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Savage River underground project update

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ABSTRACT

Grange Resources (Tasmania) Pty Ltd (Grange) operates the Savage River Mine, 100km southwest of Burnie, in Northwest Tasmania. The mine produces magnetite iron ore from a series of open pits and has been in operation for over fifty years. As at December 2023 the Mineral Resource Estimate is 472Mt at 44.4% DTR (Davis Tube Recovery). The magnetite ore is concentrated on site then transported by pipeline to the Port Latta Pellet Plant where high-grade pellets are produced for export to steel-making operations in the Asia-Pacific region (Grange Resources, 2024).

A concept study in 2018 identified the potential for underground (UG) mining below the North Pit. A resource drilling program, Exploration Decline, Bulk Sample Drive and pre-feasibility study (PFS) were then completed in 2021. Following the PFS, Grange conducted an Enterprise Optimization Study which informed the optimal transition from open pit to underground. The Definitive Feasibility Study (DFS) for a single-panel block cave commenced in 2022 and was completed in 2023.

The mineralised package is characterised by intense development of magnetite-rich lenses within a strongly deformed and metasomatised fault-bound package. Ground conditions are expected to be both favourable for caving and challenging for mine development. The Savage River Mine is also located in an area of high annual rainfall which further presents challenges for mine planning and the management of inrush or inundation hazards. This paper discusses the key outcomes of the DFS and the project evolution, including the caving strategy, mine design and materials handling system design, plans for automation, dewatering and ventilation strategies.

1 INTRODUCTION

The Savage River Mine is a magnetite iron ore mine located in Northwest Tasmania, owned and operated by Grange Resources (Tasmania) Pty Ltd (Grange). Mining operations at Savage River comprise a series of open pits, a concentrator and tailings facility. A concentrate slurry is pumped from the mine through an 85km pipeline to the pellet plant at Port Latta. The pellet plant is located on the North-West coast, 70km North-West of Burnie and alongside the port facility. Refer to

for the Site Location Map. (Grange Resources, 2024).

Figure 1 Site location map.

Over 2.5Mtpa of premium quality iron ore pellets are produced annually and exported to steel-making operations in the Asia-Pacific region, including Port Kembla in New South Wales.

Mining operations at Savage River have continued for over 55 years and are forecast to extend beyond 2038. Mining activity is currently from the North and Centre pits, with continuation of the North Pit Exploration Decline commencing in January 2024. (Grange Resources, 2023a).

2 GEOLOGY

The Savage River magnetite deposit lies within the Arthur Lineament, a narrow 110 km long by up to 10 km wide tectonic feature which transects northwest Tasmania and strikes NNE from the west coast to the north coast of Tasmania.

The mineralised package is characterised by intense development of magnetite-rich lenses within a strongly deformed and metasomatised fault-bound package. Magnetite mineralisation comprises a series of subvertical lenses elongated in a semi-meridional direction parallel to the sub-vertically bounded host rocks of the Arthur Lineament.

Magnetite ore is subdivided into three volumetrically important types based on magnetite content and gangue mineralogy. High-grade ore comprising magnetite with DTR values of >35% subdivided by dominant gangue mineralogy into pyritic, serpentinitic, and talc-carbonate ores. Minor accessory mineral phases may include talc, tremolite, actinolite, chlorite, epidote, apatite, and carbonate that may reach modal proportions. Low grade ore ranges from 15-35% DTR consisting of disseminated magnetite and high proportions of silicate minerals. Trace amounts of iron- and/or copper-bearing sulphide including pyrite, chalcopyrite, hematite, ilmenite and rutile can accompany magnetite. (Grange Resources, 2023b).

3 PREVIOUS STUDIES

A number of scoping and conceptual studies have been completed to assess underground mining methods at Savage River, first in 1994 and most recently in 2018.

An underground mining options study was completed in 2018 by AMC Consultants Pty Ltd and recommended that both Block Caving and Sub-level Caving (SLC) were technically feasible. These mining methods were further evaluated during the Pre-Feasibility Study (PFS) conducted 2019 to 2021.

During the PFS an Exploration Decline was developed in the East Wall of the North Pit, traversing from the southern end to the northern end. In total 2.5km of underground development and 11,340 metres of resource drilling was completed, and a 20,000t bulk sample of ore collected. This enabled the collection of geological and geotechnical data which was used to inform the study. The PFS concluded that underground caving was a technically and financially viable option for the North Pit orebody. (Grange Resources, 2021).

3.1 Definitive Feasibility Study

Approval was given in 2022 to conduct a Feasibility Study (DFS) to evaluate the proposed Block Cave Mine beneath the North Pit and a smaller SLC Transition Mine adjacent to the Northern end of the North Pit.

Between the PFS and the DFS, it was determined that it was economically favourable to transition after an additional cutback to the east wall of North Pit, and the final pit shell changed from Stage 6 to Stage 7. The larger shell for Stage 7 then became the battery limit for the DFS and resulted in the Extraction level elevation changing to a lower elevation.

This paper discusses the key outcomes of the DFS and the project evolution, including the caving strategy, mine design and materials handling system design, plans for automation, dewatering and ventilation strategies.

4 GEOTECHNICAL UPDATES

During the DFS updates were made to the geotechnical criteria used in the PFS, including:

- Geotechnical domains.
- Material properties for each domain.
- Additional structural faults.

4.1 Domain updates

Geotechnical domains were reinterpreted by Grange Resources following development of the bulk sample drive across the orebody (Lygin, 2022).

The rafts within the Main Ore Zone have been redefined as sub-parallel structures denoting a series of subtle internal boundaries. The boundaries are defined as surfaces at the margins of ore lenses which commonly correspond with the transition from massive to banded facies (Selley, 2019).

The reinterpretation of the domains and removal of the rafts within the Main Ore Zone was initiated by the ‘better-than-expected’ ground conditions during development of the bulk sample drive.

4.2 Material properties

A review of the intact rock database was completed by Engenex using the updated geological interpretation and available UCS test certificates to determine their failure mechanism and suitability for intact rock parameters. To ensure consistency, eight failure modes are introduced to replace the failure modes within the original database.

The UCS database has been complemented with the point load testing and Equotip databases within the majority of the domains. These two complimentary databases have also been used to quantify the bias towards UCS samples collected largely within good quality core.

In general, the intact parameters are higher than those reported in the PFS. (Hancock, 2023).

A summary of the average rock mass properties of the key geotechnical domains is given in Table 1, with descriptions following.

Table 1 Material properties by geotechnical domain (Beck Engineering, 2023)

Geotechnical domain	PFS	DFS	DFS
	UCS (MPa)	UCS (MPa)	GSI
Eastern Wall Assemblage (EWA)	54	70	65
Eastern Carbonate Envelope (ECE)	15	45	40
Eastern Ultramafic (EUMF)	-	45	40
Eastern Magnetite Contact Fault Zone (EMCF)	-	45	40
Main Ore Zone (MOZ)	44	36-60	40-60
Western Carbonate Envelope (WCE)	19	50	40
Western Ultramafic (WUMF)	49	62	65
Western Banded Schist (WBRK & WBXN)	29	75	55

4.3 Rock mass characteristics of geotechnical domains

The following summarises the geotechnical domains, which are shown in the vertical section in Figure 2.

Eastern Wall Assemblage (EWA) comprises of competent fine-grained massive to finely schistose mafic rocks with weak to moderate foliation. Most joints dip steeply to the west and are undulating barren with rough or smooth surface textures. Six joint sets were identified during the DFS with a mean persistence of between 0.5m to 1.0m. With the highest mean RQD of 91 and RMR of 69 this domain is considered the most competent and appropriate for life-of-mine infrastructure.

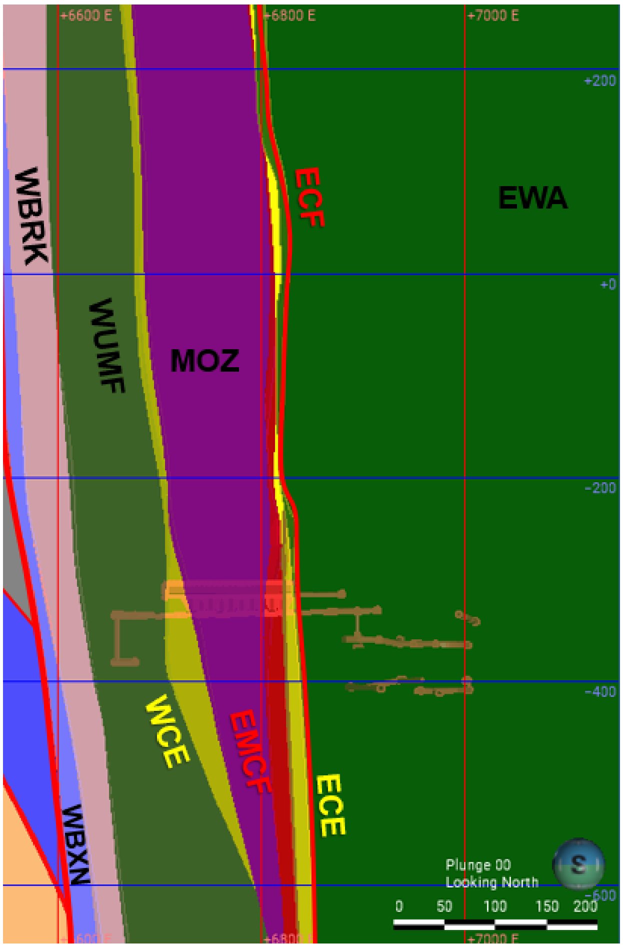

Figure 2 Cross section through the geotechnical domains showing the approximate location of the Block Cave Mine development (Lygin, 2022).

Eastern Carbonate Envelope (ECE) consists of mainly soft extensively sheared carbonate-talc-mica schists with zones of puggy clays in the northern part of the ECE with competent intervals. Logging data identified at least four joint sets, most of which were steeply dipping with a mean spacing of between 2.5m to 9.5m. This domain was considered to have a mean RQD of 58 and RMR of 52 but is highly variable.

Eastern Ultramafic (EUMF) abuts the ECE and is more competent and massive with foliated serpentinitic ultramafics, chloritic basalts and chlorite-carbonate schists. Discontinuity sets identified within this domain were similar to that of the ECE.

Eastern Magnetite Contact Fault Zone (EMCF) is a soft complex zone of fractured, brecciated and sheared mafic schists and intrusions, with ultramafic bodies and magnetite ore on the eastern boundary of the Main Ore Zone.

Main Ore Zone (MOZ) consists of thin, layered parallel intercalations on the margins to broader zones of magnetite ± pyrite (with wispy chlorite-serpentine inclusions). Carbonate-talc-serpentine veining is also seen in increasing volumes on the margins, particularly on the eastern margin. Six joint sets were identified through mapping, the majority of which were steeply dipping with a mean persistence of between 1.1m to 2.3m. Most of these discontinuities were observed to be fresh and undulating with soft infill material (carbonate-talc-serpentine veining). With a mean RQD of 67 and RMR of 55 this domain is considered potentially highly variable due to the presence of large shears and waste lenses.

Western Carbonate Envelope (WCE) and Western Ultramafic (WUMF) is primarily soft material with competent intervals. Complex zones of predominantly carbonate-talc-serpentine metasediments exist with various degrees of decoupling, brecciation and shearing with minor intervals of mafic/ultramafic bodies.

With a mean RQD of 55, obtaining orientations within the WCE domain was difficult. Three joint sets were identified with predominantly soft infill and undulating geometry with a mean RMR of 49.

4.4 Structural faults

Faults used during the DFS have been identified, interpreted and wireframed from either surface or underground observation and drill core.

The faults and internal ore lenses within the MOZ, discussed in 4.1 Domain updates, were included as surfaces within the numerical modelling conducted during the DFS.

4.5 Stress field

The insitu stress regime used for numerical modelling assessment is given in Table 2 and has been determined using four overcored ANZI strain cell measurements at two locations. These measurements sit within the expected stress magnitudes recorded across Tasmania. Further stress measurements have been planned to confirm the stress magnitude with depth.

Table 2 Stress field (Beck Engineering, 2023)

Principal stress component	Magnitude gradient (MPa/km)	Dip (°)	Dip azimuth (°)
σ_1	49	22	260
σ_2	35	11	165
σ_3	23	65	50

5 ENTERPRISE OPTIMIZATION STUDY

An EOS was completed by Whittle Consulting using results from the PFS. The EOS considered the technical and financial relationship between the open pit and the underground. This assessment indicated that the optimal transition point from the open pit to the underground is after the completion of Stage 7 (rather than Stage 6). Consequently, the DFS has used Stage 7 as the study battery limit.

6 MINE PLANNING RISKS AND HAZARDS ADDRESSED IN THE FEASIBILITY STUDY

During the PFS, a number of key and material risks were identified that related to mine planning. These risks are a result of anticipated geological, geotechnical and mining characteristics of the orebody and surrounding rocks.

These risks are related to:

- High rainfall and expected water inflow to the cave.
- The anticipated rock mass characteristics and expected ground conditions.
- Cave propagation and performance.

The mine planning strategy adopted during the DFS was to prioritize risk mitigation associated with management of water inflows, mine stability, and management of the caving rate and direction. The following sections summarize the outcomes of the DFS and changes made since the PFS. (Grange Resources, 2023c).

The underground mine design is shown in Figure 3 and referred to in the sections following.

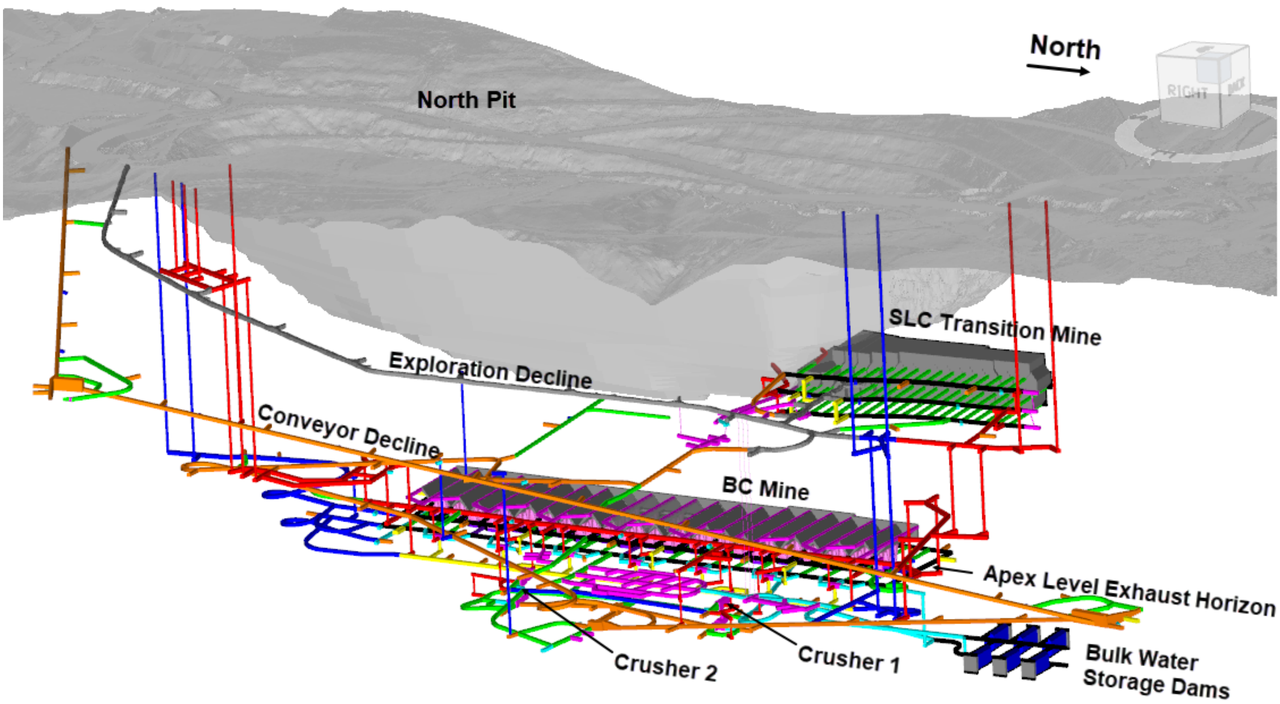

Figure 3 Underground mine design (looking south-west).

7 MANAGEMENT OF WATER

The mean average annual rainfall at Savage River is 1,947mm. Following the cave breakthrough to the North Pit, water will report to the underground mine. The average water inflows to the North Pit are estimated to range between minimum 0 to 150L/s to maximum 2,500L/s during peak rainfall.

A number of changes to the underground dewatering system and water management have been made during the DFS, shown in Table 3 and discussed below.

Table 3 Changes to the dewatering system

Item	PFS	DFS
1. Dedicated drainage level	Combined drainage and exhaust level	Dedicated exhaust at the Apex level and dedicated Drainage level.
2. Extraction level layout	Diagonal El Teniente	Offset herringbone
3. Pumping system	Maximum design flowrate 640L/s	Maximum design flowrate 750L/s
4. Undercut (UC) level drainage system	No drain holes on UC level	Large drain holes from the UC to the drainage level

1) Drainage level

The PFS risk assessment identified that flooding the mine due to potential inrush of water was a high-risk event. The PFS mine design combined the drainage and exhaust ventilation level at the bottom of the mine. During peak rainfall, automated louvres would be necessary to bypass the ventilation level to remove the risk of the primary fans stalling.

To address the risks associated with flooding the mine, the following changes were made during the DFS:

- A dedicated exhaust horizon was added at the Apex level so that the drainage level became dedicated to the management of water inflows and independent of the primary ventilation circuit.
- Access to the drainage level was re-designed so that in a flooding event, the rising water levels reach the western side of the orebody first and then flood across the Extraction level before reaching the mine infrastructure on the Eastern side last. This provided an increase in flood storage capacity.

2) Extraction level layout

The PFS risk assessment identified two high risks relevant to the Extraction level layout; potential mud rush risk and potential large scale instability making the level unserviceable.

The Extraction level design was changed from a diagonal El Teniente style to an offset herringbone with drawpoints orientated towards the west to manage the hazards associated with these risks:

- Fine material in the cave column.
- Water inflow quantities.
- Weak rock mass.
- Drawpoint intersection dimensions.

This was following a trade-off study considering the following geotechnical and operational factors:

- Mud rush management.
- Footprint stability.
- Use of tethered electric loaders.
- Loader operability.
- Ventilation direction.
- Drawbell geometry.
- Development sequencing.

Mud rush risk:

Drawpoint accesses are orientated to the west and away from the MHS infrastructure in the

East to direct material from a potential mud rush or inrush event preferentially in this direction.

Footprint Instability:

Large intersections within the weak orebody rock mass are likely to result in severe deformation and increase the difficulty of maintaining stability. Reducing the drawpoint intersection size with the offset herringbone layout provides a higher likelihood of Extraction level stability. This is discussed further in Section 8, CAVING ASSESSMENT.

3) Pumping system

The underground pumping system has been designed to de-water the mine to the lowest development horizon at the bulk water storage dams.

The maximum design capacity for the pumping system has been increased from the PFS design of 640L/s to 750L/s following updates to the water balance modelling, underground water storage volumes and change to the pit catchment resulting from the change to the final pit shell. At this increased pumping capacity, the DFS water balance simulations forecast <1% exceedance probability that the available water storage capacity below the Extraction level would be exceeded during the life of the mine.

4) Undercut level drainage system

The DFS design includes 1.5m diameter drain holes west of the Undercut Level slot drives down to the Drainage Level. These were added to provide a drainage path on the western side of the orebody to the drainage level by removing water from the western flank of the cave at the undercut level, and to bypass the Extraction level.

8 CAVING ASSESSMENT

Empirical assessments and numerical modelling were used during both the PFS and DFS to forecast the block cave growth, surface subsidence and stability of the underground excavations. These models were used to inform the cave production schedule following assessments of various iterations of the mine plan.

Table 4 outlines the key changes made to the mine plan to improve the performance of the cave, based on the numerical modelling forecasts which used the updated geotechnical inputs as outlined in Section 4.

Table 4 Changes to the mine plan

Item	PFS	DFS
1. Extraction level elevation	-295mRL (North Pit Stage 6D)	-330mRL (North Pit Stage 7E)
2. Production sequence	Two panels	Single panel
3. Drawbell opening sequence	Chevron shape	Constrained to east-west advance
4. Extraction level layout	Diagonal El Teniente	Offset herringbone
5. Drawpoint brow support	Combination of steel sets and shotcrete arches	Very high-capacity ground support with a floating brow beam
6. Undercut lead distances	UC advance >1 extraction drive	UC advance 2 drawbells
7. Drawbell shape	Rectangular	Modified circular

1) Extraction level elevation

The change to the final shell resulted in the final pit floor dropping by around 40m. A footprint evaluation was subsequently completed by Power Geotechnical to maximise the mining reserve. The outcome of this assessment was to drop the Extraction level to -335mRL.

At this elevation the cave block height ranges from 180m to 220m from the undercut level to the base of the North Pit final shell. Consistent with the PFS, this provides a conservative estimate of the drawpoint lifespan based on benchmarking completed by Beck Engineering regarding brow wear at mines with similar strength to stress ratios (S1/UCS>0.35).

2) Production sequence

The block cave was changed from two panels to a single panel to remove the interaction issues from a two-panel design and because key caving criteria regarding undercutting rate, drawpoint life and cave back advance rate for the single panel were modelled to be within reasonable ranges.

3) Drawbell opening sequence

The cave sequence was changed to prioritize opening across each Extraction drive from West to East before extending north and south. This results in a "square" undercut front, shown in Figure 4, to assist caving and reduce underbreak and chimneying. This differs from the more standard chevron front used in the PFS.

4) Extraction level layout

The Extraction level design was changed from a diagonal El Teniente style to an Offset Herringbone to reduce from 4-way to 3-way intersections. Footprint damage to the extraction level pillars with this design was assessed to be less following numerical modelling simulations (Beck Engineering, 2023). Close survey control and careful drill and blast practices will be essential to achieving good geometrical outcomes.

High-capacity ground support and reinforcement schemes with proactive maintenance will be employed within life-of-mine excavations to maximise the lifespan of infrastructure and to reduce the rehabilitation requirements.

These schemes will have a philosophy of providing high resistance to the loads applied by the rock mass (>300kPa) over a large range of displacement, in the order of 200-300mm.

5) Drawpoint brow support

The draw point brow is considered to be a high hazard area for personnel working in both equipment and on foot. During the PFS, access to the brow was required to remove and reinstall steel sets and shotcrete arches in the drawpoint drives. Due to the forecast deformation within the Extraction level and limited deformation capacity, the replacement of brow support would be expected to occur frequently with long exposures to the high hazard area.

Subsequently, the DFS brow support design was changed from steels sets and shotcrete arches which are high load with low deformation capacity to high load and deformation capacity ground support and reinforcement with a floating brow beam. This will help to limit mechanical damage to the brow and control the flow of material from the drawpoint through a small as practicable drawpoint opening.

Multiple factors were considered when this change was determined, including:

- Reducing the time personnel spend at the brow to repair brow support.
- Ensuring very high retaining pressures (>500kPa) are constantly maintained over a large range of deformation (up to 300mm).
- Maintaining the short wall lead-in distances to provide enough room to construct drawpoints bunds (refer to Figure 5).
- Minimise drawpoint opening size and rill out distances to limit spillages into the extraction drive (refer to Figure 5).
- The cost and time required to construct brow support.
- The impact of uneven cave draw due to extended drawpoint down time.
- Other lower exposure options to maintain the brow support and extended its longevity.

Brow wear will be mitigated with consistent maintenance of the draw points and protective layers of shotcrete. This approach allows the brow to slowly and continuously retreat back towards the extraction drive whilst avoiding the comparative large incremental brow loss (>2m) each time a steel set is replaced.

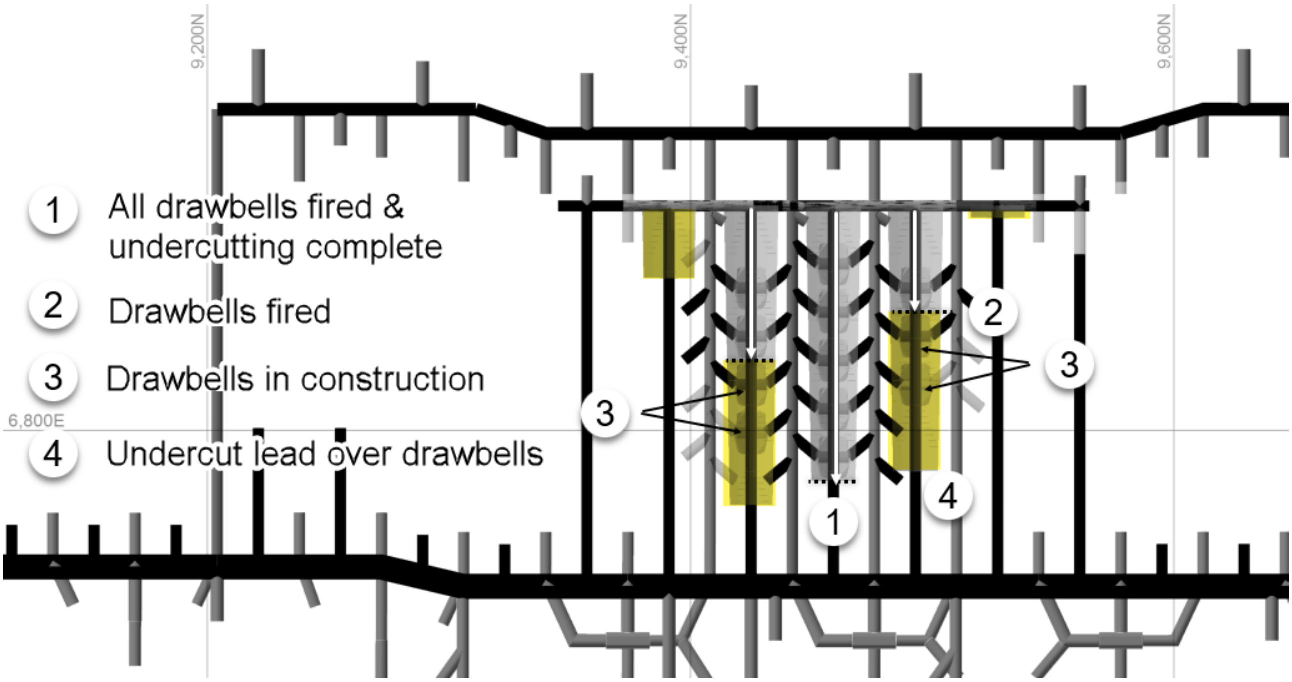

Figure 4 Square undercut front.

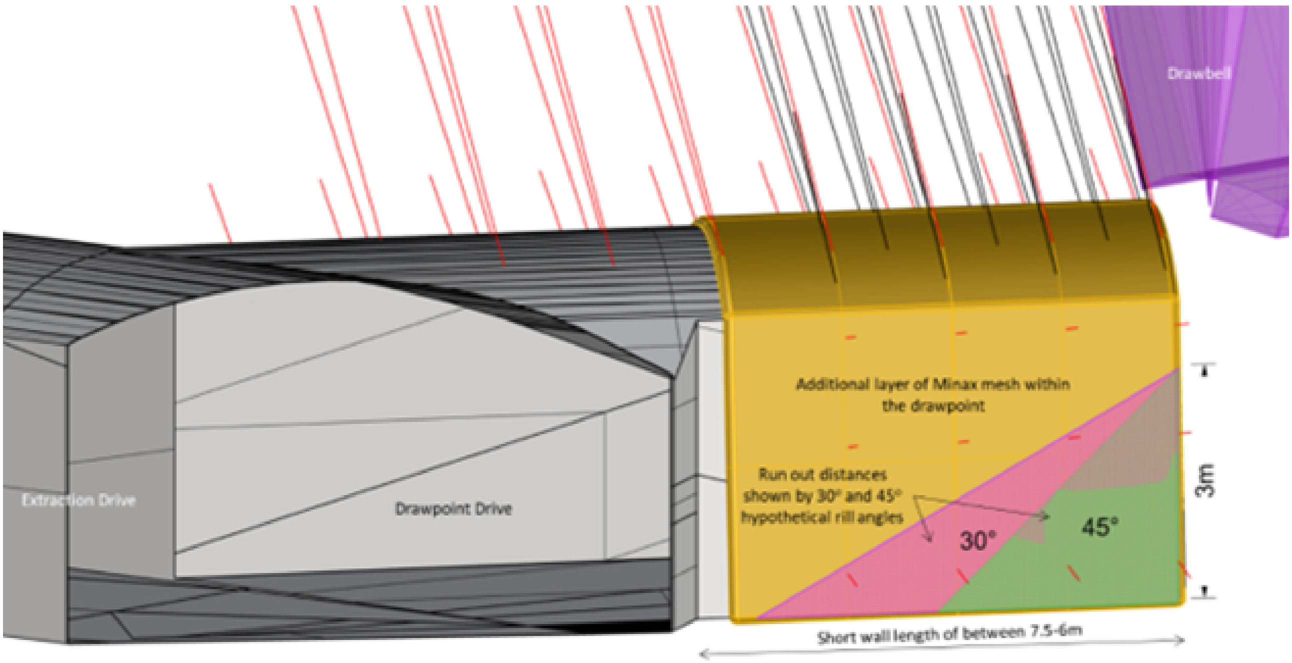

Figure 5 Brow support with a brow beam 3m from the floor showing rill angles and run out distance according to the short wall length.

6) Undercut lead distances

The undercut lead distance was shortened from >1 entire extraction drive to approximately 2 drawbells, as shown in Figure 4. The numerical modelling results identified stresses induced within the Extraction level was largely driven by the weight of the rock mass above and an increase in abutment loads as the stress arches over the advanced undercut. The former being an unavoidable issue as excavations are constructed and the weight of the cave material above is transferred to the Extraction level pillars. The additional arching stress directed to the abutments could be minimised by limiting the undercut advance to ~2 drawbells and keeping the two levels in lock-step with each other. (Beck Engineering, 2023).

7) Drawbell shape

The drawbell was changed to a circular shape similar to the shape used at the Cadia and Ridgeway caves but refined for the herringbone Extraction level layout and wide incline undercut (also referred to as “W” shape) layout. This provided a more desirable shape.

9 MATERIALS HANDLING SYSTEM

A number of changes have been made to the materials handling system (MHS), which are given in Table 5.

Table 5 Changes to the materials handling system.

Item	PFS	DFS
1. Extraction level ore passes	Four ore passes	Seven ore passes
2. Crushers	Central gyratory crusher	Two eccentric roll crushers
3. Haulage level	Truck chutes and truck haulage to crusher	Lintels at ore passes and loader transfer to crusher
4. Ore movement to surface	Decline truck haulage	Inclined conveyor system
5. Production loader fleet	Diesel	Electric tethered

1) Extraction level ore Passes

The Extraction level ore passes were changed following a trade-off study for four vs seven ore passes, considering the following:

- Production loader productivity.
- Capital expenditure for additional ore passes.
- Operating costs for production loader fleet.

The increased capital expenditure for the additional ore passes was offset by the reduction in the required production loader fleet due to productivity gains. The productivity gains came from reduced tramming distances and removal of loader interactions as each extraction drive has a dedicated orepass access.

The revised layout also simplified the use of remotely-operated loader systems by providing separate operating zones for each ore pass (Figure 6).

2) Crushers

The single, central gyratory crusher has been replaced with two eccentric roll crushers, located at the Northern and Southern portions of the footprint. The reasons for this change include:

- Reduced excavation dimensions.
- Redundancy for the MHS operation is provided with two crushers.
- Two crushers then allow for the use of production loaders to transfer directly from the ore passes to the crusher ROM bin.

Crushed ore is transferred to the inclined conveyor system via apron feeder and transfer conveyor.

3) Haulage level

In conjunction with the change to the crushers, the haulage level was changed from truck haulage to a loader transfer level which eliminated the truck loading chutes from the design. Lintels with brow beams will be built at each of the ore passes on the haulage level.

4) Ore movement to surface

The PFS considered several haulage options with associated underground configurations and underground and surface infrastructure. The underground crushing and conveying option was chosen as the go forward case for DFS for the following reasons:

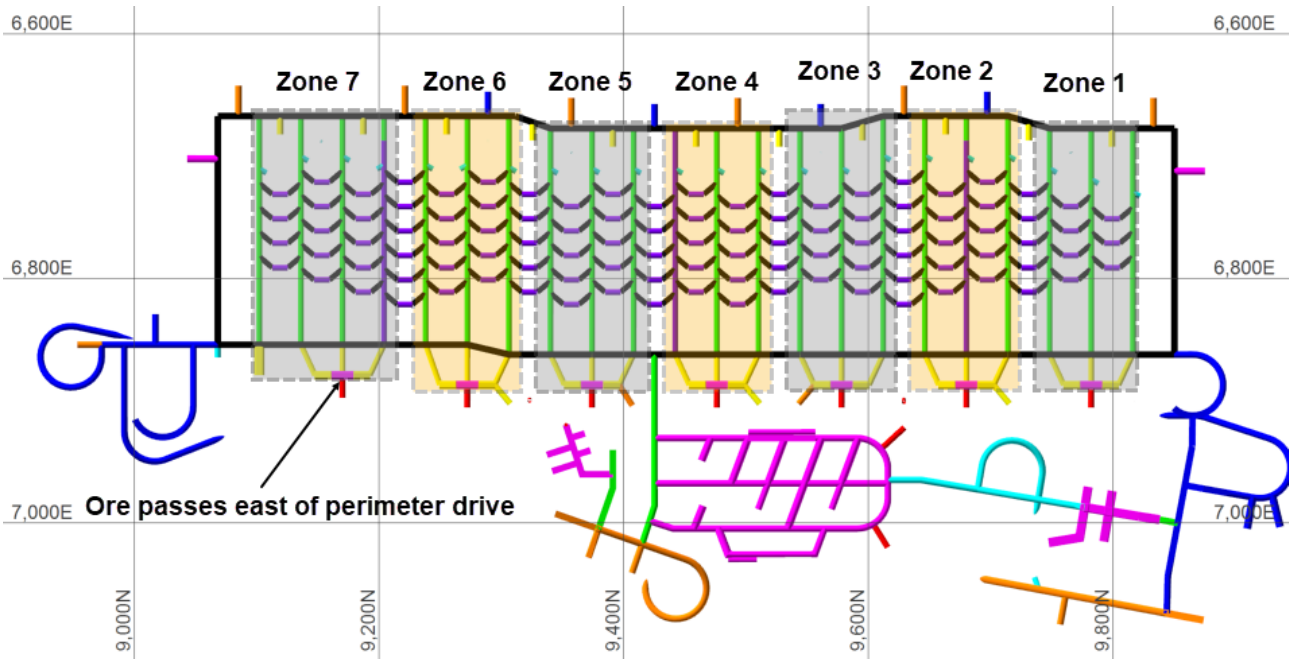

Figure 6 Extraction level production loader operating zones.

- Significant reduction in emissions and ability to meet the long-term requirements of the updated Australian Government Safeguard Mechanism.
- Lower operating costs by the removal of production trucks and significant reduction in diesel usage.
- Better future-proofing with higher ore production levels possible allowing the option of higher concentrate production.
- Improvement to the underground operating environment with improved air quality.
- Increased options for future automation.

5) Production loader fleet

The strategy adopted for the Extraction level production fleet in both the PFS and DFS is to use proven technology. For the PFS, diesel production loaders were allocated. With the change to the offset herringbone layout in the DFS, electric tethered loaders then became possible because of the consistent orientation of the drawpoint drives.

Using tethered electric loaders on the Extraction level provides the additional benefits of reducing carbon emissions and using Tasmania's low emission hydro power.

One limitation of the tethered loaders is the inflexibility to cleanup spillages from the reverse tram direction. The risk of over-filling the loader buckets is considered to be lower due to the high average ore density at Savage River due to the iron content. However, clear camera vision for the loader operators in the control room will be critical to assess conditions of the extraction drives. Where spillages occur, diesel loaders can be deployed to clean up spillages.

There is opportunity to change to battery loaders with future improvements to battery technology.

10 VENTILATION STRATEGY

The ventilation strategy for the block cave was modified to improve air quality in work areas frequented by personnel and to simplify the return air network; see Table 6.

Table 6 Changes to the ventilation strategy

Item	PFS	DFS
1. Ventilation direction of the Extraction level	East to west	West to east
2. Dedicated exhaust level	Combined Ventilation and Drainage level	Apex level

1) Ventilation direction of the Extraction level

The ventilation direction on the Extraction level was changed from west exhaust to east exhaust following a trade-off study considering:

- Exposure to potential fibrous minerals.
- Balancing airflow distribution on the level.
- Dust concentration at the ore pass tipples.
- Loader operability considering airflow direction relative to loader tramming direction.
- Ventilation of development sequence.
- Airflow quantity demand.
- Required ventilation controls.
- Impact on the primary ventilation circuit.
- Ability to ventilate a potential future recovery level.

Fresh air enters the Extraction level on the western side via the perimeter drive and exhausts on the eastern side via exhaust raises at the ore pass tipples.

Entry to the level will be from the west perimeter drive (in fresh air). This means that development, construction and rehab crews can enter extraction drives in fresh air separate to the extraction drives with active production.

The east perimeter drive will be dedicated to the production fleet. Additional intake will enter the east perimeter drive to further dilute dust at the ore pass tipples.

2) Exhaust horizon

The exhaust horizon was moved from the combined Ventilation and Drainage level in the PFS to the Apex level in the DFS.

This has simplified the ventilation circuit by enabling a dedicated exhaust horizon to be established earlier compared with the PFS design.

It is only planned to develop the initial three apex drives to assist with establishing drill and blast practices when initiating undercutting.

11 MINE AUTOMATION

In addition to changing the layout of the Extraction level to an offset herringbone, the operating strategy for the Extraction level has changed to a remotely-operated production loader fleet. This greatly reduces personnel exposure at the drawpoints during the production cycle and is part of the cave management plan. Due to the layout of the extraction drives and ore passes (Figure 6) it is planned to setup seven zones within the automation system.

It is also planned to use automated loaders on the Haulage level to transfer between the ore passes and the crushers.

12 CONCLUSION

Mine planning for the Savage River Underground Project has evolved from the PFS to the DFS based on changes to the final North pit stage, updates to geotechnical information and improvements to the mine design.

Updates to geotechnical domains, material properties of the rock mass and structural faults have driven changes to the mine design and schedule and subsequently to inform the numerical modelling of various iterations of the mine plan.

Further, the mine design has changed to mitigate the risks associated with:

- High rainfall and expected water inflow to the cave.
- The anticipated rock mass characteristics and expected ground conditions.
- Cave propagation and performance.

Changes to the Extraction level layout provides the opportunity for an automated production loader fleet which reduces personnel exposure at the drawpoints.

The change to electric tethered loaders and inclined conveying reduces carbon emissions. In addition, both the materials handling and ventilation systems have evolved during the DFS to improve and simplify these systems.

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