TETRA TECH EBA

TECHNICAL MEMO

ISSUED FOR USE

To:	Erik Pit A / Senior Project Manager	**Date:**	March 31, 2016
c:		**Memo No.:**	001
From:	Justin Pigage, P.Eng.	**File:**	ENG.WARC03039-01.005
Subject:	Site Access Geotechnical Engineering Review and Mitigation Memo Clinton Creek Mine Site, YT		

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 abandoned Clinton Creek asbestos mine near Dawson City, Yukon. This memo presents a summary of the closure options being considered with specific focus on safe site access from a geotechnical engineering perspective. It also includes proposed engineering mitigations to improve safe site access and anticipated order of magnitude costs for the proposed mitigations.

2.0 CLOSURE OPTIONS

Project parties are considering several closure options for remediation of the Clinton Creek and Wolverine Creek valleys. The proposed closure options currently being considered are summarized below in Table 2.0. The closure options being considered are presented in detail in the Life Cycle Cost Analysis for Remediation Options report prepared by Worley Parsons (Worley 2014).

Table 2.0 – Closure Option Summary

Closure Option	Clinton Creek Valley		
	Clinton Creek Channel	**Clinton Creek Waste Rock Pile**	**Hudgeon Lake**
C3	Armour channel with riprap	No remediation	No remediation
D3	Armour channel with riprap	Stabilize waste rock pile	No remediation
E3	Lower channel and armour with riprap	Stabilize waste rock pile	Lower lake water level
F	Restore channel to valley floor	Remove waste rock to open pits, exposing valley floor	Fully drain lake
I2	Construct armoured channel south of existing channel over waste rock	Stabilize waste rock pile	No remediation
Wolverine Creek			
Closure Option	**Wolverine Creek Tailings Pile**		
A	No remediation		
B	No remediation		
C	Install protective cover over tailings pile base		
D	Install protective cover over tailings pile base		
E	Stabilize tailings pile and install protective cover		

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3.0 SITE ACCESS

Site access recommendations based on our review of the proposed closure options, and geotechnical engineering judgement, are depicted visually on the figure attached to this memo and summarized below in Table 3.0. One level of site access has been defined based on perceived geotechnical risk to the public. "Restricted Access" shown in red on the attached figure indicates areas of the site where public access should be restricted (i.e. behind a locked gate).

Table 3.0: Recommended Site Access - Post Closure Option Implementation

Closure Option		Site Access Description	Figure
Clinton Creek	**Wolverine Creek**		
C3, D3, E3, I2, F	**A, B, C, D, E**	Restricted access to waste rock pile, open pits and tailings pile	Figure 1

Tetra Tech EBA completed stability analyses for the proposed closure options, the results are summarized in the Geotechnical Stability Analysis and Dam Breach Update report (R128). The analyses indicated that all of the closure options currently being considered result in factors of safety lower than the recommended minimums, particularly in the case of the design seismic event. Tetra Tech EBA recommends that access to the open pits, Clinton Creek waste rock pile, Wolverine tailings pile, and the areas immediately downslope of these structures be restricted. A large failure at the site, in particular one caused by seismic forces, poses a risk to the public in these areas. A person visiting these areas at the time of this failure could be severely injured or killed.

The stability analyses determined that a large failure of the Clinton Creek waste rock pile would likely not result in a full release of Hudgeon Lake. Lowering the water level of Hudgeon Lake, as in Closure Options E3 and F, would expose the shoreline which could result in some localized instability as pore water drains from the exposed soils. Tetra Tech EBA does not anticipate this short term instability would affect long term access to the water body from a geotechnical perspective.

If additional closure options are developed in the future that result in acceptable factors of safety, site access should be reconsidered.

4.0 SITE ACCESS MITIGATIONS

In the Life Cycle Cost Analysis for Remediation Options report prepared by Worley Parsons (Worley 2014) the project parties were provided with operational changes, such as signage and monitoring, to improve site access. Tetra Tech EBA has reviewed physical mitigations to improve site access in the following sections.

4.1 Hudgeon Lake Access Road

A new road allowing for improved access to Hudgeon Lake and beyond could be constructed along the north side of the Clinton Creek valley. The road is considered a suitable mitigation in all of the currently shortlisted closure options. The access road would be approximately 1.8 km long and would be constructed from the confluence of Clinton and Wolverine Creeks to the existing road between Hudgeon Lake and the former mill site. This mitigation provides a safer travel corridor by traversing the north side of the valley above the anticipated runout zone from a possible failure of the Clinton Creek waste rock pile. The proposed conceptual road alignment is shown on the attached Figure 1. A full model including cut/fill volumes of the proposed access road is beyond the scope of this memo.

4.1.1 Cost Estimate

The cost estimate is based on constructing a road that is 1.8 km long, has a cleared right-of-way 10 m wide, an 8 m wide base, and a 7 m wide surface. A 600 mm sub-cut will be made along the road alignment and backfilled with pit run material. A 100 mm thick gravel surface will be placed over the pit run. The unit costs for order of magnitude construction cost estimating were based on the Life Cycle Cost Analysis for Remediation Options report prepared by Worley Parsons (Worley 2014), discussions with Yukon based contractors, and Tetra Tech EBA's experience working in similar conditions. The cost estimate does not provide allowances for indirect costs or engineering, procurement, and construction management costs. The cost estimate is presented below in Table 4.0.

Table 4.0: Hudgeon Lake Access Road Order of Magnitude Construction Cost Estimate

Construction Component	Remarks	Quantity	Unit	Cost/Unit ($)	Subtotal ($)	Contingency (% - $)	Total ($)
Clear & Grub	Medium density brush	1.8	ha	12165	21,900	25% - 5,475	27,375
Sub-cut for Road Base	Excavate to sub-base 600 mm depth x 8 m width	8640	m^3	25	216,000	25% - 54,000	270,000
Backfill of Road Base	Excavate, haul, and place pit run. 600 mm thick x 8 m wide	8640	m^3	60	518,400	25% - 129,600	648,000
Gravel Resurfacing	Drill, blast, crush, haul, and place gravel. 100 mm thick x 7 m wide	1260	m^3	165	208,200	25% - 52,050	260,250
				Subtotal	**964,500**	**Total**	**1,205,625**

4.1.2 Assumptions

The estimated costs are subject to the assumptions made in sections 4.2.1, 4.2.2, and 4.2.3 of the Life Cycle Cost Analysis for Remediation Options report prepared by Worley Parsons (Worley 2014), except that the costs in Section 4.1.1 are presented in first quarter 2016 Canadian dollars. The cost estimate does not provide for indirect costs or engineering, procurement, and construction management costs. Select key assumptions from Worley 2014 are listed below:

- Land right-of-ways have been established for construction;
- A source for quality aggregate material can be developed within 15 km of the site and will require no additional road construction; and
- All surplus waste material will be dumped in the Porcupine Pit.

5.0 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 EBA Inc.

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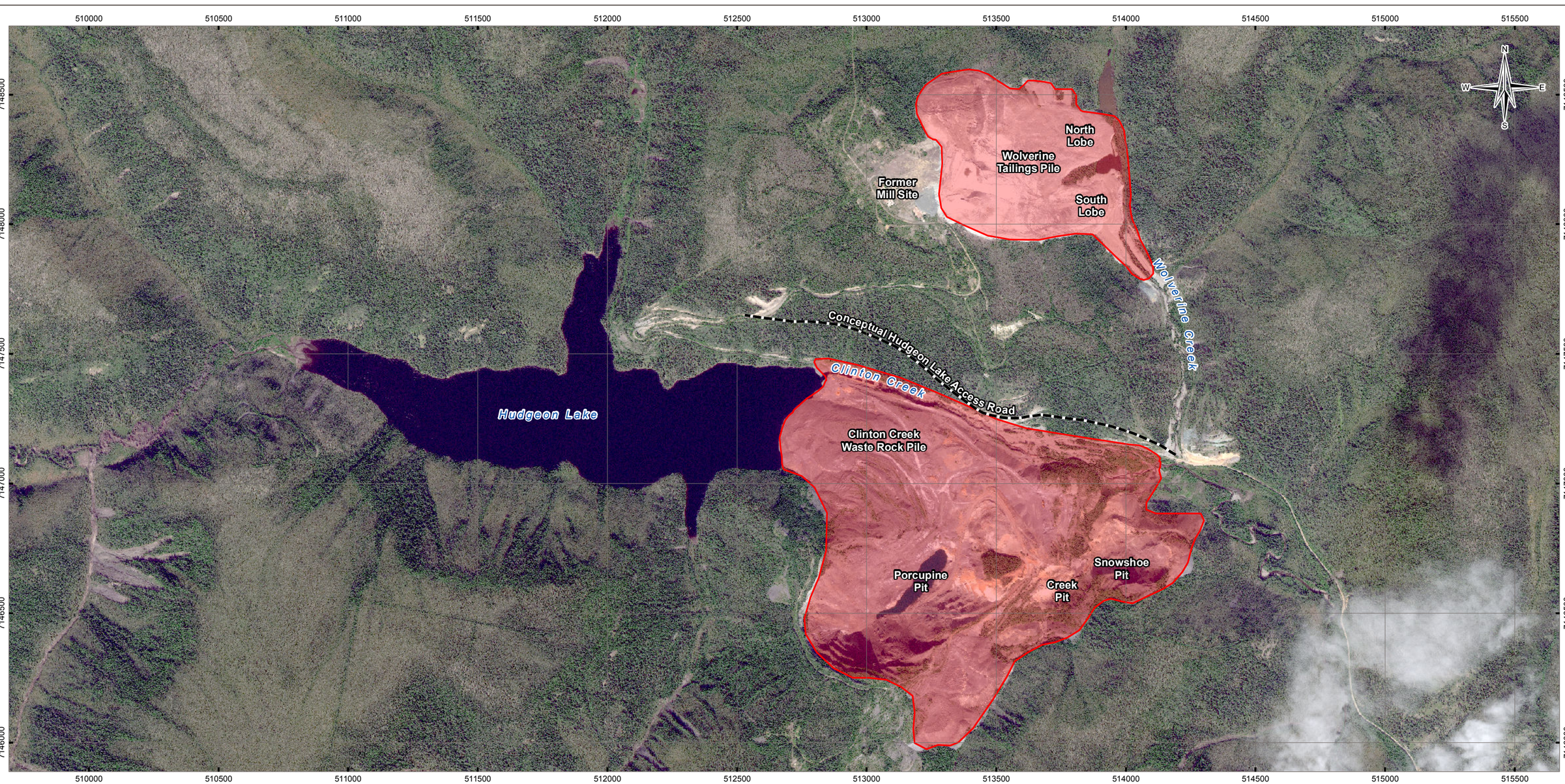
PERMIT TO PRACTICE
TETRA TECH EBA INC.
SIGNATURE
Date Mar 31/16
PERMIT NUMBER PP003
Association of Professional Engineers of Yukon

REFERENCES

Worley Parsons Group (2014). “Clinton Creek Site Lifecycle Cost Analysis for Remediation Options”.



LEGEND

- Restricted Access
- Conceptual Hudgeon Lake Access Road

NOTES
Base data source:
Imagery provided by Yukon Gov't (2012)

STATUS
ISSUED FOR REVIEW

CLINTON CREEK MINE

Site Access Delineation – All Shortlisted Closure Options

PROJECTION UTM Zone 7			**DATUM** NAD83	
Scale: 1:15,000 200 100 0 200 Metres				
FILE NO. WARC03039-01_Figure01_Closure.mxd				
PROJECT NO. ENG.WARC03039-01	**DWN** MEZ	**CKD** SL	**APVD** TM	**REV** 0
OFFICE Tt EBA-VANC	**DATE** March 30, 2016			

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

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Figure 1

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