

April 14, 2016

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ISSUED FOR USE
FILE: ENG.WARC03064-01
Via Email: simon@3pikas.caom

Attention: Mr. Simon Lapointe, MCIP, RPP - Director

Subject: Pre-Design Geotechnical Evaluation Services
Carcross Marina Land Development and Infrastructure Feasibility Study

1.0 BACKGROUND

In February 2015, Tetra Tech EBA Inc. (Tetra Tech EBA) submitted a feasibility level report summarizing the geotechnical and environmental site conditions which will likely be encountered throughout the Carcross Marina Land Development site.

3 Pikas and Kobayashi & Zedda Architects Ltd. (KZA) have since submitted a Visioning Report and a draft Final Report that describes the planning process; the existing site conditions (land, water and climate); cultural and heritage implications; the results of consultation with user groups and stakeholders (including a short list of the elements and components to be included in the conceptual designs); and finally, the presentation of all concept plans considered and the subsequent selection of the preferred concept plan (along with Class D cost estimates) to move forward towards final design and construction.

On April 5, 2016, Tetra Tech EBA received authorization to proceed with predesign level geotechnical input (from Mr. Simon Lapointe of 3 Pikas). The agreed-upon list of deliverables was to include:

- A discussion of additional information gathered regarding the possible clean-up of the PCB and hydrocarbon contamination in the area delineation in the 1996 - Phase 2 Contamination Assessment Report prepared by Tetra Tech EBA (formerly known as EBA Engineering Consultants Ltd.);
- Foundation options and predesign input for structures proposed for the site, including the wharf, permanent structures such as the rental shop, cabins as well as the boardwalks;
- Possible revisions to parking lot and access road structure options discussed in the February 2015 report that are sympathetic to the preferred concept vision will also be discussed.

2.0 CONTAMINATION ASSESSMENT

In 1997, a Phase 2 Contamination Assessment was completed for the area along the Tatasahenni Narrows between Bennett Lake and Nares Lake (File: 0105-96-12528). The objective was to determine whether or not significant levels of pentachlorophenol and hydrocarbon contamination existed in the soil and groundwater throughout much of the marina site; delineate the extent of the contamination and to prepare a reclamation plan which would restore the site to a parkland standard.

When the February 2015, report was submitted, there was no documentation in Tetra Tech EBA files confirming that an environmental site clean-up had been completed. However, recent anecdotal information indicates that Golder Associates did in fact complete a bio-soil reclamation project for the Carcross Tagish First Nation (CTFN). CTFN personnel has been contacted in hopes that additional documentation will confirm that appropriate park land standards were achieved.

3.0 FOUNDATIONS

Previously completed geotechnical site evaluations in the vicinity of the study area have confirmed:

- Poorly graded sand over fine-grained lacustrine silt and clay;
- Low soil consistency (based on blow counts during Standard Penetration Testing) for the surficial sand and underlying lacustrine soils; and
- High groundwater levels for areas close to the Narrows.

As mentioned in the February 2015 report, conventional shallow foundation systems are considered appropriate for buildings proposed in the preferred concept plan. Options and details are discussed in the following sections.

3.1 Shallow Foundation Options For Rental Shop and Cabin Structures

The rental shop and cabin structures proposed in the preferred concept option are considered to be lightly loaded structures can be supported by a variety of shallow foundation systems, including:

3.1.1 Pad and Pedestal Foundation

This foundation system would be an excellent option since sonotube pedestals constructed on pads would replicate the driven pipe pile foundations used in and along the water and would require minimal site grading during construction. It is suggested that the pads be constructed at a depth of 1.0 m and additional insulation over the pads (50 mm thick extending 1.2 m out from the edges of the pads) be placed to minimize the potential for seasonal frost heave (which could occur if there are heavy rains throughout the fall shoulder season resulting in excess moisture being trapped in the sand subgrade). This is probably the most inexpensive foundation option available.

3.1.2 Engineered Fill & Thickened Monolithic Slab-On-Grade Foundation

This foundation system has been successfully used on a variety of projects throughout the Carcross townsite. It generally includes minimal subexcavation into the sand subgrade followed by the construction of a gravel pad that ensures positive drainage away from the foundation. Although this is considered to be a very good foundation option, it would be more expensive and would require site grading where the structures are being built on shallow slopes (which may not be complimentary to the vision of the preferred concept).

3.1.3 Helical Pile Foundation System

Helical piles have been successfully used in Carcross. It is the opinion of this office that this option warrants consideration for the cabins constructed within the soil remediation area at the east end of the site since we haven't been able to verify levels of compaction for the soil placed back into the excavation.

To establish feasibility, an actual design has been completed assuming that the structures will be less than 500 ft² and a single helical pile would be installed at each of the four corners. Conceptual design loads were estimated

using the Residential Structure Design Guide and loading cases from the National Building Code of Canada (NBCC 2015).

Using standard helical pile configurations (pile diameter and disc sizes), it was determined that a 5½" pile diameter (which local drill rigs can install) and a single 18" diameter disc drilled to a depth of 3.0 m (to resist frost heave) appears appropriate for carrying the assumed building loads. This design is not to be used for construction as it only establishes feasibility. It is anticipated that this foundation option will be more expensive than the pad and pedestal option but will minimize disturbance to the area during construction. This design can be revisited if additional loading information can be provided by the architect or structural engineer.

3.2 Boardwalks

It is assumed that the timber supports for the proposed boardwalks will run the length of the structure with boards spanning the supports. Since the boardwalks will be for pedestrian traffic only, additional granular structure over the sand subgrade is not critical but if a 100 mm thick levelling course of 25 mm clear stone is placed over the sand subgrade, water will not remain in contact with the timbers supporting the boardwalk and this should result in increased longevity.

3.3 Wharf Pile Foundation

Tetra Tech EBA has completed four significant deep foundation design projects along the north side of the Natasahenni Narrows between Bennett Lake and Nares Lake in Carcross. These projects include:

- 1983 – Wharf/Warehouse Renovations (File: 209-3800). Timber pile design was completed for the additional rows of timber piles required to stabilize the foundation of the existing warehouse structure.
- 2006 – Pile Foundation Design – New Pedestrian Bridge (File: 1200211). Work was completed for Earth Tech Inc. and was based on existing geotechnical data collected by DPW in 1968 and 1969 for the Nares Bridge. Designs for rock socketed and friction piles were completed using design loads provided by Earth Tech Inc.
- 2009 – Pile Design for Community Dock and Boat Launch (File: W14101247). Since this site is located close to the Nares Bridge, the design was again based on the DPW borehole data.
- 2015 – Nares River Bridge Replacement (File: W14103626-01). Along with the DPW borehole data, six additional boreholes were drilled using a sonic drill rig (ensuring excellent sample recovery). Cone Penetration Testing (CPT) was performed in all boreholes drilled and the data is currently being used to support deep foundation design and to address the seismic design requirements as stipulated in the current *Canadian Highway Bridge Design Code*.

Relevant information from the previously completed reports include:

- Timber piles installed numerous years ago have shown signs of ice-jacking and frost heave but pile yield from ice flows has not occurred.
- For the Community Dock and Boat Launch project in 2009, horizontal ice forces and resistance to ice-jacking were used to establish pile diameter, wall thickness and blow count targets for installation (to resist ice-jacking). The design was completed in accordance with the (then current version) *Canadian Highway Bridge Design Code* which allowed for a 50% load reduction for small freshwater channels and once the horizontal ice force was calculated, it was suggested that a smaller diameter pile could be used since there is upstream development that would ensure a reduction in the size of the ice flows coming into contact with the piles. For this project, 323 mm outside diameter (OD) piles with a wall thickness of 9.53 mm were driven to a depth where

movement was less than 3 blows/25 mm (using a 31 kJ (23,000 ft-lbs) hammer). No pile installation records were found in the project file but based on recent data collected during the current Nares River Bridge Replacement project, installation depths of at least 20 m are likely.

- The 2006 pile design developed for the New Pedestrian Bridge project was originally based on the assumption that piles would be driven through soft alluvial soils to refusal on bedrock and then anchored into the bedrock using rock bolts or a rock socketed pile configuration where there was insufficient overburden to resist frost heave (south side of channel where depth to bedrock is much less than on the north side). During pile installation throughout the north side of the channel, it was determined that the alluvial overburden was much more competent than anticipated so PDA testing was performed to establish the “skin friction” component of the pile installations in hopes that the pile length could be reduced. Testing established that the 273 mm OD piles (with a wall thickness of 12.7 mm), installed to depth of between 35 and 40 m satisfied the design loads as determined by Earth Tech Inc.

The information presented above will be useful when preparing a pile design for the new wharf. Once loads have been calculated by the structural design team (dead loads, live loads, snow loads, wind loads and seismic information pertinent to the Carcross area all contributed to the pedestrian bridge design) a specific pile design for the new wharf can be developed.

4.0 PAVEMENT STRUCTURE ASSESSMENT

In 2008, a comprehensive assessment of subgrade conditions was completed and with available traffic data, pavement structure designs were prepared for access road corridors and bus parking areas along the proposed study area. Numerous design options were presented, but for single stage construction, appropriate structure included 100 mm of hot mix asphalt; 150 mm of Gran A basecourse and 360 mm of pit run or crushed sub-base gravel constructed over a prepared sand subgrade. As mentioned above, this structure was developed to handle a bus traffic component. If traffic throughout the proposed is limited to light vehicle traffic, a pavement structure comprising 75 mm of hot mix asphalt; 150 mm of Gran A basecourse and 300 mm of sub-base gravel over a prepared (and stable) sand subgrade surface will be appropriate.

The Design Characteristics listed in the draft final report includes a statement that: *Surface treatments should be sympathetic to surroundings. Curbs and sidewalks are discouraged while the use of boardwalks, gravel and chip seal (BST) is encouraged.*

If the asphalt component of the pavement structure designs presented above are eliminated, additional granular structure would be required to compensate. However, if the access roads and parking lots are not paved, maintenance can be performed as required. Therefore, if the asphalt surfacing is eliminated from the pavement structure equation, an additional 150 mm of sub-base (pit run or crushed) can be considered. This will not result in an equivalent structural number but assuming some maintenance will be assumed, this may be a reasonable compromise that should result in reduced construction costs.

5.0 LIMITS OF LIABILITY

This report and its contents are intended for the sole use of 3 Pikas and their agents. 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 3 Pikas 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 report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are attached to this memo.

6.0 CLOSURE

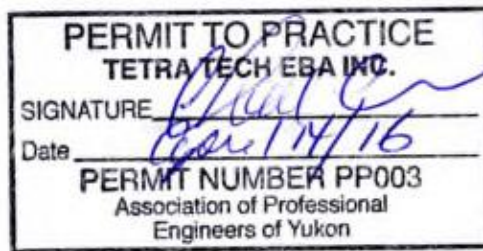
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Attachments: Appendix A: Tetra Tech EBA's General Conditions – Geotechnical



APPENDIX A

TETRA TECH EBA'S AND 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.