TETRA TECH EBA

August 11, 2014

ISSUED FOR USE
FILE: W14103444-01
Via Email: tlove@nvdlp.com

Northern Vision Development LP
Suite 200 – 2237 2nd Avenue
Whitehorse, YT Y1A 0K7

Attention: Mr. Taylor Love, Director of Business Development

Subject: Pre-Design Geotechnical Assessment
Bennett Lake Residential Development
Carcross, Yukon

1.0 INTRODUCTION

At the request of Mr. Taylor Love, Director of Business Development of Northern Visions Development LP, Tetra Tech EBA Inc. (Tetra Tech EBA) has completed a geotechnical assessment of the proposed Bennett Lake Residential Development site in Carcross, Yukon.

The work has been completed in accordance with Tetra Tech EBA's April 10, 2014 proposal (which was originally submitted to Urban Systems of Whitehorse, Yukon) with additional focus on the list of requested deliverables submitted to Northern Vision Development LP by Urban Systems on July 16, 2014.

1.1 Background

The study area is located overlooking Bennett Lake adjacent to the Carcross town site. Conceptually, the development will include single family and multi-family units, along with high density housing complexes. The lots will not be serviced with water and sewer and minimal disturbance development will be the focus.

2.0 SCOPE OF SERVICES

The Tetra Tech EBA task list included:

- The collection and review of in-house information describing terrain, surficial geology, depositional history and geotechnical conditions throughout the study area. To complete this task, Tetra Tech EBA's testhole and project databases were utilized to collect and review in-house reports and testhole logs from previously completed projects in the Carcross town site and vicinity to the study area. Surficial geology mapping (1982-*Southern Lakes Series* – Morison, Klassen, Davies) was reviewed to establish depositional history;
- A site reconnaissance was completed on August 2 and 4, 2014. Observations confirmed information collected from in-house data sources; and
- The development of pre-design recommendations in accordance to the Tetra Tech EBA proposal and the July 16, 2014 Urban Systems deliverables list.

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3.0 SITE CONDITIONS

3.1 Terrain Classification Information

According to the Morison, McKenna and Davies terrain mapping, the subject site is located within the Carcross Soil Complex. Conditions associated with this terrain polygon include:

- The surficial soils throughout the majority of the Carcross town site includes medium to fine-grained eolian sand;
- The eolian sand and topography of the study area results in well drained conditions;
- Below the eolian sand, fine-grained glaciolacustrine soil is typical;
- The surface expression is considered to be rolling with moderate to steep slopes throughout; and
- Although not presented on the terrain mapping used for this assessment, first-hand knowledge of the area has confirmed the presence of bedrock in specific locations. This will be a development concern.

3.2 Geotechnical Test hole Information.

Tetra Tech EBA's project and testhole databases were searched for pertinent information. Three projects completed within the terrain polygon and in proximity to the study area have been used for assessment and evaluation. Included are:

- *1988 – Hydrogeological Study – Carcross, Yukon* – three boreholes were advanced in the vicinity of the 7 Avenue corridor. Between 5 m (closest to Bennett Lake) and 8 m (northeast of subject site) of eolian sand was noted over the underlying fine-grained glaciolacustrine soils. Groundwater was encountered at 4.6 m (slightly down gradient of the Tagish Avenue corridor) and 6.6 m (close to the Too-Chi Avenue corridor). Further northeast in BH 01, groundwater was not encountered. Water well analysis and potential for contamination was also addressed by Tetra Tech EBA and Stanley Associates; supporting the use of septic holding tanks and water delivery.
- *2008 – Pavement Structure Design Options – Downtown Transportation Assessment, Carcross* – roadway structure designs were prepared for various traffic patterns and volumes; and
- *2010 – Water Treatment Plant and Associated Infrastructure* – three boreholes were drilled at the new water treatment plant site and foundation design recommendations were presented for a variety of foundation options and footing depths.

3.3 Site Reconnaissance

Observations made during the site reconnaissance included:

- The Tagish Avenue extension will require significant grading due to the rolling topography along with steep sided dunes and depressions.

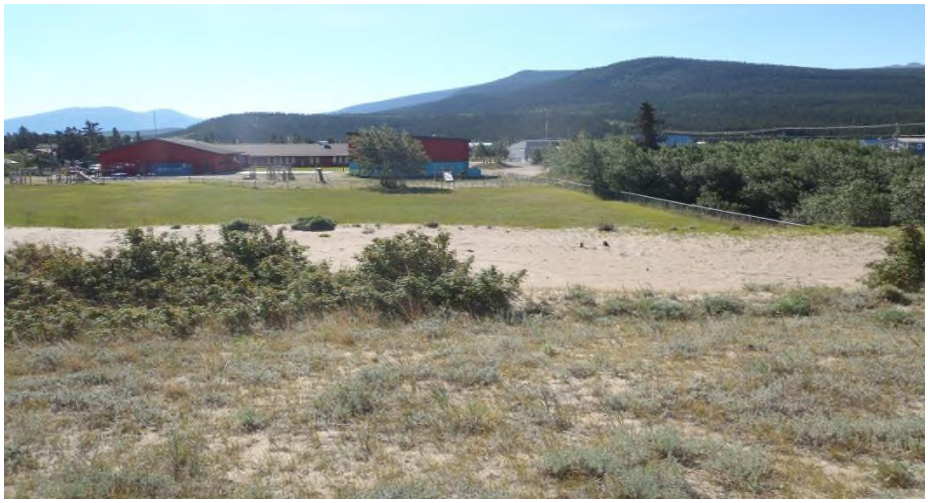


Photo 1
Dune overlooking school yard – significant depression on lake side of school yard fence

- The access roads constructed around 9, 10 Streets and Too-Chi Avenue may encounter bedrock (dependent upon the depth of the cuts in that area). This may also affect foundation design and construction throughout this portion of the study area.

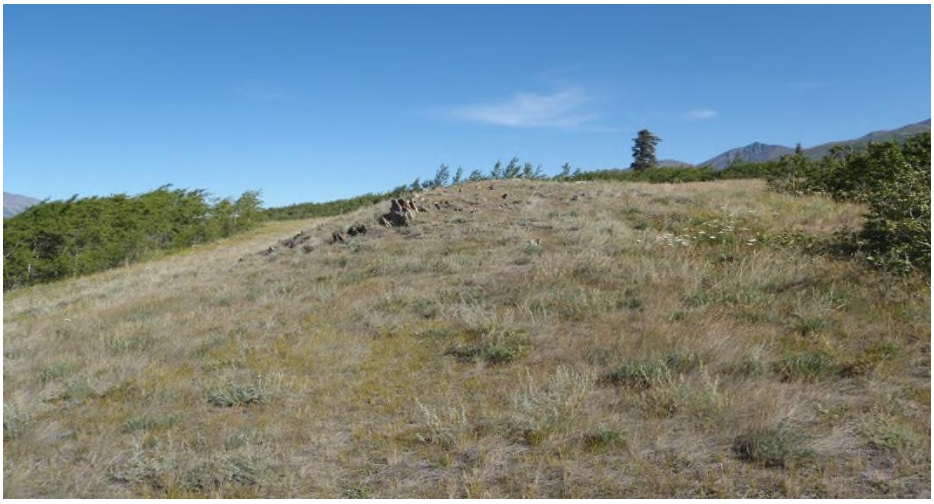


Photo 2
Bedrock in northwest corner of study area

- The eolian sands deposited across the study area have historically been worked and reworked by the wind blowing off Bennett Lake. The dune formations all run perpendicular to the shoreline, as would be expected. Where vegetation exists on slopes, there is minimal evidence of erosion but disturbance to the root mat has resulted in sloughing sands on slopes.

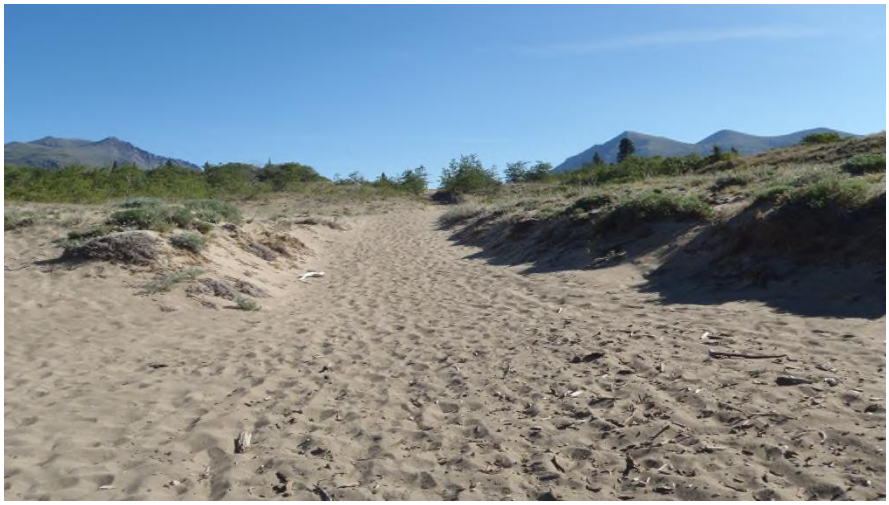
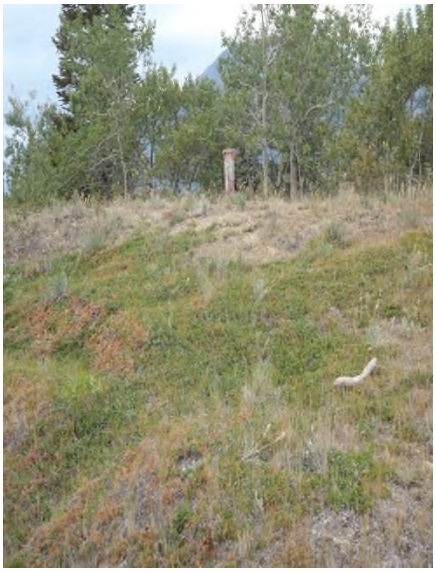


Photo 3
Undisturbed area with vegetation are quite stable;
areas that have been disturbed will slough until a natural angle of repose Is reached

- Diverse patterns of grass, shrubbery and tree cover all contribute to stable site conditions throughout undisturbed portions of the site.



Photos 4, 5 and 6 (left to right)

Coarse grass ground cover on steep slopes

Low-lying shrubbery along a moderately steep slope

Showing how cut slopes with dense vegetation can be constructed with steeper slopes

4.0 DEVELOPMENT CHALLENGES

With the development focus being on maintaining the natural look and feel of the study area, the terrain will be the biggest planning/ construction challenge. Soil deposition is oriented perpendicular to the lake while lot development runs parallel to the lake. Therefore, access roads, driveways and building sites in most areas will have to deal with moderate to steep slopes and as mentioned above, possible bedrock in the northwest corner of the site. Suggestions and recommendations are presented below.

4.1 Site Grading

In areas where re-grading is necessary, very little clearing and stripping will be required to expose the eolian sand subgrade. Contractors have typically found that the fine-grained eolian sands are difficult to work with. The uniform nature of the sand and lack of natural moisture will make the compaction process challenging. A significant amount of water will be needed to facilitate the compaction process.

Along roadways and parking areas, embankment fill should be compacted to 95% of standard proctor maximum dry density at elevations below one meter from grade. Material placed in the final meter should be compacted to at least 98% of standard proctor maximum dry density. In areas proposed as building sites, all material placed as fill should be compacted to 98% of standard proctor maximum dry density in order to ensure adequate bearing resistance.

During pre-grading, all cut back slopes and fill sideslopes should be constructed no steeper than 3 (horizontal):1 (vertical). It is also very important that the constructed slopes be armoured or vegetated as soon as possible.

4.2 Development and Building Setbacks

The preliminary concept plan submitted by Urban Systems defines a no-build easement along Bennett Lake. The site reconnaissance has confirmed that this should be adequate as a development setback distance. However, for the building sites closest to the lake, the siting of the residential structures should be as close to the front of the lots as is practical and potential owners should be informed that control of roof runoff is also important when minimizing potential for erosion.

4.3 Foundations

All conventional foundation systems, as well as helical pile systems are considered acceptable for this site. However, dependent upon site grades, some systems would be more appropriate than others. For instance, a full basement foundation system founded on strip and spread footings will require a large excavation and therefore, the disturbance to the site will be significant. If a thickened monolithic slab-on-grade foundation system is constructed on a level building site, there will be minimal disturbance. Architecturally, it seems to be quite popular to have a clear crawlspace foundation supported by spread footings and pedestals in beach areas, giving the illusion of no disturbance.

Presented below is a summary of pertinent foundation design parameters which were developed for other Carcross projects:

> *This information is presented for general pre-design consideration only and cannot be used for final foundation design purposes. While foundations for single family dwellings can be designed and constructed in accordance with the specific permits from local authorities, the larger multifamily structures should have a site specific geotechnical assessment that provides recommendations for site preparation, foundation design and construction*.

Consider the following:

- The 2010 *National Building Code* requires that a site classification be established for proposed buildings. Based on the soil conditions, (loose eolian sand) noted throughout the majority of the study area, a *Site Classification E*, per Table 4.1.8.4.A NBCC 2010 is considered appropriate.

- The *National Building Code* also stipulates that foundation design be conducted using Limit State Design methodology. Therefore, both the Ultimate Limit State (ULS) and Serviceability Limit State (SLS) bearing resistances must be calculated differently. The ULS bearing resistance is the maximum pressure that the soil can withstand prior to bearing failure, while the SLS bearing resistance is the pressure required to cause a tolerable amount of settlement. It is very important to note that bearing resistance is not only dependent upon soil properties. Footing size and shape and most importantly, the burial depth must also be taken into consideration. For instance, for the sands in the Carcross area, spread footings that are 1 m x 1 m and have 0.3 m of soil cover will have an unfactored ULS of 200 kPa and an unfactored SLS of 225 kPa, while the same footing with 1.2 m of soil cover will have an unfactored ULS of close to 600 kPa and an unfactored SLS of 250 kPa. To provide bearing resistances for final design, Tetra Tech EBA will require input from the owner's architectural design team.

- As per the specific request from Urban Systems, lamp standard bases can be designed based on an unfactored ULS of 600 kPa, while boardwalk foundations which are assumed to be shallow, can be designed based on an unfactored ULS of 200 kPa.

- Helical piles have been used in the Carcross area. At first, it would seem that advancing the piles into the sand subgrade soils would be easily achieved but at the RCMP station, an auger rig had to mobilize to predrill holes in advance of installing the piles to the design depths. At Tetra Tech EBA's Whitehorse office, there are engineers familiar with helical pile design and once additional information is available, spacing and depth as well as diameter and number of flights can be determined. The biggest unknown will be the thickness and type of fill placed and compacted when preparing the building sites.

4.4 Access Road/Parking Area Construction

Streets and access roads are all considered to be low volume roads. The presence of well drained soils throughout the study area allows us to create a roadway structure design that is based on traffic patterns only. Additional granular structure will not be required to mitigate the potential for frost heave.

From the 2008 *Pavement Structure Design Options Report*, design options were based on the following:

- A subgrade modulus of 7 MPa was assumed based on soil conditions and CBR data on similar soils;

- Structural layer coefficients of 0.14 (for 20 mm crushed basecourse aggregate) and 0.10 (for pit run sub-base aggregate) were used for design.

Based on the analysis performed using AASHTO design procedures and DARWin proprietary software, a roadway structure design comprising a prepared subgrade, 200 mm of pit run sub-base gravel and 200 mm of crushed basecourse gravel were considered appropriate for areas without asphalt. For the construction of the Tagish Avenue extension, as well as Too-Chi Avenue, 9 and 10 Streets, this roadway structure is recommended for gravel or BST surfaced roadways. For the lighter traffic access roads, the basecourse thickness can be reduced to 150 mm and for driveways and parking areas, 150 mm of sub-base with 100 mm of basecourse will be sufficient.

Subgrade, sub-base and basecourse surfaces must all be properly constructed and compacted to at least 98% of standard proctor maximum dry density. In advance of applying BST, the basecourse should be re-graded and compacted to at least 100% of standard proctor maximum dry density.

All imported granular materials (crushed basecourse and pit run sub-base) must meet the gradation limits as presented in Table 1. All materials must be placed in lifts not exceeding 200 mm in compacted thickness.

Table 1: Imported Gravel Gradation Specifications (YTG Aggregate Specifications)

20 mm CRUSHED BASECOURSE (GRAN A)		80 mm PIT RUN SUB-BASE (GRAN D)	
Particle Size (mm)	**% Passing by Mass**	**Particle Size (mm)**	**% Passing by Mass**
20.000	100	80.000	100
12.500	64 – 100	25.000	55 - 100
5.000	36 – 72	12.500	42 – 84
2.500	18 – 54	5.000	26 – 65
1.250	12 – 42	1.250	11 - 47
0.315	4 - 22	0.315	3 - 30
0.080	3 – 6	0.080	0 - 8

5.0 GROUNDWATER LEVELS AND HOLDING TANK CONSTRUCTION

Groundwater levels close to the proposed lots close to Bennett Lake will likely be around 4.5 m. Proceeding up-gradient, the depth to groundwater will increase to at least 6 m. This should allow installation without buoyancy concerns. The native sands should be appropriate for backfill but assumptions should not be made during installation because any deviation from the manufacture's installation instructions may result in warranty issues.

6.0 DESIGN PHASE GEOTECHNICAL INPUT

Information collected from in-house data sources and observations made during site reconnaissance suggest that there is good potential for development. There will obviously be terrain related challenges during subsequent planning and development phases of this unique and interesting site. Therefore, in advance of final design and during development:

- A testpitting program should be completed along the Tagish Avenue extension and the streets around the perimeter of the northwest corner of the site. Testpits will be advanced in cut areas to ensure that design elevations can be achieved and cut/fill balance expectations can be met.
- If cut/ fill balances are required along the access roads into the individual lots, it is also suggested that additional testpitting be performed to ensure that design objectives can be met.
- Based on the testpitting programs described above, enough site specific information will have been collected to support foundation design for single and multi-family residential structures. However, for foundation design of each of the multi-storey, high density structures proposed, a drilling program with testing to measure in situ soil consistency should be completed.

7.0 LIMITATIONS OF REPORT

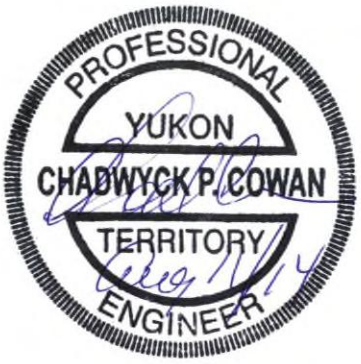
This report and its contents are intended for the sole use of Northern Vision Development LP. Tetra Tech EBA Inc. does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Northern Vision Development LP, or for any Project other than the proposed development throughout the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in the Tetra Tech EBA Inc. General Conditions presented in Appendix A of this report.

The information and recommendations presented herein are based on current and historical geotechnical information from investigations conducted throughout the Carcross townsite. The conditions presented herein are believed to be representative for the site. However, if conditions differ from those presented in this report are encountered during subsequent phases of development; we request that Tetra Tech EBA be notified so that conditions encountered can be re-evaluated in light of new findings.

8.0 CLOSURE

We trust this report meets your present requirements. Should you have any questions or comments, or clarification of any of the recommendations presented is required, please contact the undersigned at your convenience.

Sincerely,
Tetra Tech EBA Inc.



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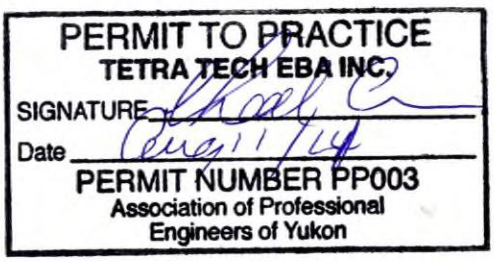
Attachment: Appendix A: Tetra Tech EBA's General Conditions - Geotechnical



APPENDIX A

TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of Tetra Tech EBA’s Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Tetra Tech EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of Tetra Tech EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, Tetra Tech EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods 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 EBA 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.

5.0 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.

6.0 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 historic environment. Tetra Tech EBA 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 investigation and review may be necessary.

7.0 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.

8.0 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.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and 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 are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as 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.

11.0 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 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.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses 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 assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

Tetra Tech EBA 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.

14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.