TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE R1

To:	Gareth Earl, P.Eng, Senior Project Manager YG Community Services	**Date:**	November 5, 2018
c:	Cara Sandulak, Project Manager YG Community Serivces	**Memo No.:**	01
From:	Sarah Sternbergh, P.Eng.	**File:**	ENW.WENW03104-01
Subject:	Summary of Water Temperature and Groundwater Level Results at Tagish Community Centre Test Wells, Tagish, Yukon		

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was contracted by Yukon Government Community Services (YG-CS) under Standing Offer Agreement (SOA 2017/18-2751-7: Drinking Water and Infrastructure) to provide hydrogeological services related to the two test wells completed near the Tagish Community Centre in 2016. Due to high estimated costs to deepen one of the test wells or advance an additional test well, Tetra Tech understands YG-CS is no longer considering a groundwater supply at this location. In addition to water supply assessment, YG-CS requested that Tetra Tech assess the potential for using one or both wells for geo-exchange heat supply. To inform this future feasibility study, Tetra Tech completed a site visit on September 12, 2018 and collected groundwater temperature data in both wells. This memo summarises the data collected.

2.0 METHODS AND RESULTS

Sarah Sternbergh of Tetra Tech visited the site on September 12, 2018 to collect well data. At the time of the site visit, the weather was clear and sunny and the air temperature was approximately 18^{o}C. Tetra Tech collected water levels manually in both wells using an electronic water level sounder, and collected temperature and depth readings using submersible Solinst® pressure-temperature dataloggers (Solinst® Levelogger Model 3001 10 m and 100 m).

2.1 Groundwater Levels and Well Depth

Well TCC-TW01

Test well No.1 (TCC-TW01) is located in the playground at the Tagish Community Centre. The wellhead was accessible through a bolted well cover. The wellhead sucked in air when opened during the site visit, indicating the groundwater level has fallen since the well was last closed creating a vacuum within the well casing. Because of this, it is possible that the measured water level after opening this well was not in a static condition (possibly falling due to release of slight vacuum when well was opened).

If accurate static water level measurements are required in TCC-TW01 (and TCC-TW02 below), there are two straightforward options. One is to remove the well cap (noting air movement when removed) and then measure the water levels within the casing over an interval to time to confirm they are static. Depending on the degree of vacuum developed within the casing, and the transmissivity of the subsurface materials around the well screen, this stabilization period may range from seconds to tens of minutes or even hours. Another option is to drill a small diameter air pressure relief hole in the side of the casing (just below cap) to equalize air pressure within the casing to atmospheric pressure. This hole could be in the range of 1/8 to ¼ inch diameter and tapped to receive a brass

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plug to seal the casing if needed (e.g., if the well resumes a flowing artesian condition). Such a tapped hole could also be used to install a gauge to measure artesian water pressure, if desired.

Details including the measured well depth, wellhead stickup and water level at the time of the site visit are summarized in Table 2-1 below.

Table 2-1: TCC-TW01 Well Details – September 12, 2018

Parameter	Details
Wellhead completion Details	Well is completed with an air-tight bolted steel cap equipped with a rubber gasket.
Wellhead Stickup	0.91 m above ground surface measured to the top edge of bottom steel flange plate
Well Depth	109.80 m below top of casing flange. The bottom of this well is filled with silt and sand that infilled the well casing during earlier attempts at well deepening. Well depth was determined from the highest pressure reading on the datalogger lowered into the well. The original well log shows that TCC-TW01 was 145.3 m deep at the time of drilling. This means the bottom 36.4 m of the well is currently infilled.
Water Level	7.15 m below top of bottom casing flange

Well TCC-TW02

Test well No.2 (TCC-TW02) is located at the edge of the baseball court at the Tagish Community Centre. The wellhead was accessible through a locked well cover. The well has been noted as flowing artesian in the past but no flow was observed upon opening the well at the time of the site visit. It is common that wells initially under artesian conditions show lower flows or no flow with time after drilling, either due to seasonal fluctuations or decrease of aquifer pressure.

The well sucked in air upon opening, indicating the groundwater level has fallen since the well was last closed, creating a vacuum within the well casing. As with TCC-TW01, it is possible that the water level were still recovering somewhat (falling) after the cap had been removed and that the measured level was not fully static (see text for TCC-TW01 for options for measuring static water levels in these wells).

Details including the measured well depth, wellhead stickup and water level at the time of the site visit are summarized in Table 2-2 below.

Table 2-2: TCC-TW01 Well Details – September 12, 2018

Parameter	Details
Wellhead completion Details	Well is completed with an airtight bolted steel cap equipped with a rubber gasket which prevents flow from the wellhead under artesian pressure.
Wellhead Stickup	0.95 m above ground surface measured to the top edge of bottom steel flange plate
Well Depth	72.04 m below top of bottom casing flange
Water Level	0.29 m below top of bottom casing flange

Note that this well is still in an artesian condition (in that the groundwater level is above the ground surface) but is not currently flowing (because the groundwater level is below the top of casing).

2.2 Groundwater Temperature

Water temperature measurements collected from each well are summarized in Table 2-3. Temperature gradient curves are shown in Figures 1 and 2. Temperature gradient was calculated along the straight part of each of the observed curves as shown in each figure. The measured temperature gradient in the two wells differs. However, as TCC-TW01 is deeper and has more recorded data points, Tetra Tech considers this result the more reliable of the two. The temperature gradient measured in TCC-TW01 is 38ºC/km.

Table 2-3: TCC-TW01 Well Details

Well ID	Depth (m bgs)*	Temperature (ºC)
TCC-TW01	7.00	2.6
	11.40	2.7
	16.07	2.7
	31.75	2.7
	52.33	3.5
	68.62	4.2
	88.78	4.9
	109.80	5.7
TCC-TW02	-0.28	10.4**
	9.43	3.2
	32.72	3.0
	52.48	3.7
	71.74	4.3

*m bgs - metres below ground surface

**This anomalously high temperature is for water that was standing in the above-ground (stickup) portion of the steel casing, which would have been strongly influenced by atmospheric air temperature (18ºC during the site visit). For this analysis, this measurement was omitted. Heat from the above-ground portion of the casing may have also conducted down the steel casing and warmed the upper part of the static water column within TCC-TW02. For these reasons as well, the data from TCC-TW01 are more indicative of groundwater temperature conditions at this site.

3.0 LIMITATIONS OF REPORT

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4.0 CLOSURE

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

Respectfully submitted,
Tetra Tech Canada Inc.

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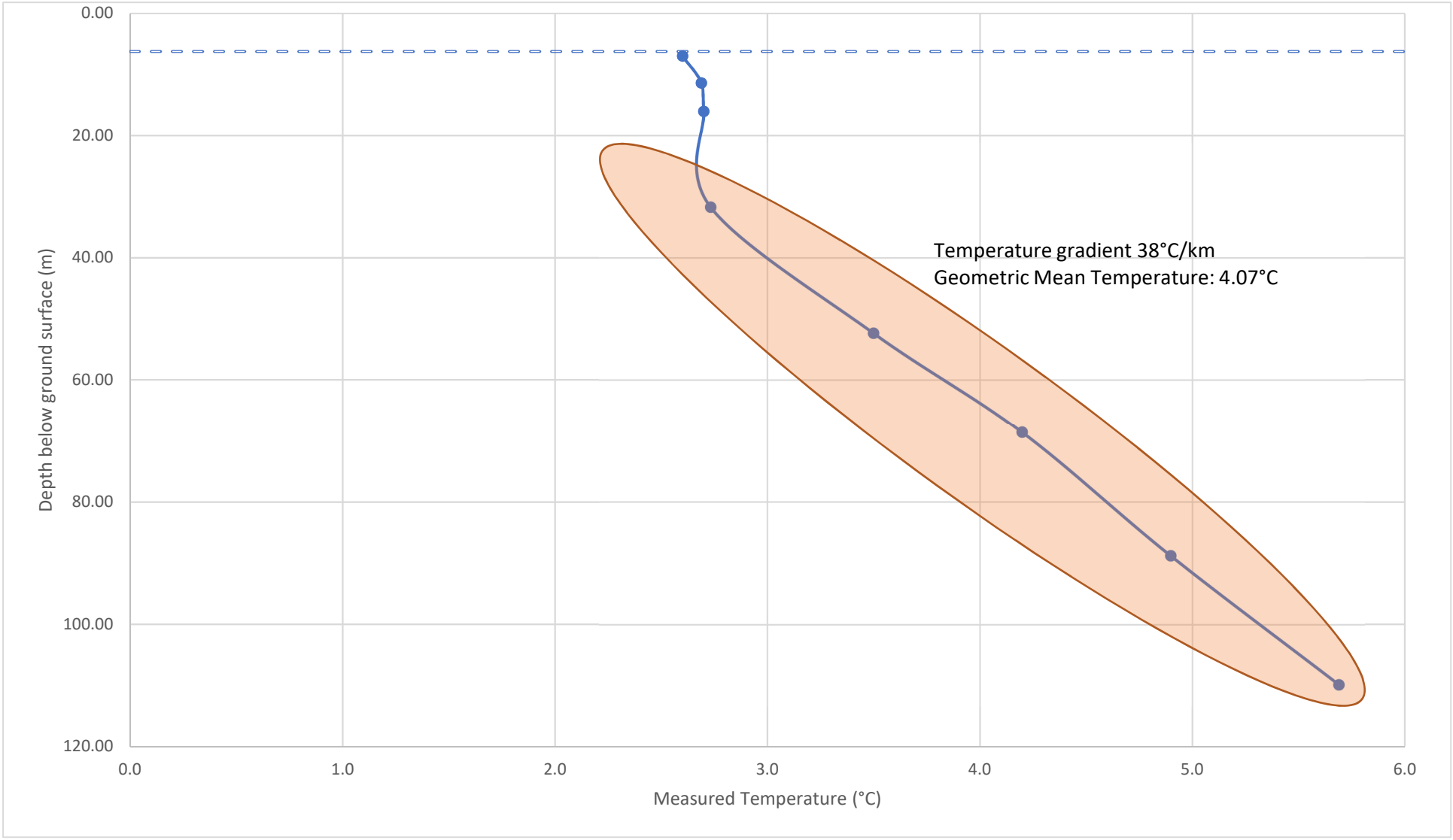
Attachments: Figure 1: TCC-TW01 Temperature Gradient
Figure 2: TCC-TW02 Temperature Gradient
Tetra Tech's Limitation on the Use of this Document



LEGEND

Points used to calculate geothermal gradient

Static Water Level

NOTES
Data collected September 12, 2018

STATUS
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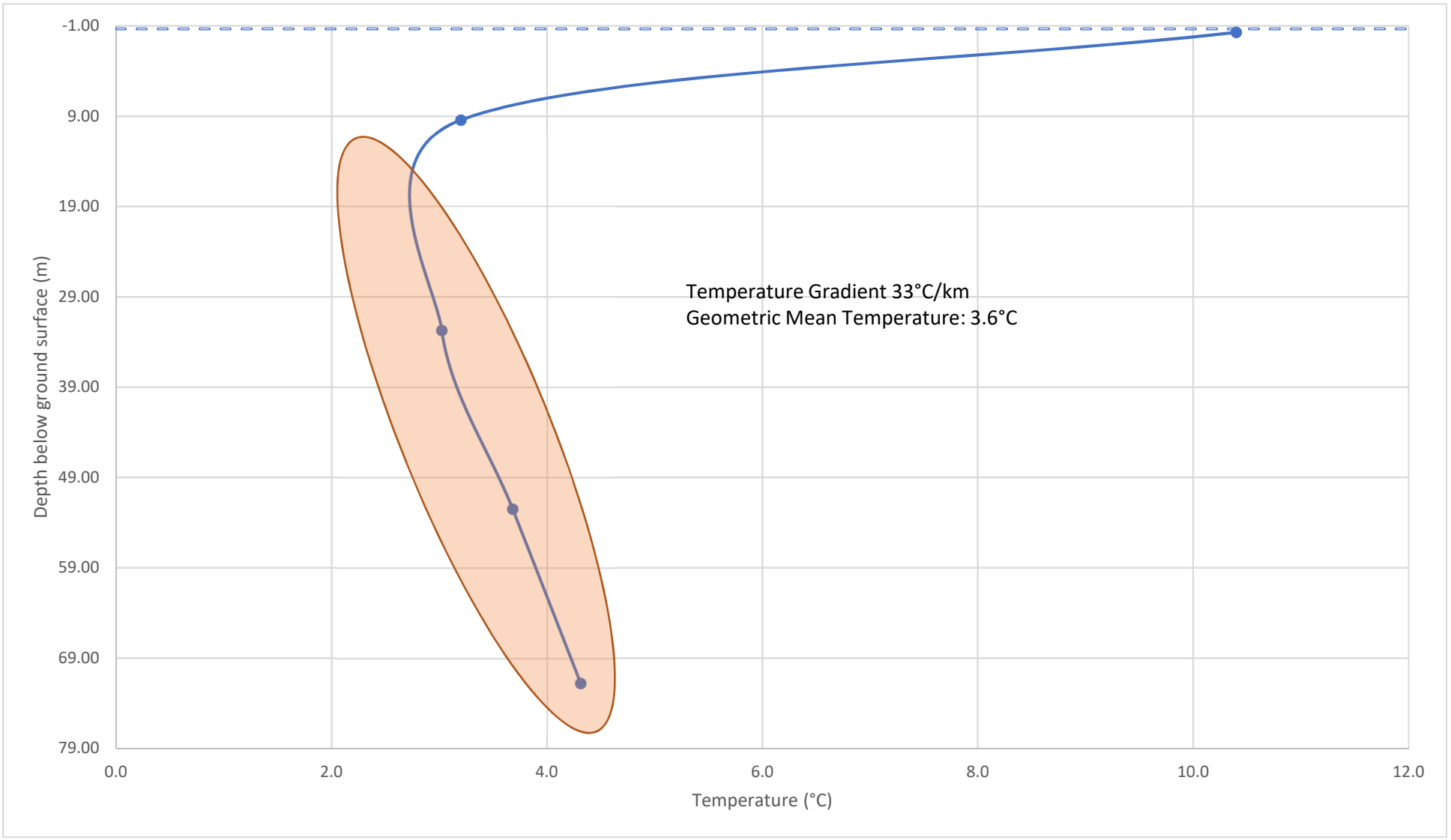
Tagish Community Centre
Well Condition Survey

TCC-TW01 Temperature Gradient

PROJECT NO.	DWN	CKD	APVD	REV
ENW.WENW03104-01	SKS	SK	SKS	0

OFFICE	DATE
EBA-WHSE	October 31, 2018

Figure 1



LEGEND

Points used to calculate geothermal gradient

Static Water Level

NOTES
Data collected September 12, 2018

STATUS
ISSUED FOR USE

CLIENT
Government of Yukon

TETRA TECH

Tagish Community Centre Well Condition Survey

TCC-TW02 Temperature Gradient

PROJECT NO.	DWN	CKD	APVD	REV
ENW.WENW03104-01	SKS	SK	SKS	01

OFFICE	DATE
EBA-WHSE	December 19, 2018

Figure 2

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL – YUKON GOVERNMENT

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

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. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

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, 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.

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 document, 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, 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 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.

1.8 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.

1.9 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.

1.10 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.

1.11 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.

1.12 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.

1.13 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.

1.14 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.

1.15 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.

1.16 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.

1.17 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.

1.18 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.