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DESKTOP GEOTECHNICAL ASSESSMENT FOR PREFEASIBILITY STUDY

Blacksmith Lease, Pilbara Iron Ore Project

REPORT

Submitted to:
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1.0 INTRODUCTION

This technical memorandum presents Golder Associates (Golder) desktop geotechnical assessment for Flinders Mines (Flinders) Blacksmith Lease which forms the Pilbara Iron Ore Project north of Tom Price, Western Australia (Figure 1). The Lease comprises seven channel iron deposits (CID) that Flinders intends to take to feasibility level study. Each of the deposits contains two or more pits that will be mined simultaneously to produce a particular product blend. The general layout of the site is presented in Figure 2.

The objective of the assessment was to highlight areas in the proposed pit designs where there is an elevated geotechnical risk, and to make recommendations for the management of these risks during the feasibility study. The following information was supplied and utilised during the geotechnical assessment:

- Topography supplied by Flinders
- Various pit designs produced by Golder
- Block model produced by Golder.

2.0 GEOLOGY

2.1 Regional Geology

The Hamersley Province contains late Archaean-Lower Proterozoic age (2800-2300 Ma) sediments of the Mount Bruce Supergroup situated between Archaean granitoid basement complexes of the Yilgarn and Pilbara blocks. The Supergroup has three sub-groups – the Fortescue, Hamersley and Turee Groups, which are overlain by remnants of the overlying Wyloo Group. The Hamersley Group Banded Iron Formations (BIFs) are the largest (in terms of contained iron), most extensive and thickest known in the stratigraphic record. On a regional scale, the Hamersley Group metasediments, including the BIF units, are described as relatively flat-lying along the northern margin of outcrop, becoming more complexly folded to the south.

The flat-lying BIF units of the Dales Gorge Member outcrop close to valley floor level in the Hamersley ranges, therefore the valley systems are floored with the Dales Gorge Member, McRae Shale or Mount Sylvia Formation. Local folding and faulting is present within the Brockman Iron Formation BIFs.

A large unconformity exists between the Archaean-Lower Proterozoic rocks and Mesozoic to Recent sediments, in the Hamersley Ranges geological record. Units within the Mesozoic sediments include the mineralised Marillana Formation. Flinders Mines Hamersley Project is exploring in the cover material and the youngest units of the Tertiary sediments overlying the Hamersley Group, within the Marillana Formation. This formation is comprised of fluvial sediments occupying the Tertiary meandering palaeochannels of the Hamersley Basin, with the type sections for this unit in the central Hamersley Range area of the Pilbara region (such as at Yandi Mine).

Recent sediments include colluvial fan, colluvial sheetflood, and alluvial fan and depositional plain sediments within the highlands, and alluvial flood plain sediments within the low elevation areas of the Hamersley Ranges.

2.2 Deposit Geology

Outcropping geology in E47/882 comprises the Brockman Iron Formation, which is known to host large bedded iron deposits (BID) in other regions of the Hamersley Ranges. Incised into this bedrock geology are large channel systems, which can hold significant tonnages of channel and detrital iron deposits (CID and DID). Formed by cyclic weathering and erosion of banded iron formation, these channels may host accumulations of iron-rich gravels distal from any obvious hard-rock iron mineralisation. These deposits represent excellent economic targets as they are near surface and easy to mine.

The hematite-rich DID ore includes all mineralisation that has been deposited in channels from the surrounding banded iron formation, and is primarily composed of detrital material of either pisolithic or fragmental types. The BID ore is generally located beneath the DID deposits in the underlying Dales Gorge

Member of the Brockman Iron Formation, and is more prevalent in the margins and in the headwaters. In some parts of Delta and Eagle CID mineralisation occurs between the DID and BID material

In general, the four DID units form a stratigraphic sequence, passing from DID-1 to DID-4, with the iron grade increasing and the contaminant concentrations decreasing with depth (Figure 3). On the basis of similarities in physical and chemical characteristics, the DID is grouped into an upper (DID1 and 2) and lower (DID 3 and 4) unit. A schematic example of a geologically interpreted cross section is shown in Figure 4 .

BID is characterised by iron content greater than 60%. Silica and alumina levels are typically low and vary depending on whether the mineralisation is derived from the Joffre or the Dales Gorge Member; the latter having higher shale content contributing to higher silica and alumina levels. (Flinders, 2010).

3.0 GEOTECHNICAL ASSESSMENT

The current mine designs are based upon a maximum inter ramp angle of 45°. This is industry standard in iron ore when little technical information is available to do preliminary pit slope designs. Changes to the batter angle and berm widths will be required in areas of elevated geotechnical risk to manage the risk to personnel, equipment and the economics of the project.

Based upon the supplied information areas of elevated geotechnical risk were identified and tabulated Table 1 to Table 21. The primary criteria for the identification of elevated geotechnical risk, based upon the information at hand, are the proposed designs and the surrounding topography. Generally risk management strategies for these elevated risks fall into two management options:

1) Change the pit design to reduce the likelihood of the hazard, or

2) Undertake further geotechnical investigation to quantify the risk to the pit design.

It should be noted that no assessment of the internal relationship of the stratigraphic units has been made at this level of study and that this will be required either at the feasibility level or prior to mining.

The approximate locations of areas of elevated risk are shown in Figure 5 to Figure 11. The naming convention used in the annotations of Figure 5 to Figure 11 was the use a numeric to identify the particular pit for each deposit and then an alphanumeric to identify the area of elevated risk.

Also presented in Table 1 to Table 21 are risk management strategies that are options for the reduction of the risks.

4.0 FURTHER WORK

Golder would recommend the following work be undertaken to manage the geotechnical risks for the Blacksmith Lease:

- Adjust the pit designs such that where practical geotechnical risks are eliminated – Prior to feasibility study.
- Where risk cannot be eliminated undertake geotechnical drilling to identify the ground conditions within the walls such that geotechnical modelling can quantify the risk – as part of the feasibility study.
- Review the hydrology and design water diversion bunds- as part of feasibility study.
- Construct a regional structural model of the BID such that areas of geotechnical risk related to instability of the basement can be identified – Flinders to construct the regional structural model, evaluation by Golder against revised pit designs as part of the feasibility study.
- Where practical, Flinders should model voids and low material strength in areas of major infrastructure/access ramps for the larger pits as part of feasibility study. Golder to review and evaluate.

- Review the modified mine designs against the above information generated during the feasibility study to assess residual risks and to assist in improving mine design safety and economics where possible.

5.0 OPERATION CONSIDERATIONS

There are operational geotechnical hazards with mining in the CID/DID geological terrain. These hazards if recognised can be managed proactively by the adoption and implementation of industry standard mining procedures and practices. Hazards include:

- Batters in CID/DID deposit are likely to continue to unravel over time, posing a hazard to personnel and equipment, especially with blasting
- Voids within the rockmass may pose stability issues in the form of blasting and batter stability
- Variable strength materials within the batters and floor causing stability and trafficking issues, and
- Induced instability of the basement due to reduction in confinement especially in relation to BIF and Ore on shale bands.

Golder would recommend that these hazards be managed proactively by the implementation of:

- Work practices that promotes batter stability and limits personnel near the crest and toe of the batters, this may involve steep low height batters, and survey tools that allow work to be done without approaching the batters. If work has to be undertaken a risk assessment should be undertaken
- Good blasting practices that identifies any void intersected, notes the depth, and limits the potential for over charging of the hole by proper management (i.e. hole lining)
- Good mechanical scaling practices to remove loose materials and leave the batters in a condition to reduce the risk to the work force.

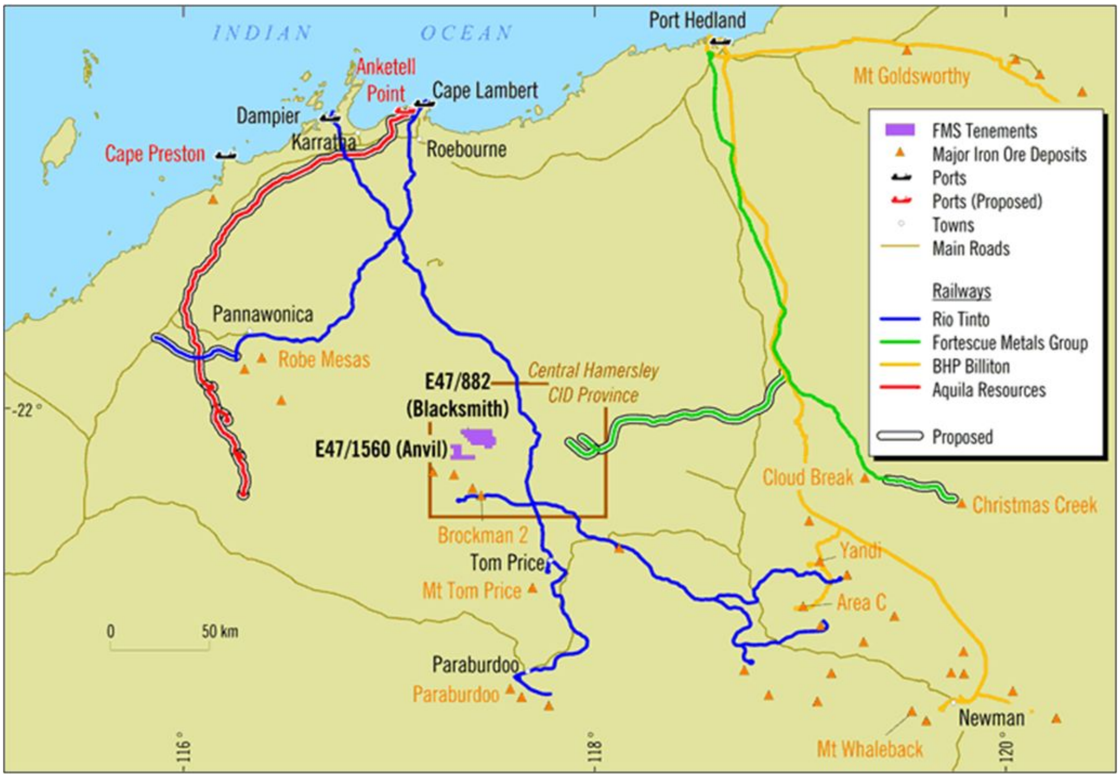

Figure 1: Location Map (taken from Flinders Mine web site)

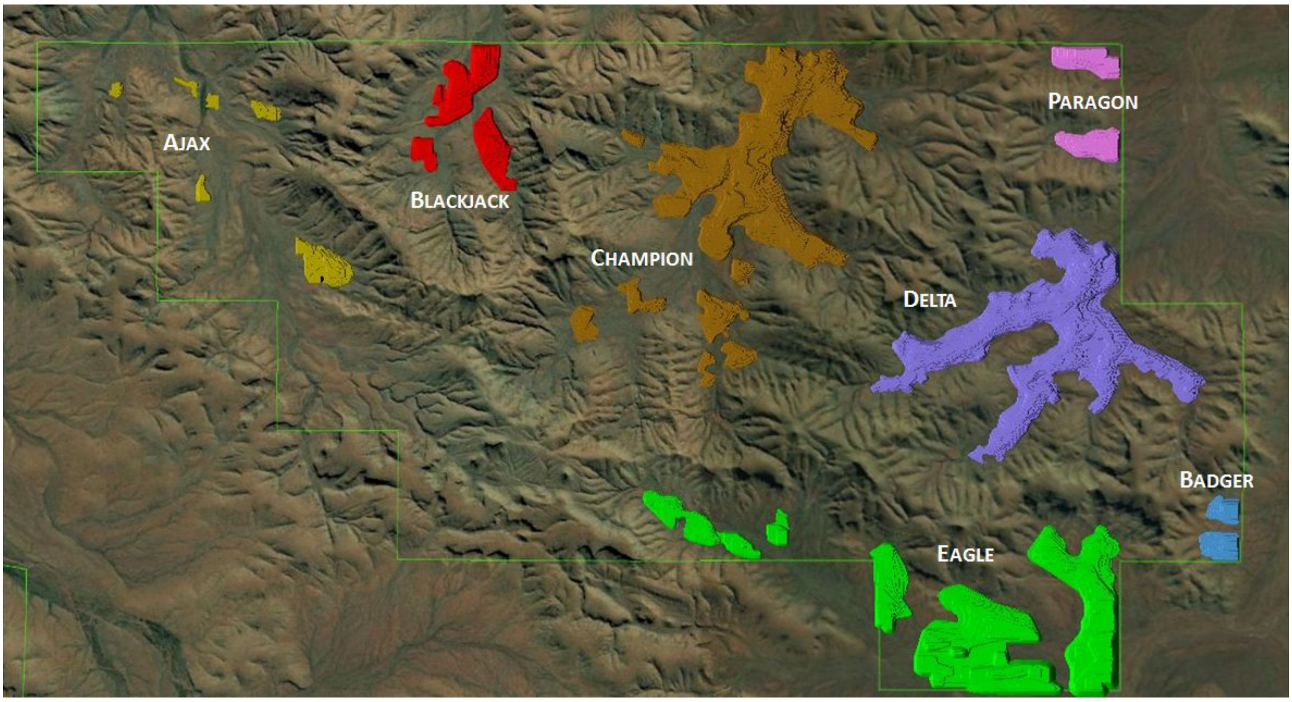

Figure 2: All proposed pits within E47/882 (Blacksmith Lease, Vulcan Screen Capture)

Stratigraphy	Resource Profile	Resource Code	Geology
Cover (RC)		RC	Recent semi-consolidated alluvium of BIF, CHT and SHL fragments within a fine silty/clay matrix
Detrital Iron Deposit (DID)		DID-1	Fine Hem pisolites with variable colluvium fragment concentrations
		DID-2	Semi consolidated detrital
		DID-3	Semi consolidated detrital
		DID-4	Competent hard Hem fragments with Hem matrix
Channel Iron Deposit (CID)		CID	Pisolitic Channel Iron Deposit
Bedded Iron Deposit (BID)		BID	Massive and vuggy vitreous with some relict banding. Variously Goethite and Hematite-rich
Basement (BM)		BM	Weakly altered/mineralised to fresh BIF, CHT and SHL

Figure 3: Pilbara Iron Project Stratigraphy

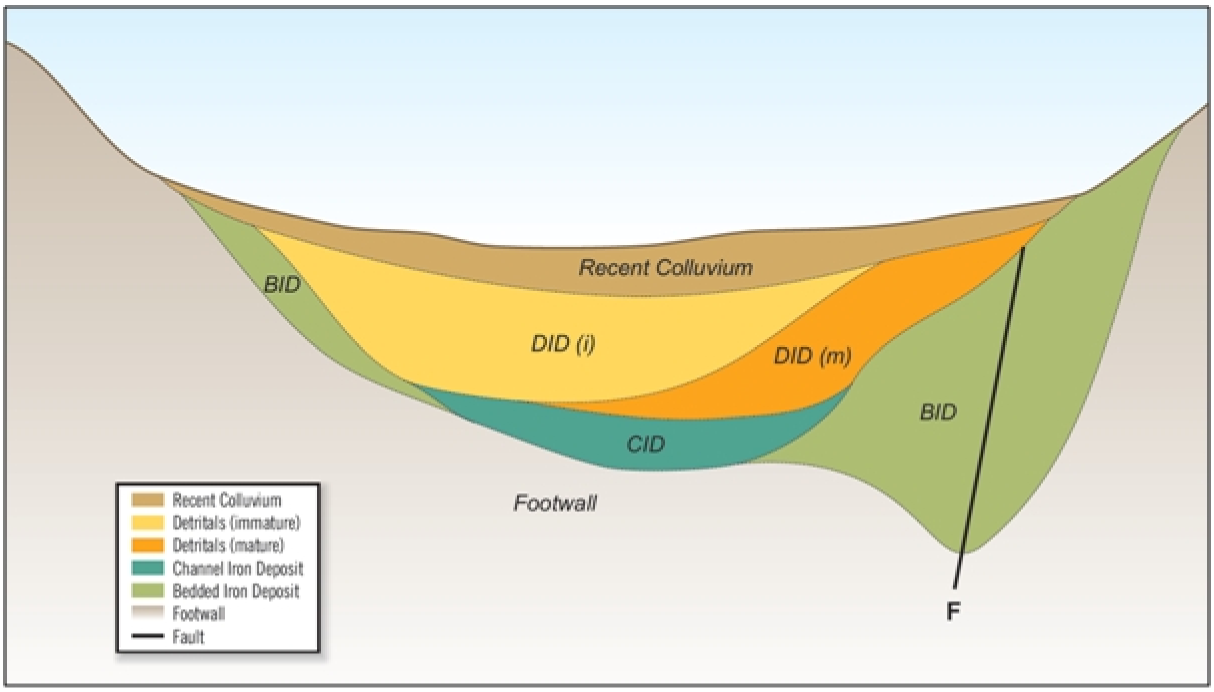

Figure 4: Example of an interpreted geological cross section

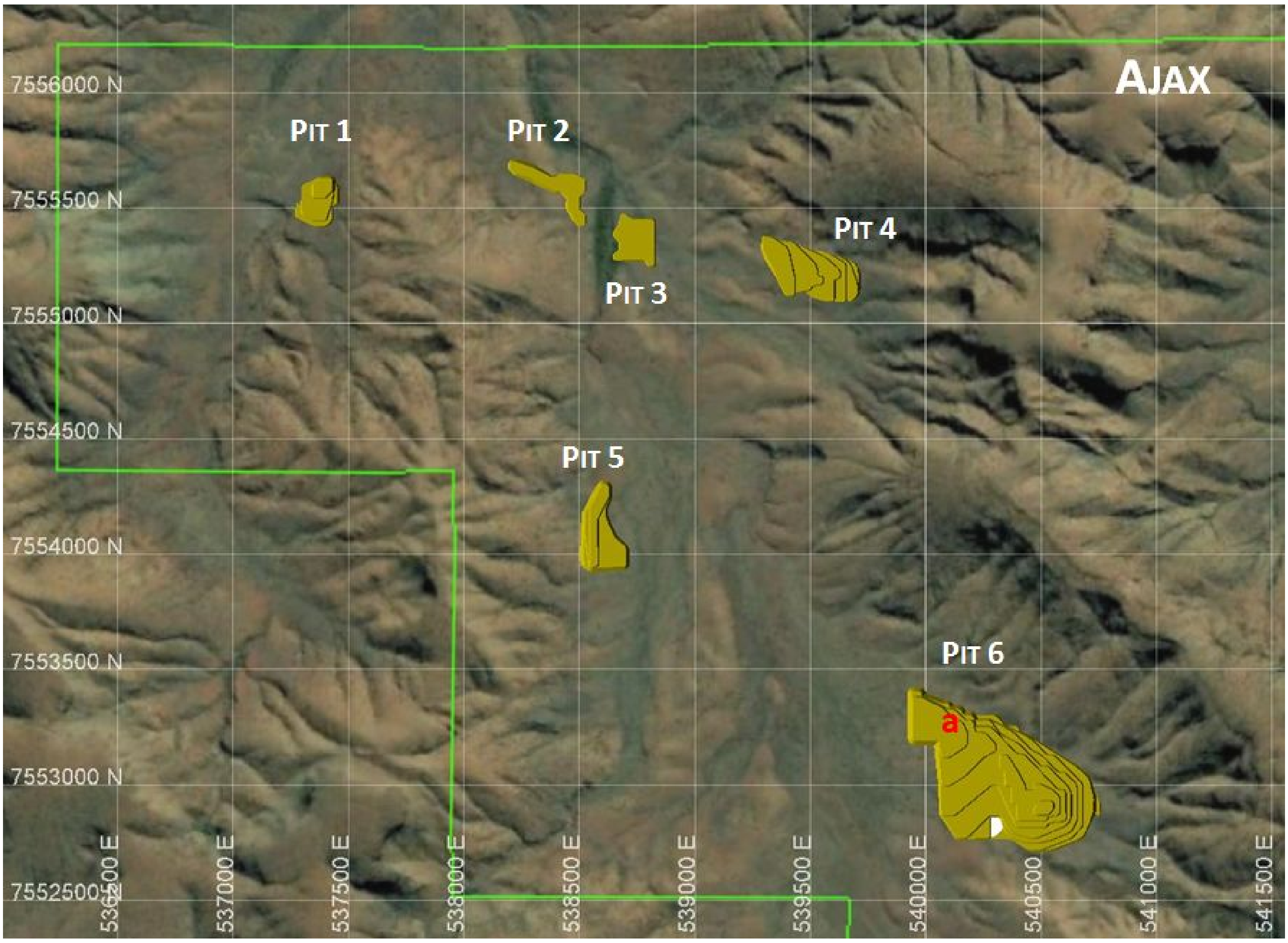

Figure 5: Ajax Pits, highlighting areas of geotechnical risk (refer to Table 1)

Table 1: Ajax, Pit 6

Area	Description	Geotechnical Risk	Risk Management
a	17 m (vertical height) undulating slope at a 45 degree angle striking for 170 m	Instability caused by the convex shape of the slope	Change design – straighten slope or make slightly concave
	natural slope at 12 degrees immediately north-east of the pit, large catchment	potential flooding	

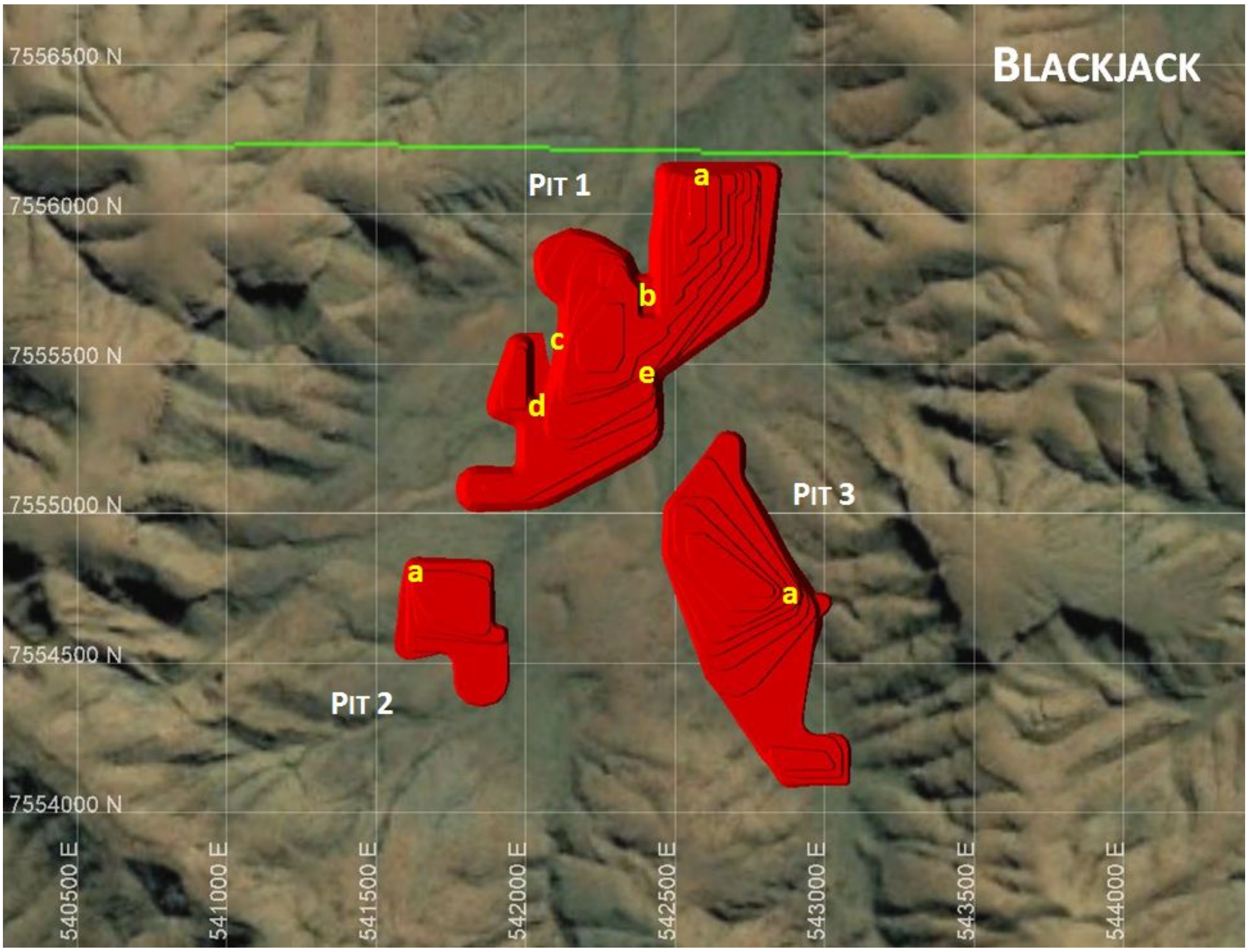

Figure 6: Ajax Pits, highlighting areas of geotechnical risk (refer to Table 2, Table 3 and Table 4)

Table 2: Blackjack, Pit 1

Area	Description	Geotechnical Risk	Risk Management
a	52 m (vertical height) slope at 45 degrees with no benches. Crest is 30 m from lease boundary	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
b	42 m (vertical height) slope at 45 degrees flanking a bullnose. The front of the bullnose is stepped with benches of 16 m (max. vertical height) and berm widths of 30 m (minimum).	Instability could pose risk to equipment/personnel below	Remove or reduce bullnose
c	47 m (vertical height) slope at 45 degrees with no benches	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
d	24 m (vertical height) bullnose at a 45 degree slope angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle
e	40 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle

Table 3: Blackjack, Pit 2

Area	Description	Geotechnical Risk	Risk Management
a	23 m (vertical height) slope at a 45 degree angle in the north-west corner of the pit	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle

Table 4: Blackjack, Pit 3

Area	Description	Geotechnical Risk	Risk Management
a	40 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle

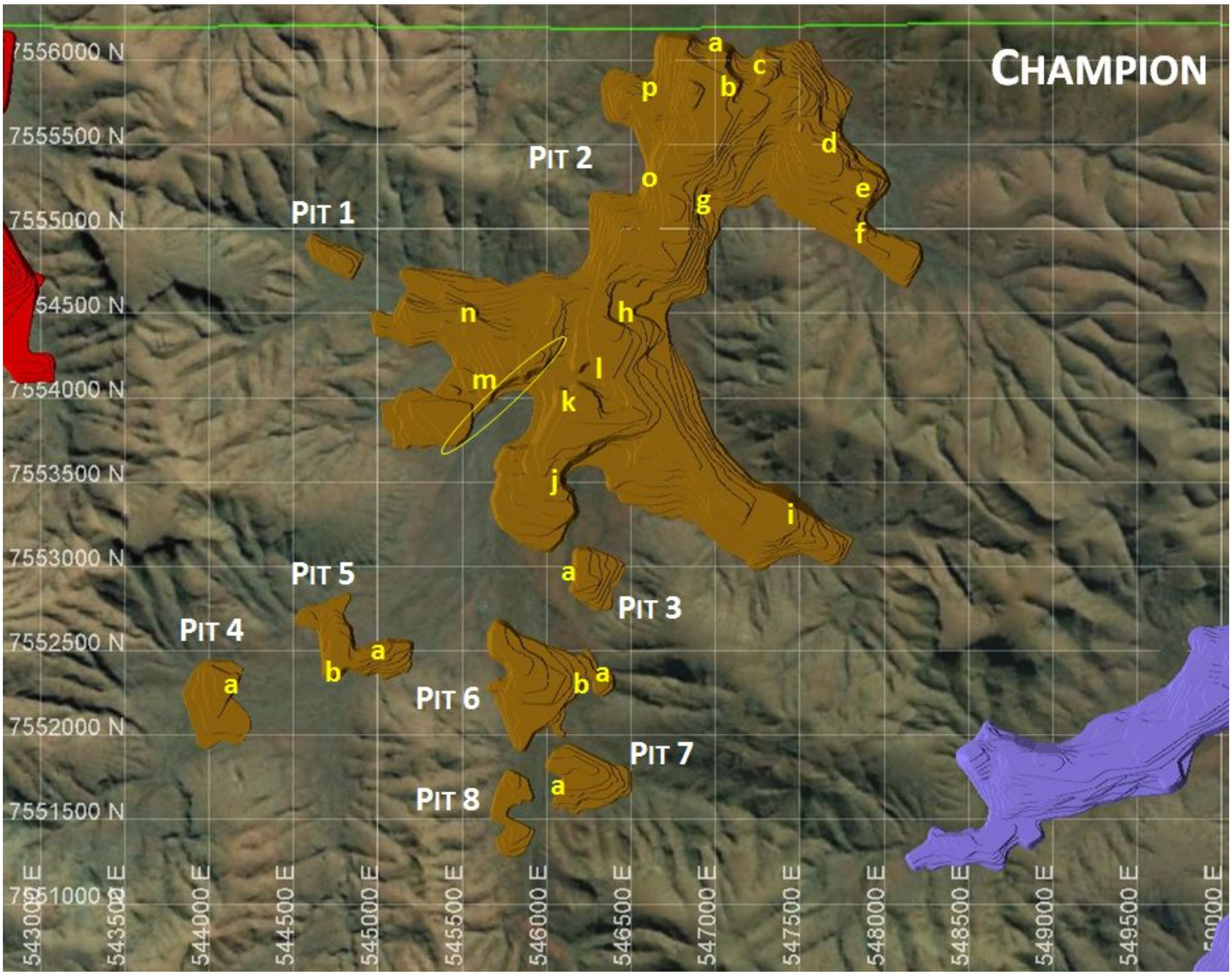

Figure 7: Champion Pits, highlighting areas of geotechnical risk (refer to Table 5, Table 6, Table 7, Table 8, Table 9, Table 10 and Table 11)

Table 5: Champion, Pit 1

Area	Description	Geotechnical Risk	Risk Management
a	22 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle

Table 6: Champion, Pit 2

Area	Description	Geotechnical Risk	Risk Management
a	57 m (vertical height) concave slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
b	36 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle
c	36 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
d	Two 18 m (vertical height) slightly convex slopes at 45 degree angles	Instability caused by the convex shape of the slope	Acceptance of risk? And procedural management
e	45 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
f	18 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Acceptance of risk? And procedural management
g	24 m (vertical height) slightly convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle, Acceptance of risk and procedural management?
h	18 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Acceptance of risk? And procedural management
i	72 m (vertical height) slope at a 45 degree angle with a natural slope at a 20 degree angle above it	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
j	42 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle
k	24 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle, acceptance of risk? And procedural management
l	24 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle, acceptance of risk? And procedural management
m	36 m (vertical height) undulating slope at a 45 degree angle striking for 440 m	Instability caused by the convex shape of the slope	Change design – straighten slope or make slightly concave. Drilling may be required
n	36 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
o	54 m (vertical height) slightly convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle
p	18 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle, acceptance of risk? And procedural management

Table 7: Champion, Pit 3

Area	Description	Geotechnical Risk	Risk Management
a	27 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle

Table 8: Champion, Pit 4

Area	Description	Geotechnical Risk	Risk Management
a	22 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle, acceptance of risk? And procedural management

Table 9: Champion, Pit 5

Area	Description	Geotechnical Risk	Risk Management
a	31 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
b	28 m (vertical height) convex slope at a 45 degree angle		

Table 10: Champion, Pit 6

Area	Description	Geotechnical Risk	Risk Management
a	21 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle, acceptance of risk? And procedural management
b	12 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Acceptance of risk? And procedural management

Table 11: Champion, Pit 7

Area	Description	Geotechnical Risk	Risk Management
a	18 m (vertical height) convex slope at a 45 degree angle	Instability caused by the convex shape of the slope	Acceptance of risk? And procedural management

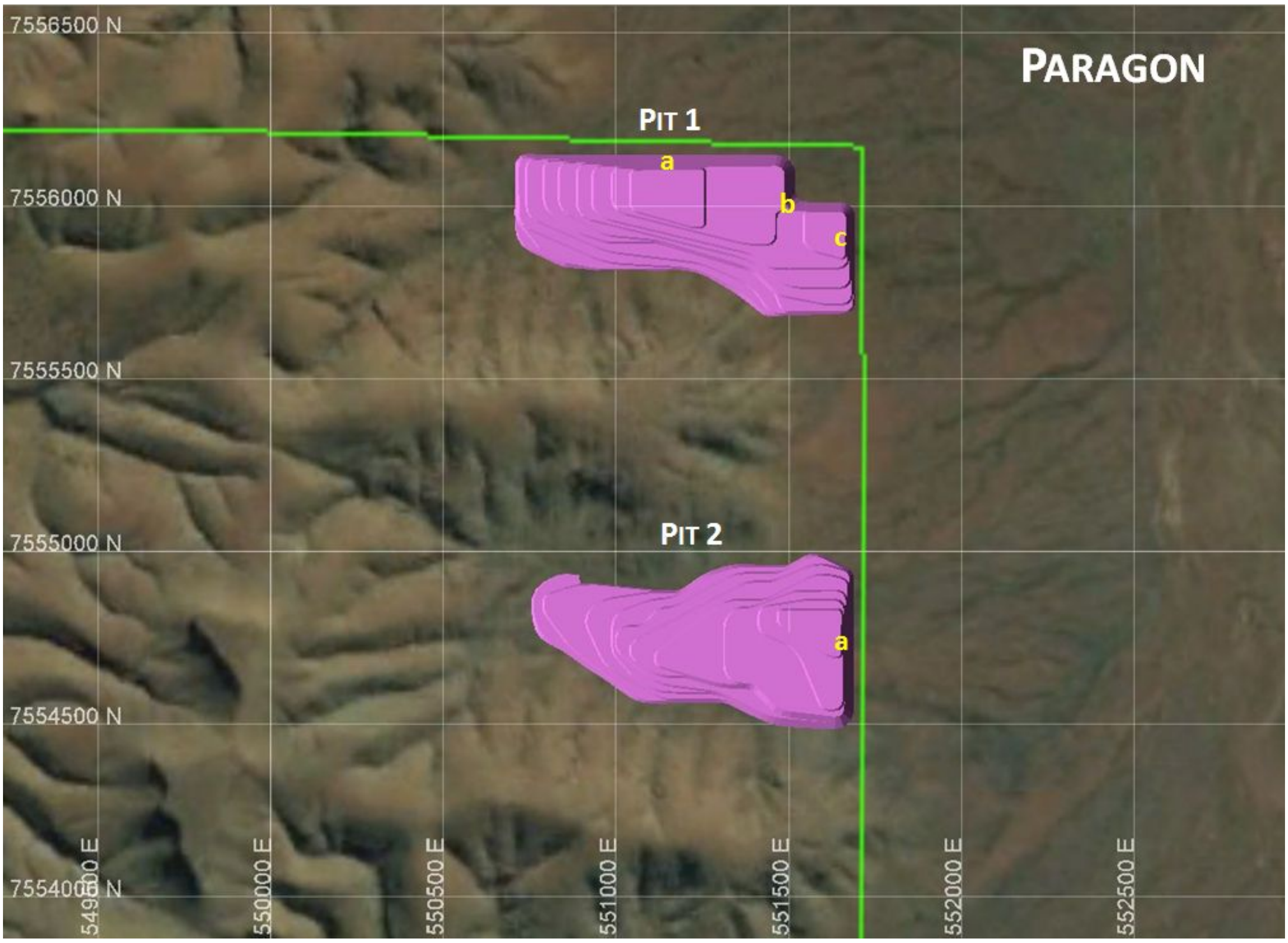

Figure 8: Paragon Pits, highlighting areas of geotechnical risk (refer to Table 12 and Table 13)

Table 12: Paragon, Pit 1

Area	Description	Geotechnical Risk	Risk Management
a	44 m (vertical height) slope at 45 degrees with no benches. Crest is 30 m from lease boundary	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
b	25 m (vertical height) bullnose at a 45 degree slope angle on the flanks and a 32 degree slope angle at the front	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle
c	27 m (vertical height) slope at a 45 degree angle with the crest 19 m from the lease boundary	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle

Table 13: Paragon, Pit 2

Area	Description	Geotechnical Risk	Risk Management
a	36 m (vertical height) slope at a 45 degree angle with the crest 26 m from the lease boundary	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle

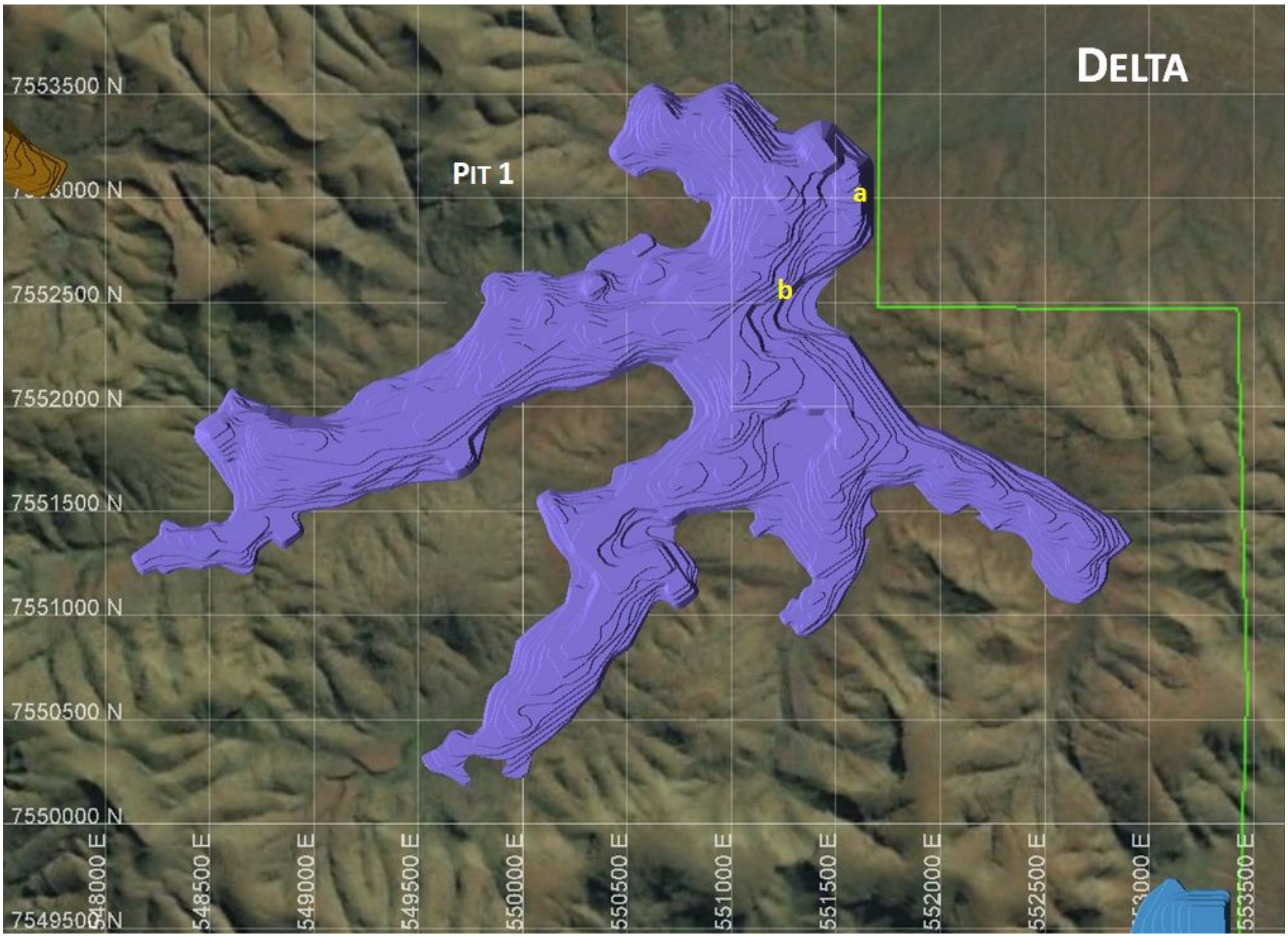

Figure 9: Delta Pit, highlighting areas of geotechnical risk (refer to Table 14)

Table 14: Delta, Pit 1

Area	Description	Geotechnical Risk	Risk Management
a	75 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
b	30 m (vertical height) slightly convex slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle

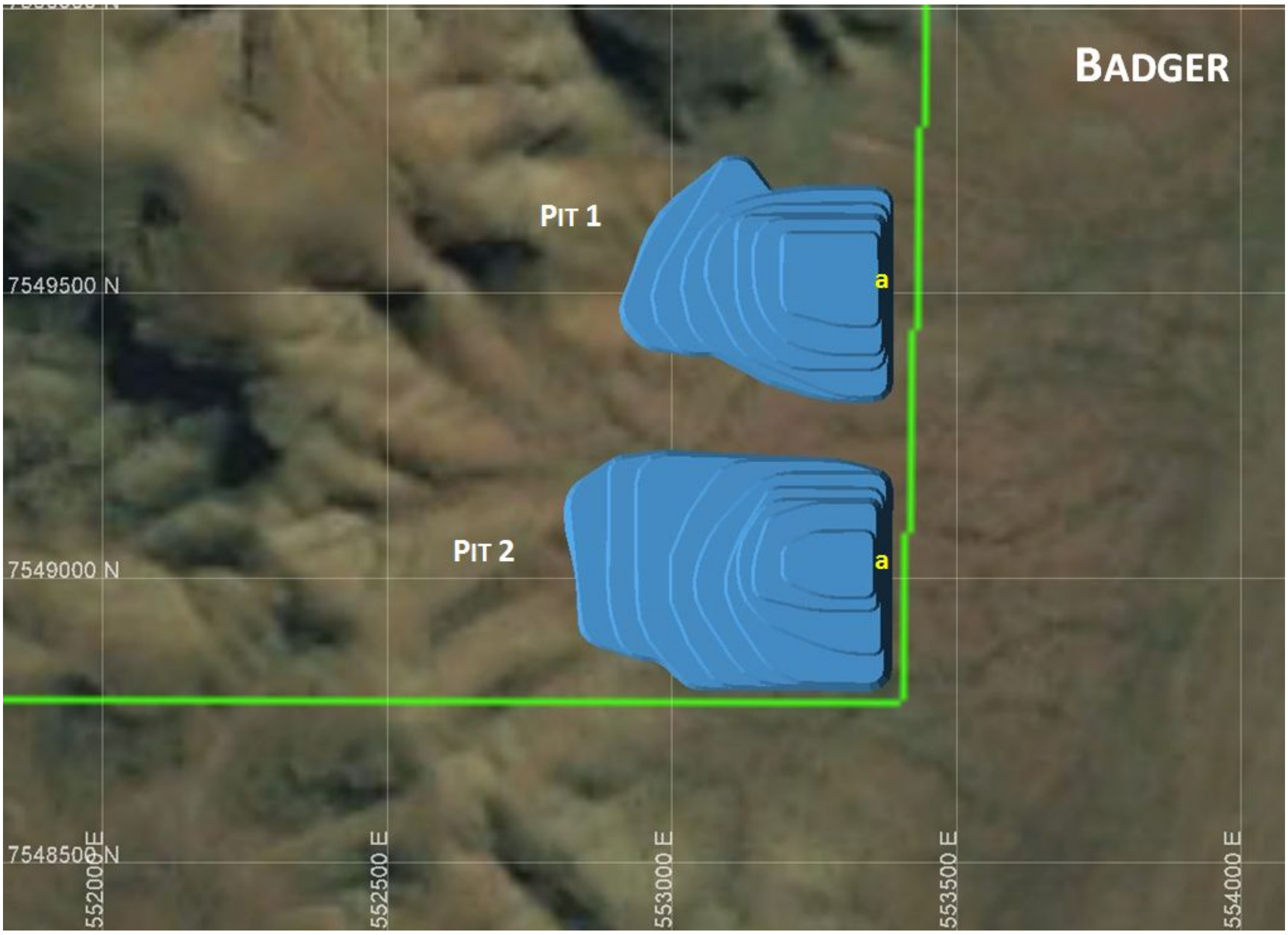

Figure 10: Badger Pits, highlighting areas of geotechnical risk (refer to Table 15 and Table 16)

Table 15: Badger, Pit 1

Area	Description	Geotechnical Risk	Risk Management
a	27 m (vertical height) slope at a 45 degree angle with the crest 31 m from the lease boundary	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle

Table 16: Badger, Pit 2

Area	Description	Geotechnical Risk	Risk Management
a	34 m (vertical height) slope at a 45 degree angle with the crest 20 m from the lease boundary	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
	Southern edge of pit 20 m from lease boundary		

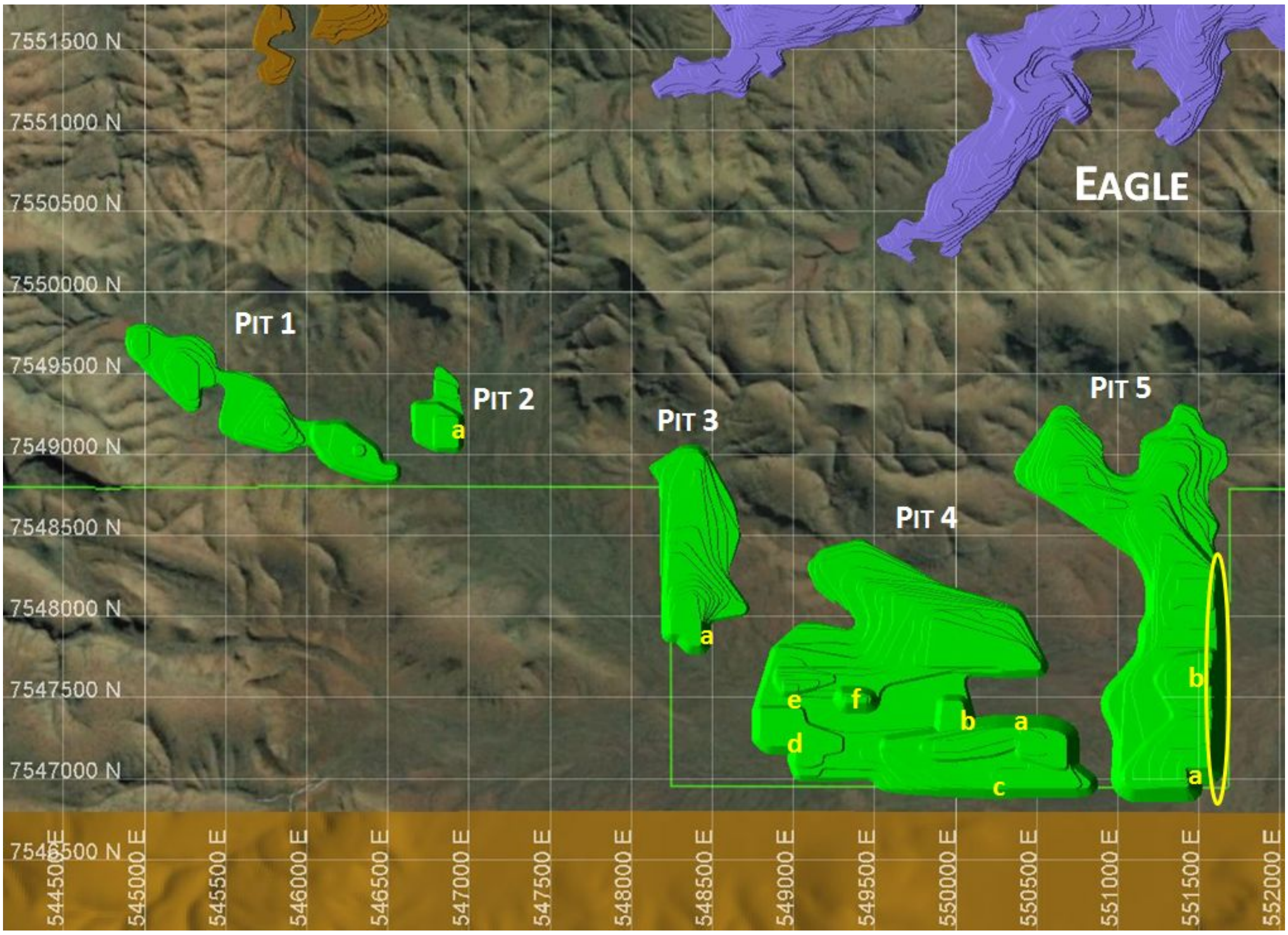

Figure 11: Eagle Pits, highlighting areas of geotechnical risk (refer to Table 17, Table 18, Table 19, Table 20 and Table 21)

Table 17: Eagle, Pit 1

Area	Description	Geotechnical Risk	Risk Management
	Southern edge of pit is 20 m from lease boundary		

Table 18: Eagle, Pit 2

Area	Description	Geotechnical Risk	Risk Management
a	32 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle

Table 19: Eagle, Pit 3

Area	Description	Geotechnical Risk	Risk Management
a	57 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
	Western edge of pit approximately 56 m outside of lease area		

Table 20: Eagle, Pit 4

Area	Description	Geotechnical Risk	Risk Management
a	88 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
b	55 m (vertical height) convex slope (bullnose) at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle
c	65 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
d	48 m (vertical height) convex slope (bullnose) at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle
e	40 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
f	65 m (vertical height) slope at a 45 degree angle	Instability could pose risk to equipment/personnel below	Either step in a bench or flatten slope angle
	Southern edge of pit is 60 m outside lease boundary		

Table 21: Eagle, Pit 5

Area	Description	Geotechnical Risk	Risk Management
a	100 m (vertical height) convex slope (bullnose) at a 45 degree angle	Instability caused by the convex shape of the slope	Either step in a bench or flatten slope angle
b	60-90 m (vertical height) slope at a 45 degree angle striking for 1.2 km along the eastern margin of the pit	Instability caused by the convex shape of the slope	Change design – straighten slope or make slightly concave. Drilling may be required
	Southern edge of pit is 90 m outside lease boundary		
	Eastern edge of pit is 16 m from lease boundary		

Report Signature Page

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APPENDIX A

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