TETRA TECH EBA

March 31, 2016

ISSUED FOR USE
FILE: 704-ENG.WARC03039-01.004
Via Email: Erik.Pit@gov.yk.ca

Assessment and Abandoned Mines
Energy Mines and Resources
Room 2C – Royal Centre
PO Box 2703, Whitehorse, YT Y1A 2C6

Attention: Mr. Erik Pit
A / Senior Project Manager

Subject: Geotechnical Investigation Program Recommendations
Abandoned Clinton Creek Asbestos Mine Site, Yukon

1.0 INTRODUCTION

Government of Yukon, Assessment and Abandoned Mines (AAM) have retained Tetra Tech EBA Inc. (Tetra Tech EBA) to assist with the summary and evaluation of geotechnical information related to closure of the Clinton Creek asbestos mine near Dawson City, Yukon. This report presents a proposed scope of work for a geotechnical investigation program to gather subsurface information required for more detailed closure option design. This report includes recommended drilling equipment, borehole locations, depths, field and laboratory testing, instrumentation, and discussion of rationale behind program design.

1.1 Scope

Tetra Tech EBA has been retained to provide engineering services for the above captioned project in an attempt to better understand the mechanisms driving the slope instability of the waste rock and tailings piles. The general scope of work includes summarizing existing information and data gaps, evaluating the data and monitoring programs, as well as assessing site access mitigations, fish passage, and stability for the five short listed closure options. This work is being conducted to guide project parties in making decisions regarding future design and implementation of short listed closure options.

2.0 GEOTECHNICAL INVESTIGATION PROGRAM

The stability analyses completed on the Clinton Creek waste rock pile and Wolverine tailings pile were based on very limited available information supplemented with many engineering assumptions. A geotechnical investigation program is recommended prior to continuing with more detailed analyses and design of closure options. The investigation will further define the subsurface conditions through soil stratigraphy and permafrost logging, in-situ and laboratory testing, and instrumentation installation. Subsurface information collected during the investigation will be used to confirm the physical property assumptions made in the stability analyses and provide more accurate physical properties in future phases of design. The instrumentation will be used to confirm the movement, temperature, and groundwater conditions affecting current performance of the waste rock and tailings pile and provide a more accurate understanding of the conditions for future phases of design. The following sections describe our proposed geotechnical investigation program in detail, the borehole locations, depths, and instrumentation are shown on the attached Figure 1.

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2.1 Drilling Equipment

Tetra Tech EBA recommends executing the geotechnical investigation program using a drill rig with a high power to weight ratio, equipped with HQ (63.5 mm) tooling for continuous core retrieval. A Longyear Super 38 or equivalent would be an acceptable drill. The program should be completed using chilled brine drilling fluid.

Chilled brine drilling fluid is necessary because it is anticipated that warm permafrost exists in the foundation soils under the Clinton Creek waste rock pile and possibly the Wolverine tailings pile. Retrieving undisturbed core samples of the ice rich permafrost is critical to better understanding the strength properties of the foundation soils.

A lightweight track mounted or heli-portable drill is recommended because topography of the site is steep and access is limited. Such a rig could be flown around site or moved using a bulldozer depending on acceptable levels of surface disturbance determined by the project parties. A truck mounted drill rig is not considered agile enough to navigate the aggressive terrain of the site.

A drill with HQ tooling is recommended because of the granular nature and thickness of the waste rock. Advancing a borehole through the waste rock to obtain undisturbed samples from the foundation soils below would be difficult with other drilling technology. We believe that auger, Becker hammer, or sonic drill rigs that would be agile enough to navigate the site might lack the power required to overcome the thickness of the waste rock and provide undisturbed samples from the underlying warm permafrost. An air rotary drill rig would be capable of completing the investigation but undisturbed sample collection and permafrost logging would be compromised. HQ core will provide the most favourable opportunity for undisturbed sample collection, subsurface strata identification and permafrost logging, and subsequent laboratory testing.

2.2 Borehole Locations and Depths

Tetra Tech EBA recommends advancing 24 boreholes in the locations shown on the attached Figure 1. The locations were selected based on obtaining information about the foundation conditions for the waste rock and tailings piles with specific focus on gathering data relevant to verifying the assumptions in our current stability analyses and for future more detailed closure option design. The recommended borehole locations target areas of movement identified in the movement evaluation report and failure planes identified in the geotechnical analysis report. Additionally, some boreholes are located beyond the footprints of the structures to obtain background data and subsurface conditions that could have significant impacts on design considerations. These background holes are currently shown well beyond the extents of previous site disturbance to ensure natural conditions are encountered. It may be possible to relocate the boreholes closer to the edge of existing disturbance at the time of the investigation to reduce the impacts to undisturbed areas and the associated future maintenance arising from that access.

The anticipated termination depths for each borehole are shown on the attached Figure 1. Depths are based on assumed overburden, waste rock, and tailings thicknesses and may vary based on conditions encountered during the investigation. The intent is to terminate boreholes at least three metres into competent bedrock below the foundation soils of each site component. Finishing boreholes in competent bedrock provides a vertical boundary for future design and analysis efforts and a stable reference point for instrumentation installations.

2.3 Testhole Logging and In-Situ Testing

Tetra Tech EBA recommends the geotechnical program be executed by a geotechnical engineer with suitable experience in soil and permafrost logging techniques. It is critical that permafrost conditions are logged accurately in the field because describing ice content and structure is not possible after the sample thaws.

Standard penetration testing (SPT) to obtain soil strength properties should be completed in boreholes advanced through unfrozen soils at 1.5 m intervals or whenever a stratigraphy change is noted. It is recognized that SPTs in the waste rock may not be representative or possible depending on the subsurface conditions encountered.

Seismic cone penetration testing (SCPT) to obtain soil strength properties and shear wave velocities should be completed in some of the boreholes advanced within the footprints of the waste rock and tailings piles. Specifically, BH06 and BH10 in the waste rock, and BH19 and BH23 in the tailings.

2.4 Laboratory Testing

Subsequent to completing the geotechnical drill investigation, Tetra Tech EBA recommends laboratory testing to further define the physical properties of the subsurface soils. Routine physical property testing in the form of natural moisture contents, particle size analyses (sieve and hydrometer), and Atterberg limits should be conducted on samples from all subsurface strata encountered during the investigation. The quantity and distribution of routine physical property testing can be determined at the time of the investigation.

In addition to routine physical property testing, more advanced strength testing in the form of cyclical direct shear testing on reconstituted samples or if possible tri-axial testing on undisturbed samples should be conducted. The quantity and distribution of specialized strength testing can be determined at the time of the investigation.

If undisturbed permafrost cores are obtained and preserved, some thaw-consolidation testing should be completed.

2.5 Instrumentation

Tetra Tech EBA recommends the installation of instrumentation to gather subsurface movement, temperature, and pore pressure data. The recommended instrument locations are shown on the attached Figure 1 and described in detail below.

2.5.1 Slope Indicators

The existing monitoring program quantifies movement of the waste rock and tailings pile through periodic surveys of specific points on the surface of the structures. Although indicative of general failure movements, surficial surveys do not identify the depth at which that failure is occurring. Installing and monitoring slope indicators will provide data identifying which strata is the source of the current failure. The locations recommended for slope indicator installations were selected based on intercepting failure planes identified in the stability analyses along the analysed sections established during movement evaluation.

The slope indicators should be monitored monthly from the time of installation until a more reasonable long term monitoring interval can be determined based on observed movements.

2.5.2 Ground Temperature Cables

Temperature has considerable impact on the long term strength properties of ice rich permafrost. For the purpose of the stability analyses it was assumed that ice rich permafrost exists in the foundation soils. The analyses was conducted using strength parameters consistent with ice rich permafrost. Tetra Tech EBA recommends installing ground temperature cables where frozen ground is encountered during the investigation to confirm the presence of permafrost, validate the assumptions used in stability analyses, and better define strength properties of the foundation soils for more detailed closure option design. Six ground temperature cables for the waste rock pile and four ground temperature cables for the tailings pile is considered sufficient. Existing ground temperature information is sporadic and incomplete so identifying which boreholes are to receive ground temperature cables prior to the investigation is difficult. Such decisions should be made by the field engineer during the investigation based on

subsurface conditions encountered, borehole spacing, and termination depth. Ground temperature cables should be preferentially installed in boreholes where notably ice rich permafrost conditions are encountered.

The ground temperature cables should be monitored daily through the use of data loggers and the data downloaded monthly (during site visits to obtain slope indicator readings) from the time of installation until readings below the active layer stabilize. The frequency of readings can then be re-evaluated and adjusted based on the general site monitoring plan.

2.5.3 Piezometers

Increased pore pressure from surface water infiltration or thawing ice rich permafrost can have considerable impact on the strength of soils. For the purpose of the stability analyses pore pressure conditions were assumed based on physical properties of the foundation soils and water elevations in Hudgeon Lake, Porcupine Pit, and Clinton Creek for the waste rock, and Wolverine Creek for the tailings. Tetra Tech EBA recommends installing nested vibrating wire piezometers where wet ground is encountered during the investigation to validate the assumptions used in stability analyses, and better define pore pressure conditions in the foundation soils for more detailed closure option design. Four piezometer installations for the waste rock and two piezometer installations for the tailings pile is considered sufficient. Existing groundwater information is sporadic and incomplete so identifying which boreholes are to receive piezometers prior to the investigation is difficult. Such decisions should be made by the field engineer during the investigation based on subsurface conditions encountered, borehole spacing, and termination depth. Piezometers should be preferentially installed in boreholes where notably wet conditions are encountered.

The piezometers should be monitored continuously through the use of data loggers to acquire understanding of the effects of precipitation events on subsurface pore pressure conditions.

3.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Government of Yukon Assessment and Abandoned Mines and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) 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 Assessment and Abandoned Mines, 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. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

4.0 CLOSURE

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

Tetra Tech EBA Inc.

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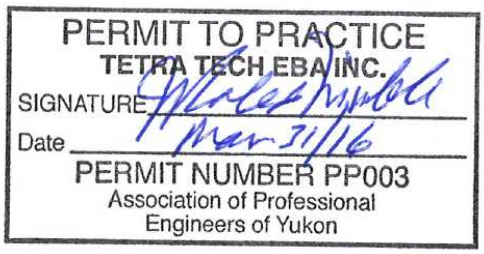
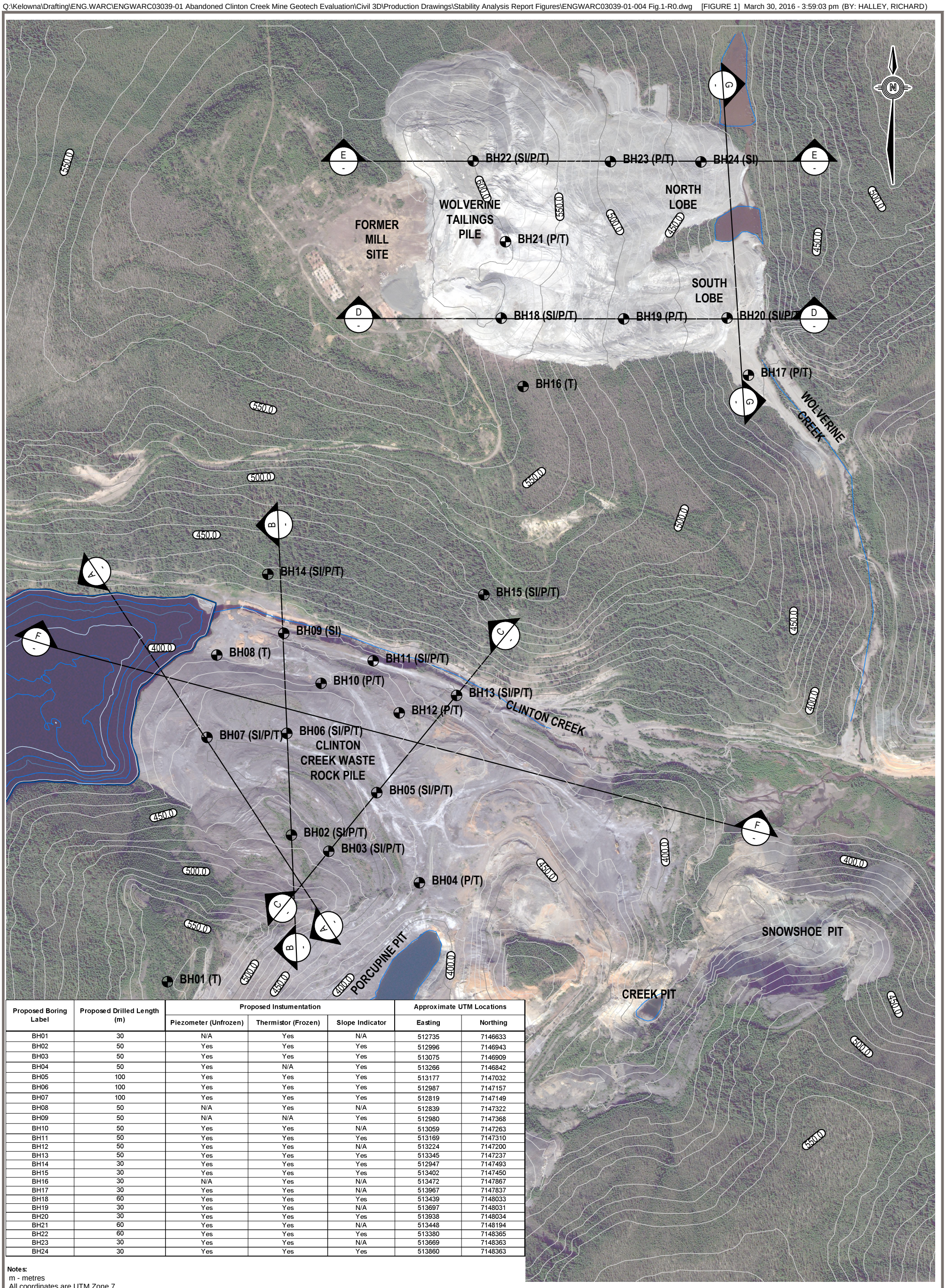


FIGURES



Proposed Boring Label	Proposed Drilled Length (m)	Proposed Instumentation			Approximate UTM Locations	
		Piezometer (Unfrozen)	Thermistor (Frozen)	Slope Indicator	Easting	Northing
BH01	30	N/A	Yes	N/A	512735	7146633
BH02	50	Yes	Yes	Yes	512996	7146943
BH03	50	Yes	Yes	Yes	513075	7146909
BH04	50	Yes	N/A	Yes	513266	7146842
BH05	100	Yes	Yes	Yes	513177	7147032
BH06	100	Yes	Yes	Yes	512987	7147157
BH07	100	Yes	Yes	Yes	512819	7147149
BH08	50	N/A	Yes	N/A	512839	7147322
BH09	50	N/A	N/A	Yes	512980	7147368
BH10	50	Yes	Yes	N/A	513059	7147263
BH11	50	Yes	Yes	Yes	513169	7147310
BH12	50	Yes	Yes	N/A	513224	7147200
BH13	50	Yes	Yes	Yes	513345	7147237
BH14	30	Yes	Yes	Yes	512947	7147493
BH15	30	Yes	Yes	Yes	513402	7147450
BH16	30	N/A	Yes	N/A	513472	7147867
BH17	30	Yes	Yes	N/A	513967	7147837
BH18	60	Yes	Yes	Yes	513439	7148033
BH19	30	Yes	Yes	N/A	513697	7148031
BH20	30	Yes	Yes	Yes	513938	7148034
BH21	60	Yes	Yes	N/A	513448	7148194
BH22	60	Yes	Yes	Yes	513380	7148365
BH23	30	Yes	Yes	N/A	513669	7148363
BH24	30	Yes	Yes	Yes	513860	7148363

Notes:
m - metres
All coordinates are UTM Zone 7

NOTES :
- ONSITE TOPOGRAPHY CONTOURS PROVIDED BY CLIENT (DATED 2012), AND ARE SET TO INTERVALS OF 10 m
- IMAGERY WAS EXTRACTED FROM GOOGLE EARTH PRO EDITION (DATED 2012)

0 250m

Scale: 1:7,500 @ 11"x17"

LEGEND

- BOREHOLE LOCATION
P - INDICATES PIEZOMETER (UNFROZEN)
T - INDICATES THERMISTOR (FROZEN)
SI - INDICATES SLOPE INDICATOR

CLIENT

Yukon Government
Energy, Mines & Resources
Assessment & Abandoned Mines Branch

TETRA TECH EBA

GEOTECHNICAL INVESTIGATION RECOMMENDATIONS ABANDONED CLINTON CREEK MINE, YUKON

SITE PLAN SHOWING PROPOSED GEOTECHNICAL INVESTIGATION

PROJECT NO.	DWN	CKD	REV
ENGWARC03039	RERH	SB/JP	0

OFFICE	DATE
EBA-WHSE	March 30, 2016

Figure 1

APPENDIX A
TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT – YUKON GOVERNMENT

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, the Yukon Government. 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 the Yukon Government, the Client, or Tetra Tech EBA. It is acknowledged that the Yukon Government, the Client, may reproduce the report freely for internal usage.

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.