TETRA TECH

March 31, 2023

ISSUED FOR USE
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Via Email: Laura.Prentice@yukon.ca

Government of Yukon
Community Services
Land Development Branch
Box 2703
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Attention: Laura Prentice – Director

Subject: Lot Development and Foundation Design Bulletin – Revision 1
Phase 6 Whistle Bend Subdivision, Whitehorse, Yukon

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Government of Yukon, Department of Community Services Land Development Branch (YG) to provide geotechnical recommendations pertaining to lot development and foundation design for Phase 6 of the Whistle Bend Subdivision, Whitehorse, YT.

2.0 SCOPE OF SERVICES

Tetra Tech's scope of services included the following:

- Describing the site and soil conditions that will be encountered throughout Phase 6.
- Discussing the site and soil conditions that may affect lot grading and site drainage, along with presenting appropriate methods of controlling surface water flow and disposal.
- Considerations for foundation design and construction including descriptions of foundation systems considered most appropriate for Phase 6.
- Discussion of seasonal frost considerations and providing perimeter insulation recommendations for use during foundation construction of single detached and multi-family structures to minimize potential for damage caused by seasonal frost heave.

3.0 SITE CONDITIONS

3.1 Location and Surficial Features

Whistle Bend Subdivision's Phase 6 is located north of Phase 4 and west of Phase 5. The proposed development in Phase 6 will consist of single-detached, duplex, townhouse, and multi-family residential properties.

In general, Phase 6 is quite flat and the only terrain features noted consisted of a glaciofluvial deposit along the west side of Wyvern Avenue and a smaller feature along Vedder Avenue north of Witch Hazel.

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3.2 Soil Conditions

The entirety of Phase 6 is underlain by glaciolacustrine silt. A thin layer of surficial sand up to approximately 0.3 m in thickness exists in some areas, overlying the silt. A glaciofluvial landform consisting of several meters of sand was encountered along the west side of Wyvern Avenue. It is assumed much of this sand has been used during deep utilities and surface works construction but may be encountered during lot development.

3.3 Groundwater

Groundwater was not noted in any of the test holes within Phase 6. However, since the construction of previous phases where water has never been encountered, water has been noted running through deep utility trenches (most commonly encountered in excavations for water and sanitary service connections).

Investigation work is ongoing to determine if this water is naturally sourced (e.g., from surface water infiltration) or artificially sourced (e.g., from leaks in buried municipal services), and determine how to best mitigate potential concerns with foundations and developments. The precise extents and elevations of this groundwater have not been delineated and therefore there is potential it may be encountered during water and sanitary service connection work, or foundation and/or basement excavation.

Developers should be prepared to mitigate if required.

4.0 LOT GRADING AND DRAINAGE CONSIDERATIONS

Grading plans for all lots (single detached and multi-family) should ensure positive drainage of surface water onto paved roadways and/or into the storm sewer system. Rock pits constructed on individual lots for stormwater management are not considered suitable or feasible for Phase 6.

5.0 FOUNDATION CONSIDERATIONS

The design and construction of residential housing typically falls under Section 9 of Division B in the National Building Code of Canada (NBCC 2020). This includes Group C residential structures that are 3 stories or less in building height and having a building footprint area not exceeding 600 m^2.

This section of the building code provides general guidelines for the design and construction of residential housing, often without the requirement of additional geotechnical input. Typical foundation systems, as described below are expected to perform suitably in Phase 8, provided the guidelines in Section 9 of NBCC 2020, including Section 9.4.4.4 – Soil Movement, and the recommendations included in this bulletin, are followed.

Tetra Tech understands that there have been some occurrences of ground movement impacting residential foundations in the Whistle Bend subdivision. It is our understanding that these occurrences have been predominately caused by frost-related ground movement, which can be mitigated as discussed below in Section 6, as well as in the referenced NBCC 2020 sections.

Foundation systems that are considered appropriate for Phase 6 include:

- Thickened monolithic slab-on-grade and engineered fill construction minimizes the risk of development challenges or damage caused by water travelling along deep utility corridors and service connections. A properly constructed engineered fill supporting the slab foundation ensures stable foundation soils and makes

positive drainage away from foundation elements easier because fill elevations can be set above existing site grades.

- Shallow strip footings foundation systems are also considered acceptable. It should be noted that throughout the Whistle Bend Subdivision, the deeper the footings, the higher the risk of encountering wet, soft foundation soils and possibly water flowing through utility trenches. This foundation system must adhere to the standards presented in this report and it is recommended that geotechnical input into perimeter insulation be provided.
- Strip footings supporting a full basement is also considered acceptable if the soils at depth are not excessively wet and soft. Waterproofing the foundation walls and the exterior face of the footings is critical.
- Helical piles are also considered acceptable. The piles must be augered into soils below seasonal frost penetration depths to minimize potential for differential frost heave movement and damage, as well as resist vertical and lateral loading. There is a local contractor completing this type of work, they should be contacted for pricing.

If development in Phase 6 falls under Section 4 of Division B of NBCC 2020 additional geotechnical evaluation of the site may be required. This may include a geotechnical drilling program, seismic cone penetration (SCPT), and laboratory testing to assess foundation soil conditions, determine an appropriate Site Designation, and assess liquefaction risk. A geotechnical engineering firm should be contacted to provide specific pricing; however, developers should be prepared to spend between $30,000.00 and $50,000.00 to complete a site-specific geotechnical evaluation.

5.1 Foundation Drainage Considerations

According to the City of Whitehorse Building Advisory October 25, 2010, *Drainage Standards for Building Foundations* (City of Whitehorse, 2010*)*, any new building constructed in Whitehorse with below-grade foundations must adhere to prescribed standards for drainage. The relevant standards referenced in the City of Whitehorse document include the following:

- Permanent Wood Foundations, as outlined in CAN/CSA S-406-92, *Construction of Preserved Wood Foundations* and identified in the 2005 edition of the National Building Code of Canada (NBCC 2005).
- Concrete Foundations, as described in NBCC 2015, Section 9.14, which identifies minimum requirements for foundation drainage, drainage tile and associated piping, granular drainage layers, drainage disposal, and control of surface runoff.

The prescriptive measures are based on CSA and NBCC specifications as summarized in the following sections, as understood from the updated 2020 edition of the National Building Code of Canada (NBCC 2020).

5.1.1 Permanent (Preserved) Wood Foundation Drainage

If the use of permanent (preserved) wood foundations (PWF) is desired, a granular drainage layer should be installed beneath all footings and basement slabs, in accordance with CAN-CSA S406, because of the low permeability of the underlying glaciolacustrine material. Adequate thicknesses of free draining soil (sand and/or gravel) is generally not expected throughout Phase 6, therefore this requirement will not likely be waived for new developments, however this can be reviewed on a case-by-case basis by a geotechnical engineer if required.

The granular drainage layer should be constructed using a clean crushed stone or screened drain rock material of maximum particle size 40 mm and having less than 10% sand (passing the 5 mm sieve). This layer shall be at least 125 mm thick and shall extend at least 300 mm beyond the perimeter footing plate. The granular drainage layer

shall be graded to drain to a sump which, in turn, shall drain to a point of final disposal beyond the building's footprint. It is common to use bedding stone that is produced to satisfy the City of Whitehorse 25 mm Bedding Stone specification as described in the City of Whitehorse's Servicing Standards Manual (City of Whitehorse 2020). If alternative granular materials are considered, testing should be completed to confirm suitability.

In accordance with CAN-CSA S406, the use of perimeter drainage tile or pipe is not recommended with PWF.

Existing site soils can be used as backfill around foundations and in service trenches. All backfill materials should be moisture conditioned and compacted to at least 95% of standard Proctor maximum dry density.

The design life of a preserved wood foundation system relies on keeping water away from the preserved wood foundation elements, so waterproofing of the foundation wall and the proper construction of the granular drainage layer is critical. As well, all backfill material placed within 600 mm of the foundation walls should be free of deleterious debris, frozen materials, and large, angular rocks larger than 150 mm in diameter.

When considering the use of potentially frost susceptible fine-grained soil for backfill along the perimeter of the PWF foundation walls, season frost protection may be required to avoid frost related movement. It is recommended that a geotechnical engineer be contacted to provide recommendations to mitigate frost related movement.

5.1.2 Concrete Foundation Drainage

If the use of concrete foundations (including ICF Block Wall foundations) is desired, the drainage tile and pipe, granular drainage layers, drainage disposal, and surface drainage specifications outlined in NBCC 2015, Section 9.14 "Drainage" must be followed. As mentioned above, soil throughout Phase 6 is not generally expected to be free draining, however this can be reviewed on a case-by-case basis by a geotechnical engineer if required.

Concrete footing and foundation wall systems are required to have perimeter drainage tile which terminates in a sump pit. A sump pit shall be installed to assist in the removal of water from the foundation area (should water accumulation in the sump pit warrant it).

All backfill material placed within 600 mm of the foundation walls shall be free of deleterious debris, frozen materials, and boulders larger than 150 mm in diameter.

Existing site soils can be used as backfill around foundations and in service trenches. All backfill materials should be moisture conditioned and compacted to at least 95% of standard Proctor maximum dry density.

6.0 SEASONAL FROST CONSIDERATIONS

6.1 Seasonal Frost Related Movement

Seasonal frost-related movement is common in cold climates when three conditions exist, including:

- Ground temperatures are below freezing for a period of time that allows frost penetration to below footing elevations;
- Frost susceptible soils (i.e., fine grained soils that are susceptible to the formation of ice lenses, causing frost heave during freezing) are present; and
- Soil pore space is near 100% saturation.

Since the Yukon experiences sub-zero temperatures through the winter months and during the shoulder seasons, and the subject site (Phase 6) is underlain with frost susceptible glaciolacustrine soils that are wet to saturated, the best way to mitigate potential for frost heave is to prevent surface water infiltration into the soils under the footings and to reduce seasonal frost penetration by installing adequate perimeter insulation around all foundations.

Considering a seasonal frost depth of 2.4 m (typical for soils underneath foundations in Whitehorse), frost-susceptible foundation soils, and the presence or possible presence of water within these soils, there is potential for frost-related ground movement, and additional protection will be required wherever building foundations, floor slabs, or other elements are installed within the depth of seasonal frost penetration.

6.2 Foundation Insulation Recommendations

Current local codes now dictate the use of insulation around all foundations as under Section 86 of City of Whitehorse's Building and Plumbing Bylaw 99-50 (City of Whitehorse, 2016). However, this insulation specification is intended for energy efficiency (to prevent heat loss from the building) and is ***not considered adequate for seasonal frost protection, where frost heave potential exists***. Tetra Tech recommends installing additional perimeter insulation near the surface or at depth around foundations constructed on frost susceptible soils to mitigate potential for seasonal frost-heave damage. This requirement for seasonal frost protection insulation is also discussed in NBCC 2020 Section 9.4.4.4 – Soil Movement.

Tetra Tech typically recommends an equivalent of 2.5 m of equivalent frost protection. Therefore, additional perimeter insulation will be required where there is less than 2.5 m of foundation wall backfill. For example, if strip footings are constructed at 1.2 m below finished site elevations, additional perimeter insulation will be required. A "rule of thumb" determination can be used, where 25 mm (1") of moisture resistant, backfillable, rigid insulation is roughly the equivalent of 300 mm (1') of soil cover; therefore, an additional 100 mm (4") of insulation will be required to satisfy the 2.5 m minimum for the footings founded at a depth of 1.2 m.

Attached or detached garages are often problematic, as they are typically constructed on near surface footings or a thickened monolithic slab-on-grade foundation. As well, temperatures in garage structures are often kept much cooler than the adjoining residence. Therefore, additional perimeter insulation would likely be required to mitigate potential for movement and damage caused by seasonal frost.

Perimeter insulation may need to extend a minimum of 1.8 m (6') out from the building's perimeter. Builders should be aware that this requirement may affect the setback distance from the foundation to shared lot lines. Insulation should be installed to ensure positive drainage away from the foundation.

Different foundation burial depths and foundation soils can affect the required frost protection (i.e., thickness, horizontal length, burial depth, etc.). To ensure that the foundation is adequately protected, it is recommended that builders contact a geotechnical engineer so that site specific perimeter insulation solutions can be provided.

6.3 Frost Heave and Lot Drainage Considerations

Drainage is also crucial to minimizing the potential of frost heave. The lot drainage requirements presented as STD DWG D2.0 and D2.1 in the City of Whitehorse Servicing Standards Manual must be enforced. This is particularly important for sites where residential structures are constructed along a slope and as presented on D2.0 and D2.1, "flows are to be carried around houses in defined shared or internal swales".

Along with drainage control, it is important that the structure have functioning rain gutters and downspouts installed to minimize potential for water to make its way down along the foundation wall and under the footings.

It is important to limit the infiltration of surface water into foundation soils to minimize seasonal frost-related ground movement. Surface water infiltration should be minimized through site grading, functioning eavestroughs, and snow management. Installation of perimeter insulation will also aid in directing water that has infiltrated into the foundation wall backfill away from foundation elements.

7.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Government of Yukon, Department of Community Services Land Development Branch (YG) and their agents. Tetra Tech Canada Inc. (operating as Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Government of Yukon, Department of Community Services Land Development Branch (YG), or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

8.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
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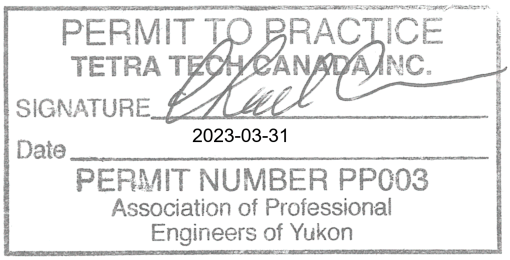

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APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL – YUKON GOVERNMENT

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the use of TETRA TECH's Client, its officers, employees, agents, representatives, successors and assigns (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH. Any changes to the conclusions, opinions, and recommendations presented in TETRA TECH's Professional Document must be authorized by TETRA TECH.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems, as per agreed project deliverable formats. TETRA TECH makes no representation about the compatibility of these files with the Client's future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be brought to the attention of TETRA TECH within a reasonable time.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, and subject to the standard of care herein, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage, except where TETRA TECH has subcontracted for such information.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to make, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the Client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.8 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.9 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.10 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.11 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.12 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.13 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.14 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.15 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.16 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.17 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.18 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.19 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.