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TECHNICAL MEMORANDUM 24053D

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11 March 2026

BENDIGO-OPHIR GOLD PROJECT
RISE & SHINE DEPOSIT
SUBSIDENCE POTENTIAL UNDERGROUND MINING

Attention: Cheryl LOW

Introduction

This memorandum provides background discussion regarding potential for surface subsidence resulting from proposed underground mining on the Rise and Shine (RAS) deposit at the Matakanui Gold Limited (Matakanui, MGL) Bendigo-Ophir Gold Project (BOGP), Otago, New Zealand.

Scope

Following a request for information from the Otago Regional Council, Peter O'Bryan & Associates has been engaged by MGL to provide *"… a relatively brief description of the potential surface level effects of the underground mining activity, for example, the likelihood, nature, and approximate magnitude of adverse effects on land stability, surface watercourses, and mine infrastructure such as the TSF and processing plant".*

Overview: Subsidence potential at Rise & Shine

Underground mining at the Rise & Shine (RAS) deposit will occur at an average depth of ~ 250 m below natural ground surface using longhole open stoping with cemented paste backfill. While some deformation of the rock mass surrounding underground excavations is inevitable, several factors significantly limit the potential for deformation to propagate to the surface.

Large Depth of Cover

Any failure mechanism would need to propagate through ~ 250 m of cover to reach the surface. This level of cover typically results in attenuation of deformation with height above the excavation.

Progressive Mining & Backfilling

Stopes are to be mined sequentially, and each stope will be backfilled with cemented paste as soon as is practicable after extraction. This approach limits the size of unsupported openings at any one time and aims to allow stresses to redistribute gradually.

Progressive mining significantly reduces the likelihood of the development of large continuous voids that could initiate extensive caving.

Development of Arching

As the rock mass above stoping relaxes, loads are transferred laterally into the abutments, forming a stable compressive arch above the mined panel. This mechanism is a principal control on stability above underground openings and for the proposed mining configuration at RAS a stable arch would be expected to develop within tens of metres of the original stope back positions.

Bulking & Choking of Caved Material

If localised overbreak or slabbing occurs in the hangingwall, the fragmented rock will bulk-up and occupy a larger volume than the original material in situ and progressively fills available void space.

For a conservative bulking factor of ~ 25%, ~ 4 m of overbreak debris would choke a 1 m void above the stope backfill. Once this choking occurs, further upward propagation of the failure mechanism becomes is highly constrained.

Support Provided by Cemented Paste Backfill

Cemented paste backfill provides structural support to the hangingwall wherever contact is established between the fill and the rock mass. Even where small gaps remain locally, paste fill provides confinement and significantly limits deformation once the fill has cured.

Timing of backfilling

A key operational requirement is to minimise the delay between stoping and backfilling. This interval must be as short as can be managed practicably in order to limit time-related relaxation and possible overbreak of ground over and around the void.

Expected Form of Surface Deformation

Based on the planned mining configuration and strategy and the described ground response mechanisms, no credible risk of extensive surface deformation is anticipated at RAS.

It is not possible for uniform deformation to span the entire stoped-out area as much of the area will in fact be tight-filled. Vertical transmission of displacement (spanning the entire area) to surface is not credible. If this could somehow occur, screening calculations indicate the expected surface expression would be manifest as a broad, low-amplitude settlement with:

- Average potential settlement: ~ 0.2 m
- Maximum potential settlement: ~ 0.4 to 0.7 m

These values represent conservative estimates assuming the entire void closure volume contributes to surface settlement and that the displacement can be transferred to surface. Given that individual stope voids are filled when completed, closure spanning the entire stoping panel is not a credible risk.

Likely Interaction Mechanism

The geometry of the mining layout suggests that interaction between underground stopes and the open pit wall is more likely than disturbance of the natural ground surface above the northern portion of the stoping panel. Such interaction would typically manifest as incremental wall relaxation or localised sloughing, rather than large-scale subsidence.

Interaction with Infrastructure

The assessed subsidence zone, if expressed at surface would not impact the TSF or the main body of the eastern waste rock landform (ELF).

Surface flow between the north-eastern crest of the pit and the toe of the ELF feeds naturally into Shepherds Creek. Disturbance due to subsidence of the north-eastern RAS pit wall, if occurrent, could divert flow into the pit. It is expected that a bund would be constructed around the periphery of the pit crest and that such a bund would continue to direct surface flows towards the creek.

Background

Screening-level assessment using empirical methods has been performed to identify potential for ground deformation and subsidence resulting from proposed underground stoping on the RAS deposit. The assessment considered ground response to ultimate stope excavation.

In underground production MGL plans to mine modestly sized longhole open stopes (LHOS) in several panels, progressively backfilling the voids with cemented paste fill. Completed panels comprise contiguous backfilled inclined back, average ~ 20m high, 15m wide LHOS. The stoping panels, initially separated by ~ 20m wide temporary pillars, eventually coalesce to form an ultimate continuous panel spanning ~ 150 m along strike and ~ 450m down-dip.

The proposed final site-wide configuration of open pit and underground operations is illustrated in Figure 1. Figure 2 illustrates the ultimate stoping footprint and the empirically derived limit of potential disturbance (calculated using the limit-angle method). Maximum subsidence occurs in the central zone, reducing to zero at the boundary. The figure also shows the locations of eight (8) oblique cross-sections cut through the open pit and proposed stoping and includes natural topography. The sections, which are presented in Appendix A, are 10m wide cuts spaced at 50 m.

Figures 1 and 2 also show the inferred position of an empirically defined surface disturbance zone.

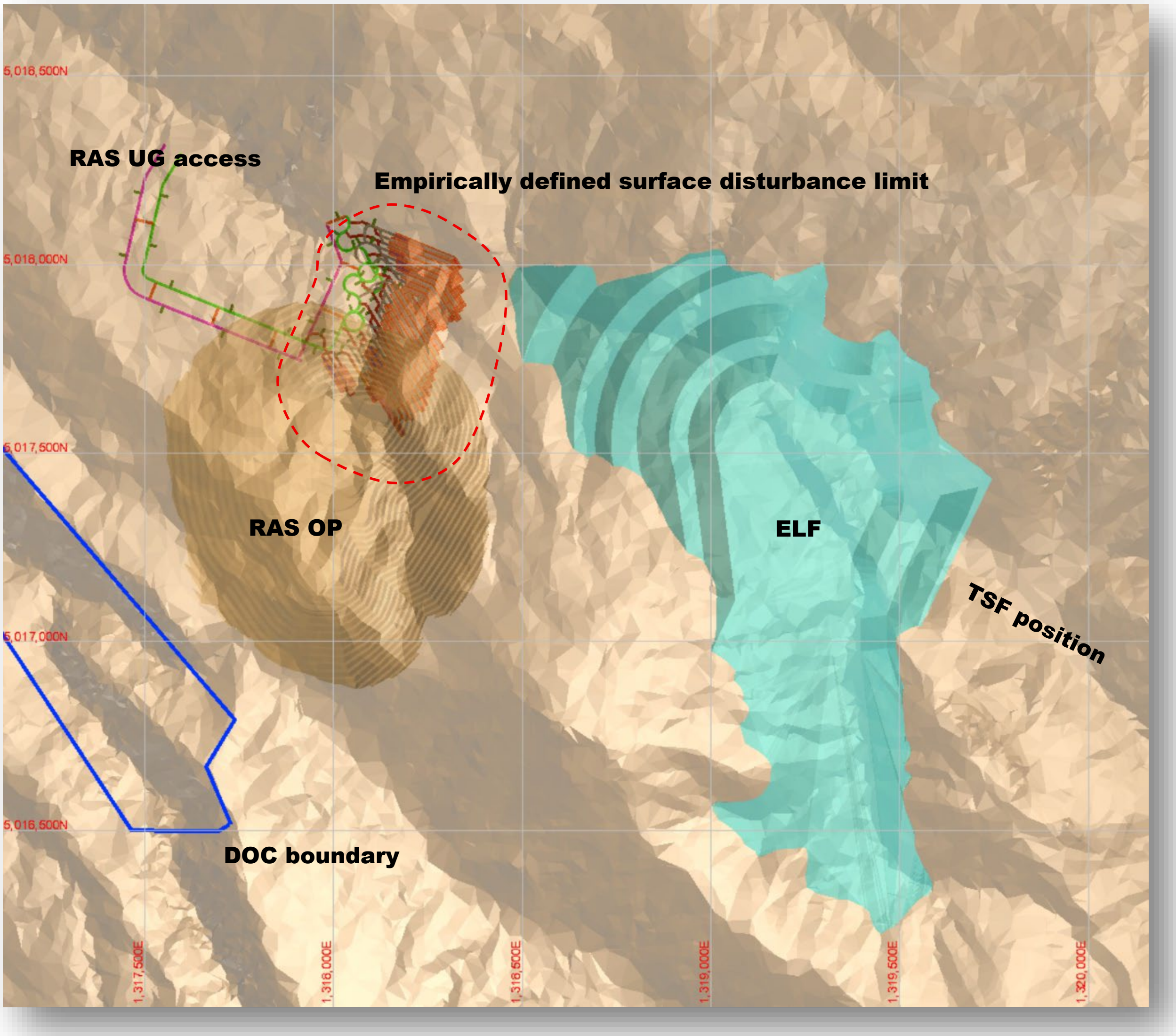
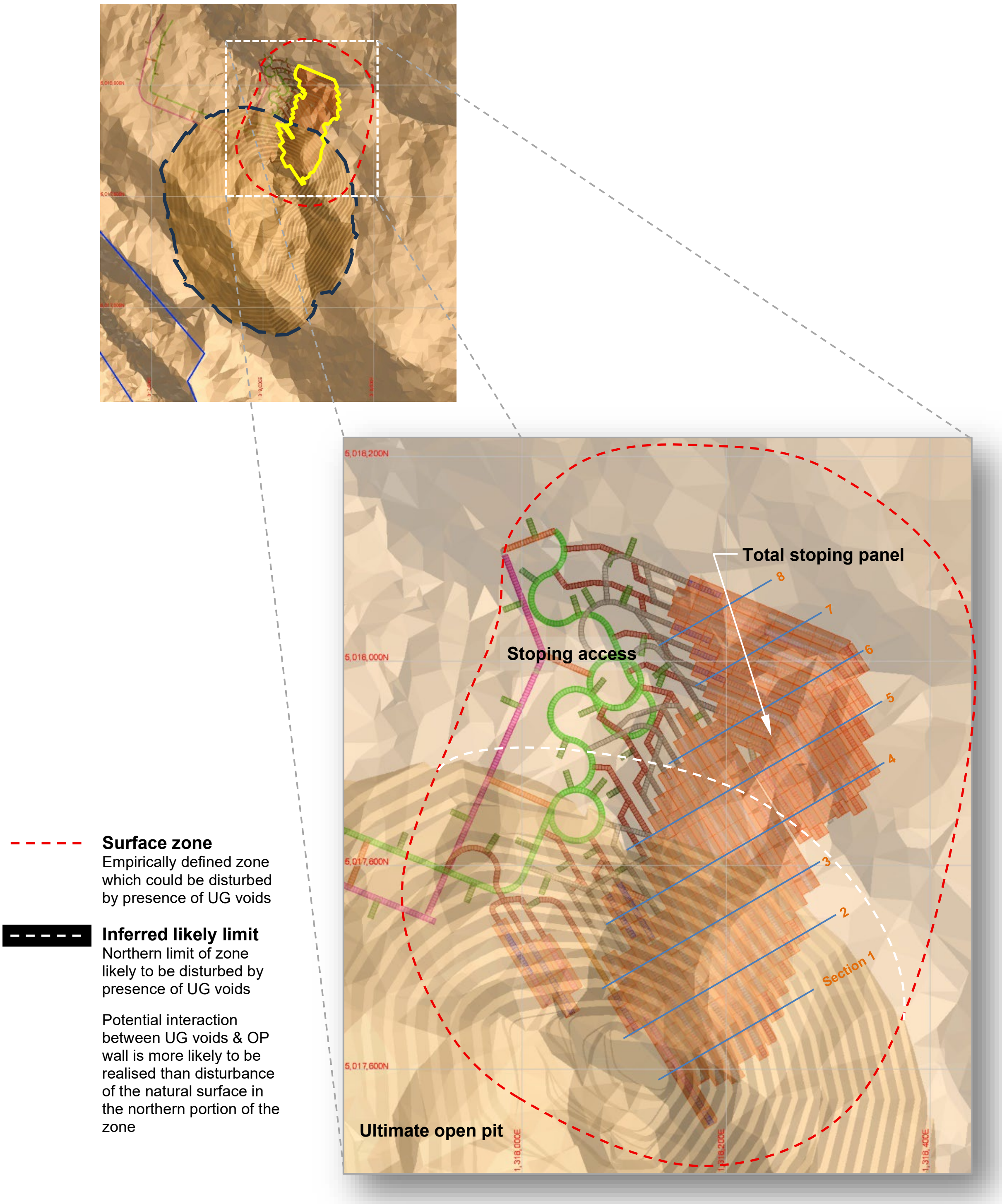


Figure 1 **RAS proposed mining – ultimate pit, total conceptual stoping footprint. possible surface disturbance area & ultimate eastern waste rock landform (TSF buttress)**



Surface zone
Empirically defined zone which could be disturbed by presence of UG voids

Inferred likely limit
Northern limit of zone likely to be disturbed by presence of UG voids

Potential interaction between UG voids & OP wall is more likely to be realised than disturbance of the natural surface in the northern portion of the zone

Figure 2 **RAS proposed mining – ultimate pit, total conceptual stoping footprint & estimated extent of possible surface disturbance due to UG mining**
Sections 1 through 8 are presented in **Appendix A**

Empirical Assessment

The average depth of cover between natural surface and stope backs is ~ 250m; however, part of the area overlying the stoping panel is identified as a landslide block (Figure 3). The thickness of in situ rock in the hangingwall to stoping is estimated at ~ 200 m (the landslide is assumed to be 50m thick).

The landslide debris contributes to the overburden load but has no direct influence on initiation of subsidence mechanisms. Subsidence commences at the stope panel backs and propagates upwards and through the debris, but not necessarily faster than through in situ material – the landslide may comprise large coherent blocks (a dip-slope block translation slide).

An empirically-defined disturbance zone has been identified using the limit-angle method projecting a horizontal offset from the edge of the ultimate stoping panel.

Rudimentary calculations based on empirical methods, for a configuration of near-complete stope backfilling, assuming a continuous ~ 1 m air gap between the backfill and stope backs, suggest a possible average subsidence of ~ 0.2 m and a localised maximum surface subsidence (in the central subsidence area) of ~ 0.4 to 0.7 m. Subsidence at the edge of the zone would be < 0.2 m.

Appendix B lists assumptions for and presents fundamental calculations of the area of possible disturbance and depth of possible subsidence. The empirically defined area (shown in Figures 1 and 2) is that calculated from a base of stoping at 250 m depth.

While potential for subsidence is suggested, it is most important to note that the stope backs will have:

- Back reinforcement and support installed during top sill development prior to stoping.
- Backfill support, variously available directly on fill curing where paste makes direct contact with the stope back, or as the bulked fretting debris chokes off progressive overbreak elsewhere.
- Potential for subsidence will be offset by the capacity of the hangingwall rock mass to establish arches over individual stopes and ultimately over the entire stoping panel.

For this exercise consideration of the ultimate extent of the stoped out panel is conservative. Actual stope extraction will, however, be sequenced and stopes will be backfilled progressively. Using this strategy, the rock mass can respond to and recover from numerous individual and largely isolated disturbances. The time afforded for recovery and stress re-distribution by a relatively steady progression of disturbance will be beneficial to management of the stability of the mine structure.

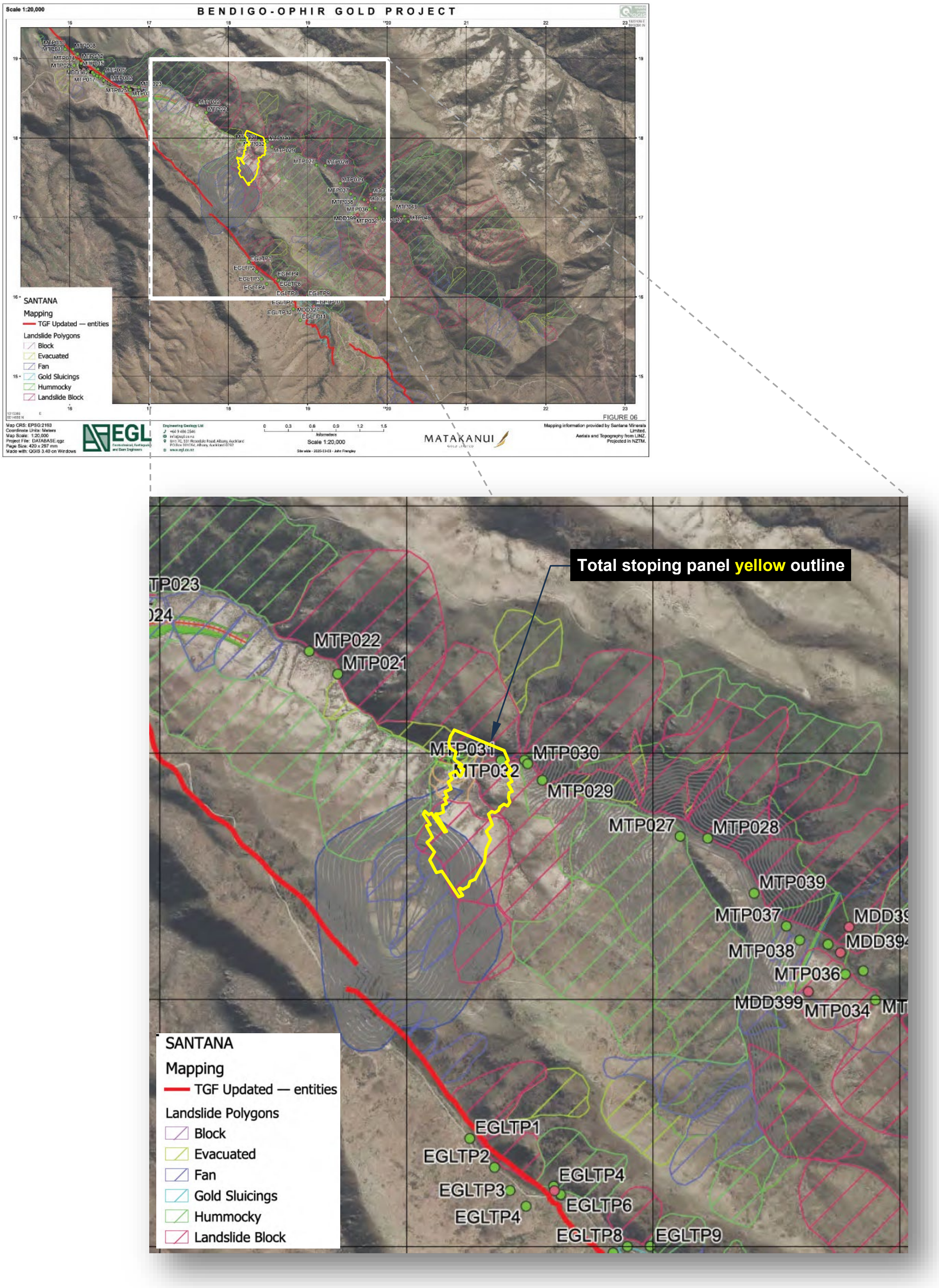


Figure 3 **RAS preliminary pit plan, conceptual stoping footprint & interpreted landforms**
Source: Engineering Geology Limited (EGL) Doc.B22

Assumptions Used in Screening Subsidence Calculations

Rise & Shine Underground Mining Assessment

Mining geometry

- Ultimate stoping panel footprint assumed: 150 m (strike) × 450 m (down-dip)
- Representative stoping method: longhole open stoping with cemented paste backfill
- Approximate stope dimensions: 20 m high × 15 m wide

Depth of mining

- Average depth from natural surface to stope backs assumed: ~ 250 m

Backfill configuration

- Stopes assumed to be progressively backfilled with cemented paste fill
- Residual crown void above paste assumed: ~ 1 m

Rock mass response

- Some local hangingwall slabbing or ravelling assumed prior to void closure
- Broken rock assumed to bulk (~ 25%), progressively choking the crown void
- Rock mass assumed capable of developing arching above the stoping panel

Subsidence influence

- Surface disturbance estimated using the limit-angle method
- Limit angles adopted: 30° to 40° from vertical

Resulting estimates:

- Horizontal offset of influence: ~ 144–210 m
- Surface influence area: ~ 36 to 54 ha
- Representative influence area used in calculations: ~ 44 ha (440,000 m^2)

Settlement calculation

- Maximum theoretical closure volume based on 1 m void across the panel
- Average settlement calculated assuming uniform distribution over influence area

Resulting screening estimates:

- Average settlement: ~ 0.2 m
- Maximum settlement (central trough): ~ 0.4 to 0.7 m
- Settlement near edge of influence: < 0.2 m

Mining sequence

- Stopes assumed to be mined progressively and backfilled promptly, limiting the effective unsupported span at any time.

Potential Subsidence Mechanisms

The following mechanisms are considered credible under the proposed RAS mining configuration:

Hangingwall Sag & Void Closure

The RAS lode dips shallowly at ~ 20° but is laterally extensive with an ultimate footprint of ~ 150 m × 450 m. Vertical propagation of overbreak would tend to occur as local hangingwall slabbing or progressive bedding-parallel shearing with limited sagging toward the void.

The stoping configuration involves panel extraction rather than isolated stopes. Caving would tend to spread laterally via broad flexural subsidence rather than propagating vertically (chimneying).

The overlying rock mass can behave like a bending beam or plate, especially where stratification or schistosity is well developed. The capacity of the TZ3 to resist bending is limited, tensile failure would occur under modest loading/ minor deformation, and the mass would unravel rather than bend. Hence upward overbreak could progress, as well as lateral spread of overbreak via broad flexural failure.

Overbreak/ caving debris will ‘bulk-up’ and consume more space/ volume when coming to rest. It is inferred that the bulking factor would be at least 25%, hence the overbreak mechanism would be choked when the caved height reaches four (4) times the height of the initial void. For example, with a residual void of ~ 1 m between the as-placed backfill and stope hangingwall, caving into the overlying weak TZ3 rock mass would be choked-off once overbreak reaches ~ 4 m above the original back position. It is critical that all practicable efforts are made to minimise the void.

Paste backfill will be used at RAS to maintain general stability within stoping areas. However, paste fill is not expected to completely fill the stopes which results due to stope geometry and the impracticality of placing paste discharge points to achieve tight filling.

In practice tight fill (paste contact with the stope back/ hangingwall) will be achieved locally where the combination of opening geometry, accessible fill discharge points and paste beaching characteristics will enable flow to fill the void and provide restraint against future hangingwall deformation (on curing). Where the hangingwall contacts the paste fill, load will be transferred to the backfill mass, forming a composite rock-fill system that limits further deformation.

The key issues are establishment of stable stopes and timely completion of backfilling. Some closure is likely to occur within the TZ3 hangingwall before deformation propagates upward.

Further, arching is expected to develop above the RAS stoping panel(s). Arching is a fundamental mechanism controlling the stability of underground openings and refers to redistribution of loads to form a compressive arch over an opening. The load previously acting through the material removed to form the void is transferred laterally into the abutments of the opening. In the RAS case, choking of back overbreak into an ~ 1m high gap over stope backfill is anticipated to occur well beneath the geometric arch position. While the arch will likely still form at the ‘natural’ position, the loosened mass beneath the arch will be confined.

Pit-Wall Interaction

The most critical aspect of the geometry is the very shallow position of the upper stoping zone beneath the pit wall toe. Where stopes occur directly beneath the pit wall, rather than broad surface settlement, deformation would be expected to manifest as increased wall relaxation and wall strain, bench cracking, crest tension cracking and/ or localised sloughing or block release (daylighting deformation along structures).

Accordingly, the principal geotechnical risk associated with the ultimate RAS stoping footprint is likely to be underground void(s) – pit wall interaction, rather than broad regional subsidence.

Broad Subsidence Trough

Development of a broad deformation trough is unlikely. If deformation mechanisms were transmitted upward through the entire ~ 250 m thickness, a broad settlement trough could theoretically form above the stoping panel. However, given the presence of cemented paste fill and anticipation of choking off overbreak, the probability of broad trough development is considered low. Localised underground deformation remains possible.

Fault Influence on Subsidence

A steep to sub-vertical cross-cutting fault could act as a structural boundary and likely limit lateral spread of subsidence; however, localised differential movement or stepping could occur along the fault zone. The overall volume of subsiding rock may not change greatly, but the shape of the subsidence zone could be controlled by the fault, possibly producing a truncated or asymmetric subsidence trough.

In summary, a steep valley-bounding fault typically that localises and shapes subsidence, reducing its propagation across the fault while potentially concentrating deformation along the fault plane itself.

General Observations

The extent to which subsidence can occur is dependent on the:

- Capacity and behaviour of the hangingwall rock mass above unfilled stopes
- Effectiveness of installed stope back reinforcement and support
- Time delay between stoping and stope backfilling
- Support able to be provided by stope backfill.

In this respect:

- The progressively exposed stope back and walls inevitably remain exposed until the stope is backfilled. Significant resistance to choking back overbreak and resisting wall deformation is not available until the fill has cured.
- Paste backfill (once cured) in direct contact with the stope backs will provide local support to/ restraint against overbreak and displacement of the hangingwall. That support will not be continuously against the stope backs as it is not practicably possible to fill all stopes completely. MGL has designed stopes obliquely to the dip direction of the lode such that stope back s are inclined, thereby maximising direct paste to hangingwall contact on placement.

Relaxation/ overbreak/ settlement of the hangingwall of the ultimate stoping panel is expected; however, potential for significant disturbance to be transferred/ transmitted to the ground surface is inferred to be low. There is a very low likelihood of sudden, large surface collapse.

For the shallow-dipping RAS lode, a typical surface expression (***if*** such occurs) would be:

- A broad, gentle settlement trough rather than a steep-sided depression/ hole.
- Asymmetric troughing is likely, offset toward the open pit side.
- Delayed (possibly by months to years) if movements are driven by progressive fracturing, time-dependent weakening, and/ or porewater pressure effects.

Because the planned ultimate stoping area is sizeable, the *cumulative* voiding/ relaxation potential is not trivial. Destabilising mechanisms which could lead to eventual surface subsidence involve:

- Local (single stope) back slabbing / ravelling into the void until an arch forms.
- Separation along foliation fabric in TZ3, potentially creating a loosened zone.
- Limited capacity of the rock mass to establish a stable arch over the opening.

These factors manifest underground as increased overbreak/ sloughing and dilution:

- As the effective span increases via interaction of multiple stopes.
- Hangingwall beam / arch failure and progressive upward ravelling could occur in poor quality TZ3.

Rock mass-capacity dictates behaviour until the overbreak debris chokes the ravelling process. Paste backfill provides resistance only when contact paste-debris-in situ hangingwall rock is established.

Far-field propagation to surface is the least likely eventuality but has the highest consequence. Development would, however, require a connected failure path (caving/chimneying) through ~ 250 m of cover.

Due to proximity of the up-dip stopes to the open pit wall, the most credible deformation pathway is toward the existing pit free face, not vertical propagation to natural ground surface. Accordingly, pit wall deformation or daylighting is considered a higher likelihood surface expression than crown-hole formation on undisturbed ground. Dedicated pit wall monitoring and TARPs must be incorporated into the management plan. The proximity of the open pit to stoping does not materially increase the likelihood of catastrophic wall collapse.

Further investigation and analysis, including in situ stress measurement and numerical modelling of mining sequences are required to refine this preliminary assessment. Modelling is critical to improving prediction of overbreak extent and assessment of potential for surface subsidence.

The assessed subsidence zone, if expressed at surface would not impact the TSF or the main body of the eastern waste rock landform (ELF).

The presence of the RAS open pit limits the southern extent of disturbance from underground mining. However, walls in the north-eastern sector of the pit are the structures most likely to experience disturbance due to the influence of stoping voids. The natural surface overlying the northern portion of the ultimate stoping panel is inferred to be subject to a significantly lower risk.

The conservatively defined limit of geometrically possible disturbance undercuts only the RAS open pit. The north-eastern boundary of the zone is tangential to the westernmost toe of the ELF and interfere with the dirty water diversion channel planned to run around the toe of the landform; however, the potential that disturbance could reach that position at ~ 300m above the nearest stope is remote.

Surface flow between the north-eastern crest of the pit and the toe of the ELF feeds naturally into Shepherds Creek. Disturbance due to subsidence of the north-eastern RAS pit wall, if occurrent, could divert flow into the pit. It is expected that a bund would be constructed around the periphery of the pit crest and that such a bund would continue to direct surface flows towards the creek.

Backfill is essential while stoping within or in the vicinity of the TZ3, Rise and Shine Shear Zone (RSSZ) including the uppermost zone of the TZ4, and the Thomson Gorge Fault (TGF). Intensive ground support will be required in development of stope access to these areas.

Comprehensive monitoring of surface displacement above underground operations will be crucial.

The key factors in managing potential for subsidence at RAS are:

- Developing robust systems and sequences for access development and stoping preparation through the TZ3, RSSZ, TGF and upper TZ4 units/ structures.
- Establishing and maintaining general ground stability while stopes are developed and until each stope is backfilled with paste. Provision of comprehensive reinforcement and support to the stope back from the sill drive prior to stoping will be essential.
- Prompt placement of backfill to minimise self-supporting requirements, thereby reducing opportunity for excessive time-related stope wall and back relaxation.
- Limiting the void remaining after backfilling completed stopes. It is not practicably possible to completely or uniformly fill the voids due to the interplay of opening geometry (dictated by ore shape) and the practical limitations of placing and containing a fluid medium (paste).

Practical controls

1. **Minimise & break up the effective span**
   - Sequence stopes to avoid creating large, continuous unsupported backs.
   - Consider leaving temporary pillars or tighter stope lengths if needed.
2. **Back condition management in weak TZ3**
   - Design for controlled overbreak: conservative stope design, stringent drilling/ blasting control, and realistic equivalent linear overbreak slough (ELOS) assumptions.
3. **Tight filling strategy**
   - Target fill practices that reduce the persistence of the crown gap:
     - Staged pours and top-up pours
     - Improved dewatering management (to reduce shrinkage)
     - Operational focus on achieving early contact (even partial contact) where possible.
4. **Instrumentation / trigger-action monitoring**
   - Given the proposed mining configuration, underground convergence and surface settlement must be monitored.

Subsidence Monitoring

Subsidence monitoring will be required to detect the development and sequence of displacements and deformation. Monitoring thus aims to detect early rock mass relaxation; development of a subsidence trough; and localised deformation or fault movement before significant surface damage occurs.

A comprehensive subsidence monitoring program using some combination of the following methods:

Regional scale

- InSAR (Interferometric Synthetic Aperture Radar)
- Periodic aerial/ UAV surveys

Local ground control

- GNSS stations (Global Navigation Satellite System)
- Precise levelling networks
- Total station prisms (EDM electro-optical distance measurement)

Subsurface behaviour

- Stope CMS
- Borehole extensometers variously from surface or underground
- Borehole TDR (time domain reflectometry) attenuation monitors
- Inclinometers (traversing or in-place inclinometers)
- Microseismic monitoring (rock noise monitoring).

Closure

At ~ 250 m average depth, a void above paste, even a 1 m gap, increases the risk of local hangingwall degradation and progressive overbreak in poor quality TZ3, and therefore increases the *possibility* of broad, low-amplitude surface settlement, especially if multiple stopes interact across the full 150 × 450 m area. It does not automatically imply a high likelihood of dramatic surface collapse, but it does warrant conservative stope sequencing, realistic dilution allowances, and monitoring aimed at detecting any upward-propagating loosening.

We trust that the information provided meets at least some of your immediate requirements.

The above listed comments are from a screening-level assessment. Clarification and/ or elaboration of the contents of this memorandum can be provided.

Please contact the undersigned if there is any need for such clarification or comment on other geotechnical issues related to mining.

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per:

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