TECHNICAL MEMORANDUM

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TO:	John Brodie, P.Eng. Technical Manager Faro Mine Closure Planning Office	**DATE:**	November 14, 2006
FROM:	Mike Jefferies, John Cunning	**JOB NO:**	06-1413-068
EMAIL:	mjefferies@golder.com; jcunning@golder.com		
RE:	**SEISMIC STABILITY OF TAILINGS COVER – ANVIL RANGE MINING COMPLEX (FARO MINE), YUKON**		

INTRODUCTION

In September 2006, at your request, we provided a Technical Memorandum that elaborated on our 2004 report "Rose Creek Tailings Impoundment Site Characterization and Seismic Stability Assessment Report ARMC, Yukon" regarding potential post-liquefaction flow slide movements. That Technical Memorandum considered soil strength variation in detail, but used average tailings impoundment slopes in estimating potential disturbing forces. Subsequent discussions by email lead to a further request that local tailings surface slope be used, rather than an overall average, in evaluating potential for flow-slides following an MCE. It is the detailed consideration of local slopes that is the subject of this memorandum.

It is assumed that readers of this memorandum also have access to both our 2004 report and the September 8, 2006 memorandum and are familiar with the background to the project and the context and limitations of our study.

DATA USED

The considerations presented in this memorandum are based on: (i) the residual strength profiles at each CPT location (See Appendix V of our 2004 report); (ii) the fraction within each CPT profile possessing less strength than needed to support the average 1% slope to the impoundment as documented in the September 2006 memorandum; and, (iii) the tailings slope at each CPT location computed based on the elevation contours shown on Figure 4.1 of our 2004 report. The validity of the estimated residual strength was further documented in our September 2006 memorandum. It is also understood from

email discussions with yourself and Cam Scott that the contours shown on Figure 4.1, which were provided to us in the reference AutoCAD drawing "8856_north.dwg", are the most accurate available.

RESULTS

Table A2 summarizes the inferred tailings slope at the individual CPT locations, those CPTs having been grouped according to the section lines shown on Figure 4.1 of our 2004 report. The fraction of each sounding with insufficient residual strength to support a 1% slope post-liquefaction are tabulated at each CPT. Then, our judgment of the implied response in the post MCE situation is presented at each location. The detailed residual strength profiles as presented in Appendix V of our 2004 report have been reviewed whenever ambiguity arose in forming the tabulated judgments. These judgments have been broken into four groups:

- Essentially only limited post earthquake settlement;
- Potential for differential settlement, but minimal horizontal movement;
- Potential for horizontal and vertical movement, but likely limited by the relatively small fraction of soil causing this behaviour; and,
- Potential for large scale settlement or sliding.

It is understood that the Tailings Working Group regards differential settlements as not a great concern for the proposed cover. Development of the impoundment closure is therefore primarily interested only in the potential for large scale settlement or sliding.

There are three instances of potential post-liquefaction sliding but with only a small fraction of the tailing being affected (at CPT03-09, 12B, and 07) such that it would not be unreasonable to expect movements to be local in nature because the cause seems to be weak layers rather than a general attribute of the tailings in the are. However, the area upstream of the Secondary Dam is still predicted to be prone to post-MCE liquefaction slides, even allowing for the flatter local slopes, because of a substantial fraction of the tailings in that area being exceedingly loose. The behaviour is inferred based on CPT's 03-21 and 03-22, but it is evident from Figure 4.1 that these could be characteristic of the much of flatter area upstream of the Secondary dam (i.e. before the rise to the higher ground around CPT 03-04 and 03-05 etc). Locations CPT 03-18 and 03-19 have been excluded from a sliding scenario because of the apparently horizontal ground.

CLOSURE

The Rose Creek impoundment contains substantial areas of very liquefiable tailings and which are prone to flowslides. However, the impoundment morphology is highly correlated to the tailings state, with the extremely liquefiable sediments largely in areas with a near horizontal surface – in effect, it appears that these areas have already moved to their stable post-liquefaction configuration. As such, further flow sliding would not be expected.

The exception to this pattern is an area upstream of the Secondary Dam and including the locations of CPT03-21 and SCPT03-22 in particular. Here, the tailings apparently still has sufficient slope that further flowslides are expected. It is understood that the use of fill to flatten this area is being considered, and which would eliminate the flowslide potential by removing the driving force.

This conclusion of minimal lateral movement post-liquefaction, despite the very liquefaction prone nature of the tailings, is based on the tailings slope. The slopes used in reaching this conclusion are apparently based on an existing air photograph contour interpretation. Given the crucial nature that the near-level surface topography plays in the evaluation of the possible remediation, prudence dictates that the tailings surface should be surveyed on the ground. We recommend that this be done.

Although attention has concentrated on flowslide potential, the extensive zones of loose tailings will cause surface settlement as liquefaction excess pore pressures dissipate. We understand that the Tailings Working Group has considered this issue and regards the proposed cover as capable of adsorbing differential settlements so induced. Nevertheless, we also recommend formal evaluation of the vertical settlement potential so that the decision on its acceptability for the cover can be fully defended.

MJ/JCC/cm/kt
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Table A2: Estimated Tailings Movement in post-MCE Situation

	Slope: (%) [1]	Fraction with s_r < 1% slope	Judgment
Section AA			
CPT03-01	0.0%	13%	Potential for local differential settlement
CPT03-02	0.0%	3%	Minimal movement expected
CPT03-12	-3.3%	0%	Minimal movement expected
CPT03-12B	-3.3%	4%	***Potential post-liquefaction slide movement***
CPT03-13	0.0%	3%	Minimal movement expected
CPT03-14	0.0%	25%	Substantial potential for local differential settlement
Section BB			
CPT03-03	0.0%	7%	Potential for local differential settlement
CPT03-11	0.0%	0%	Minimal movement expected
CPT03-11B	0.0%	0%	Minimal movement expected
CPT03-16	0.0%	11%	Potential for local differential settlement
CPT03-15	0.0%	24%	Substantial potential for local differential settlement
Section CC			
CPT03-07	-2.3%	1%	***Potential post-liquefaction slide movement***
CPT03-04	0.0%	0%	Minimal movement expected
CPT03-10	0.0%	3%	Minimal movement expected
SCPT03-17	0.0%	14%	Potential for local differential movement/settlement
Section DD			
CPT03-07	-0.7%	1%	***Movement expected on line of Section CC***
SCPT03-05	4.0%	0%	Minimal movement expected
CPT03-09	-1.7%	1%	***Potential for post-liquefaction slide movement***
CPT03-18	0.0%	6%	Probably minimal movement
CPT03-19	0.0%	43%	Substantial potential for local differential settlement
CPT03-20	0.0%	0%	Minimal movement expected
Section EE			
SCPT03-21	-1.0%	30%	***Expected post-liquefaction slide movement***
CPT03-31	-1.0%	0%	Minimal movement expected
CPT03-24	-0.7%	12%	Potential local differential movement/settlement
SCPT03-25	-0.7%	1%	Probably minimal movement
CPT03-26	0.0%	0%	Minimal movement expected
CPT03-27	-1.0%	1%	Probably minimal movement
SCPT03-32	0.0%	15%	Potential local differential movement/settlement
Section FF			
CPT03-06	-0.7%	0%	Minimal movement expected
CPT03-08	-0.7%	0%	Minimal movement expected
CPT03-30	-0.7%	12%	Potential local differential movement/settlement
CPT03-22	-1.0%	13%	***Expected post-liquefaction slide movement***
CPT03-20X	3.4%	0%	Minimal movement expected
CPT03-23	-2.0%	0%	Minimal movement expected
CPT03-29	-1.6%	0%	Minimal movement expected
CPT03-28	-0.8%	0%	Minimal movement expected
CPT03-33	0.0%	27%	Substantial potential for local differential settlement

Notes: 1 Tailings surface slope at the CPT location has been inferred from the topography drawing ("8856-north.dwg.")