MEMORANDUM

To:	Mining & Energy Technical Services Pty Ltd
Attention:	Damien Plucknett
Prepared By:	Ty Grantham
Reviewed By:	Tom Sullivan
Date:	16th March 2022
Memo Ref:	BMS-P22010C-VIT-VUL-M-1-V0.2
Subject:	Vulcan South Project – Final Landform Geotechnical Assessment

1 INTRODUCTION

This memorandum presents the results of a geotechnical assessment for the Vulcan South Project (VSP) final landforms, i.e., rehabilitated in-pit and ex-pit spoil dumps. Two-dimensional (2D) limit equilibrium analyses were performed to determine the overall slope stability in terms of a Factor of Safety (FoS) as part of mine closure requirements.

The assessment was carried out by Blackrock Mining Solutions Pty Ltd (Blackrock) at the request of Mining and Energy Technical Services Pty Ltd (MET Serve) as part of their Progressive Rehabilitation and Closure Plan (PRCP).

2 SLOPE STABILITY ANALYSIS

2.1 Material Properties and Assumptions

The current assessment is based on the Mohr-Coulomb shear strength parameters and material types specified in Blackrock's Vulcan Complex Geotechnical Assessment Report (BMS Report No. BMS-VIT-VUL-201910-01-V4.0), as summarised in Table 2-1.

As indicated by Mining & Energy Technical Services Pty Ltd (MET Serve), dry tailings would be co-disposed with the spoil. Therefore, a reduction of the spoil shear strength parameters from Category 2.5 to Category 2 (Simmons & McManus, 2004) was applied to the analyses. A basal saturated spoil layer of approximately 5 m thickness was assumed for the ex-pit spoil dumps.

Table 2-1: Mohr-Coulomb Shear Strength Parameters

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type
Tertiary and Weathered Permian		23	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Fresh Permian		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
Cat 2.0 (U)		18	Mohr-Coulomb	30	28	Water Surface	Automatically Calculated
Cat 2.0 (S)		20	Mohr-Coulomb	15	23	Water Surface	Automatically Calculated

2.2 Design Geometry

Final landform designs were provided to Blackrock by METServe on 23 February 2022. Rehabilitated dump slopes were designed to approximately 9° (1V:6H) in accordance with Queensland Government's regulations, as shown in Figure 2-1 to Figure 2-3.

In-pit spoil dumps would be backfilled to natural ground level and then surcharged with additional spoil to final landform specifications.

Figure 2-4 and Figure 2-5 shows the sectional geometries of the in-pit and ex-pit spoil dumps.

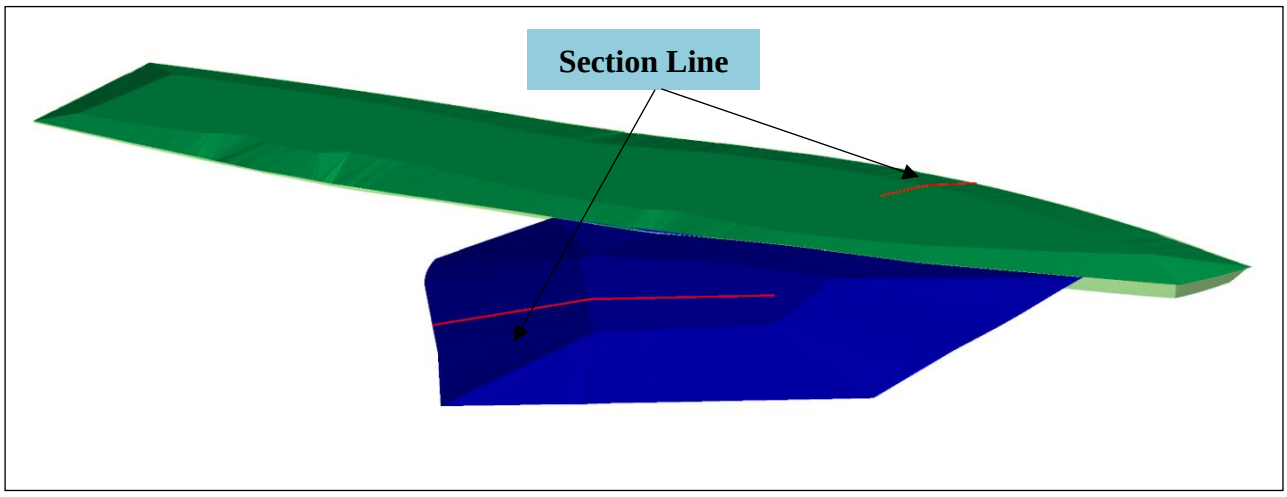

Figure 2-1: Vulcan North Pit Final Landform Design – North Facing View Showing In-Pit Dump (Green) and Ex-Pit Dump (Blue) Footprints

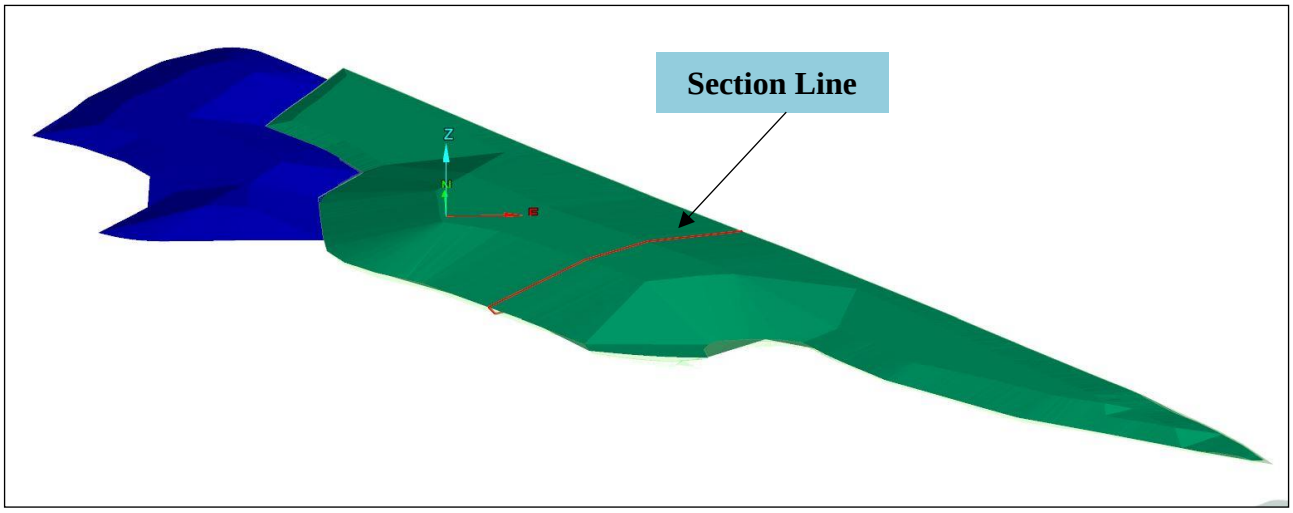

Figure 2-2: Vulcan Main Pit Final Landform Design – North Facing View Showing In-Pit Dump (Green) and Ex-Pit Dump (Blue) Footprints

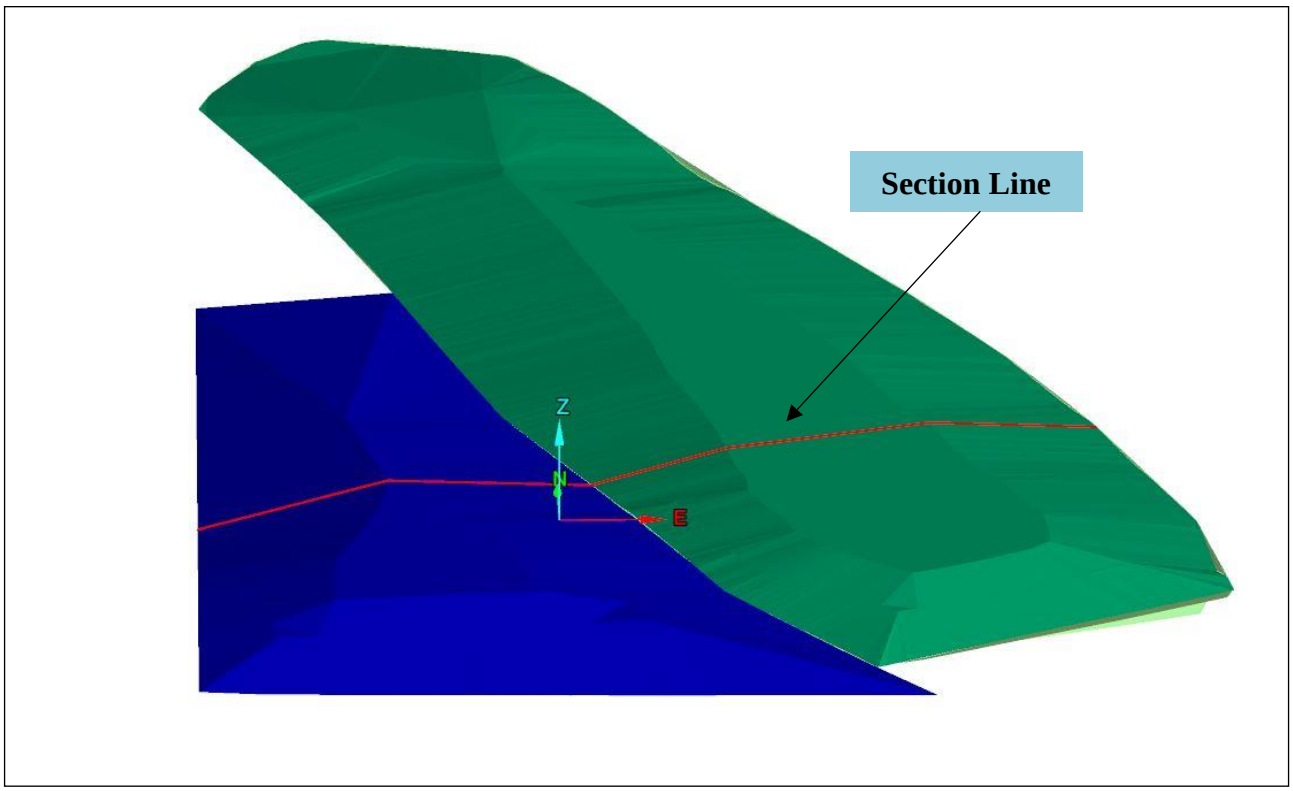

Figure 2-3: Vulcan South Pit Final Landform Design – North Facing View Showing In-Pit Dump (Green) and Ex-Pit Dump (Blue) Footprints

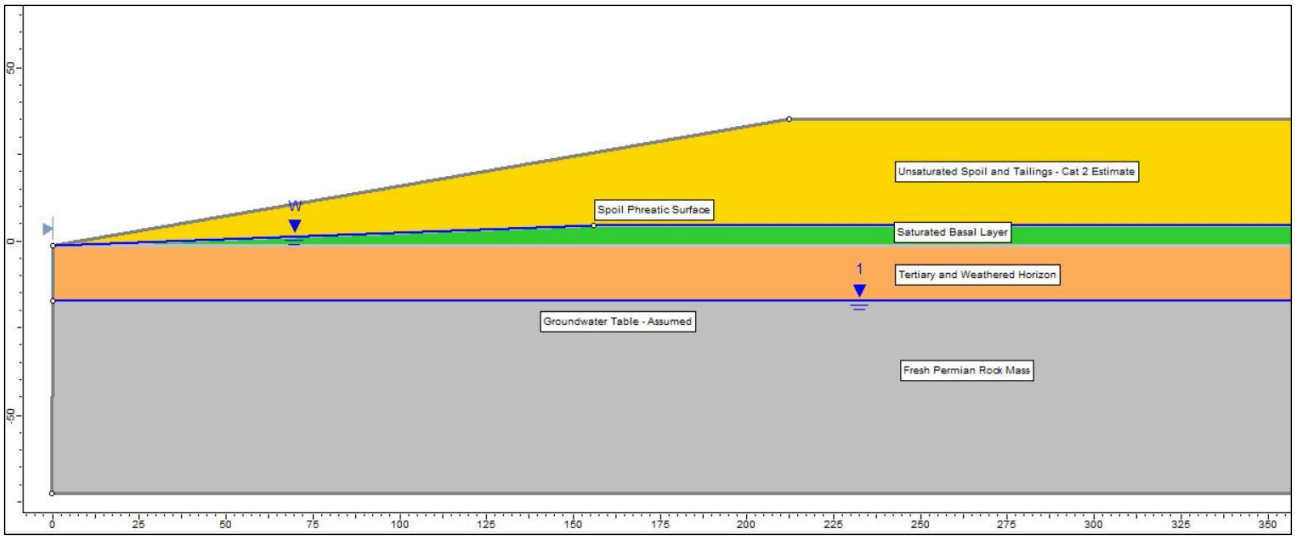

Figure 2-4: Ex-Pit Spoil Dump Geometry

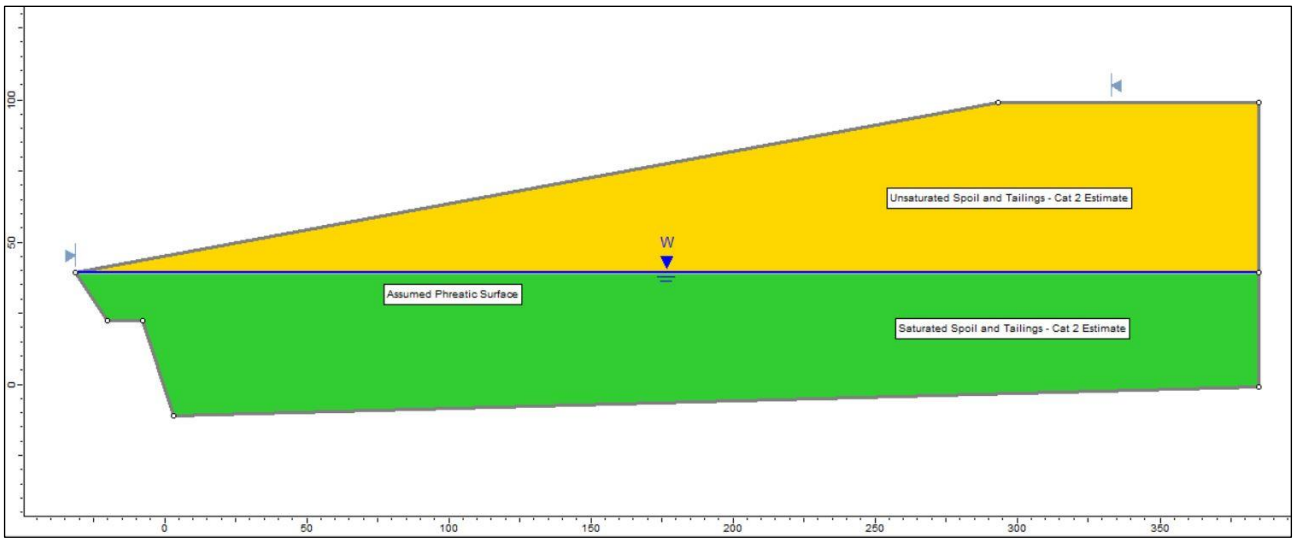

Figure 2-5: In-Pit Spoil Dump Geometry

2.3 Limit Equilibrium Analysis & Results

Two-dimensional limit equilibrium analyses were assessed in terms of a circular failure mechanism acting through the unsaturated and saturated Category 2 spoil material for the in-pit and ex-pit spoil dumps, respectively.

The Category 2 material parameters are derived from the coal spoil shear strength framework developed by Simmons & McManus (2004). In this case, the estimated spoil category used for the analysis was Category 2, which generally comprises fine-grained, low plasticity spoil with larger clasts.

Analyses were made for representative cross-sections of the final landform (i.e., in-pit and ex-pit spoil dumps), as shown in Figure 2-1 to Figure 2-3(Section 2.2). Analyses were carried out using industry-standard 2D limit equilibrium methods in Slide2 (V9.020) developed by Rocscience.

The accepted Factor of Safety (FoS) criterion for final landform slopes is ≥1.5. The FoS is a measure of driving forces versus resisting forces in a system, where a FoS of 1 equates to a 50% probability that failure will occur. FoS values >1 generally indicate that a system is likely to be geotechnically stable.

The analyses indicated critical FoS values between 2.56 and 4.03 for the in-pit and ex-pit dumps, respectively, using the General Limit Equilibrium/Morgenstern-Price (GLE/M-P) method. These results are considered satisfactory in terms of meeting final landform design acceptance and long-term geotechnical stability criteria.

The results of the limit equilibrium analyses are summarised in Table 2-2, and presented in Figure 2-6 to Figure 2-11, for in-pit and ex-pit dump final landforms from Vulcan North Pit to Vulcan South Pit.

Table 2-2: VSP Final Landform Slope Stability Analysis Results

Final Landform	Failure Surface	Search Method	FoS
Vulcan North - Ex-Pit Dump	Circular	Auto-Refine	**3.48**
Vulcan North - In-Pit Dump			**3.01**
Vulcan Main - In-Pit Dump			**2.56**
Vulcan Main - Ex-Pit Dump			**3.99**
Vulcan South - In-Pit Dump			**3.14**
Vulcan South - Ex-Pit Dump			**4.03**

GLE/M-P FoS reported

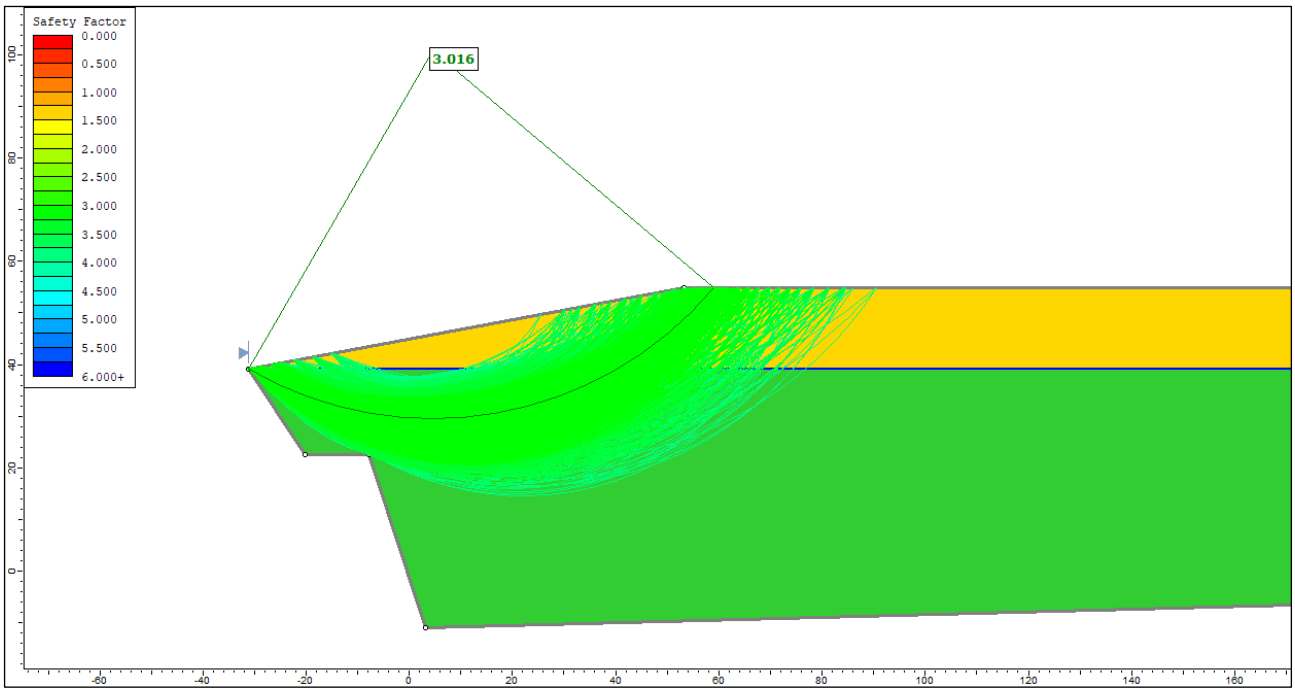

Figure 2-6: Vulcan North Pit – In-Pit Dump – Final Landform – Circular Failure (Auto-Refine) – FoS 3.01 (GLE/M-P)

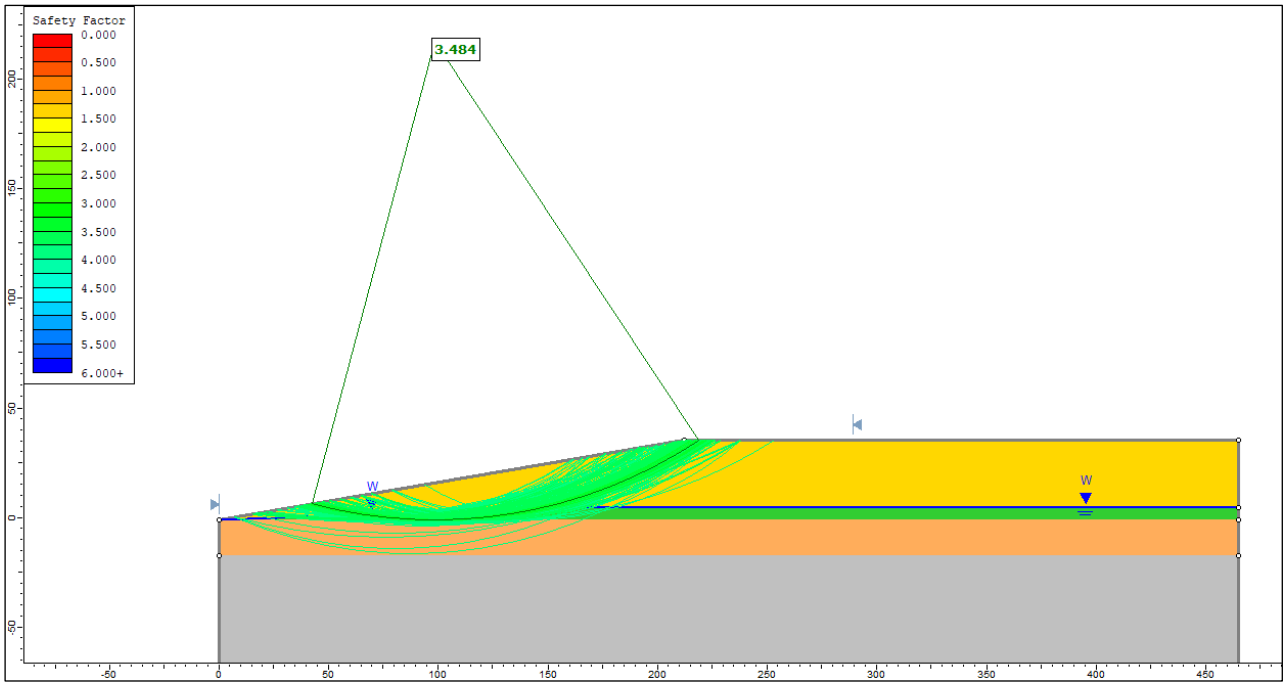

Figure 2-7: Vulcan North Pit – Ex-Pit Dump – Final Landform – Circular Failure (Auto-Refine) – FoS 3.48 (GLE/M-P)

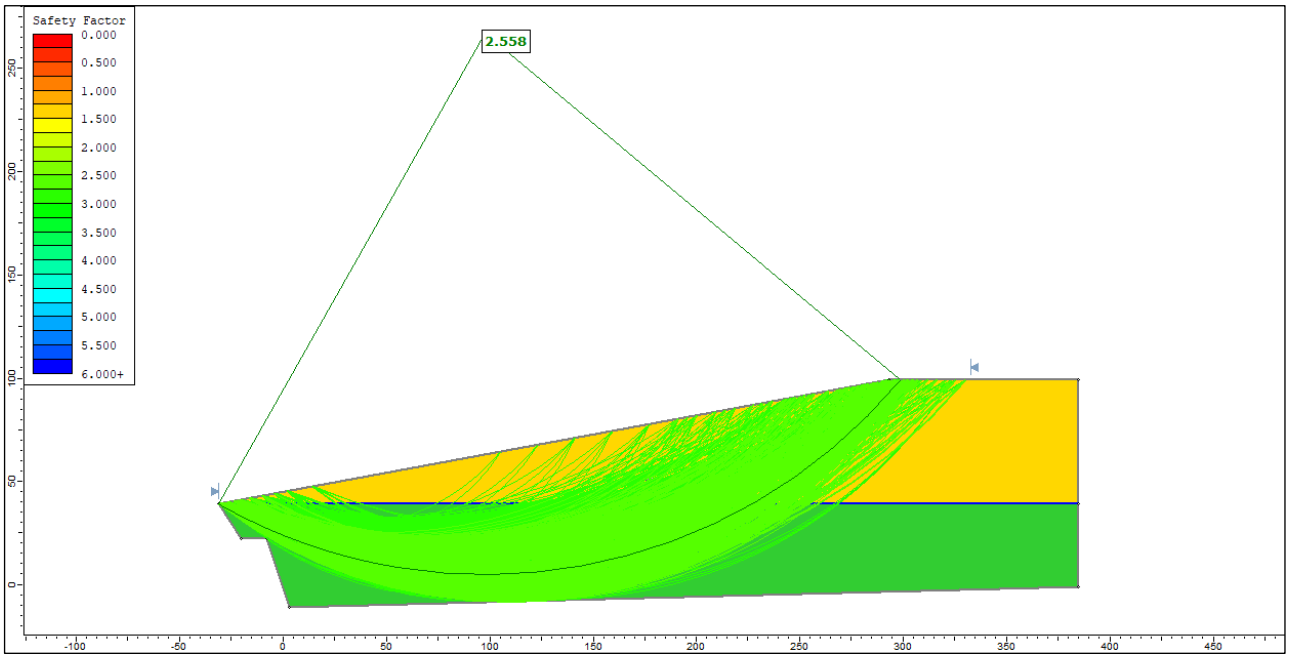

Figure 2-8: Vulcan Main Pit – In-Pit Dump – Final Landform – Circular Failure (Auto-Refine) – FoS 2.56 (GLE/M-P)

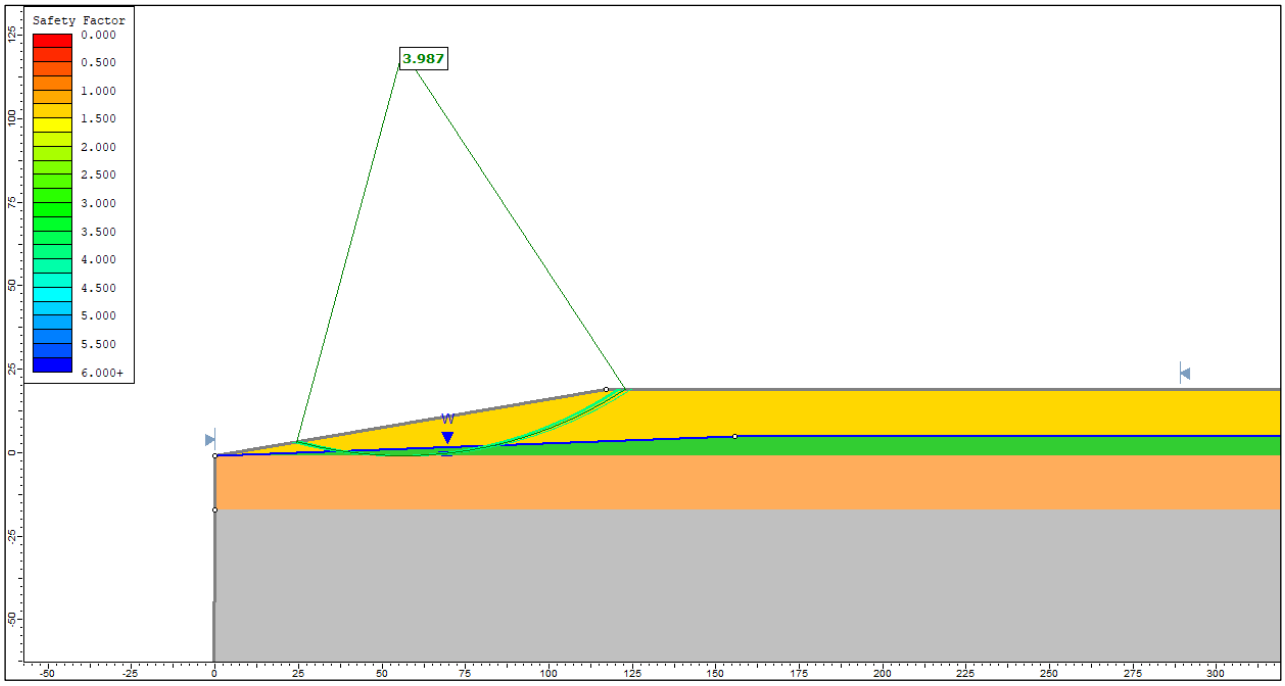

Figure 2-9: Vulcan Main Pit – In-Pit Dump – Final Landform – Circular Failure (Auto-Refine) – FoS 3.99 (GLE/M-P)

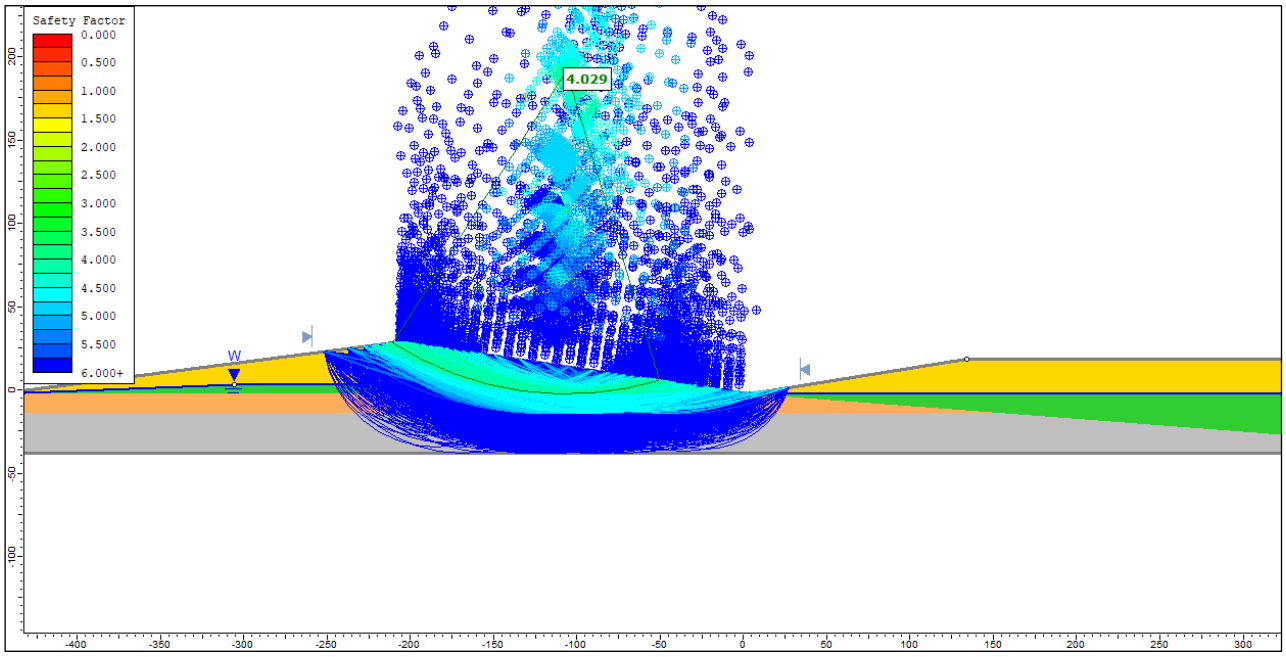

Figure 2-10: Vulcan South Pit – Ex-Pit Dump – Final Landform – Circular Failure (Auto-Refine) – FoS 4.03 (GLE/M-P)

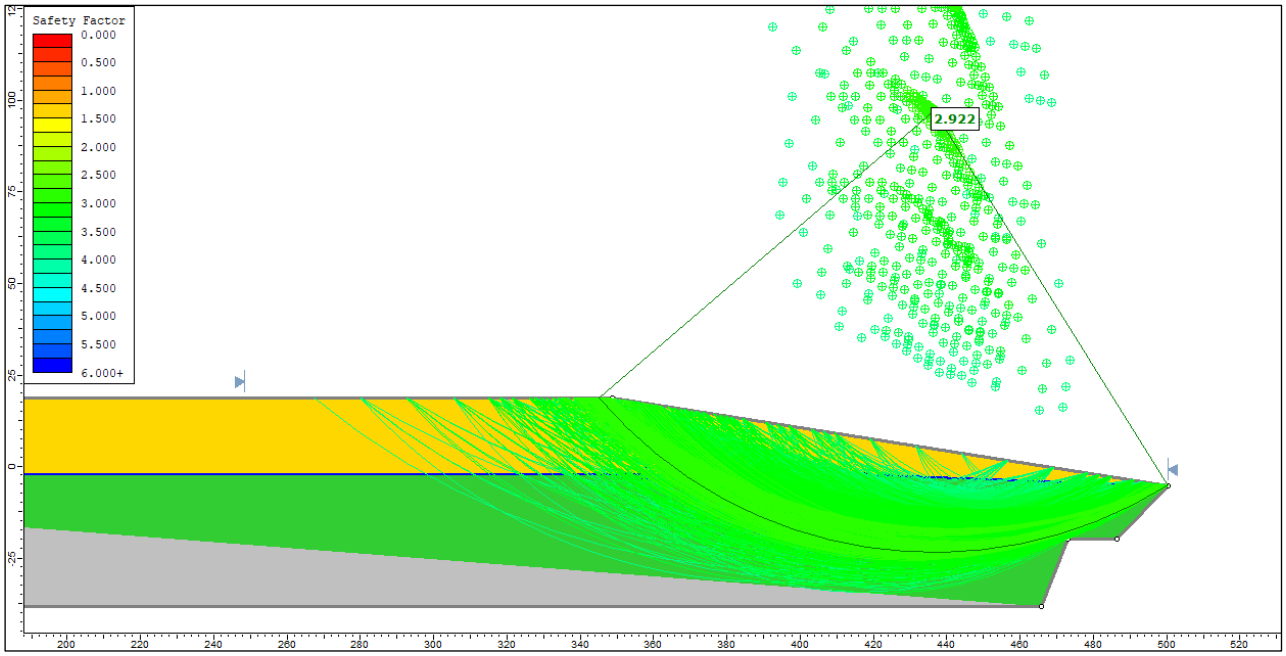

Figure 2-11: Vulcan South Pit – In-Pit Dump – Final Landform – Circular Failure (Auto-Refine) – FoS 3.14 (GLE/M-P)

3 CONCLUSIONS

It can be concluded from the 2D limit equilibrium analyses that:

- In-pit and external spoil dumps were assessed to be geotechnically stable, based on the assumptions and final landform designs provided by METServe; and
- The proposed final landform design exceeds the minimum FoS of 1.5 for long-term stability, based on the assumptions, and is therefore acceptable from a geotechnical perspective.

4 REFERENCES

Blackrock Mining Solutions Pty Ltd (Blackrock) (2019). "Vulcan Mine Complex Geotechnical Assessment". Report ref: BMS Report No. BMS-VIT-VUL-201910-01-V4.0, 27th August 2021.

Rocscience, Inc (2021). Slide2 v9.020. Available from www.rocscience.com.

Simmons, JV & McManus DA (2004). "Shear Strength Framework for Design of Dumped Spoil Slopes for Open Pit Coal Mines". Proceedings of *Advances in Geotechnical Engineering: The Skempton Conference*, Jardine RJ, Potts, DM & Higgins KG (eds), Vol 2, 981-991, Thomas Telford, 2004.

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