conditions at the time of the review were assessed through visual observation methods. This document presents a summary of the recommendations that should be adhered to in consideration of the precipitation.

- During the site consultation, ponding of surface water in excess of 300 mm was observed across portions of the subgrade in areas where silty sand (consistent with a basal Capilano deposit or Vashon Till) was observed.
- The general contractor indicated intent to discharge excess water into the municipal stormwater system.
- A sediment control tank was observed on-site at the time of the review.

The following commentary was relayed to the general contractor on-site. The following information should be considered, and recommendations adhered to:

- It is recommended that the sediment control tank be incorporated into temporary groundwater management strategy prior to any water being discharged into the municipal system. Our office should be contacted to evaluate water quality prior to discharging.
- Exposed subgrade areas comprised of undisturbed soils or engineered fill should be covered with non-woven geotextile to prevent excess saturation and loosening of the subgrade during ongoing precipitation.
- Our office should be contacted upon construction continuation, once precipitation has stopped, to continue to assess subgrade conditions and engineered fill approval and compaction.



We trust that the observations and recommendations presented herein meet the current development requirements. Should any questions or concerns arise, please do not hesitate to contact our office.

Sincerely,

Arya Engineering Inc.

Emir Hot, EIT
Geotechnical Project Engineer

Benjamin Tomasz, P.Eng.
Principal | Senior Geotechnical Engineer





Memorandum

File No.:	19-231-SC	Date:	September 13, 2019
To:	Element Landscape Group		
Email:	info@elementgardens.ca	Phone:	604.741.3528
From:	Emir Hot, EIT; Ben Tomasz, P.Eng.	CC:	kjscontracting@gmail.com
Subject:	Memo. 3 – Construction Field Reviews – Construction Monitoring 438 Gower Point Road, Gibsons, British Columbia		

This document presents a summary of the observations and recommendations made during construction monitoring conducted by our office from August 22, 2019 to September 8, 2019 as needed to review subgrade preparation and compaction of engineered fill (blanket drain implementation) across the site. Site conditions during monitoring activities were assessed through visual observation methods, manual probing methods, pocket penetrometer readings, and soil density gauge readings. This document also presents additional commentary and recommendations that should be considered and adhered to in the continued construction of the proposed works and the development of the site for the proposed structures.

August 22, 2019

- During the site visit, the subgrade was sequentially exposed on the southwestern extent of the site (comprising approximately 25% of the total subgrade area to be prepared).
- A maximum of 300 mm of standing water was encountered across portions of the subgrade on the southwestern extent of the site.
- The excavation extended to a depth ranging from 1.2 m to 1.5 m below grade into a subgrade comprised of undisturbed gravelly sand with trace to some cobbles. The westernmost 7 m of the subgrade (measured from the western excavation cut) was generally observed to consist of a silt and sand matrix consistent with a basal Capilano deposit or Vashon Till.
- Pocket penetrometer readings of the silt/sand deposit across the southwestern exposed excavation cut slopes and subgrade were observed to average 100 kPa.
- Localized portions of the subgrade where fine to medium grain size sand and silt were encountered were observed to be loose to an approximate depth ranging from 100 mm to 150 mm at the maximum possible excavation depth of 1.5 m which could be explored without development permit application (as stipulated by the Town of Gibsons).
- A localized loose/soft portion of the subgrade located approximately 5 m from the western property boundary, comprising an approximate area of 3 m by 3 m, was observed to contain saturated soils, organics, and construction debris to an approximate depth of 0.6 m below



adjacent exposed subgrade areas. It is understood by this office that this loose section coincides with a previous test hole location advanced by others. Loose materials and construction debris were removed from the aforesaid loose section, and replaced with 19 mm, clear open-graded gravel (“clear crush gravel”) which was placed in 300 mm lifts and compacted via vibratory compaction methods prior to placement of non-woven geotextile in this area. Based on conversations with the client and a review of conceptual site plans provided by the client during construction monitoring activities, it is our understanding that the proposed structure will be located approximately 10 m east of this previous test hole location. It is our understanding that the southwestern extent of the site will accommodate unpaved driveways, garden space, and parking space, and subgrade areas that were observed to be loose/soft will be outside of the influence of loading of proposed permanent structures. This was reviewed on site with the client and general contractor.

- Due to the extent of surficial ponding encountered during the monitoring, it was generally recommended that loose/softened material comprising the uppermost 100 mm to 150 mm of the subgrade be removed as needed to expose an undisturbed, compact subgrade.
- Upon exposure of a suitable subgrade material, as continually assessed via pocket penetrometer readings and/or manual probing methods, non-woven geotextile (Nilex 4545) was placed directly atop the approved subgrade. Adjacent sections of fabric were placed with a 300 mm overlap.
- Clear crush gravel was placed in loose, 200 mm to 300 mm lifts that were moisture conditioned upon placement and compacted with vibratory methods. The first two to three lifts of engineered fill were implemented on the southwestern extent of the subgrade.
- Generally, the engineered fill material met compaction specifications throughout the course of monitoring as measured via soil density gauge testing.
- Recommendations provided in the recommendations and conclusions section of this document should be adhered to in the continued construction of the proposed works.

August 23, 2019

- On August 23, 2019, excavation on the northwestern extent of the subgrade had commenced.
- The subgrade in this area was generally comprised of a bluish grey, sandy silt and grey silty sand at an approximate depth of 1.2 m below grade. Generally, the subgrade was observed to be loose/soft and very moist to saturated to an approximate depth of 150 mm to 300 mm below grade.
- Exposed excavation cuts across the subgrade were observed to exhibit pocket penetrometer readings averaging 125 kPa.
- Approximately mid-lot (as measured from north-south) and approximately 3 m east of the western excavation cut slope, a log was removed from the subgrade at a depth of 1.2 m below grade. The log exhibited an approximate length of 1.5 m with a diameter of 450 mm (Photographs



3 and 4). The localized void from where the log was removed was subsequently filled with clear crush gravel that was placed in 300 mm lifts and compacted via hand tamping (due to spatial constraints).

- In consideration of the extent of loose surficial soils encountered on the northwestern extent of the site, 150 mm to 300 mm of additional excavation was conducted as needed to expose a compact/stiff, undisturbed subgrade.
- Non-woven geotextile (Nilex 4545) fabric was placed directly atop the subgrade once approved by an Arya representative. Adjacent sections were placed with a 300 mm overlap and clear crush gravel was placed in loose, 300 mm lifts that were compacted, and moisture conditioned upon placement.
- The first two lifts of engineered fill were implemented on the northwestern extent of the subgrade. Generally, the lifts met the compaction specifications set by our office.
- It was recommended that a temporary groundwater management plan be implemented to control drainage and promote positive drainage towards the municipal stormwater system during construction. It was recommended that 100 mm diameter perforated pipe be implemented at the subgrade along the western property boundary (extending in a north-south direction). The recommended plan consisted of subsequently tying the perforated pipes into a closed 100 mm diameter pipe to be located approximately mid-lot and extended toward the municipal stormwater system near the eastern property boundary. Based on conversations with the general contractor, it is our understanding that permission to connect into the existing municipal system was granted by the Town of Gibsons. Additionally, it was also recommended that an additional perforated pipe be extended adjacent to the closed pipe (east-west oriented). Throughout the course of the construction monitoring, the drainpipes were placed atop a suitable subgrade approved by our office, that was subsequently covered with geotextile, and backfilled with a bedding layer of clear crush gravel prior to placement of the pipe. The pipes were then backfilled with clear crush gravel and the entire pipe-gravel system was wrapped in geotextile.
- It was recommended that vertical risers be implemented at the high end of the system and at the connections point of the closed and perforated pipes.
- It was recommended that a sediment control tank be implemented to prevent fine grained soils from entering the municipal stormwater system.
- The drainage system was partially completed on August 23rd, 2019. While this office did not provide full time monitoring for temporary drainage control, conversations with the client and general contractor suggest that the recommendations provided for the implementation of the drainage system were generally adhered to during construction.
- General recommendations provided in the recommendations and conclusions section of this document should be adhered to in the continued construction of the proposed works.



August 26, 2019

- During construction monitoring conducted on August 26, 2019, the third lift of clear crush gravel was implemented on the northwestern corner of the site and across the southern half of the site at large.
- Generally, a total of 0.7 m to 1.0 m (thickness) of clear crush had been elevated in these areas.
- The third lift of clear crush gravel in the aforesaid areas was compacted and moisture conditioned and met the compaction specifications provided by our office.
- From the northwestern extent of the site, excavation and subgrade exposure continued eastwards. Up to this time, the southern half of the subgrade had been fully exposed, and the northwestern corner comprising roughly 15% of the total subgrade area, had been exposed.
- Generally, at an excavation depth ranging from 1.2 m to 1.5 m below grade, the subgrade was observed to be comprised of sand with some gravel and trace to some cobbles. The northernmost 2 m to 4 m of the subgrade measured from the northern excavation cut slope was generally observed to consist of silty sand.
- The subgrade was observed to be compact/stiff apart from localized saturated areas that were loose/soft to an approximate depth ranging from 150 mm to 300 mm upon exposure. Additional excavation was conducted in these areas, and localized excavations were filled with clear crush gravel that was subsequently compacted prior to placement of non-woven geotextile across the subgrade.
- It is important to note that across select, localized saturated locations of the subgrade, where loose soils were encountered to an approximate depth of 100 mm to 150 mm below subgrade, these areas could not be removed due to the maximum 1.5 m excavation depth being reached.
- During construction monitoring, the client was notified of the localized loose areas. As these portions of the site are not expected to accommodate any permanent structures, the client indicated preference to continue with subgrade exposure and fill compaction at this time, despite the presence of loose/soft and saturated areas (as opposed to halting construction and gaining permitting approval to conduct additional excavation). The client agreed to conduct in-situ load testing of the prepared subgrade later (at final grade), as needed to quantify allowable bearing pressures and settlement under future loading conditions.
- Non-woven geotextile and the first lift of engineered fill were placed in conformance with the recommendations provided by our office.
- The first lift of engineered fill was moisture conditioned and compacted and generally met the required compaction specifications.
- Upon implementation and compaction of the first lift of clear crush, a portion of the subgrade where silty sand was encountered was observed to be loose/soft. The general contractor indicated intent to implement Uniaxial 1100 Geogrid on this portion of the subgrade.
- The localized loose portion where geogrid implementation was recommended by the general contractor was observed to be located approximately 8 m northwest of the location of the proposed structure, and thus is not expected to be loaded by the proposed structure. The client



and general contractor were informed that while the implementation of geogrid would not be expected to negatively affect subgrade performance, our office cannot certify the performance of the geogrid or confirm that it would improve overall stability conditions of the subgrade and overlying fill.

- Geogrid was placed with an overlap of 300 mm over the localized loose portion of the subgrade.
- General recommendations provided in the recommendations and conclusions section of this document should be adhered to in the continued construction of the proposed works.

August 27, 2019

- On the morning of August 27, 2019, the general contractor was instructed to elevate clear crush gravel to a minimum depth coinciding with the elevation of silt/sand (basal Capilano deposit or Vashon Till) observed in the excavation side walls, as this depth is expected to coincide with groundwater levels. The general contractor and client informed Arya representatives that due to the site grading plan, clear crush could not be implemented to the elevation of this silt/sand exposure in all areas. Groundwater seepage is possible in these areas during the wetter winter months which may lead to performance issues in the proposed parking areas/recreational areas, unless a groundwater management plan is implemented. This was relayed to the client and the general contractor on-site.
- On the southern half of the site, and on the northwestern corner of the site, non-woven geotextile fabric was placed atop the final lift of clear crush (0.7 m to 1.0 m of clear crush implemented) at a 300 mm overlap between adjacent layers in conformance with the recommendations provided by our office (completing the blanket drain on this portion of the site).
- Clean sand and gravel (“road base”) sourced from Elphinstone Aggregates Ltd. was implemented atop the blanket drain (lifts of compacted clear crush gravel surrounded by filter fabric) on the southern half of the site.
- The first 300 mm lift of road base was placed, moisture conditioned and compacted.
- Generally, the first lift of road base across this portion of the site met the compaction specifications provided by our office as determined through modified proctor testing.
- General recommendations provided in the recommendations and conclusions section of this document should be adhered to in the continued construction of the proposed works.

August 28, 2019

- During construction monitoring conducted on August 28, 2019, the northeastern portion of the subgrade was exposed.
- Excavation was conducted to an approximate depth ranging from 1.2 m to 1.5 m below grade into a subgrade comprised partially of sand with some gravel and some cobbles, and partially of bluish grey sand/silt.
- Ponding of surface water in excess of 300 mm was observed across portions of the subgrade in areas where undisturbed silt/sand was observed.



- Pocket penetrometer readings averaging 125 kPa were observed on the silt/sand exposures of the excavation cut slopes on the northeastern portion of the site.
- The subgrade was generally inferred to be compact/stiff with localized areas of loose material to a maximum depth of 300 mm. Additional excavation was conducted in these areas, and local excavations were replaced with clear crush gravel that was subsequently compacted via vibratory plate compaction prior to implementation of non-woven geotextile.
- Non-woven geotextile was placed atop the subgrade in conformance with the recommendations provided by our office and the first lift of clear crush gravel (300 mm to 450 mm) was placed, moisture conditioned and compacted. The first lift of clear crush on the southeastern extent of the site generally met the compaction specifications provided by our office.
- Due to material availability, Arya representatives were informed that subsequent lifts of road base would be sourced from Lehigh Materials Ltd. (as opposed to Elphinstone Aggregates Ltd., the previous supplier).
- Arya representatives collected samples of the new road base product to perform modified proctor testing as needed to determine compaction requirements.
- General recommendations provided in the recommendations and conclusions section of this document should be adhered to in the continued construction of the proposed works.

August 29, 2019

- During construction monitoring on August 29, 2019, the second and third lifts of clear crush gravel were loosely placed on the northeastern portion of the site. The lifts were moisture conditioned and compacted and generally met the compaction specifications provided by our office.
- The clear crush was subsequently covered with non-woven geotextile in conformance with the recommendations provided by our office.
- The general contractor indicated that a drainpipe connection (located mid-lot near the western property boundary) would require replacement due to a connection fracture which occurred during construction. This portion of the site was re-excavated as needed to expose the pipe and replace the fractured connection. Non-woven geotextile was re-implemented at the subgrade elevation prior to replacement and re-compaction of clear crush gravel. The gravel was placed in loose, 300 mm to 450 mm lifts and compacted via vibratory plate compaction and hand tamping (hand tamping was utilized due to spatial limitations).
- It is our understanding that this portion of the site will not contain any permanent structures.
- The portions of the subgrade comprised of clear crush gravel was completed by this time (top of the subgrade was covered with geotextile completing the blanket drain) in all areas apart from a localized section mid-lot near the eastern property boundary where the drainpipes were located.
- General recommendations provided in the recommendations and conclusions section of this document should be adhered to in the continued construction of the proposed works.



August 30, 2019

- On August 30, 2019, the first three lifts of road base had been implemented across the site.
- The first three lifts were moisture conditioned and compacted across the site and were tested to meet the compaction specifications provided by our office as determined through modified proctor testing.
- A catch basin was implemented approximately mid-lot (north-south) on the eastern extent of the site. Based on conversations with the general contractor, it is our understanding that the catch basin would be connected to the municipal system at a later date, coinciding with the replacement of municipal connection pipes (lateral connections).
- General recommendations provided in the recommendations and conclusions section of this document should be adhered to in the continued construction of the proposed works.

September 4, 2019

- Arya representatives re-visited the site on September 4, 2019 to review compaction of the final lift of engineered fill (road base) across the site. Generally, the final lift of engineered fill did not meet the compaction specifications provided by our office.
- The catch basin had not been tied into the municipal system at the time of the site visit.
- General recommendations provided in the recommendations and conclusions section of this document should be adhered to in the continued construction of the proposed works.

Recommendations and Conclusions:

The following commentary has been relayed to the general contractor and client. The following information should be considered, and recommendations adhered to:

- Surficial ponding and loose soils were encountered across discrete areas of the undisturbed subgrade at the maximum 1.5 m excavation depth. These areas are expected to be outside of the influence of loading of permanent structures. These areas should be reviewed onsite between Arya personnel and the client and general contractor when project plans are finalized, prior to forming for foundations/footings.
- It is recommended that in-situ load bearing testing (plate load testing) and proof rolling be conducted, and monitored by an Arya representative, upon finalization of project plans to determine the anticipated settlement under applied structural loading. At this time, it is anticipated that an allowable bearing pressure of at least 50 kPa will be suitable for the prepared subgrade and fill (maximum settlement of 25 mm over a 6.25 m span).
- Contingent upon the structural loading criteria and the results of load testing, alternative foundation strategies may be required.
- To facilitate load testing, the footprint of all permanent structures on the site should be delineated prior to plate load testing and proof rolling.



- Upon finalization of the structural plan set and delineation of the building footprint on-site, our office should be given the opportunity to conduct additional engineering analysis as needed to assess potential surcharge loading of the structure on the implemented drainpipes and the catch basin.
- Based on the site grading plan, clear crush gravel could not be elevated to the recommended height, where Vashon Till or the basal Capilano deposit was observed on the excavation cut slopes, indicating groundwater level. In consideration of this, it is possible that elevated groundwater levels could lead to excess surficial moisture and ponding across portions of the site. Contingent upon the extent of this condition and the performance of the parcel during the wet winter months, it may be required that permanent stormwater and groundwater management works be implemented across the property to control surface water and groundwater.
- During construction monitoring, drainage pipes from the neighboring properties to the north were observed to be discharging onto the subject site. It is recommended that these features be re-routed towards approved discharge facilities.
- Based on conversations with the client, it is our understanding that a current project goal consists of the implementation of a 1.2 m high boulder stacked landscaping wall to border the northern and western extents of the excavation. Our office should be given the opportunity to provide design consultation and recommendations pertaining the implementation of these features prior to construction.
- As the subgrade had not been fully prepared at the time of the last site visit, our office should be contacted to monitor completion of subgrade preparation to ensure adequate compaction has been achieved.
- Design and construction review of temporary groundwater management installations were outside of our scope of services. This office provides no assurance for the performance of temporary groundwater management installations (drainpipes, catch basins, etc.).

We trust that the observations and recommendations presented herein meet the current development requirements. Should any questions or concerns arise, please do not hesitate to contact our office.

Sincerely,

Arya Engineering Inc.

Emir Hot, EIT
Geotechnical Project Engineer

Benjamin Tomasz, P.Eng.
Principal | Senior Geotechnical Engineer



2019-09-13



Appendix A : Photographs



Photograph 1 – August 22, 2019 - Loose soils and debris encountered in previous test hole location



Photograph 2 – August 22, 2019 – Geotextile placement on southwestern corner of site



Photograph 3 – August 23, 2019 – Log removed from northwestern extent of subgrade



Photograph 4 – August 23, 2019 – Void in log location



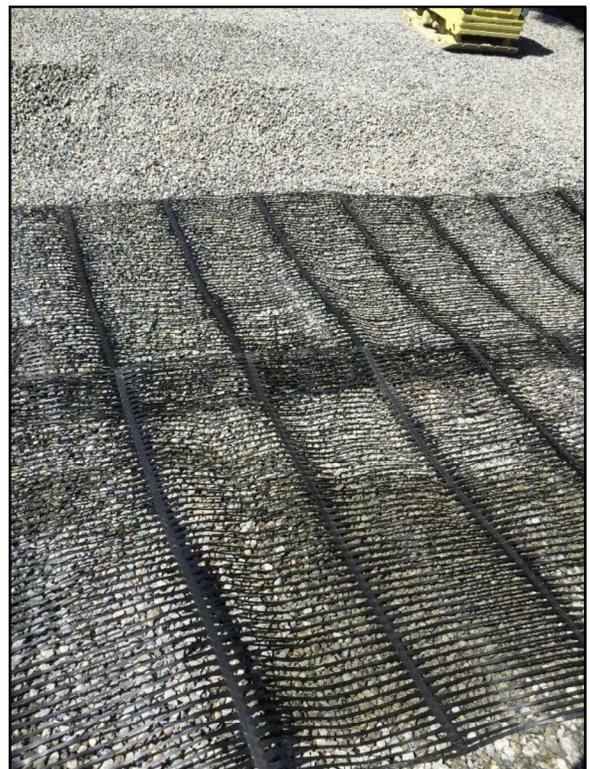
Photograph 5 – August 23, 2019 - Northwestern extent of subgrade



Photograph 6 – August 23, 2019 – Compaction of clear crush (northwestern extent of site)



Photograph 7 – August 26, 2019 – Sequential subgrade exposure



Photograph 8 – August 26, 2019 – Geogrid implemented on loose portion of subgrade



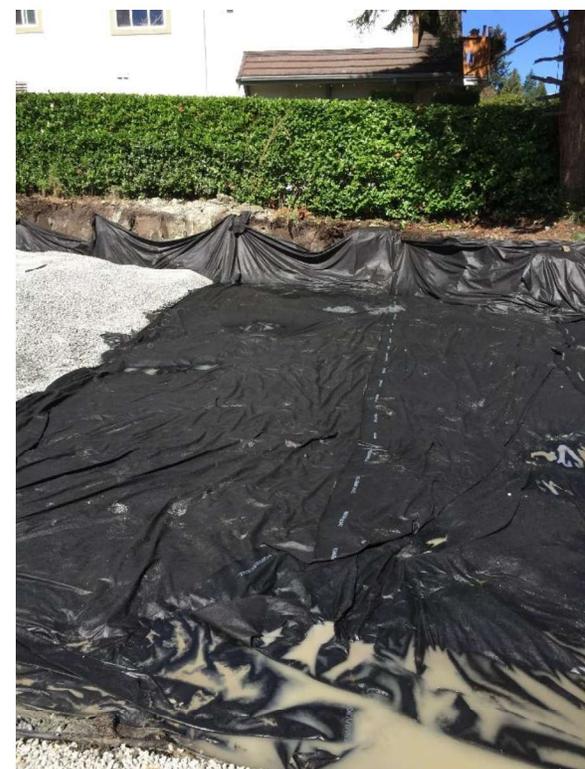
Photograph 9 – August 27, 2019 - Implementation of geotextile atop clear crush



Photograph 10 – August 27, 2019 - Implementation of first lift of road base



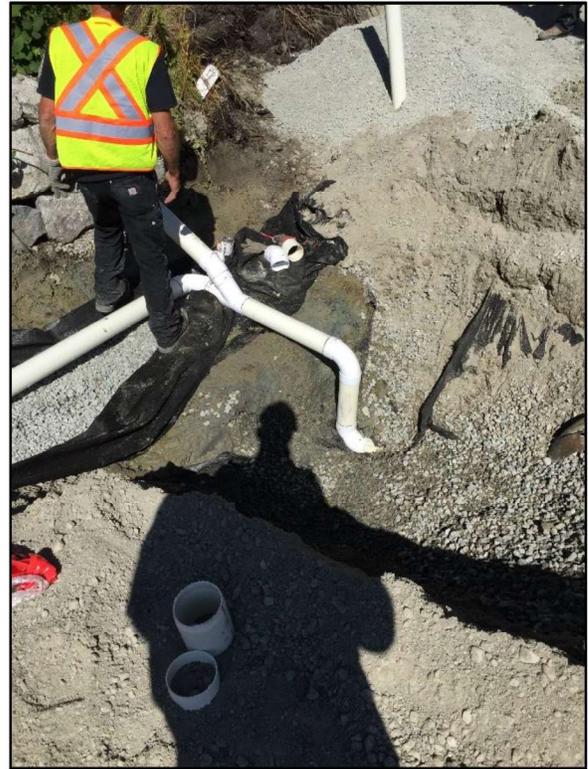
Photograph 11 – August 28, 2019 – Subgrade on northeastern corner of site



Photograph 12 – August 28, 2019 – Geotextile (Nilex 4545) on northeastern extent of site



Photograph 13 – August 29, 2019 – Compaction of engineered fill continued



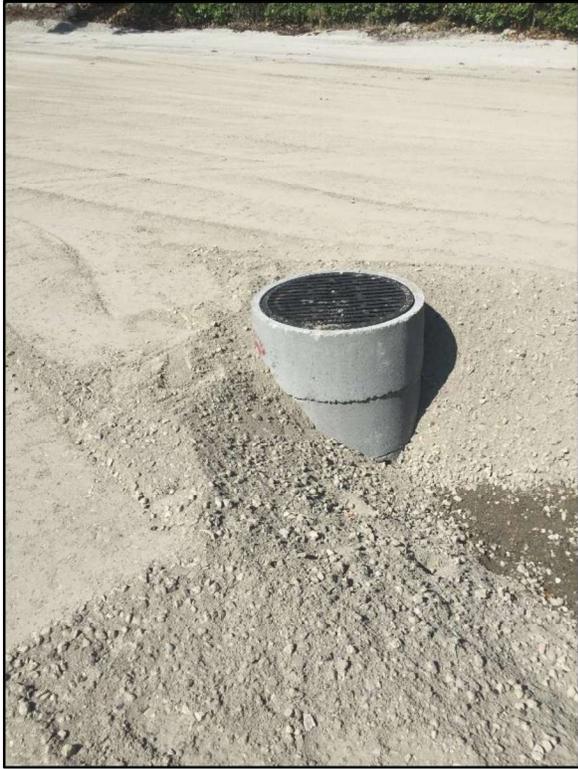
Photograph 14 – August 29, 2019 – Drainage connection repair



Photograph 15 – August 30, 2019 – Catch basin



Photograph 16 – August 30, 2019 – Subgrade preparation



*Photograph 17 – September 4, 2019 – Catch basin
(not connected to municipal system)*



*Photograph 18 – September 4, 2019 – Prepared
Subgrade*



Memorandum

File No.:	19-231-SC	Date:	March 3, 2020
To:	Element Landscape Group		
Email:	info@elementgardens.ca	Phone:	604.741.3528
From:	Emir Hot, EIT; Benjamin Tomasz, P.Eng.	CC:	
Subject:	Memo. 4 – Development Permit Area 9 Review – Gibsons Aquifer 438 Gower Point Road, Gibsons, British Columbia		

INTRODUCTION

Arya Engineering Inc. presents the following document summarizing an assessment conducted to evaluate the anticipated impact of the proposed development project at the above-listed address on an underlying aquifer (Gibsons Aquifer). We understand that initially, the scope of proposed development consisted of site preparation activities needed for the development of an unpaved driveway/parking areas to accommodate parking and vehicle conveyance for the adjacent parcel (444 Gower Point Road). The construction of an auxiliary structure (greenhouse) was also planned as part of the initial scope of work. It is our understanding that the project scope has since been updated to include the construction of a single-story commercial structure at the subject property. Given the updated proposed scope of development, we understand that development permit area (DPA) criteria for DPA 9 – Gibsons Aquifer (Lower Gibsons Subarea and Gibsons Well Head Protection Area) need to be addressed as outlined in the Town of Gibsons' Official Community Plan (OCP), adopted in March 2015. The intent of this memorandum is to provide the requisite geotechnical commentary in support of development permit application for the proposed development.

PREVIOUS GEOTECHNICAL WORKS AND CONSTRUCTION ACTIVITIES

Previous geotechnical works for the subject site in support of initial project objectives included the following:

- A geotechnical assessment, including a site investigation to observe current conditions across the site, such as observations of surficial soils, topography, vegetation, and drainage conditions. The site investigation included a subsurface exploration program consisting of the excavation of five (5) test pits excavated to a maximum depth of 1.5 m below natural ground surface, to characterize subsurface conditions across the site.
- Construction monitoring during site preparation for the proposed parking areas/driveway and auxiliary structure, including:
 - Site monitoring during excavation and subgrade exposure; and
 - Site monitoring during placement and compaction of engineered fill.



Geotechnical works completed to date have been comprehensively described in the following documents prepared by our office:

- *Geotechnical Assessment – Proposed Auxiliary Structure (Greenhouse)*, dated August 9, 2019.
- *Memo. 1 – Construction Field Review – Subgrade Preparation and Compaction of Engineered Fill Construction Monitoring*, dated August 22, 2019;
- *Memo. 2 – Construction Field Review – Site Consultation*, dated August 22, 2019; and,
- *Memo. 3 – Construction Field Review – Construction Monitoring*, dated September 13, 2019.

These documents will be submitted as separate deliverables in support of development permit application.

Based on the results of the subsurface exploration program conducted as part of the geotechnical assessment and construction monitoring activities, the site is underlain by compact to dense (stiff to very stiff) sand/silt with trace gravel, trace clay and trace cobbles at depths ranging from 1.2 m to 1.5 m below natural ground surface. This material was inferred to be consistent with the low permeability Basal Capilano or Vashon Till deposit which is expected to confine the underlying Gibsons Aquifer in the area.

AQUIFER/AQUITARD CHARACTERISTICS AT SUBJECT SITE

An aquifer mapping study prepared for the Town of Gibsons by Waterline Resources Inc. (Waterline 2013) was reviewed as part of this assessment. Waterline 2013 was completed to evaluate aquifer boundaries, hydraulic properties, and recharge/discharge properties of the aquifer, and includes a schematic geologic cross section through the Gibsons Aquifer, extending from Upper Gibsons to the oceanic waters of the Howe Sound through the Lower Gibsons Subarea. In Lower Gibsons, the cross section was extended from near the intersection of Abbs Road and Winn Road, southeast towards the intersection of Gower Point Road and Glassford Road, and from this point continuing to the east-northeast towards Gibsons Harbour. Waterline 2013 suggests that the aquitard ranges in thickness from a veneer near the contact of the oceanic waters of Howe Sound to approximately 10 m in thickness near Winn Road, generally increasing in thickness beyond this point towards Upper Gibsons. At its closest point, the Waterline 2013 geologic cross section passes approximately 90 m southwest of the subject site, where a minimum aquitard thickness of 5 m is provided. Aquitard thickness approximately 95 m south of the subject site is mapped at approximately 4 m in thickness.

Published well log data (sourced from iMap BC) was also reviewed to evaluate surficial geology and groundwater conditions within 300 m of the subject property as stipulated by the OCP. Well log data for the following wells was referenced as part of this assessment:



Table 1 – Coordinates and Well Tag Numbers of Local Wells within 300 m of Subject Site

Well Tag Number	Latitude	Longitude
19896 (Town Production Well 1)	49.399873	-123.509172
76196 (Town Production Well 4)	49.400841	-123.507997
33950 (Town Production Well 2)	49.397374	-123.510979
53237 (Town Production Well 3)	49.396997	-123.510713
70506	49.39672	-123.508216
117705	49.39752	-123.51121
76155	49.397502	-123.510443
11667	49.398746	-123.509905
117708	49.40098	-123.50929
11709	49.40047	-123.50776
5468	49.400067	-123.50814

Based on a review of the lithological information available for the water wells located within a 300 m radius of the site, the aquitard is expected within 3 m to 6 m of existing ground surface, and the Gibsons Aquifer is expected between 6 m to 12 m below existing ground surface. In the study area evaluated, an aquitard thickness ranging between 5 m and 7 m is expected.

Previous project work conducted by Arya personnel in Lower Gibsons corroborates the well log data reviewed and the findings of Waterline 2013. Previous subsurface exploration activities including geotechnical borehole drilling programs located within 70 m of the subject site, indicate that if present, the Gibsons Aquifer is likely located beyond 6.5 m from existing ground surface in this area, corresponding to an aquitard thickness of at least 5 m at the subject property.

DEVELOPMENT IMPACT ON GIBSONS AQUIFER

Town of Gibsons production wells (Town Well 1 – Town Well 4,) are located within 250 m of the subject site. These wells are situated at an elevation ranging from 5 m to 12 m above the property. Per Waterline 2013, three primary recharge mechanisms are recognized for the Gibsons Aquifer. These include mountain block recharge (recharge movement through bedrock fractures suspected near the base of Mt. Elphinstone), creek recharge (recharge through creek beds that may be connected to the underlying aquifer where the aquitard cover is thin or has been eroded away), and recharge windows through Capilano Alluvium. Anticipated recharge windows are located in the north of Upper Gibsons and near the base of Mt. Elphinstone, in areas where erosion of the Basal Capilano/Vashon Till cover has resulted in a direct pathway for recharge to enter the Gibsons Aquifer. Waterline 2013 indicates that further mapping is required to comprehensively delineate recharge areas, and suggests that those areas of primary interest include Upper Gibsons to the peak of Mt. Elphinstone (mountain recharge), 150 m within creek corridors (creek recharge), and across Upper Gibsons to the base of Mt. Elphinstone (Capilano Sediment recharge windows).



Based on consultation with the client, it is our understanding that site drainage (rainwater collection and perimeter drainage collection) will be discharged into the Town of Gibsons' municipal stormwater system.

No evident recharge windows are present in the vicinity of the property and the nearest creek is located beyond 150 m from the area of proposed development. Furthermore, no excavation is anticipated into the aquitard as part of this development project, and the recently elevated site grade has been established at the anticipated maximum transient groundwater level. This indicates that perimeter drainage interception of transient groundwater conditions is expected to be minimal. As such, it is not expected that the proposed development will impact current recharge conditions of the Gibsons Aquifer.

The geotechnical assessment completed by this office provides for an allowable bearing pressure (contact pressure between footings and soils) of 50 kPa. Based on conversations with the client, it is our understanding that the updated scope (development of a single-story commercial structure) does not constitute additional loading beyond that provided for in the geotechnical assessment. It is our understanding that a shallow foundation support strategy is intended through the incorporation of strip footings and pad footings with maximum widths 600 mm.

In consideration of the aforesaid foundation design specifications and loading criteria, and existing site conditions, including site preparation works conducted to date (at least 1.2 m of compacted engineered fill atop compact/stiff Basal Capilano/Glacial Till deposits), the increased vertical stress in the soil matrix below proposed footings was calculated. At a depth of 1.2 m below proposed footing elevation, which coincides with the minimum upper limit of the aquitard, a maximum increase in vertical stress on the order of 5 kPa is expected. The anticipated induced loads are therefore considered negligible with respect to their influence on the existing stress state of the aquitard, and the proposed works are therefore not expected to impact the underlying Gibsons Aquifer.

CLOSURE AND LIMITATIONS

Final project plans for proposed structures were not available for review at the time of drafting of this document. It is important to note that several localized loose subgrade areas were encountered during excavation and subgrade preparation, in areas that were previously intended for landscaping/parking. Our office should be given the opportunity to review final project plans and to provide updated foundation design recommendations as needed when the final building footprints are determined. If design objectives change throughout the planning stages of this project, our office should be given the opportunity to review the suitability of the commentary provided in this memorandum.

This memorandum has been prepared for the exclusive use of Element Landscape Group for the development activities proposed on the subject site at the time this document was drafted. 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 document 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. This assessment was conducted in accordance with current geotechnical engineering practice and principles.

We trust that the observations and recommendations presented herein meet the current development requirements. Should any questions or concerns arise, please do not hesitate to contact our office.

Sincerely,

Arya Engineering Inc.

Emir Hot, EIT
Geotechnical Project Engineer

Benjamin Tomasz, P.Eng.
Principal | Senior Geotechnical Engineer