

BEFORE THE EXPERT PANEL

FTAA-2507-1089

UNDER
IN THE MATTER

Fast-track Approvals Act 2024
of the Bendigo-Ophir Gold Project

**STATEMENT OF EVIDENCE OF PROFESSOR STEVEN EMERMAN ON
BEHALF OF SUSTAINABLE TARRAS**

Dated 7 August 2026

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TO THE EXPERT PANEL

1. My name is Steven Emerman. I provided a statement of evidence on behalf of Sustainable Tarras Inc in relation to mine waste dated 23 March 2026. My qualifications and experience were set out in that earlier statement.
2. The purpose of this statement is to address the Applicant's response to Minute 40 which addressed a series of questions from Commissioner Johnson on geotechnical aspects.

Summary

3. The Applicant has proposed significant geotechnical work be done (in the future) to inform consent conditions and monitoring. Much of that work, and more, should have been done before now as a prerequisite to establishing the mine concept feasibility suitable for consideration under the Fast Track Approvals Act.
4. The Applicant has treated a factor of safety (FoS) between 1.3 and 1.5 as generally acceptable. A FoS of 1.3 is appropriate only where geotechnical parameters are well understood. Given the current uncertainty, the minimum static FoS should be 1.5. Further, the applicant has failed to recognize that the minimum factor of safety must increase in the transition from the operational to the post-closure period.

Response to Table 1

Open Pit Slopes

5. Table 1 as set out in the Applicant's response contains a summary of slope stability design guidance for the project's open pits and states "Static FoS generally within the accepted open pit mining guidance range of 1.3 – 1.5 for high consequence slopes."
6. Table 9.9 of the Guidelines for Open Pit Slope design is set out below.¹

Table 9.9: Typical FoS and PoF acceptance criteria values

Slope scale	Consequences of failure ^b	Acceptance criteria ^a		
		FoS (min) (static)	FoS (min) (dynamic)	PoF (max) P[FoS ≤ 1]
Bench	Low-high	1.1	NA	25–50%
Inter-ramp	Low	1.15–1.2	1.0	25%
	Medium	1.2	1.0	20%
	High	1.2–1.3	1.1	10%
Overall	Low	1.2–1.3	1.0	15–20%
	Medium	1.3	1.05	5–10%
	High	1.3–1.5	1.1	≤5%

a: Needs to meet all acceptance criteria

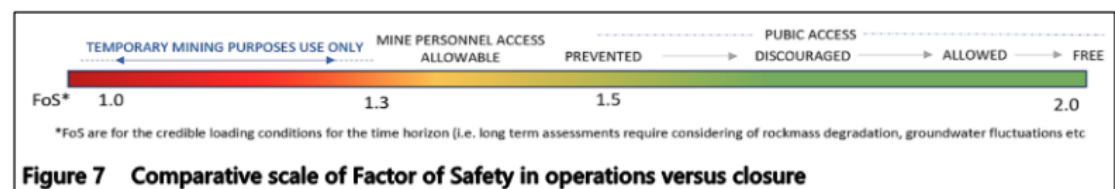
b: Semi-quantitatively evaluated (see Figure 13.9)

7. The Applicant's response is misinterpreting the range 1.3-1.5. This does not mean that any factor of safety in the range 1.3-1.5 is good enough. The lower end of the range (1.3) would be appropriate when the geotechnical parameters are well known. On the other hand, a factor of safety of 1.5 would be appropriate when the geotechnical parameters are poorly known, such as

¹ *Guidelines for open pit slope design Read & Stacey (editors), 2009.*

at the BOGP. Therefore, I would recommend a minimum factor of safety of 1.5.

8. Table 1 in the Applicant's response also contains a heading "confidence in achieving closure outcomes" and it is stated "High confidence due to staged development, ongoing monitoring, groundwater control, adaptive management and progressive refinement of the geotechnical model using observed site conditions. Residual risks at closure will be managed through exclusion zones and public safety controls."
9. I consider that, in this column, the Applicant has misinterpreted the Guidelines for Open Pit Slope Design, which includes guidelines for safe operation, not guidelines for safe closure. The guidelines for safe open pit closure are contained in the companion volume Guidelines for Open Pit and Waste Dump Closure.
10. The figure below from Carter et al (2022) (one of the three editors of Guidelines for Open Pit and Waste Dump Closure) shows how the appropriate minimum factor of safety against slope failure might increase from less than 1.3 during mine operation to even greater than 2.0 during post-closure.



11. There are two primary reasons as to why the minimum factor of safety must increase in the transition from the operational to the post-closure period.
12. First, any data uncertainty during the operational period is amplified into the post-closure period. Even if there is excellent knowledge of the geotechnical properties during pit operation, there is much less certainty about the rate and extent of the degradation over time of the strength of the rock masses adjacent to the pit walls.² In addition, there are still gaps in theoretical knowledge regarding the processes that drive rock strength degradation.³
13. This is demonstrated in the Figure below from de Graaf et al (2024) (another one of the three editors of Guidelines for Open Pit and Waste Dump Closure), which refers to the processes of erosion, slope instability and climate change.

² de Bruyn et al., 2019; Carter et al., 2022; de Graaf et al., 2024

³ de Graaf et al., 2024

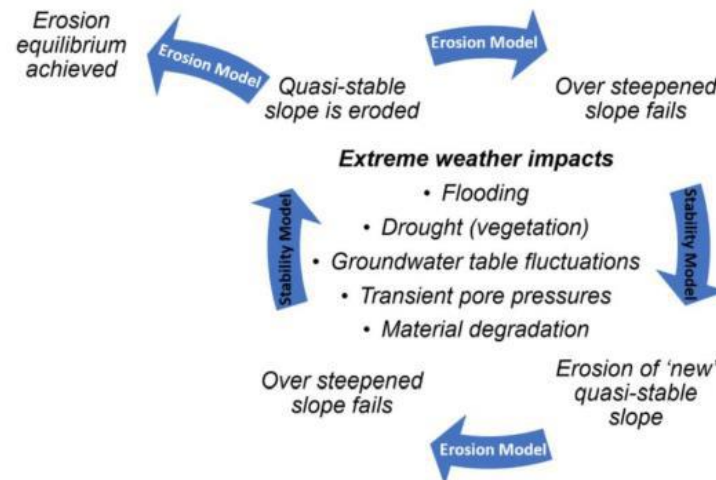
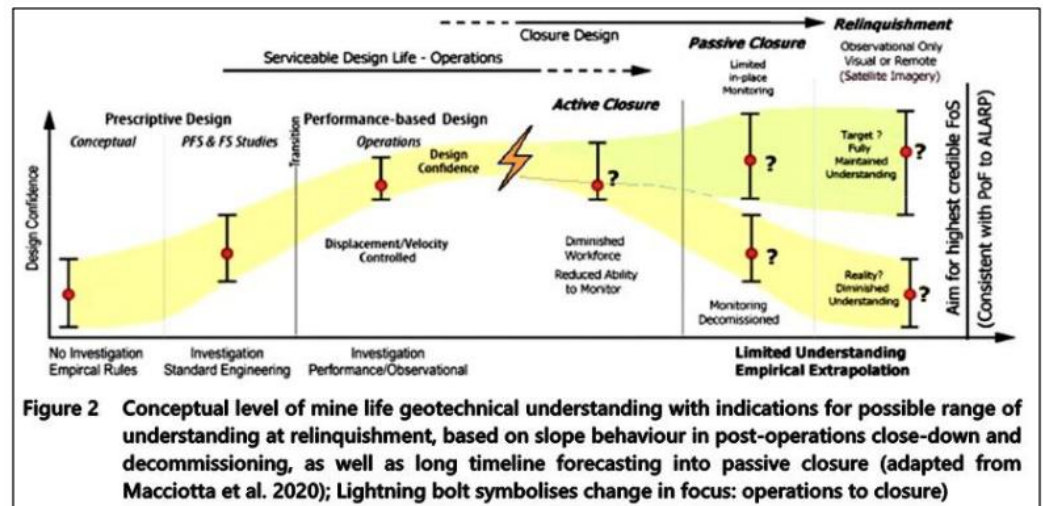


Figure 9: Coupled erosion-stability models with consideration for extreme weather impacts.

14. Therefore, keeping the factor of safety fixed even as the data uncertainty increases has the potential to greatly increase the probability of failure during the post-closure period.
15. The second reason as to why the minimum factor of safety must increase is that the post-closure period will see a reduction in or complete cessation of monitoring, as well as a reduction in or the complete absence of an onsite trained workforce. Thus, the reduced ability to detect instability or to respond to instability in a timely manner means that the probability of failure must be greatly reduced. Carter et al. (2022) has proposed a minimum factor of safety even greater than 2.0 during the post-closure period. Carter et al. (2022) has also emphasized that the calculation of factor of safety for the post-closure period must be based upon the strength of the rock masses and the groundwater levels that will exist in the post-closure period, not the greater strength and lower water table of the operational period. There are case studies and recommendations for estimating post-closure shear strengths.⁴ These estimates of post-closure strength degradation involve a great deal of uncertainty, which leads precisely to the point that there must be an increase in the minimum factor of safety.
16. The choice of the correct post-closure factor of safety is not simple and cannot be simply picked off a table. Carter et al. (2022) provide a step-by-step procedure for choosing the correct post-closure factor of safety and I recommend that their procedure be followed. I have attached, as an example, a report of mine that follows their step-by-step procedure for the Rhyolite Ridge open-pit lithium mine in Nevada (**Annexure A**).
17. Below I have included a table from Carter et al (2022). According to this diagram the minimum factor of safety against slope failure during the post-closure period (or certainly by the time of the relinquishment of the open pit) should aim for the highest credible value, while the maximum probability of failure should be reduced to the ALARP (As Low as Reasonably Practicable) level.

⁴ de Bruyn et al., 2019



Engineered Landforms

18. Table 1 in the Applicant's response also addresses the feature Engineered Landforms (ELFs). This refers to "Interim FoS ≥ 1.3 . Closure FoS ≥ 1.5 . Post-earthquake FoS ≥ 1.2 where relevant. Final outer slopes $\leq 1V:3H$. Progressive rehabilitation, drainage control, deformation monitoring and erosion management."
19. The expression "Interim FoS" needs clarification. The static factor of safety could be 1.3 only before there is any introduction of tailings and water on the upstream side of the ELF. During operation, as well as after closure, the static factor of safety must be 1.5.
20. I refer to the following extract from the (U.S.) Federal Emergency Management Agency (FEMA) Tailings Dam Safety Best Practices:⁵

"End of construction conditions are conventionally applied to water dams to recognize that construction-induced pore pressures frequently develop in foundations and/or embankments prior to placing the dam into service. The minimum factor of safety has typically been set to 1.3 because this is a temporary condition with no storage and the consequence of failure would be low. For tailings dams, this could apply to the construction of the starter dam or the raised section before solids and water are stored considering excess pore pressures. However, when a sustained or long term undrained shearing risk exists, factors of safety developed for short-term loading conditions do not apply."

Open Pit

21. Below I respond to the Applicant's information under the heading Open Pit (from paragraph 15 of the Minute 40 response).
22. The Applicant states that Read & Stacey Table 9.9 lists a range from 1.3 to 1.5 FOS of *high failure consequence* slopes under static loading and 1.1 for seismic loading. I have commented on this above in addressing Table 1.
23. The Applicant's response states at paragraph 22 that the FOS obtained for the RAS NE slope under dry static and dry seismic (0.13g seismic

⁵ FEMA (Federal Emergency Management Agency), 2025. Tailings dam safety best practices: April 2025 Final Draft for Limited Release, 350 p.

coefficient) were 2.05 and 1.66, respectively, and for a partially saturated slope the FOS were 1.42 and 1.21 respectively for static and seismic conditions. A static FOS of 1.42 for the RAS NE slope means that the slope will be unstable when it is partially saturated. I pose the question of what would happen if the slope were saturated? I also note the meaning of "slope stability": An engineered slope is stable when it is operated with an acceptable factor of safety under the design operating conditions.

24. At paragraph 24 of the Applicant's response it is stated:

At the current (pre-feasibility) stage of assessment, use of DAC of 1.3 to 1.5 is reasonable, considering the remoteness of the open pit from Project boundaries, the nature of the features which could theoretically be encroached on by crest retreat and that public access to the open pit will be physically denied.

25. This does not make sense to me. The choice of the minimum factor of safety will determine the size of the open pit and will thus affect every other aspect of the project. Thus, now is an appropriate time to set a minimum factor of safety of 1.5.

26. The Applicant's response at paragraph 25 states that the FOS obtained by 2D analysis alone is not a holistic assessment of slope stability and the analysis technique has well known limitations.

27. I agree and this is the reason for setting a minimum factor of safety of 1.5.

28. The Applicant's response states:

26. All components of the geotechnical model must be considered, including variations in lithology, major structures, pervasive fabric and fracture network(s), groundwater variations and hydrogeological assessment of the extents and rate of drawdown must be acknowledged.

27. Three-dimensional numerical analysis of open pit stability is part of the assessment and will be undertaken as part of detailed design which is regularly updated as part of the development of the pit.

28. As further data are gathered and the understanding of the RAS rock mass increases, so too will the ability to apply realistic probabilistic analysis methods to slope assessment and design.

29. All of this should have been done prior to the Fast-Track Application being lodged. The above is crucial information. It determines the size of the open pit, which will affect every other aspect of the project.

The Applicant's experience

30. The Applicant's response refers to examples within New Zealand and overseas where staff of the Applicant have experience managing sites during operations and closure to achieve compliance.

31. This is concerning because I understand these sites have a history of open-pit slope failures. I pose the question – what has the Applicant learned from all of these failures and how has this knowledge been put into practice in the Bendigo Ophir project?

32. By way of example with respect to the Macraes Mine, a 2024 report by PSM recorded that:⁶

Several pit slope instabilities have occurred during mining, most notably:

- A 20 Mm³ west wall slide along the Footwall Fault in April 2014
- A large unravelling planar failure within the eastern highwall in 2012
- A zone of highwall movement extended laterally along the geological structures from the 2012 failure following an underground production blast in December 2022.

33. A further example is the Ok Tedi mine. Kennedy and Casagrande (2020) state in the article attached as **Annexure B** that:

Since 2008, the West Wall of the Ok Tedi mine has been experiencing instability with many large areas showing failure or pre-failure movements, with an estimated volume for 'Block 1A' of >8 Mm³. These failures pose significant risk to the operation from a safety and economic perspective, with the larger areas of instability posing a huge challenge to reaching the life-of-mine design.

Applicant's comments on draft conditions

34. At paragraph 42 the Applicant's response states:

For example, if stability at closure needs a $FOS \geq N$, that FOS must be applied from the onset of development of final walls. While a lesser FOS may be acceptable where comprehensive slope monitoring is applied, it is impossible to increase the FOS once the slope is developed.

35. This is right, and that is why it is critical to set the minimum factor of safety at 1.5 at the present time.

36. The Applicant states:

44. The initial steps taken in this iterative process include drilling of additional geotechnical investigation boreholes, preliminary open pit 3D modelling (sensitivity only to this stage in the absence of an in-situ stress regime for the Site) and empirical/preliminary subsidence assessment.

45. Next steps include in-situ stress measurement, further structural interpretation, re-run of open pit numerical modelling and extension of modelling to include underground extraction and backfilling and closer examination of potential for surface subsidence.

46. Models are to be calibrated against actual behaviour where practicable and monitoring data are to be used to validate model output. Modelling parameters must be updated where field evidence is obtained or assumptions change.

37. All of this is critical for the determination of the size of the open pit. Therefore, all of this should have been done prior to the Fast-Track Application being lodged.

Steven Emerman

⁶ <https://www.orc.govt.nz/media/jrendyh2/appendix-7-psm-2024b-macraes-phase-4-consenting-project-element-432-open-pit-stability-assessment-for-frasers-tsfc.pdf>, executive summary. See also 3.2 (Existing Slope Performance).

References:

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de Bruyn, I., D. Prado, J. Mylvaganam, and D. Walker, 2019. Geotechnical considerations for the stability of open pit excavations at mine closure—Some scenarios: In Tibbett, M. and A.B. Fourie (Eds.), *Mine Closure 2019* (pp. 235-248), Australian Centre for Geomechanics, Perth, Australia. Available online at: https://papers.acg.uwa.edu.au/p/1915_19_de_Bruyn/

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