# APPENDIX A

Rejects Management Options Gap Assessment

# Report

## Rejects Management Options

## GAP ANALYSIS

| | |
|---|---|
| **Client** | Simec Mining |
| **Site** | Tahmoor, NSW |
| **Date** | November 2019 |
| **Doc No.** | SIM5155-02 |

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**Version Management**

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## EXECUTIVE SUMMARY

Palaris Australia has been engaged by Tahmoor Coking Coal Operations (TCCO) to complete a review of reject management options, including the following:

- Review and update the 2014 SKM Reject Strategy Report; and
- Address comments by NSW EPA in relation to reject management options.

In 2013 Jacobs (SKM at the time) were engaged by TCCO to undertake an assessment of Rejects Disposal options for the Tahmoor South Project, the outcomes of which are contained in the 2014 SKM Reject Strategy Report. During the exhibition of the EIS in 2019, the EPA provided a submission on the 12 March 2019 recommending that the Department of Planning and Environment request that "…. the EIS be updated using knowledge acquired from currently operating underground emplacement paste plants."

Following a review of a range of publicly available information, Palaris has found that there is unlikely to be any new knowledge obtained since 2014, or gaps in the original work that would have the potential to *materially* alter the two July 2014 reports' fundamental conclusions and recommendations. The conclusions of the two 2014 reports appear to be generally sound.

The emplacement of coal rejects in active longwall goaves remains to be technically challenging. There is a relative degree of certainty that fines and ultrafines can be emplaced in a longwall goaf of favourable seam dip, however this is done at a considerable capital and operating cost disadvantage compared to on-site surface emplacement.

An attempt to quantify costs and benefits of this option in 2019 dollars has therefore been undertaken and found that the net increase in capital costs alone outweighed any environmental benefit by a factor of 11:1.

It is therefore recommended that the current strategy of 100% surface emplacement continue to be pursued for the Tahmoor South project, on the basis of the fact that this alternative represents the best value to TCCO and does not unduly increase operational complexity and risk.

# 1 BACKGROUND

## 1.1 Introduction

TCCO proposes to extend underground coal mining to the south of the Tahmoor Mine pit top area into the Bargo area (refer to Figure 1).

The project will extend the life of underground mining at Tahmoor Mine by around 13 years, until approximately 2035.

TCCO currently produces up to 3 million tonnes per annum (Mtpa) of run of mine (ROM) coal from the Bulli Coal Seam. This coal is mostly hard coking coal that is used for steel production.

Underground mining at the existing operational area, known as Tahmoor North, is anticipated to be completed by 2022. The project would continue the use of the longwall mining method to extract up to 4 Mtpa of coal within TCCO's existing mining tenements. The new underground mining area would be accessed via the existing Tahmoor Mine, and the existing surface infrastructure would continue to be used and upgraded as part of the project.

Figure 1 outlines the proposed project area and extent of longwall mining for the project. The extent of longwalls, and the additional surface facilities, are the focus of the environmental assessments undertaken for the EIS. The project also includes:

- Expansion of the existing Reject Emplacement Area (REA); and
- Construction of two new mine ventilation shafts

Mining of the Bulli coal seam within the project area, would be at a depth of between about 375 metres and 430 metres below ground level.

The Tahmoor South Project EIS has been on public exhibition and TCCO are now at the stage of responding to submissions from the public and government agencies.

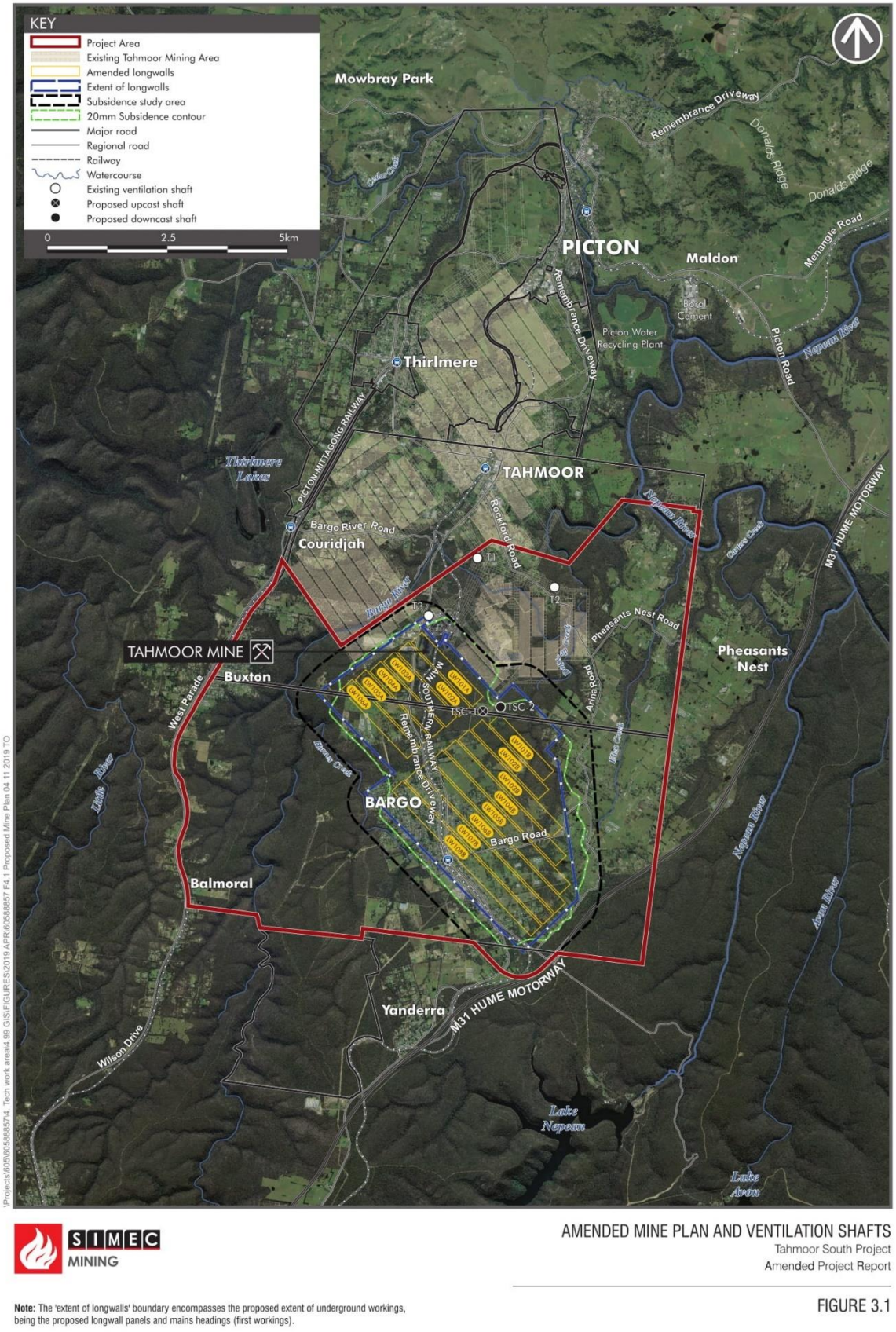



**Figure 1 - Tahmoor South project area**

## 1.2 Scope

Palaris Australia has been engaged by TCCO to complete a review of reject management options, including the following:

- Review and update the 2014 SKM Reject Strategy Report; and
- Address comments by NSW EPA in relation to reject management options.

Palaris Australia proposed to undertake this work via the use of a gap analysis to identify any potential areas of new knowledge or areas where the original 2014 SKM report could be updated, specifically areas of new knowledge gained from recent work done at either Metropolitan Colliery or the Hume Coal project.

## 1.3 Materiality

Materiality is an important consideration in undertaking this work. Gaps in the original assessment or areas of new knowledge are only relevant where they have the potential to change the overall assessment outcome, either alone or in combination. For completeness, all gaps and new knowledge that have been identified are reported herein, however an assessment has been made as to their materiality to the overall assessment. No gaps have been identified that are assessed to be sufficiently material to change the overall outcomes of the initial assessment undertaken by SKM in 2014.

## 1.4 Information and Resources

### 1.4.1 Information supplied by TCCO

The following information has been provided by TCCO and reviewed by Palaris Australia:

- Rejects Disposal Options, Study Strategy Report, QN10312-EAM-RP-E4-0002, Revision D, Sinclair Knight Merz Pty Ltd, 10 July 2014;
- Rejects Disposal Options Study, Technical Report, QN10312-EAM-RP-E4-0001, Revision F, Sinclair Knight Merz Pty Ltd, 24 July 2014;
- Rejects Disposal Options Study, Project Number: QN10312, Review of 2017 Secretary's Environmental Assessment Requirements, Jacobs, 31 July 2017;
- EPA correspondence dated 12 March 2019; and
- Tahmoor South project reject tonnage and schedule.

### 1.4.2 Publicly available information

In addition to the information supplied by TCCO, other publicly available information has been reviewed, including:

- Worsley, J.H., Marsh, J.E., Patel, R. and Feldman, S.B., 'Optimisation and stabilisation of coal rejects at the Peabody Metropolitan Mine using Acti-Gel® 208', in RJ Jewell and AB Fourie (eds), *Proceedings of the 18th International Seminar on Paste and Thickened Tailings, 2015*, Perth, Western Australia, ISBN 978-0-9924810-1-8, pp.309-319.
- Metropolitan Coal 2018 Annual Review

- Metropolitan Coal 2017 Annual Review
- Metropolitan Coal CCC meeting minutes (April 2016 - April 2019)
- EMM, 2017, Hume Coal Environmental Impact Statement
- EMM, 2018, Hume Coal Response to Submissions
- EMM, 2019, Hume Coal Submission to the IPC

# 2 SUMMARY OF PRIOR WORK AND LITERATURE REVIEW

## 2.1 Prior work undertaken for TCCO

### 2.1.1 Summary of findings

Palaris Australia has reviewed the following reports that have previously been undertaken for TCCO:

- Rejects Disposal Options, Study Strategy Report, QN10312-EAM-RP-E4-0002, Revision D, Sinclair Knight Merz Pty Ltd, 10 July 2014;
- Rejects Disposal Options Study, Technical Report, QN10312-EAM-RP-E4-0001, Revision F, Sinclair Knight Merz Pty Ltd, 24 July 2014;
- Rejects Disposal Options Study, Project Number: QN10312, Review of 2017 Secretary's Environmental Assessment Requirements, Jacobs, 31 July 2017;

Palaris has found that there is unlikely to be any new knowledge obtained since 2014, or gaps in the original work that would have the potential to *materially* alter the two July 2014 reports' fundamental conclusions and recommendations. The conclusions of the two 2014 reports appear to be generally sound.

The reason for this is that the reports' basic findings and premises are not disputed, because:

- There is unlikely to be enough void space to emplace the material in old workings; and re-entry to sealed parts of the existing mine was assessed to be costly, technically challenging and present a range of operational and safety risks
- It is not feasible to emplace all of the reject material generated by the proposed Tahmoor South project underground in the active longwall goaf, particularly at a product yield of 70-80%, however, it may be feasible to emplace part of the material in the goaf, under certain conditions (e.g. favourable seam dip directions and goaf conditions).
- Apart from TCCO's preferred option of full surface emplacement of the reject material, the only other viable option involves operating a surface emplacement facility and an underground emplacement facility simultaneously. The environmental benefits of this partial underground solution do not outweigh the additional costs it would incur compared to a base-case of 100% on-site surface emplacement – as sought in the DA. The reason for this is that any potential environmental benefit is relatively small compared to the additional capital and operating costs that would be incurred in setting up and running the additional processing plant, pumps, pipelines and modified longwall equipment, not to mention the increase in operational complexity, nuisance and risk associated with emplacing part of the reject into the active longwall goaf.
- A further consideration in the assessment which has not been quantified in the initial cost-benefit analysis is the potential for the full or partial sterilisation of resources in the underlying Wongawilli Seam.

A flowable paste emplaced in Bulli Seam longwall goaves may present an unmanageable future inrush hazard to workings in the Wongawilli Seam. If this consideration was quantified in the CBA, it would enhance the case for the preferred option of 100% on-site surface emplacement – potentially materially so. It is understood that, while gassy and lower-yielding, the Wongawilli Seam is potentially economic in the area. Furthermore, mining of the overlying Bulli Seam will

likely result in a substantial decrease in gas content in the underlying seams via the de-gassing associated with gas drainage activities for mining the Bulli Seam and via fracturing into the floor. The existing mine infrastructure effectively means that any tonnes mined from the Wongawilli Seam are able to be extracted at relatively low capital costs compared to a new mine, although the EIS does state that the current CHPP may not be suited to Wongawilli Seam coal and would require an upgrade or replacement to do so.

Indeed, following the exhaustion of the Bulli Seam reserves in 13 years' time, mining the Wongawilli Seam is the logical progression for the operation.

Under the "project alternatives" section, the Tahmoor South EIS states:

> *"Resolution of the current expenditure constraints and market limitations, along with development of suitable subsidence management measures in future years, may allow mining of the Wongawilli seam under a future consent. However at the current time single seam mining of the Bulli seam is preferred."* (AECOM, 2018)

For purely illustrative purposes, if a future mining operation in the Wongawilli Seam had a value of A$100m in 13 years' time, the present-day NPV would be around $39 million, discounted at 7% annually.

The challenges posed by emplacement of coal rejects into active longwall goaves that were identified by SKM and Tahmoor personnel in 2013 and 2014 are further supported by the fact that the Hume Coal project independently came to the same conclusions, resulting in the adoption of a non-caving system of mining specifically to facilitate underground reject emplacement (EMM, 2017, p. 124). The Hume Coal project does not have any potential for future mining in underlying coal resources and therefore resource sterilisation in underlying seams is not an issue that is relevant to that project.

The requirement to emplace all reject underground was imposed upon the Hume Coal project by the NSW Department of Planning and Environment in 2014 and resulted in a re-design of the project and mining system to incorporate underground emplacement. This redesign included a change of proposed mining method with the specific goal of generating open mine voids rather than goaves. TCCO does not have the option of utilising a non-caving mining method for Tahmoor South due to significant differences in mining parameters such as depth of cover and seam gas content, as well as the sizeable capital investment already made in the existing longwall equipment.

### 2.1.2 Multi-factor analysis

The initial step in the 2014 assessment was to reduce the number of options considered by undertaking a multi-factor analysis. The remaining options were then selected for further analysis using an economic cost-benefit assessment.

This analysis applied weightings to scores across multiple assessment criteria to determine the most suitable options for further analysis. Assessment criteria were evaluated for each identified option according to economic, environmental, social, technical, and safety categories.

Certain options were also ruled out after failing to meet key criteria and technical hurdles – one of those being the capacity to meet the required throughput rates.

A summary of the outcome of the multi-factor analysis is provided below in Figure 2. The preferred option of full surface emplacement ranked as the number 1 option in the multi-factor analysis. Alternatives 2-4 and 6-9 were ruled out due to their inability to meet key criteria, and Alternative 5 was the only other option be taken for further cost-benefit analysis. Alternative 5 is a partial underground and surface emplacement option.

| WEIGHTED SCORES | | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 | Alternative 5 | Alternative 6 | Alternative 7 | Alternative 8 | Alternative 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Surface disposal at existing REA | UG disposal as dry material | UG disposal as paste material (Disused Road, | UG disposal as paste material (Former Goaf | UG disposal as paste material (Active goafs via a | UG disposal as Slurry (Disused Road, Goafs via | UG disposal as Slurry (Former Goaf areas via | UG disposal as Slurry (Active goafs via a trailing | Reuse of Rejects Materials as Road base |
| **Category** | **Criteria** | Compatible | Incompatible | Incompatible | Incompatible | Compatible | Incompatible | Incompatible | Incompatible | Incompatible |
| Economic | Economic interference | 12 | 9 | 6 | 6 | 6 | 6 | 6 | 6 | 9 |
| | Low CAPEX (compared to other | 25 | 10 | 10 | 10 | 5 | 15 | 10 | 10 | 15 |
| | Low impact on available reserve | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 16 | 20 |
| | Low impact on production | 20 | 10 | 25 | 25 | 15 | 25 | 25 | 5 | 25 |
| | Low OPEX (compared to other | 20 | 10 | 5 | 5 | 5 | 5 | 15 | 15 | 25 |
| | Requires minimum processing c | 20 | 20 | 4 | 4 | 4 | 12 | 12 | 12 | 20 |
| Environmental | Dust emissions are minimal | 10 | 15 | 25 | 20 | 25 | 25 | 25 | 25 | 10 |
| | Low GHG Emissions | 4 | 4 | 12 | 12 | 12 | 12 | 12 | 12 | 8 |
| | Low risk of groundwater and su | 15 | 15 | 10 | 10 | 10 | 10 | 5 | 5 | 15 |
| | Low water usage | 20 | 20 | 20 | 20 | 20 | 4 | 4 | 4 | 16 |
| | No leachate contamination to t | 25 | 25 | 5 | 5 | 5 | 5 | 5 | 5 | 25 |
| | Offers good control of spills | 16 | 16 | 8 | 12 | 8 | 12 | 12 | 4 | 12 |
| | Reduced Visual Impact | 6 | 10 | 10 | 8 | 10 | 10 | 8 | 10 | 4 |
| | Rejects are emplaced / containe | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 9 |
| | Requires minimal use of foreign | 20 | 20 | 8 | 8 | 8 | 8 | 8 | 8 | 20 |
| Safety | Is safe in application and causes | 20 | 5 | 15 | 20 | 15 | 20 | 20 | 15 | 15 |
| | Level of experience at Xstrata o | 15 | 9 | 3 | 3 | 3 | 9 | 9 | 6 | 12 |
| | Low impact on mine stability | 12 | 12 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Low Risk of liquefaction of emp | 15 | 15 | 12 | 12 | 12 | 3 | 3 | 3 | 15 |
| | Risk of damaging bulkheads | 10 | 10 | 8 | 8 | 8 | 6 | 4 | 10 | 10 |
| Social | Limited noise emission | 4 | 12 | 16 | 12 | 16 | 16 | 12 | 16 | 8 |
| | Reduced footprint, limiting the | 3 | 15 | 15 | 6 | 15 | 15 | 6 | 15 | 15 |
| Technical | Dependence on local geologic c | 20 | 8 | 12 | 8 | 8 | 12 | 8 | 8 | 20 |
| | High Automation | 2 | 2 | 8 | 10 | 8 | 8 | 10 | 8 | 8 |
| | High reliability | 16 | 12 | 12 | 4 | 4 | 16 | 4 | 8 | 12 |
| | Increased subsidence control | 3 | 6 | 9 | 9 | 12 | 9 | 9 | 12 | 3 |
| | Is versatile and flexible | 12 | 9 | 3 | 3 | 9 | 3 | 3 | 9 | 3 |
| | Low Geological confidence neec | 15 | 12 | 9 | 6 | 9 | 9 | 6 | 9 | 15 |
| | Low Maintenance | 16 | 12 | 12 | 12 | 8 | 12 | 12 | 12 | 16 |
| | Proven technology | 15 | 15 | 9 | 9 | 3 | 12 | 9 | 9 | 15 |
| | Meets capacity and throughput | 25 | 5 | 10 | 10 | 20 | 5 | 5 | 15 | 5 |
| Totals | | 451 | 378 | 351 | 327 | 333 | 354 | 317 | 322 | 420 |
| Ranking | | 1 | 3 | 5 | 7 | 6 | 4 | 9 | 8 | 2 |
| Compatible Solution | | Yes | No | No | No | Yes | No | No | No | No |

**Figure 2 - Summary results of multi-element analysis (SKM, 2014)**

### 2.1.3 Cost-benefit analysis

The cost-benefit analysis completed in 2014 is summarised in Figure 3 below. It must be noted that the option numbering changed in the later chapters of the SKM report and Option 2 below corresponds to Alternative 5 in the multi-element analysis. Option 1A related to a hypothetical option where the NSW government reject emplacement levy applied for part of the surface REA.

| Decision criteria | Option 1 | Option 1A | Option 2 |
|---|---|---|---|
| PV Costs | -$17.6 | -$17.6 | -$63.1 |
| PV Benefits | $139.6 | $135.7 | $114.3 |
| NPV | $121.9 | $118.0 | $51.3 |
| BCR | 7.91 | 7.69 | 1.81 |
| IRR | 58% | 58% | 9% |

**Figure 3 - Excerpt from SKM (2014), summary of costs and benefits**

The 2014 SKM report found that the expanded surface REA under Option 1 (full surface disposal) would result in the best cost-benefit ratio. Under Option 1, the loss of native vegetation resulted in environmental costs of $7.13 million in 2013 Australian dollars, compared to the base-case of full-offsite disposal. This cost was based on a total expansion of the surface REA of 200 Ha, of which 132 Ha would require a land acquisition for the purposes of offsetting. Under the SKM CBA, these environmental costs were classified as negative benefits, and therefore are not included in the total present value of costs (the row labelled "PV Costs") shown in Figure 3. Regardless of their treatment as costs or negative benefits, the net outcome is the same.

The operating savings for both options analysed are presented relative to the cost of the "base case", which was assumed to be 100% offsite disposal at the Glenlee facility operated by SADA once the existing approved REA was full. The cost of offsite disposal includes the NSW government's offsite coal reject emplacement levy.

It is not clear from the SKM report whether any externalities from offsite disposal were factored into this cost estimate. Examples of potential externalities under the base case include impacts from truck movements on public roads, air quality and noise impacts on neighbouring residences to the Glenlee site, and remnant vegetation clearing at the alternative (offsite) emplacement area.

## 2.2 Literature review

Other literature reviewed for this gap analysis has included:

- Worsley, J.H., Marsh, J.E., Patel, R. and Feldman, S.B., 'Optimisation and stabilisation of coal rejects at the Peabody Metropolitan Mine using Acti-Gel® 208', in RJ Jewell and AB Fourie (eds), *Proceedings of the 18th International Seminar on Paste and Thickened Tailings, 2015*, Perth, Western Australia, ISBN 978-0-9924810-1-8, pp.309-319.
- Metropolitan Coal 2018 Annual Review

- Metropolitan Coal 2017 Annual Review
- Metropolitan Coal CCC meeting minutes (April 2016 - April 2019)
- Hume Coal Environmental Impact Statement
- Hume Coal Response to Submissions
- Hume Coal Submission to the IPC

### 2.2.1 Metropolitan Colliery

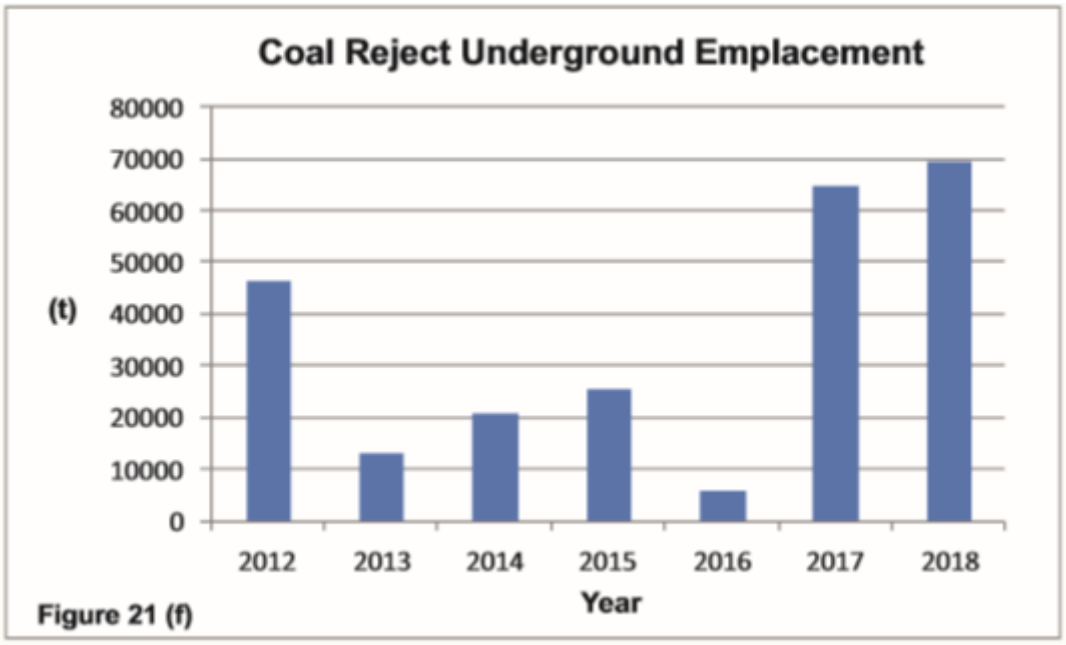
A summary of the findings of the literature review for Metropolitan Colliery is provided below.

- Only around 16% of reject material has been emplaced underground in the last year to-date, 2018 (2018 Annual Review)
- During the 2016 review period, the capacity of the coal reject backfill emplacement plant was upgraded to allow up to 60% of coal rejects generated by Metropolitan Colliery to be disposed of by underground emplacement into the operating goaf. (2018 Annual Review)
- The operating cost of underground emplacement at Metropolitan Colliery is higher than the cost of trucking the reject materials for offsite disposal (April 2018 CCC minutes)
- Transport of rejects offsite via rail has been trialled (April 2019 CCC minutes)
- A rheology modifier trialled in 2015 was successful in assisting with maintaining non-settling behaviour in the material trialled (Worsley et al., 2015)

It is also understood that:

- Emplacement behind the active longwall has been undertaken (December 2016 CCC minutes), however
- Activities have shifted back to emplacement of fines in old workings
- Only fines are being emplaced underground in old workings or behind longwall supports.
- All coarse reject is still trucked offsite.
- The site does not operate any type of milling facility to produce a thixotropic paste.

Figure 4 below is an extract from the Metropolitan Colliery 2018 Annual Review and shows the historical tonnages of reject emplaced offsite at the Glenlee facility and in the mine workings at Metropolitan Colliery. In 2018, around 69,000 tonnes of reject material was emplaced underground and around 295,000 tonnes was trucked offsite to Glenlee. A further 74,000 tonnes was trucked to an urban development site for use as engineered fill material. This represents around 16% of the total volume of reject material produced being emplaced underground.



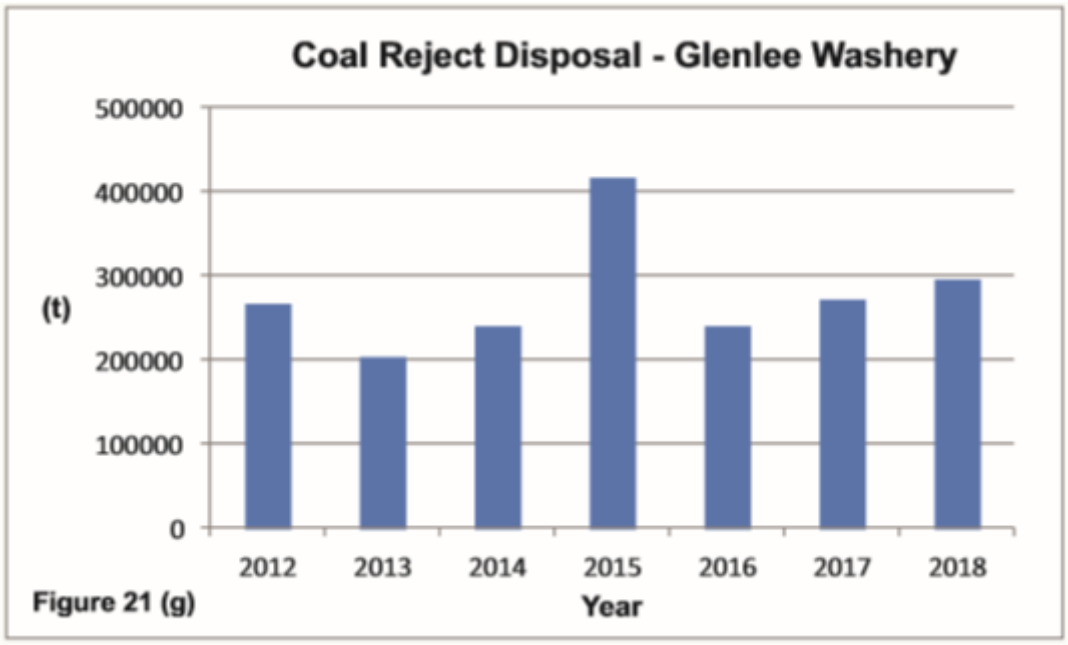




**Figure 4 - Offsite and underground reject emplacement history at Metropolitan Colliery (Metropolitan Coal 2018 Annual Review)**

### 2.2.2 Hume Coal project

The literature review for the Hume Coal project has revealed the following findings of relevance to the Tahmoor South project:

- The proposed non-caving mining method was specifically designed to facilitate underground reject emplacement in open mine voids (EMM, 2017)
- The use of underground reject emplacement is more expensive than an alternative of surface emplacement (EMM, 2019)
- The addition of 1-2% cement to the reject to provide a solid-setting material resulted in unacceptable alkalinity in the potential leachate water. (RGS, 2017)
- The use of paste backfill was discounted as an option because of the variability of the particle sizing in the feed. (EMM, 2019)

- Uncertainty over the availability and ability to effectively utilise goaf void space was a contributing factor to ruling out the use of miniwalls or full extraction bord and pillar methods for the mining system. (EMM, 2017)
- Consideration of the emplacement of unconsolidated reject in underground panels was one of the drivers of panel design and orientation, so that the majority of panels run down-dip away from the main headings (EMM, 2017)

# 3 GAP ANALYSIS

A gap analysis has been undertaken to determine where any additional work may be of benefit in assessing the potential reject emplacement options for the Tahmoor South project.

None of the gaps identified are material enough to change the overall conclusions reached in 2014. This is because the key finding of the original report remains valid – the environmental benefits currently do not outweigh the costs and risks of underground emplacement in an active longwall goaf.

The key gaps identified include:

- The base year of the economic assessment
- The size of the REA under the preferred case
- The cost of externalities
- Plant assumptions
- New knowledge around rheology modifiers
- New knowledge around the behaviour of reject in longwall goafs

| Item | SKM report | Update | Palaris view | Justification |
|---|---|---|---|---|
| Base year of assessment | 2013 | 2019 | 2019 would be an appropriate base year, however this would not change the conclusions of the report | The conclusions are based on the relativities between the options, which will not change with a change in base year |
| Size of REA | 200 Ha | Tahmoor South EIS provides the size of the REA expansion footprint as 11.06 Ha | The smaller size of the surface emplacement expansion area should add to the case for surface emplacement | Tahmoor South EIS |
| Cost of externalities for expanded REA | A$7.31 million | Tahmoor South EIS: approx. A$14M | Does not change the conclusions of the 2014 SKM report because the benefits of surface emplacement still outweigh the costs by multiples | The capital cost to retrofit pipe ranges and paste plant is a multiple of the total externality cost. In addition, operating costs for underground emplacement are higher than for surface emplacement. |

| Item | SKM report | Update | Palaris view | Justification |
|---|---|---|---|---|
| Plant assumptions | -Crushing-only comminution strategy<br>-Rubber lined pipe<br>-No strategy for sticky materials<br>-Mechanical costs A$2.7M | -Likely difficult to emplace coarser material into LW goaves<br>-Pipe wear may necessitate basalt lining<br>-Materials may need to be processed through log washers prior to crushing<br>-Mechanical costs may need to be updated | The updated assumptions will not alter the overall conclusions of the initial SKM report | The updated plant assumptions support surface emplacement |
| Rheology modifiers | Some form of rheology modifier used (Cellcrete's proprietary product) | An alternative rheology modifier was tested with positive results | Has no material impact on the overall conclusions of the initial SKM report | Some form of rheology modifier was already assumed to be successfully utilised by the SKM report |
| Behaviour of reject in goaves | Material can only be emplaced behind supports when seam dip is favourable | Supported by the mine design principles used at Hume Coal and by experience at Metropolitan Colliery | Has no material impact on the overall conclusions of the initial SKM report | Recent experience supports the assumptions in the SKM report |

**Table 1 - Gap analysis summary**

## 3.1 The base year of the economic assessment

The original work was undertaken in 2013/2014 and used 2013 as the base year for the assessment. Prices and costs would have changed marginally since 2013, however it is unlikely that this change would be enough to change the relativities between the options assessed.

A more contemporary base year for assessment purposes would be 2019.

No action is considered necessary, however if the economic assessment is updated, more recent prices should be sought from suppliers and incorporated into the assessment.

## 3.2 The size of the REA under the preferred case

The size of the REA under the preferred option has shrunk from some 200 Ha in 2014 to some 67 Ha under the approval sought in 2019.

This should favour full surface emplacement over underground emplacement or a hybrid surface/underground option, when compared to the 2014 assessment.

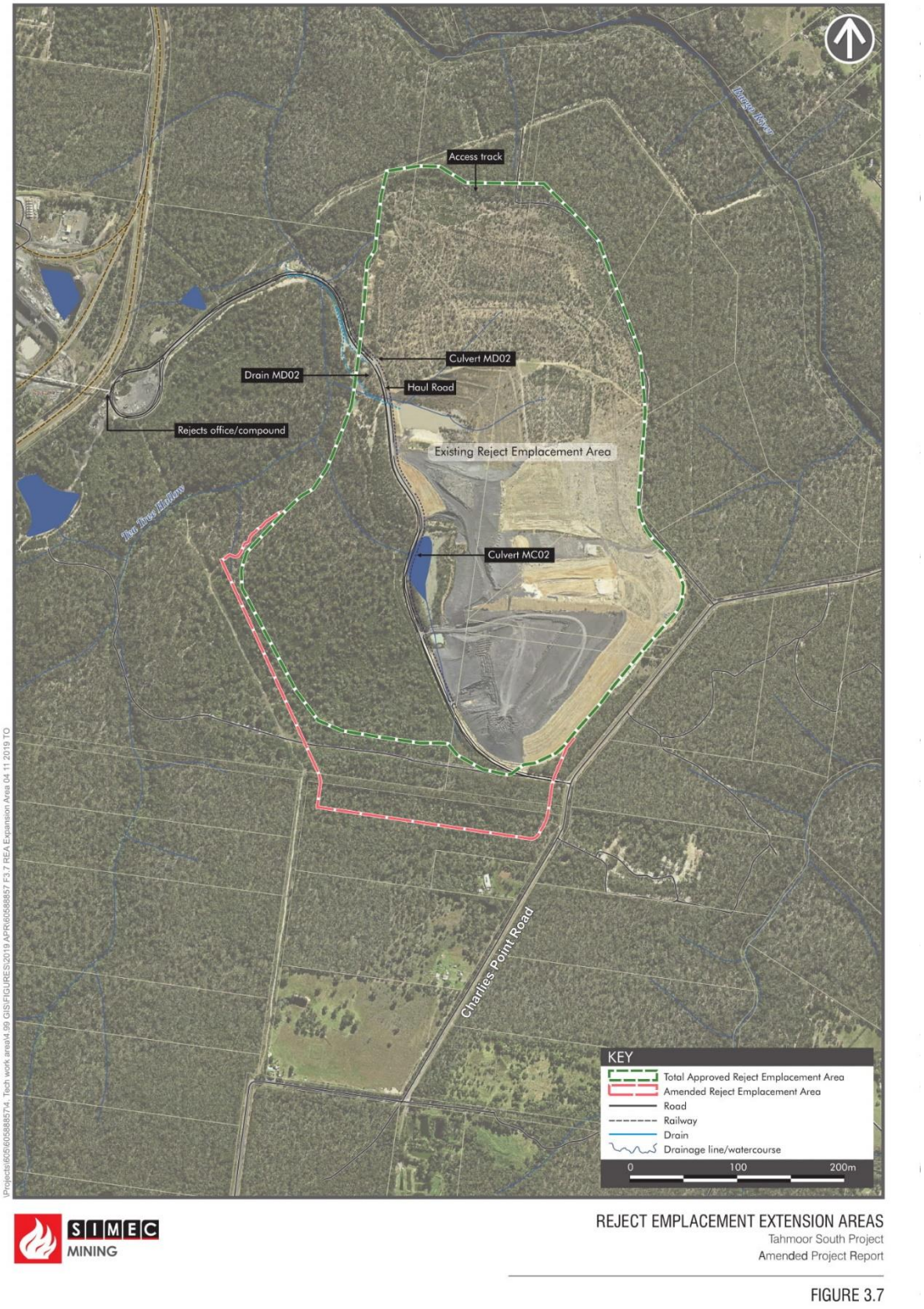



**Figure 5 - Size of proposed surface emplacement area in the 2019 EIS**

## 3.3 The cost of externalities

The cost of externalities (primarily biodiversity offsets) has grown since the 2014 assessment, from an assumed net cost of $7.13 million in 2013 Australian dollars to approximately $15 million in 2019 dollars. This assumes that around $4 million of the total biodiversity offset cost is related to the ventilation shaft site in the 2019 assessment, equating to 420 credits for HN556 habitat, discounted back to 2019 dollars. The 2014 report is silent on whether any external costs were assumed under the base-case (offsite disposal at Glenlee). It is assessed to be unlikely that some 20Mt of reject could be trucked to the Glenlee site with no external costs, particularly given the amount of residential development that has occurred recently in the Spring Farm and Mt Annan area.

In addition, the EIS quantified $10 million in noise-related externalities for the project in aggregate, however it is not possible to determine whether any of this is related to the REA. From the noise contours provided in the noise assessment, it appears that most of the affected receptors are west of the mine and therefore not in the vicinity of the REA, which is to the east.

On-balance, the impact of the increase in assessed external costs is likely to be somewhat moderated if the costs of externalities of the off-site trucking option were correctly accounted for.

This increase in external costs of surface emplacement is unlikely to change the overall assessment; however, it may add weight in favour of the underground emplacement option.

## 3.4 Plant assumptions

Four key assumptions have been found in the SKM report that are potentially able to be updated:

### 3.4.1 Comminution strategy

It is unknown how particles as large as 5 millimetres (or greater) would behave in a longwall goaf, and whether this particle size would allow effective penetration of the material into the goaf void interstices, when compared to a true paste comprised only of fine particles. A commonly accepted rule of thumb is that bridging of aggregate particles can occur when an aperture of less than 5x the particle size is encountered, meaning that particles of 5 mm may not effectively penetrate voids of less than 2.5 cm aperture. The immediate roof of the Bulli Seam on the South Coast is typically laminated siltstone and sandstone. This material tends to break up quite well in a goaf. Individual particles can be quite small, and the roof tends to fall immediately behind the roof supports, grinding itself into smaller particles in the process. There is typically no roof cantilever behind the hydraulic supports and the goaf is observed to pack quite tightly behind the supports – with the exception to this being immediately alongside the chain pillars, where open voids can persist for some metres behind the face, aided by the roof bolts installed in the gateroad.

A material with a fine paste consistency may be able to be forced through the pore spaces in the broken rock behind the longwall supports – in a manner akin to pressure-grouting broken rock to consolidate it, however, a sub-5mm reject material may be problematic due to particle bridging. It is unknown whether a rheology modifier such as Acti-gel would alleviate or worsen this issue. Furthermore, the impacts of such additives on groundwater, as well as their potential for health impacts on workers would need to be assessed.

The addition of grinding or milling plant (e.g. a rod or ball mill) would be required to produce a true non-settling paste that could readily penetrate such pore spaces. Such plant is likely to substantially increase the capital and operating costs of the reject paste plant and will heavily tilt the assessment to favour full surface reject emplacement.

An alternative option is to only emplace fines and ultrafine reject underground. Under this option, the crushers can be removed altogether from the proposed plant list, however the surface emplacement would still need to be expanded. Under this option, perhaps 15-20% of the total reject material could be emplaced underground – a similar percentage of the overall coal reject material to what is being achieved at Metropolitan Colliery where fines and ultrafine material is being emplaced underground and coarse reject is being disposed of elsewhere.

It is understood that this is the option that the EPA has asked the proponent to explore in more detail.

### 3.4.2 Pipe lining type

SKM (2014) assumed the pipes quoted for the reticulation of reject materials down the drift and into the underground workings would be rubber lined. It is uncertain whether rubber lining would provide enough longevity to be the most cost-effective option, considering lifecycle costs. It is understood that both Metropolitan Colliery and the proposed system at the Hume project opted for basalt lined pipes in at least part of the reticulation system. In the case of the Hume Coal project, basalt lined pipes were costed into the project capital estimate for the parts of the reticulation system where the longest pipe life was desired (i.e. on the surface and in the drift), with a lower specification of pipe in less critical areas, such as sections within mining panels. Rubber lined pipe may be more appropriate for applications where a true non-settling paste (and therefore lower pipe velocity and smaller particle size) were to be used.

### 3.4.3 Crusher/material compatibility

Horizontal and vertical shaft impact crushers risk becoming clogged if they are used with clayey and/or moist materials. Coal reject material is typically shaly and clayey and can be very sticky. The Tahmoor South EIS describes the reject material as consisting "mostly of the shale and claystone material from the roof and floor of the underground workings with a small proportion of carbonaceous material and coal from the seam" (p. 3-11). It is due to the stickiness of the material that the Hume Coal project chose to utilise log washers in the process flow sheet to remove clayey materials from the crusher feed. Sticky material can also enter the reject feed from areas of atypical geology – for instance, where a dyke or sill is encountered – both of which are relatively common on the Southern Coalfield.

The addition of log washers into the process flow sheet is likely to slightly increase project capital and operating costs and therefore favour the surface emplacement option. Further test work might be required to determine if a log-washer was necessary for Bulli Seam rejects, however this is not required if only fines are to be emplaced underground, since no crushers would be needed for this option.

### 3.4.4 Capital cost estimate for underground emplacement

The capital cost estimate for the underground emplacement option might have some areas that are contestable. For example, the mechanical component has a direct cost of $2.71 million (in 2013 Australian dollars), and this is stated to include all crushers, pumps, tanks, mixer, thickener and piping (except the underground reticulation). A cost breakdown of individual items is not provided, however, the direct cost appears to be insufficient, particularly considering the cost of Geho or MW Wirth high-capacity positive displacement pumps, which are likely in the order of $1M each (depending on the exact specification), and for a project of this nature at least two such pumps would be required to provide a spare in-line pump in case of pipe blockage and possible a third in a warehouse as a critical spare.

This may be offset by the factored 20% EPCM cost applied to the reticulation pipework, which adds around $6m to the project capital cost for what is essentially a procurement item; or covered by the assumed project contingency which equates to about 18% of the direct costs.

On balance, these issues are likely to cancel each other out and to have little bearing on the overall assessment.

## 3.5 New knowledge around rheology modifiers

Worsley et. al., 2015 found that the use of the Acti-gel rheology modifier was successful in creating a non-settling fill to minimise the risk of pipe blockage and to reduce the pressure drop in the pipeline, using a reject sample from Metropolitan Colliery with a reported top size of 16 mm. The fines portion of the particle size distribution in the Acti-gel trial appears to be similar to the assumed PSD from the HSI and VSI crushers for Tahmoor South, and so the modifier is likely to achieve similar results for Tahmoor South coal reject material.

## 3.6 New knowledge around the behaviour of reject in longwall goafs

It is understood that Metropolitan Colliery has trialled the emplacement of reject material into longwall goafs, and the assumptions made for the Tahmoor South assessment as to seam dip and beaching angles have largely been validated.

Furthermore, test work conducted for the Hume Coal project found that the addition of cement (at dose rates of 1-2%) substantially increased the alkalinity of leachate water, ruling out the addition of cement for environmental reasons.

# 4 REVISED CBA FOR 20% UNDERGROUND EMPLACEMENT

The only option that is therefore able to be technically implemented with relative certainty in a longwall goaf setting using current knowledge and experience is the underground emplacement of fines and ultrafines, with the surface emplacement of all other coarse fractions. An attempt to quantify costs and benefits of this option in 2019 dollars has therefore been undertaken to determine if this option has any economic merits.

## 4.1 Base case

The assumed base case for the purposes of this exercise is the case for which approval has been sought (full on-site surface emplacement). Net costs and benefits under an option where 15-20% of the total reject material is emplaced underground are presented relative to this case.

## 4.2 Benefits

Under an option where 15-20% of the total reject material is emplaced underground (compared to 70% under the original 2014 assessment), the following environmental benefits are considered to be reasonable estimates:

| Cost/Benefit | Change | Explanation | Basis of assumption | Value (2019 AUD) |
|---|---|---|---|---|
| Biodiversity | A 20% reduction in the total NPV of the biodiversity cost for the enlarged REA as assessed in the EIS | The EIS supersedes the SKM report. | Based on a 20% reduction in native veg clearing area | A$3 million |
| Noise | A 5% reduction in the NPV cost of noise externalities assessed in the EIS | Noise was not considered in the SKM report | Most noise receptors are west of the mine pit-top, and the REA is east of the pit-top, therefore the impact of a 20% reduction in activities at the REA likely has little positive noise impact | A$0.05 million |
| Net benefits | | | | A$3.05 million |

**Table 2 - Environmental costs mitigated by 20% underground emplacement**

## 4.3 Costs

It is not possible that a paste plant with underground reticulation could be installed and operated over the life of mine for a cost difference (in NPV terms) of only A$3.05 million, which is what would be necessary to achieve a benefit to cost ratio for the proponent of greater than unity.

The assumed capital cost for a plant and underground reticulation with the capacity of 70% of the total reject material generated by Tahmoor South was estimated to cost $59 million in 2013 dollars. The capital cost of a plant with 20% capacity does not scale linearly from a plant with 70% capacity because many of the costs involved are identical regardless of the capacity. For example, all of the instrumentation costs will be identical, the length of pipe required is identical and many of the earthworks, foundation costs and design costs will be similar, if not identical.

Even if the costs were linearly proportional to capacity (i.e. 100% variable), the factored capital cost at 20/70 of the capacity assumed in the original SKM report is $17 million in 2013 dollars, outweighing any environmental benefits from a reduction in biodiversity offsets and noise.

For the purposes of this exercise, however, it has been assumed that 40% of the original 2014 capital cost estimate is relatively fixed in nature and the other 60% is variable based on throughput. This is shown in Table 2 below.

Similarly, the capital costs associated with surface emplacement are not linearly reduced, since many costs for this facility are also fixed – for example, haul road and sediment dam construction, and plant mobilisation and demobilisation. Under the 2014 SKM report, the capital cost in 2013 dollars for full surface emplacement was A$29 million, and for an option with only 30% surface emplacement, the capital cost was estimated to be $26 million, meaning that most of the capital works for an expanded REA needed to be done whether a large or small expansion were carried out.

| Cost/Benefit | Change | Explanation | Basis of assumption | Value (2019 AUD) |
|---|---|---|---|---|
| Underground emplacement CAPEX | A$59 million (2013) >> A$38 million (2019) | A$59M (2013)<br>At 2% p.a. escalation:<br>A$66.44M (2019)<br>Of which it is assumed:<br>40% is fixed<br>60% is variable | Professional judgement. Sensitivities also conducted at 60% fixed and 20% fixed | A$38 million (40% fixed)<br>Sensitivity 1: A$47.5 million (60% fixed)<br>Sensitivity 2: A$28.5 million (20% fixed) |
| Surface Emplacement CAPEX Reduction | A$3 million (2013) >> A$3.3 million (2019) | Used the entire capex reduction for the 30% surface emplacement only option | The analysis is insensitive to variation in the surface emplacement area, since most of the cost is fixed regardless of the size of REA expansion | A$3.3 million |
| Resource sterilisation | Unquantified cost | The underlying Wongawilli Seam may be sterilised due to the inrush hazard associated with underground fines emplacement | | Unquantified cost |
| Operational complexity | Unquantified cost | Complexity of emplacing reject into active longwall extraction panels introduces interdependencies between the longwall and emplacement systems | | Unquantified cost |
| Operating costs | Unquantified cost | Operating costs for underground emplacement are higher than for surface emplacement | | Unquantified cost |
| Net costs | | | | Greater than A$34.7 million |

**Table 2 - Cost-benefit summary of fines underground emplacement option**

The net capital costs of a partial underground emplacement option outweigh the potential environmental benefits by around 11:1, under the base case assumptions, when compared to full surface emplacement, without quantifying a range of other potential costs.

# 5 CONCLUSIONS

Palaris Australia reviewed a range of publicly available documents to gain an understanding of the advances in knowledge gained since the SKM reports were completed in 2014.

A subsequent gap analysis was undertaken to identify any potential gaps in the original work, and any new knowledge that has been gained as an industry since that time.

A number of areas were identified where different or new assumptions could have been utilised in the original SKM report, including:

- The base year of the economic assessment
- The size of the REA under the preferred case
- The cost of externalities
- Plant assumptions
- New knowledge around rheology modifiers
- New knowledge around the behaviour of reject in longwall goafs

It is assessed, however that none of these items would materially alter the conclusions of the work undertaken by SKM in 2013 and 2014.

Specifically, the conclusions that remain valid are that:

- There is unlikely to be enough void space to emplace the material in old workings; and re-entry to sealed parts of the existing mine was assessed to be costly, technically challenging and present an increased operational and safety risk profile.
- It is not feasible to emplace all of the reject material generated by the proposed Tahmoor South project underground in the active longwall goaf, particularly at a product yield of 70-80 %, however, it may be feasible to emplace part of the material in the goaf, under certain conditions (e.g. favourable seam dip directions and goaf conditions).
- Apart from TCCO's preferred option of full surface emplacement of the reject material, the only other viable option involves operating a surface emplacement facility and an underground emplacement facility simultaneously. The environmental benefits of this partial underground solution do not outweigh the additional costs it would incur compared to a base-case of 100% on-site surface emplacement – as sought in the DA. The reason for this is that any potential environmental benefit is relatively small compared to the additional capital and operating costs that would be incurred in setting up and running the additional processing plant, pumps, pipelines and modified longwall equipment, not to mention the increase in operational complexity, nuisance and risk associated with emplacing part of the reject into the active longwall goaf.
- A further consideration in the assessment which has not been quantified in the initial cost-benefit analysis is the potential for the full or partial sterilisation of resources in the underlying Wongawilli Seam.

The only option that could be technically implemented in an active longwall goaf setting (requiring favourable geological dip and sufficient goaf porosity) is the underground emplacement of fines and ultrafines; with the surface emplacement of all coarse fractions. In Tahmoor South the Bulli seam dip is regionally in a NE direction (perpendicular to longwall retreat direction) and very flat between 1-2 degrees which is unfavourable in achieving effective emplacement of fines and ultrafines. Significant further studies would be required to determine

whether this option could achieve emplacement of material amounts of fines and ultrafines. An estimate of costs and benefits of this option in 2019 dollars has been undertaken with an estimated net cost of greater than A$34.7M.

The total environmental benefits of an option where some 20% of the material is emplaced underground are outweighed 11:1 by the increase in capital costs of this option alone. This does not even consider the additional costs associated with resource sterilisation, plant reliability, increased operational complexity and operating costs arising from underground emplacement.

# 6 RECOMMENDATIONS

It is recommended that the current strategy of 100% surface emplacement continue to be pursued for the Tahmoor South project, on the basis of the fact that this alternative represents the best value to TCCO and does not unduly increase operational complexity and risk.

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