PART FIVE
VIABLE REHABILITATION OPTIONS

PART 5 VIABLE REHABILITATION OPTIONS

5.1 OVERVIEW

Term of Reference 8 requires the Board to inquire into and report on short, medium and long-term options to rehabilitate land on which work has been, is being, or may lawfully be done in accordance with a work plan approved for the Hazelwood mine, the Yallourn mine, and the Loy Yang mine; and in relation to which an application for variation of the work plan is under consideration for the Hazelwood mine, the Yallourn mine, or the Loy Yang mine.

This Part identifies rehabilitation options for open cut mines, then assesses them to identify which are potentially viable options for the rehabilitation of the Latrobe Valley mines. In Part 6 of this report, the potentially viable options are assessed in detail against the criteria provided in Term of Reference 9.

Term of Reference 8 does not define 'short', 'medium' or 'long-term'. The Board has therefore adopted the following time periods:

Short-term: from now until the end of mining operations.

Medium-term: from the end of mining operations to 15 years after the end of mining operations.

Long-term: the period commencing 15 years after the end of mining operations.

The Board understands 'options for rehabilitation' under its Terms of Reference to mean options for final rehabilitated landforms. The Board considers that the 'final land use' of the mines is a separate consideration, which is dependent on the landform achieved.

In considering Term of Reference 8, the Board sought advice from a number of experts. The Board commissioned a report from Jacobs Group (Australia) Pty Ltd (Jacobs), titled *Review of future rehabilitation options for Loy Yang, Hazelwood and Yallourn coal mines in the Latrobe Valley*[1] (the Jacobs options report). The Jacobs options report also provides a high-level technical analysis of rehabilitation options against the criteria in Term of Reference 9.

In response to the Jacobs options report, AGL Loy Yang retained Adjunct Professor Timothy Sullivan, Director and Principal of Pells Sullivan Meynink, who produced a report titled *Hazelwood Mine Fire Inquiry: Expert report on rehabilitation relevant to Loy Yang mine*.[2] GDF Suez retained Dr Christopher Haberfield, Principal Geotechnical Engineer and Principal, Golder Associates, and Dr Clint McCullough, Associate and Principal Environmental Scientist, Golder Associates, who each produced a report, titled *Hazelwood Mine Fire Second Inquiry: Review of Jacobs' report* and *Hazelwood Mine Fire Inquiry – Terms of Reference 8 and 9* respectively.[3] The State, EnergyAustralia and Environment Victoria did not provide any expert reports to the Board.

The Board also obtained statements from Professor Jim Galvin, Chair, Technical Review Board; Professor Rae Mackay, Director, Geotechnical and Hydrogeological Engineering Research Group (GHERG), Federation University Australia; and Ms Corinne Unger, a Board member of the Technical Review Board.

On 3 December 2015, the Board convened a meeting of technical experts to further inform its deliberations. Professor Galvin, Dr Haberfield, Professor Mackay, Dr McCullough, Adjunct Professor Sullivan, and Mr Greg Hoxley, Principal Hydrogeologist at Jacobs, participated in the meeting.

The Board posed a number of questions to these experts relevant to rehabilitation objectives and principles, technical issues, landform options, research needs, and the mine operators' rehabilitation plans. The experts drafted a report for the Board in response to these questions, referred to as the 'joint expert report' in this report. Areas where the experts agree and disagree on rehabilitation options are highlighted in the joint expert report. The same group of experts gave evidence as a panel at the Inquiry's public hearings in Traralgon. Mr Charlie Speirs, the Latrobe Valley Mine Operations Adviser for the Jacobs options report, also gave evidence as part of the panel.

This Part is further informed by the submissions and evidence of the mine operators, the State, key stakeholders, and the community.

When considering rehabilitation options, the Board has taken into account:

- the purposes and key principles of rehabilitation
- the features of the Latrobe Valley region, including its landscape, coal resource, hydrogeology and environmental context
- the specific features of the mines.

5.2 REHABILITATION DEFINITIONS, AIMS AND OBJECTIVES

The features of each of the Latrobe Valley mines (such as size, depth, stability, available overburden, intersection of aquifers and proximity to infrastructure) dictate the features of final landforms.[4] In turn, the features of the final landform will to some extent limit potential final land uses. As discussed in Part 6 of this report, features of the Latrobe Valley mines, including their sheer size, their low strip ratio and their potential instability, have significant implications for the viability of landforms and therefore final land use options.

There is currently no definition of 'rehabilitation' in relation to coal mines in the *Mineral Resources (Sustainable Development) Act 1990* (Vic) (Mineral Resources Act). The joint expert report records that there are no generally accepted criteria that define 'safety' and 'stability'.[5] In the absence of widespread agreement about effective rehabilitation, the operators of each mine have nominated specific rehabilitation goals and objectives in their rehabilitation plans.

EnergyAustralia describes its rehabilitation goal for the Yallourn mine as designing a landform that:

- protects the safety and health of the public by ensuring mining hazards and residual environmental impacts are minimised
- is compatible with the surrounding natural and altered landscape
- is compatible with the surrounding natural landscape and existing landforms created by overburden disposal operations
- is sustainable and requires minimal ongoing maintenance
- expresses, where practicable, the land uses and ecological values that existed on this site prior to mining, within the limits of final land capability
- [s]upports future beneficial uses
- provides a diversity of landform, vegetation and wildlife values that is sustainable
- at [Yallourn North Open Cut], accommodates the volume of ash targeted under the Yallourn Energy ash disposal strategy...[6]

GDF Suez describes its rehabilitation and mine closure goal as providing 'a technically feasible, safe, stable and sustainable landscape that reflects the aspirations of stakeholders within the practical constraints of rehabilitation for the mine...'[7] The Hazelwood mine's rehabilitation plan states the following objectives of rehabilitation:

- A safe and stable self-supporting structure.
- To maximise the opportunities for establishment of a self-sustaining ecosystem.
- To minimise the use of natural resources.
- To minimise the cost of recovery of resources.[8]

AGL Loy Yang states that the aims of long-term rehabilitation of the Loy Yang mine are to:

- eliminate long-term exposed coal to reduce fire risk,
- create a geotechnical stable landform...
- [c]omplete the majority of the rehabilitation works within 15 years of closure; with a subsequent period of monitoring and maintenance as required.
- create a land form that provides access for maintenance and end use purposes.[9]

Drawing on applicable regulations and published guidelines, Adjunct Professor Sullivan proposed the following list of 'objectives and principles' that he considers 'appropriate for an open cut coal mine, regardless of its location and particular characteristics':

a. Ensure the statutory requirements are met.
b. The long term objective of rehabilitation is to convert the area to a safe and stable condition.
c. Safety is a high priority and post closure the mine should be left in a condition that ensures public safety.
d. Erosion must be minimised.
e. Recognition that the physical attributes of the site place ultimate constraints on what can be achieved with rehabilitation.
f. Absolute standards for stability are not set out rather there is recognition that because stability can be impacted by many elements including the site constraints (including the Setting), it is important to agree on the objectives for the landform associated with the final land use, including stability aspects.
g. Rehabilitate the land in accordance with appropriate post-mining land uses.
h. The final land use should be practical and achievable and the final landform should be compatible with the surrounding areas.
i. Develop well-defined rehabilitation plans.
j. Develop and create appropriate landforms, which will behave in a predictable manner.
k. Consult stakeholders and develop a closure plan that clearly defines the post-closure land use.
l. Agree success criteria with stakeholders.
m. Rehabilitate progressively, but commensurate with the rate of mining and the nature of the mining operation.
n. Undertake research into the land and water aspects.
o. Use appropriate technologies to reduce negative impacts.
p. Use appropriate standards.
q. Monitor, review and report on performance.[10]

The experts advising the Board considered Adjunct Professor Sullivan's list of objectives and principles at the meeting on 3 December 2015. There was general consensus among the group that these objectives were appropriate for each of the Latrobe Valley mines, with some experts suggesting minor changes. For example, Professor Mackay, Adjunct Professor Sullivan and Mr Hoxley suggested that management of fire risk should be added to the list, and Professor Galvin and Adjunct Professor Sullivan suggested that objective (c) be expanded to include 'public health and safety'.[11]

In the absence of a common definition of rehabilitation, the Board has taken into account the objectives agreed to by the experts, and the objectives under the mine operators' rehabilitation plans, when assessing potential options for rehabilitation.

5.3 POTENTIAL FINAL LANDFORMS AND THEIR VIABILITY

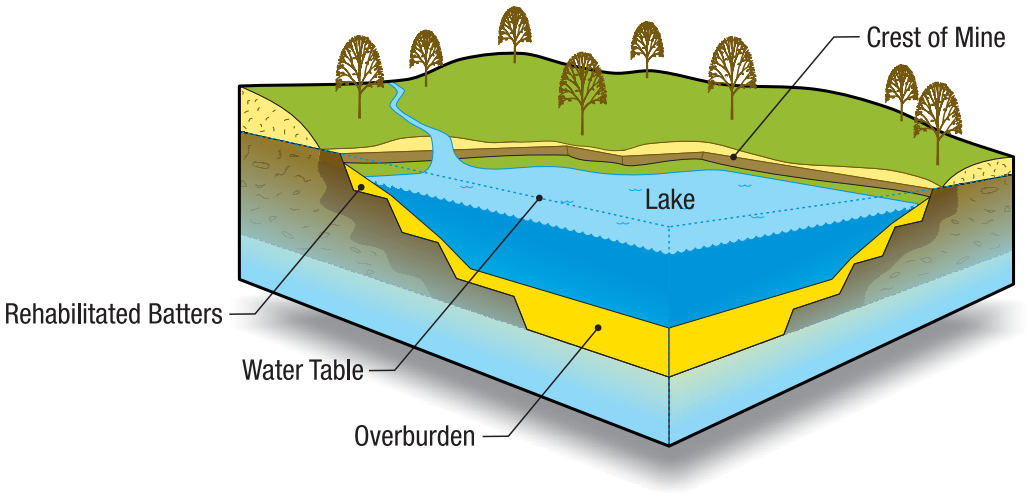
5.3.1 POTENTIAL FINAL LANDFORMS

The Jacobs options report identifies and assesses six final landforms that are potentially viable for rehabilitated open cut mines.[12] Each option is considered below.

PIT LAKE

Under this option, minimal overburden or non-polluting mine waste is placed back in the mine pit. A large, deep lake is then formed by filling the remainder of the mine pit to its crest with water.[13] The groundwater is allowed to recover to its natural level (the level prior to the commencement of dewatering). Water is likely to be diverted from adjacent natural waterways to maintain the water level. The lake will extend across the full breadth and width of the pit, with underwater batters to remain steep. Batters above water level are reshaped to land use requirements.[14] Disturbed areas outside the pit are reshaped and rehabilitated to meet land use requirements.[15]

Figure 21. Pit lake[16]



Pit lake case study – Lake Kepwari, Collie, Western Australia

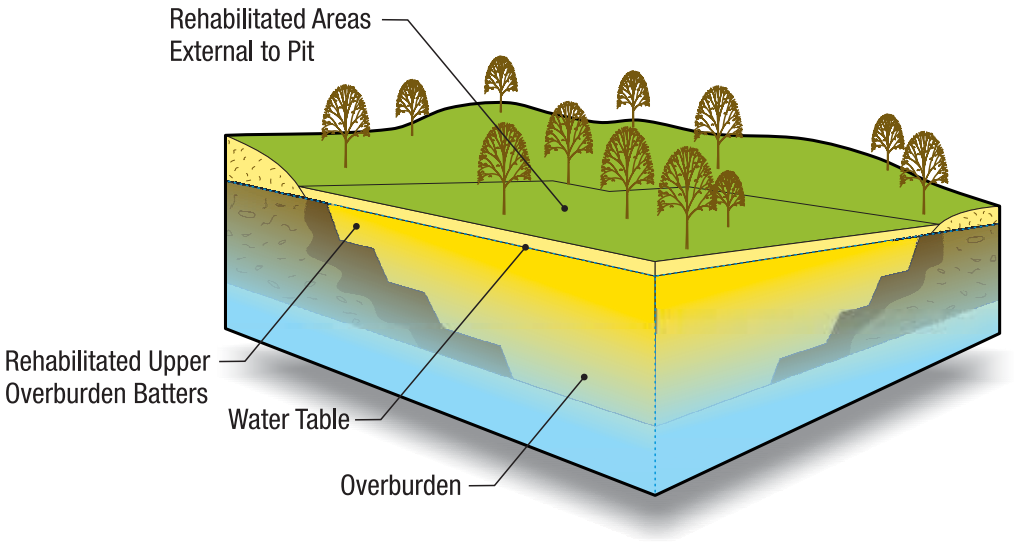
Lake Kepwari is an artificial lake situated in the southwest of Western Australia, approximately 10 kilometres southeast of Collie. The lake was an open cut coal mine from 1970 until 1996. It is approximately two kilometres long, one kilometre wide and 70 metres deep. It covers an area of around 100 hectares and holds roughly 30 gigalitres of water. Lake Kepwari took about five years to fill with water that was diverted from the Collie River South Branch.

Lake Kepwari's intended final land use was recreational uses such as boating and water skiing. However, public access to the lake has been delayed due to concerns about low pH levels and elevated metal levels. Lake Kepwari reconnected to Collie River South Branch during a flood event in 2011 and the subsequent improvement in lake water quality prompted an engineered lake–river flow through trial from 2012–14. The flow through trial proved successful in improving Lake Kepwari's water quality without adversely impacting on downstream water quality and beneficial uses.[17]

FULL BACKFILL

Under this option, the mine pit is fully filled to the crest level using all available overburden and non-polluting mine waste.[18] This landform will return the mine void area to approximately natural relief (the original ground level), allowing for rehabilitation of all disturbed areas without any water body. The pit area is reshaped to be free draining, so that water drains, or is diverted, to natural adjacent waterways, and the groundwater is allowed to recover to natural levels.[19] Disturbed areas outside the pit are reshaped and rehabilitated to meet land use requirements.[20]

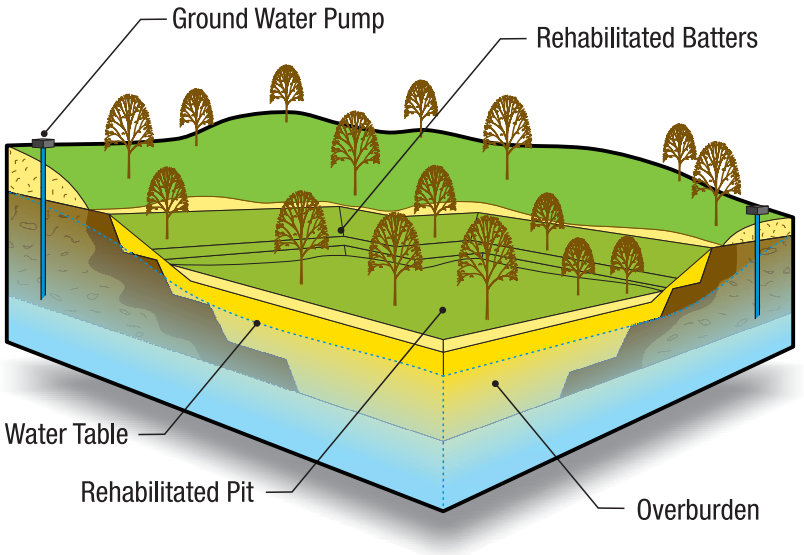
Figure 22. Full backfill[21]



PARTIAL BACKFILL ABOVE THE WATER TABLE

Under this option, the mine pit is partially filled with overburden and non-polluting mine waste to a level above the natural groundwater level. The groundwater is allowed to recover to natural levels. This creates a dry landform that is significantly lower than the mine crest and is not free draining (meaning that it will require active management, such as pumping, to remain dry). Batters above the filled area are reshaped to meet land use requirements. Disturbed areas outside the pit are rehabilitated to meet land use requirements.[22]

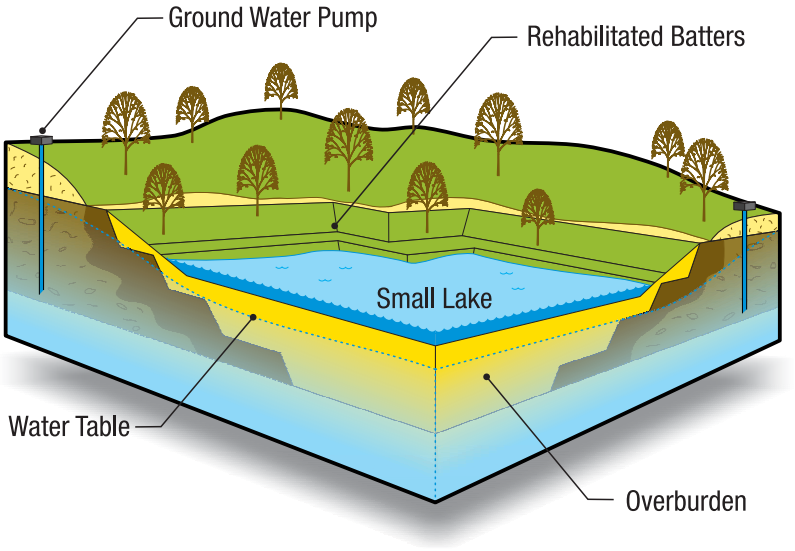
Figure 23. Partial backfill above the water table[23]



PARTIAL BACKFILL BELOW THE WATER TABLE

Under this option, the mine pit is partially filled with overburden and non-polluting mine waste. Areas below the natural groundwater level are filled with water to form a shallow lake (usually less than 50 metres deep). Some areas that have been backfilled will remain dry, but will be significantly lower than the mine crest. The shallow lake is not free draining. Batters above the water level are reshaped to meet land use requirements, and underwater batters are likely to be shallow.[24]

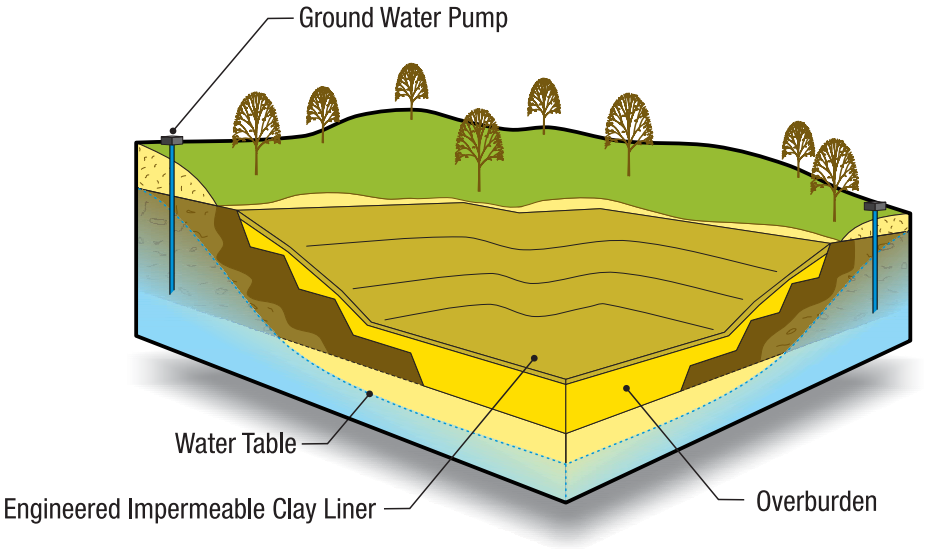
Figure 24. Partial backfill below the water table[25]



LINED VOID

Under this option, the mine pit is partially filled with overburden and non-polluting mine waste. The pit is then lined with clay to form an impermeable seal that inhibits the flow of water into or out of the pit. The area inside the pit is a significantly lower relief and is not free draining. Ongoing groundwater dewatering is likely to be required.[26]

Figure 25. Lined void[27]



Lined void case study – Woodlawn Bioreactor, New South Wales

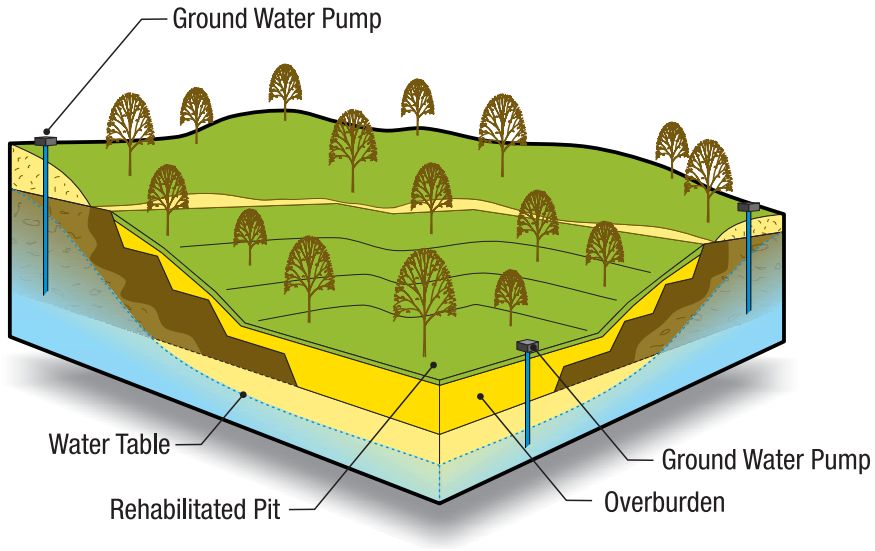
The Woodlawn Bioreactor is located south of Goulburn in New South Wales. It was formerly a copper, lead and zinc mine. In remediating the open cut mine, the site was re-graded, the road into the pit was secured, the water was pumped out, a liner was put in place and leachate and groundwater sumps were constructed.

The bioreactor was established in around 2004 at the site, which is capable of handling 400,000 tonnes of municipal waste from Sydney. The waste is hauled by train from Sydney, which is about 250 kilometres away. The facility, including the bioreactor and the wind farm, has the capacity to generate sufficient electricity to power an estimated 3,000 homes per year. The cost of the facility and associated remediation works was approximately $60 million. Aside from generating electricity from waste at the site, the operator is also undertaking rehabilitation works and has established an innovative wind farm, aquaculture and horticulture projects.[28]

REHABILITATED VOID

Under this option, the mine pit is partially filled and is rehabilitated as a dry lowered landform. The area within the pit is a significantly lower relief and is not free draining. Ongoing groundwater dewatering is likely to be required.[29]

Figure 26. Rehabilitated void[30]



5.3.2 VIABLE FINAL LANDFORMS

Jacobs assessed these six options against the criteria in Term of Reference 9. Jacobs provided a high-level analysis of the viability of each landform for the Latrobe Valley, without conducting a full risk assessment.

The options were considered in relation to each mine; however Jacobs made findings about the viability of each option that are consistent across all three mines.[31] Jacobs concluded that four options are unviable—full backfill, partial backfill above the water table, lined void, and rehabilitated void. Jacobs provided a detailed analysis of why these options are unviable in its report, noting that:

> [a]ll preliminary options can be implemented to achieve a safe and stable landform. It is the very substantial cost, high fire risk and sheer practicality of the [four] preliminary options above that currently preclude them being seriously considered potentially viable.[32]

In summary, the key issues that render these landforms unviable are:

- Full backfill—unviable due to the lack of available fill material onsite or locally, and the significant costs associated with bringing in new material.
- Partial backfill above the water table—unviable due to the lack of available fill material onsite or locally, and the significant costs associated with bringing in new material. This landform will also require active management and extensive drainage to remain dry in perpetuity.
- Lined void—unviable due to the likely impact on environmental amenity, potential high costs associated with creating the lining, and limitations for end land use, as it would only support landfill or waste disposal.
- Rehabilitated void—unviable due to the need for ongoing landform stability works, such as dewatering in perpetuity.[33]

Jacobs advised the Board that only two options are currently viable for each of the three mines—the pit lake or the partial backfill below the water table. In its report, Jacobs states that:

> [t]he potential viability of the Pit Lake and Partial Backfill below the Water Table landforms acknowledges the fact that key risks (e.g. fire, stability, water) are most effectively mitigated and managed through the combination of in-pit overburden placement and filling of the residual void to achieve fire cover and weight balance. These options are close to the landforms that are proposed in the current work plans.[34]

Jacobs further advised the Board that the pit lake and the partial backfill below the water table options also meet the aims of minimising risks to biodiversity and supporting beneficial future land uses of the rehabilitated mines.[35]

Mr Hoxley told the Board that the pit lake option would have a higher water level than the partial backfill below the water table option, but 'it may or may not necessarily be full.'[36] He explained that:

> the key differences between the pit lake and the landform below the water table is the ratio of fill and fill material that's placed in the pit as opposed to water that is in the pit…[The pit lake option] would use water as a primary means of achieving a weight balance or achieving stability. In the partial backfill below the water table there is a combination of fill material—could be overburden, could be a range of other things—and water, that is used to achieve a stable landform and it could be a lowered landform of some type.[37]

Mr Hoxley was asked by Counsel Assisting what the position would be if the outcomes of future research about issues such as stability and water availability and quality were that a pit lake in one or more of the mines was not viable. He replied that:

> [if] we found that the engineering was not possible or too difficult to bear to achieve that landform, then I would suggest that that would open up an ability to look at some of those other things that up to that point had been regarded as not moveable or not feasible.[38]

In their joint expert report, the experts agree with Jacobs' assessment that the two options identified as viable by Jacobs are the only currently viable rehabilitation options for the Latrobe Valley mines.[39] Adjunct Professor Sullivan also noted that, while there are significant uncertainties about how these options can be achieved, the alternative options are less practicable.[40]

Jacobs emphasised that there are key differences between the two options, namely the 'extent, area and depth of batters, above backfill and water level, to be reshaped, covered and rehabilitated.'[41] This includes covering the exposed batters with non-polluting waste rock, such as overburden and interseam sediments (referred to collectively as 'overburden' in the remainder of this report).[42]

The joint expert report records the consensus position of the experts that the two options identified as viable by Jacobs are variants of the one basic outcome, which is that the final mine pit for all mines will be backfilled with overburden and water to varying degrees. The experts emphasised that '[i]t is important that the Inquiry and the public understand that the water level in each of the mine voids will differ.'[43]

5.4 BOARD'S DISCUSSION AND CONCLUSIONS

The Board accepts the evidence of Jacobs that there are six possible rehabilitation options for open cut mines.

The Board is persuaded by the expert evidence that the pit lake and the partial backfill below the water table options are currently the most viable. The Board notes that these options are most closely aligned with the mine operators' current rehabilitation plans.

The Board accepts the opinions of Professor Galvin, Adjunct Professor Sullivan, Professor Mackay, Dr McCullough and Dr Haberfield that the two viable options identified by Jacobs can be considered as one landform with variable elements. Therefore the Board refers to the option as the 'pit lake option' for the remainder of this report, while recognising that each lake will have varying levels of overburden and water, and different lake depths.

The Board accepts the evidence of Mr Hoxley and Adjunct Professor Sullivan that it is possible that the two options may be considered less attractive or viable in the future once additional research is undertaken. The Board accepts that there are many unresolved issues about how the lake option will be achieved. These issues are discussed in Part 6.

While the potential for beneficial final land use is a key criterion in assessing rehabilitation options, the Board considers the safety, stability and sustainability of the landform to be of paramount importance.

The pit lake option is assessed in detail against Term of Reference 9 in the following Part.

PART SIX
ASSESSMENT OF REHABILITATION OPTIONS

PART 6 ASSESSMENT OF REHABILITATION OPTIONS

6.1 OVERVIEW

This Part assesses the options identified in Part 5 of this report against Term of Reference 9, which requires the Board to consider:

a. Whether, and to what extent, the option would decrease the risk of a fire that could impact the mine and if so, the cost of the option relative to the cost of other fire prevention measures.

b. Whether, and to what extent, the option would affect the stability of the mine.

c. Whether, and to what extent, the option would create a stable landform and minimise long-term environmental degradation.

d. Whether, and to what extent, the option would ensure that progressive rehabilitation is carried out as required under the *Mineral Resources (Sustainable Development) Act 1990* (Vic).

e. The estimated timeframe for implementing the option.

f. The option's viability, any associated limitations and its estimated cost.

g. The impact of the option on any current rehabilitation plans for each mine.

h. Whether, and to what extent, the option would impact the future beneficial use of land areas impacted by the mines.

i. Whether the option is otherwise sustainable, practicable and effective.

The Board notes that there is considerable overlap between some of these requirements. For example, the timeframe for filling a mine void with water (Term of Reference 9(e)) will inform the estimated cost (Term of Reference 9(f)). Given this overlap, this Part considers the requirements of Term of Reference 9 thematically, according to the following sequence:

- 6.2 Fire risk—Term of Reference 9(a)
- 6.3 Stability—Term of Reference 9(b) and 9(c)
- 6.4 Water sourcing—Term of Reference 9(f) and 9(i)
- 6.5 Water quality—Term of Reference 9(c)
- 6.6 Progressive rehabilitation—Term of Reference 9(d)
- 6.7 Timeframe—Term of Reference 9(e)
- 6.8 Impacts on current rehabilitation plans—Term of Reference 9(g)
- 6.9 Future beneficial use—Term of Reference 9(h)
- 6.10 Cost—Term of Reference 9(f)

Part 6.11 considers the knowledge gaps relevant to these areas.

In considering Term of Reference 9, the Board had regard to the evidence of the experts detailed in Part 5 of this report including:

- Mr Greg Hoxley, Principal Hydrogeologist, Jacobs Group (Australia) Pty Ltd (Jacobs), and Mr Charlie Speirs, consultant to Jacobs, and the Jacobs report titled *Review of future rehabilitation options for Loy Yang, Hazelwood and Yallourn coal mines in the Latrobe Valley*[1] (Jacobs options report)
- Adjunct Professor Timothy Sullivan, Principal, Pells Sullivan Meynink, retained by AGL Loy Yang, and his report titled *Hazelwood Mine Fire Inquiry: Expert report on rehabilitation relevant to Loy Yang mine*[2]
- Dr Christopher Haberfield, Principal Geotechnical Engineer and Principal, Golder Associates, retained by GDF Suez, and his report titled *Hazelwood Mine Fire Second Inquiry: Review of Jacobs' report*[3]
- Dr Clint McCullough, Associate and Principal Environmental Scientist, Golder Associates, retained by GDF Suez, and his report titled *Hazelwood Mine Fire Inquiry – Terms of Reference 8 and 9*[4]
- Professor Jim Galvin, Chair, Technical Review Board, and his statement[5]
- Professor Rae Mackay, Director, Geotechnical and Hydrogeological Engineering Research Group (GHERG), Federation University Australia, and his statement[6]
- Ms Corinne Unger, a member of the Technical Review Board, and her statement.[7]

The Board also considered the joint expert report that was developed at a meeting of technical experts convened by the Board on 3 December 2015.[8] Professor Galvin, Dr Haberfield, Mr Hoxley, Professor Mackay, Dr McCullough and Adjunct Professor Sullivan participated in this meeting.

This Part is further informed by the submissions and evidence of the mine operators, the State, key stakeholders, and the community. When considering rehabilitation options, the Board has taken into account:

- the purposes and principles of rehabilitation
- the features of the Latrobe Valley community, including its landscape, coal resource, hydrogeology, planning requirements, history and environmental context
- the regulatory framework applicable to mines, and the roles of mine operators, government and key agencies under this framework
- the specific features of the mines
- current rehabilitation activity and future plans for the mines.

The joint expert report records that it is essential that decisions regarding rehabilitation are site-specific, as the unique features and settings of each mine mean that there is no 'one size fits all' approach. Proximity to towns or infrastructure, mine size and depth, and the characteristics of geological materials, geological setting and hydrology are just some of the factors that determine how a safe and stable landform will be achieved.[9] To the extent possible, the Board has considered these factors when assessing the 'pit lake option' against each criterion in Term of Reference 9.

After reviewing all of the evidence (as outlined below), the Board documents its findings in relation to each consideration under Term of Reference 9 at Part 6.12 'Board's discussion and conclusions'.

6.2 FIRE RISK

Term of Reference 9(a) asks 'whether, and to what extent, the option would decrease the risk of a fire that could impact the mine and if so, the cost of the option relative to the cost of other fire prevention measures.' The pit lake option provides for partial backfilling with overburden on the mine floor, flooding the pit by water and reshaping the batters above the water level.[10] Fire risks are therefore to be assessed as they relate to the exposed coal above the final lake level, and below the final lake level during filling, and the way in which the mines will be flooded.

As the 2014 Hazelwood mine fire demonstrated, uncovered coal represents a serious fire risk.[11] The Board heard evidence about covering coal with water or overburden to decrease that risk. In its report, Jacobs notes that water coverage will be important in the medium and long-term to mitigate fire risk, along with other controls. Jacobs observes that the proposed lake at the Yallourn mine will be filled nearer to the mine's crest than the other Latrobe Valley mines, meaning that there will be fewer batters to shape and cover.[12] In the short-term (that is, prior to closure), Jacobs recommends that all mines use overburden to cover the exposed coal and other operational controls to decrease the risk of fire.[13]

6.2.1 COVERING THE COAL WITH WATER

Under the approved rehabilitation plans of the mine operators, proposed rehabilitation of the Loy Yang and Hazelwood mines seeks to achieve 'weight balance' by creating a shallow lake that partially fills the mine pit.[14]

Weight balance is the level of fill that is required to counterbalance the upward pressure of the underlying, deeper aquifers by downward pressure from the water and/or backfill.[15] The Hazelwood and Loy Yang mine operators have estimated this level based on the predicted aquifer pressures once dewatering ceases, and the density of the overburden that will be used to backfill the pit.[16] They have modelled the minimum fill levels for their mines to achieve weight balance, as a relative level, and then modelled the length of time it will take for the lakes to fill to the 'weight balance level'.[17]

The Yallourn mine operator plans to fully flood the mine pit to provide the best batter stability conditions. Batter stability is a greater consideration than weight balance at the Yallourn mine due to relatively lower aquifer pressures.[18]

To reduce fire risk, exposed coal between the weight balance or batter stability level and the pit crest need to be covered. Current rehabilitation plans indicate that coal faces above the proposed weight balance level will be covered with overburden and/or topsoil, but coal faces below this level will be left exposed while the lake is filling, and until the weight balance level is reached.[19] Both the Hazelwood and Loy Yang mine operators stated to the Board that they intend to maintain fire services to manage the fire risk below the weight balance level during this time.[20]

The length of time it will take to reach weight balance or batter stability level varies for each mine. EnergyAustralia has estimated that it will take 17 years for the Yallourn pit to achieve batter stability level (approximately one metre below crest height), assuming natural fill (rainfall and run-off) and access to its bulk entitlement.[21] The estimate for the Hazelwood pit to reach weight balance level (RL -22m) has been modelled at seven years, assuming natural fill, seepage, and continued access to its allocation under the mine's groundwater licence and water from the Hazelwood pondage.[22] The current estimate for the Loy Yang pit to achieve weight balance (RL -22.5m) is 10 years, assuming access to Loy Yang A power station's bulk entitlement, the mine's groundwater licence and natural fill, and based on historic climate conditions.[23]

In each case, these estimates assume access to current water entitlements for many years after the mines and associated power stations cease operating. If the assumptions about access to existing water allocations prove unfounded, the fill times will be considerably longer.[24] Environment Victoria points out that the worst-case scenario is that this may be as long as 200 years for the Hazelwood mine.[25] Differences between the assumptions each mine operator makes about water sources in its modelling are explained in Part 6.4.2 of this report. There will be a number of years during which coal below the weight balance level is exposed and may pose a fire risk that needs to be managed.[26]

The weight balance level is different to the final predicted lake level, which can be considerably higher and will take longer to achieve. For example, GDF Suez has predicted the fill level required for weight balance at Hazelwood mine is RL -22m, which is a 38 metre deep lake approximately one-third of the depth of the mine pit. The surface of the RL -22m weight balance level lake will be approximately 80 metres below the pit crest. However, it has predicted that the lake will eventually reach RL +8m, which is 68 metres deep and between 50 and 60 per cent of the mine pit depth.[27] Figure 16 (in Part 4.3.3) shows GDF Suez's representation of these levels.

6.2.2 COVERING THE COAL WITH OVERBURDEN

The mine operators and some experts provided opinion to the Board about the appropriate depth of overburden and vegetation to be placed on rehabilitated batters above weight balance or batter stability level to manage fire risk. The Board heard that there is no agreed depth of overburden that is required to reduce the risk, to an acceptable level, of the coal igniting.[28] The Latrobe Valley mines have low strip ratios which means that rehabilitation costs could dramatically increase if more overburden is required than is available from mining activities.[29]

Dr Haberfield identified some key considerations in choosing the depth of overburden and the type of vegetation to cover the coal. He explained that cracks could appear in the overburden due to instability or natural drying of the overburden materials, allowing a fire to gain access to the coal. He suggested that this be dealt with by monitoring and repairing cracks, and by selecting a sufficient overburden depth that is appropriate for the type of materials used.[30] Dr Haberfield also noted that deep tree roots that go through the full depth of the overburden could carry fire down to the coal. He recommended that shallow-rooted plants be used to prevent that risk.[31]

Mr James Faithful, Technical Services Manager – Mine, GDF Suez, gave evidence that the areas of coal covered by one metre of overburden did not catch fire during the 2014 Hazelwood mine fire.[32] He believes that this demonstrates that one metre of overburden is a safe depth of coverage.

In contrast, the assessment by Jacobs concludes that two metres of overburden is a better estimate of the required depth.[33] Mr Speirs was the Latrobe Valley Mine Operations Adviser for the Jacobs options report, and between 1982 and 2009, he was the production manager and the general manager of mining at the Loy Yang mine.[34] Mr Speirs explained to the Board that the rationale behind choosing two metres over one metre as the appropriate overburden depth for fire protection is that 'in this situation we are talking about treatment of a batter that's got to last hundreds of years', and it is currently unclear how overburden will behave on a batter at different layer thicknesses.[35] He added that 'we really didn't know the right answer so we went for a conservative depth that we thought was safe to achieve the outcome and wouldn't be overly costly.'[36]

The Board also heard from Professor Galvin that there is a tension between flattening the batter angle to minimise erosion (a priority in reducing fire risk) and maintaining slope stability.[37] The Board notes that this is one example of the interconnectedness between various factors relevant to rehabilitation, which adds complexity to the Latrobe Valley mine rehabilitation tasks.

6.2.3 RISK MANAGEMENT AND IMPACT ON FIRE SERVICES

The Board heard that, at present, each mine operator manages fire risk through a combination of mine design, training, on-hand expertise, equipment, vegetation management and monitoring.[38] Since the introduction of mining licence condition 1A in January 2015, each mine operator has prepared a Risk Assessment and Management Plan, which includes a focus on fire risks and controls. Mr Luke Wilson, Lead Deputy Secretary of Agriculture, Energy and Resources at the Department of Economic Development, Jobs, Transport and Resources (DEDJTR), indicated to the Board that the risk assessments undertaken 'are likely to result in changes to operations at the mines as well as the mine rehabilitation plans', and may result in the Department Head directing the mine operators to submit work plan variations to take into account any changed risks relating to the operations.[39]

Fire services, including mains, pumps and pipes, are located throughout each mine, including on the mine floor.[40] Mr Faithful identified that the removal and relocation of in-pit fixed fire services will be an issue after the Hazelwood mine's operations cease, and during the lake filling and rehabilitation of batters above the planned water level. The removal will reduce the existing fire protection capabilities of the mine operators.[41] It will necessarily occur at a time when there will be fewer employees present, who often perform crucial roles[42]—for example, at the Yallourn mine employees perform fire-spotting and fire suppression work.[43]

For the Hazelwood mine, Mr Faithful proposed solutions including progressively removing pipes as the lake fills, placing pumps on floating pontoons, or limiting the size of the batter area being rehabilitated at any one time. The viability and cost of these and other alternative solutions for each mine are currently unknown.[44]

6.3 STABILITY

Term of Reference 9(b) requires the Board to consider 'whether, and to what extent, the [rehabilitation] option would affect the stability of the mine.' Term of Reference 9(c) directs the Board's attention to whether, and to what extent, the option would create a stable landform. This section addresses both 9(b) and 9(c).

6.3.1 COMPLEXITIES OF STABILITY IN THE LATROBE VALLEY MINES

The Board repeatedly heard that there are significant uncertainties and complexities regarding mine floor and batter stability, and how to create stable landforms in the long-term.[45]

Professor Galvin informed the Board that '[m]ine stability is particularly important in the Latrobe Valley because of the closeness to mine crests of key infrastructure, such as highways, railway lines, power transmission lines, telecommunication systems, rivers, and drains.'[46]

Adjunct Professor Sullivan described the Latrobe Valley as a 'complex system' due to the fact that there is interaction between each of the mines.[47] Each of the mines has groundwater pressure within the batters, coal joints and below the mine floor.[48] Adjunct Professor Sullivan explained that the stability of batters in the mines is very sensitive to water pressures:

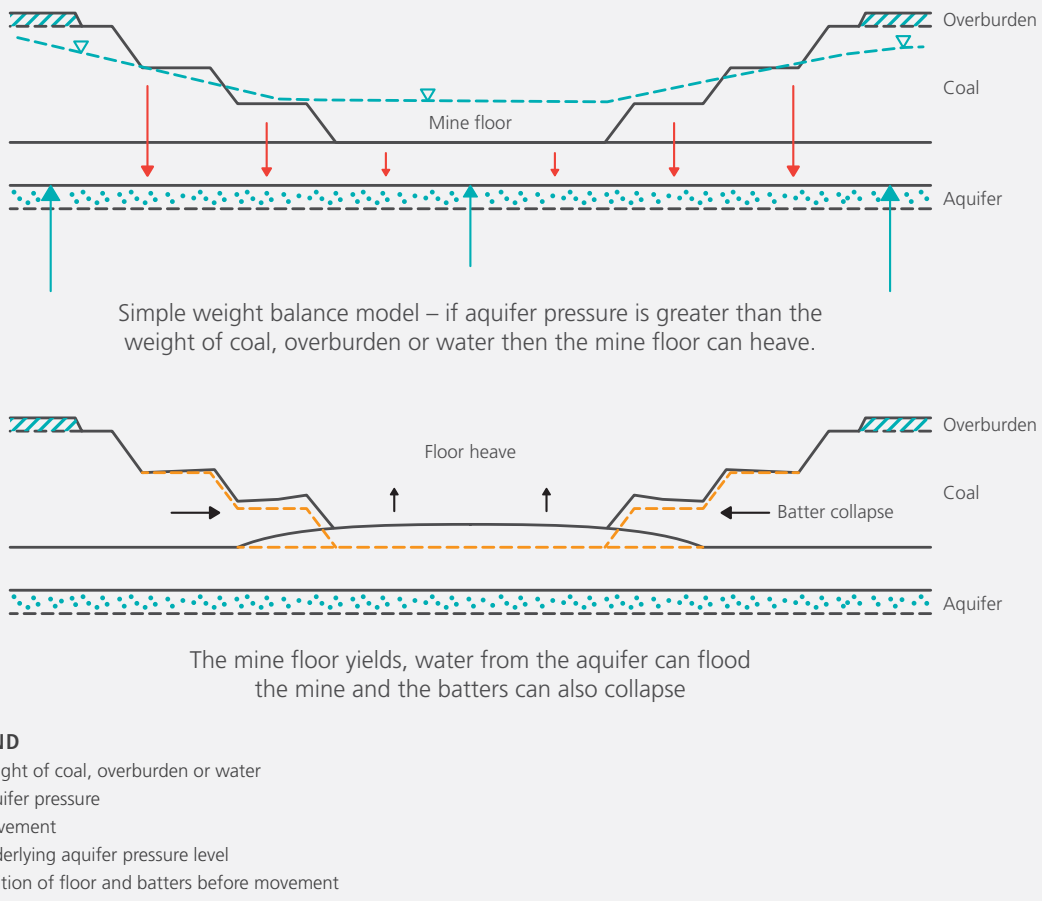
> This basic situation is exacerbated by three factors, the thick coal seams, the continuous joints in the coal and the very large stress related movements that have occurred and are continuing around all the mines. This means it is easy for groundwater pressures to build up under rainfall runoff events and to destabilize the mine batters. This also means it is easy for water to cause uplift pressures on the coal seams, basically because the coal almost floats in water.[49]

Adjunct Professor Sullivan noted that there are two available scales for understanding stability—geotechnical stability (which refers to the large-scale stability of the landform) and erosional stability (which refers to local instability of the surface of the landform).[50] This Part focuses primarily on geotechnical stability.

The two principal modes of geotechnical instability are floor heave and batter instability.[51]

Floor heave occurs when there is an imbalance between the upward pressure of the aquifers underlying the mines, and the weight of the coal and interseam above the aquifers. As coal and interseam materials are removed, the aquifer pressure causes the mine floor to push upwards.[52] Figure 27 demonstrates this imbalance.

Figure 27. Example of floor heave[53]



Floor heave is primarily managed through dewatering (pumping water out of the aquifers).[54] Mr Ronald Mether, Mine Manager at EnergyAustralia, explained that due to the distance between the mine and the nearest aquifer, 'the risk of floor heave is not as significant at the Yallourn Mine compared to other Latrobe Valley mines, and is largely limited to specific identified areas. Consequently, dewatering of the aquifer at the Yallourn Mine is not a significant requirement.'[55]

Batter instability can result in block sliding, which occurs when water pressure builds up in the batters, resulting in a block of coal shifting towards the centre of the mine pit.[56] Part 4.2.5 describes this mechanism further. The key methods of managing batter instability are dewatering (pumping water out of the batters) and horizontal bores (long drains drilled into the batters).[57]

Instability can impact mining operations, or result in waterways breaching the mine, as seen when around six million cubic metres of coal collapsed during the 2007 Yallourn northern mine batter collapse. Instability can also lead to land movements beyond the mine. An example is the cracks that appeared on the Princes Highway and in southern Morwell as a result of the Hazelwood northern batter instability event in 2011 (see Part 4.3.5 of this report).[58]

Specific batters have particular stability concerns. For example, the stability of the Hazelwood mine's northern batter has long been a concern of Adjunct Professor Sullivan.[59]

The particular complexity associated with the stability of the Latrobe Valley mines is reflected in their special treatment as 'declared mines' under s. 7C of the *Mineral Resources (Sustainable Development) Act 1990* (Vic) (Mineral Resources Act), which refers to 'geotechnical or hydrogeological factors' within the mines that pose 'significant risk to public safety, the environment and infrastructure'. Consequently, each mine must report to the Mining Regulator every six months.[60]

As noted by Adjunct Professor Sullivan in his report, the 'long-term objective of rehabilitation is to convert the area to a safe and stable condition.'[61] In their joint expert report, all experts agree that in geotechnical engineering there is no universal definition of 'safe and stable', and therefore no clear criteria for what long-term safety and stability entails.[62] Adjunct Professor Sullivan told the Board that subjective judgment contributes significantly to determining what constitutes a safe and stable landform.[63] The joint expert report also records that all experts agreed that:

> The approved rehabilitation plans of the Latrobe Valley brown coal mines…do not deal adequately with the complex stability issues that impact on both progressive and final rehabilitation…[and] fall well short of what could reasonably be considered as adequate for achieving long-term safe and stable batters from a ground control perspective.[64]

6.3.2 FLOODING THE MINES

The process of filling a mine with water may itself create 'undue risks' due to the coal's sensitivity to water, potentially resulting in movements.[65] Several experts noted the possible reactivation of the Lewis Anomaly—a 'vertical discontinuity' that runs underground through Morwell. The Anomaly caused movement in the 1960s, bending the gas pipes in Morwell towards the mine.[66]

Professor Mackay told the Board that the flooding process will raise the groundwater levels in the surrounding area, and this 'will have an interesting effect in potentially reversing some of the subsidence that's taken place. These things never go back the way they started out, so it won't be just coming back to its original surface, it will go back to a different surface with different problems.'[67]

The Jacobs options report states that the interconnectivity of the aquifers beneath the Latrobe Valley mines means that as one mine stops dewatering, increased dewatering may be required for one or both of the other mines.[68]

Dr Friedrich von Bismarck, Head of Germany's Joint-Governmental-Agency for Coal Mine Rehabilitation, stated that the German experience is that a filled pit is easier to stabilise than an empty pit, and therefore it is desirable to fill the pits as quickly as possible.[69] However, the time taken to fill a mine pit may impact its stability, and as Mr Stephen Rieniets, General Manager of AGL Loy Yang's mining operations, noted, research has not yet identified a safe rate to fill the pit lake.[70] Mr Faithful recently undertook a study tour of brown coal mines in Germany. Based on his experience, he notes that 'the rapid filling of the mine void with water to form a lake is seen as an effective means of managing geotechnical stability throughout the final rehabilitation process'.[71]

EnergyAustralia submitted that the Board should have regard to the various studies it commissioned in response to Condition 7 of its approved 2011 work plan variation (referred to in Part 4.2.3). Condition 7 of the work plan variation requires EnergyAustralia to review its rehabilitation plan to consider the feasibility of the flooded mine scenario against other alternatives. EnergyAustralia submitted that the research developed in response to Condition 7 of the work plan variation is 'vital and shows that, at Yallourn, work towards the refinement and implementation of the Lake Option is well advanced and on track'.[72]

One of the reviews obtained by EnergyAustralia to address Condition 7 is a 2012 report by GHD titled *Report for Yallourn mine rehabilitation: Geotechnical assessment of flooding options.*[73] Based on modelling, GHD found that flooding of the pit would increase the stability of some of the batters and decrease the stability of other batters.[74] Overall, GHD concludes in its report that '[s]table and safe batters can be achieved under a rehabilitation flooding option, but significant additional stabilising works will be required regardless of which option is selected.'[75] GHD notes that its report 'cannot and does not provide an overall recommendation with respect to the best rehabilitation strategy for the mine' and that considerable further work is needed in the form of assessments, reviews and modelling of stability issues 'prior to developing a full rehabilitation master-plan.'[76]

6.3.3 USING OVERBURDEN TO COVER BATTERS AND BACKFILL THE PITS

The strategic placement of overburden on the batters and the pit floor may be one way to increase stability.[77] Adjunct Professor Sullivan told the Board that overburden must be used effectively as 'it's the one physical thing that can probably withstand the sort of critical loading events that will happen in the very, very long-term'.[78] However, as with fire risk, the depth of backfilling or overburden placement required to achieve stability in a pit lake is not known. It may be that different depths are required in different parts of each pit.[79] Backfilling could end up consuming a large amount of the limited available overburden, and have significant cost implications.[80]

Even with backfilling, it is possible that the submerged batters could collapse.[81] Dr Clint McCullough, Associate and Principal Environmental Scientist, Golder Associates, explained that such a collapse could impact water quality and result in '[d]angerous surge waves which of course can impact upon recreational users, leading to further instability and…direct life loss or property loss from that.'[82] He informed the Board that monitoring for such issues will therefore need to occur 'for a very long time.'[83]

While Adjunct Professor Sullivan noted that it is 'too early to talk about a layer thickness' of overburden, he highlighted the importance of understanding the relationship between batter stability and overburden.[84] He explained that sinkholes can appear in overburden, and are a result of material being washed down into the coal joints. Adjunct Professor Sullivan told the Board that it is important to achieve stability so that the joints do not continue to open, allowing the overburden material to migrate into the coal beneath.[85]

Mr Faithful stated that GDF Suez recognises that there are areas within the Hazelwood mine that may require additional support or buttressing with overburden to prevent instability in the mine during flooding. GDF Suez has retained GHD to undertake a study about stability, which is ongoing.[86]

Mr Mether informed the Board that 'stability at the Yallourn mine is a key consideration in relation to the overall rehabilitation strategy.'[87] Stability issues associated with rehabilitation include batter movement, toe saturation and floor heave.[88] Currently, EnergyAustralia is managing batter stability by drilling horizontal bores, buttressing batters with overburden and backfilling the pit with overburden.[89]

6.3.4 BATTER ANGLE

The Board heard that when using overburden on the exposed batters, there is a tension between flattening the batter angle to minimise erosion (a priority in reducing fire risk), and maintaining slope stability. Professor Galvin explained that:

> because the coal is so light and wants to slide when impacted by water pressure, batter stability decreases as a batter slope is made flatter. This is the opposite behaviour to that associated with most other mine slopes and surface excavations. Since steep batters are an impediment to covering the batters with soil materials, this conflict can present a serious impediment to undertaking rehabilitation that remains safe and stable in the long-term.[90]

The batter angle that best ensures stability, including the angle at which overburden can be permanently retained on a batter, is presently unknown.[91] Adjunct Professor Sullivan noted that AGL Loy Yang's plans and some regulatory documents refer to 1v:3h (where the horizontal length of the batter is three times more than the vertical height) as being the preferred batter angle.[92] However he and the other experts advised the Board in their joint expert report that there is no 'scientific and engineering' evidence to support the 1v:3h ratio as being the 'generally accepted' or 'generally adopted' long-term angle for all rehabilitated mines in the Latrobe Valley.[93] Further, Professor Galvin stated that the 1v:3h batter angle is 'too simplistic', as it is 'extremely unlikely' that each mine or even each batter will require the same angle. He noted that it is possible that multiple different angles would be required within a long batter 'because of factors such as variation in joint direction, dip of the strata and groundwater.'[94]

Establishing optimal batter angles for each mine, and potentially each batter or batter area, may impact significantly on the cost of rehabilitation.[95]

6.3.5 EROSION

Another uncertainty related to stability is the potential impact of wave erosion. This form of erosion is caused by waves on the surface of the lake washing up against the batters during filling, and after the proposed lake level has been reached. It is unclear what, if anything, will be required to ensure any such erosion does not destabilise the walls of the lake.[96]

To minimise the effect of erosion due to wave action, Jacobs advised that 'rip rap' should be installed at the lake level.[97] Rip rap is a conventional method for managing erosion in which a collection of loose rock or other material, such as concrete, is deposited on the waterline. The experts disagreed about the need for 'rip rap' in each pit.[98] Installing rip rap has significant cost implications.[99] GDF Suez indicated that it would undertake further work on the impact of wave erosion to ascertain whether rip rap is necessary for its pit lake option.[100] AGL Loy Yang's 2015 work plan variation states that rip rap will be used to protect sandy interseam from wave erosion, along with alternative protection measures.[101]

6.3.6 MAINTAINING AND MONITORING STABILITY

The Board heard about the need for ongoing maintenance and monitoring to ensure mine stability. Professor Mackay suggested that this 'will be a significant expense.'[102] For example, monitoring and maintaining horizontal bores 'requires funding and a management system that provides for oversight by appropriately qualified personnel.'[103] The Jacobs options report notes that the significant aquifer pressures at the Hazelwood and Loy Yang mines would require ongoing management to achieve stability.[104]

Mr Rieniets acknowledged that AGL Loy Yang's current presumption that maintenance requirements will 'taper off' as flooding occurs, assumes that once achieved, stability is permanent.[105] Mr Faithful notes that for the Hazelwood mine, to maintain batter stability and avoid floor heave during the flooding of the mine pit, active management and continual monitoring will be necessary, and that it will be done in accordance with its Ground Control Management Plan.[106]

Professor Mackay stated that '[t]he research is simply not strong enough to give a clear indication of how quickly we can expect to see stability reached' and that it might be decades after the proposed water level is achieved.[107] Dr McCullough told the Board that monitoring would be required 'for a very long time.'[108] Similarly, Dr von Bismarck told the Inquiry that the Joint-Governmental-Agency for Coal Mine Rehabilitation anticipated having to monitor stability in the German mine pit lakes for a 'very long time.'[109]

6.3.7 FURTHER RESEARCH ON STABILITY

Two studies will shortly commence to progress knowledge about stability. The first is the Mine Batter Stability Project (Batter Stability Project), which is being undertaken by the Mining Regulator in partnership with GHERG at the Yallourn mine. The project was established in response to a recommendation of the Technical Review Board in 2012, which identified the need for studies into mine stability 'in order to re-establish a robust technical platform to manage geotechnical risk.'[110]

The Batter Stability Project will look at issues such as the properties of overburden, interseam and coal over time and under stress, and investigate batter movement and other geotechnical risks, as well as controls and tools for ongoing monitoring.[111] The Batter Stability Project received funding of $2.2 million in August 2014.[112] Part 6.11 discusses this further.

Professor Galvin told the Board that this study is 'the tip of the iceberg.'[113] He noted that 'a significant amount of further research directed towards achieving mine stability in the long-term is required. Addressing this issue will require significant funding.'[114]

The second study is being conducted by AGL Loy Yang with Monash University and Federation University Australia. It will trial and monitor different approaches to rehabilitating the Loy Yang mine's batters above the waterline of the proposed lake. This includes looking at the optimal batter angle to minimise erosion and fire risk, as well as addressing dust issues and controlling water flows.[115]

In addition to these studies, the Board notes that GHD is also conducting a study in relation to the stability of the Hazelwood mine during the flooding of its mine pit.[116]

6.4 SOURCING WATER

Term of Reference 9(f) requires the Board to consider the viability of the rehabilitation option and any associated limitations. Term of Reference 9(i) directs the Board to assess 'whether the option is otherwise sustainable, practicable and effective.'

While a range of considerations is relevant, a strong theme in the evidence throughout this Inquiry was the viability and sustainability of sourcing water. Therefore this section focuses on that issue, as it is central to the question of whether the pit lake option can be implemented. In particular, it considers whether the mines' current water allocations would enable them to source water for the purpose of creating the pit lakes, and whether there will be sufficient water for that purpose. If sufficient water is not available to one or more of the mine operators, they may not be able to implement the pit lake option, or at least not at an affordable cost or within the anticipated timelines.

6.4.1 VOLUME OF WATER

The Board heard that an enormous amount of water will be required by each mine to fill its pit to the intended final lake depth. In the case of the Yallourn and Hazelwood mines, the volume of water required to reach crest height (RL +37m for Yallourn mine) and final partial fill level (RL +8m for Hazelwood mine) is 748 gigalitres and 740 gigalitres respectively. At the Loy Yang mine, approximately 700 gigalitres of water are required to reach weight balance level (RL -22.5m).[117] In comparison, Sydney Harbour contains 500 gigalitres of water.[118]

6.4.2 WATER MODELLING

Each of the mine operators has proposed various water source scenarios in their rehabilitation plans to establish the rate at which the mine pits will fill. These include scenarios that combine rainfall and natural groundwater seepage (collectively known as 'natural fill'), and the water currently allocated to the mines and power stations pursuant to groundwater licences, bulk entitlements and water supply agreements. In addition, the mine operators have each considered using surface water to augment their water allocations and fill the pits, through, for example:

- diverting water from Latrobe and Morwell Rivers into the pit at the Yallourn mine[119]
- pumping water from the Hazelwood Pondage into the pit at the Hazelwood mine[120]
- diverting flood water from Traralgon Creek and Sheepwash Creek into the pit at the Loy Yang mine.[121]

Each of the mines has commissioned water modelling to gain a better understanding of the time it might take to create pit lakes, as discussed below.

YALLOURN MINE

The modelling undertaken by EnergyAustralia in response to Condition 7 of its 2011 work plan variation was based on a rehabilitation concept of a fully filled lake with a depth of RL +37m and capacity of 748 gigalitres.[122]

A range of scenarios was considered, commencing with a natural fill scenario.[123] Each subsequent scenario combined the previous scenario with an additional water source, including:

- the power station's bulk entitlement[124]
- excess water resulting from flood events from both the Latrobe and Morwell Rivers.[125]

An alternative modelling scenario that has been undertaken is filling the pit to the RL +20m level (estimated to be 97.9 gigalitres) by using existing water that is stored in the mine's Township Field.[126]

Table 6 summarises the results of the modelling, based on current climate conditions. Other scenarios based on wetter and drier climate conditions were also modelled.[127]

Table 6. Yallourn mine modelled fill times for a pit lake (RL +37m, 748 GL) post-closure[128]

Scenario		Years to fill
A	Natural fill only	81
B	(A) + bulk entitlement	17
C	(B) + Latrobe River overflow	6
D	(C) + Morwell River overflow	6

As shown in Table 6, the modelling found that the time it would take the Yallourn mine pit to fully fill to RL +37m is between six years (assuming all water sources can be used) and 81 years (assuming that only natural fill can be used). These findings were peer reviewed by expert consultants GHD.[129]

HAZELWOOD MINE

In 2015, GDF Suez engaged GHD to predict the rate at which the future lake would fill under differing water supply scenarios.[130] A range of scenarios was considered, commencing with natural fill and adding additional water sources for each subsequent scenario. The additional water sources included:

- groundwater pumping at a rate of 9.16 gigalitres a year in 2033–2034 and 6.47 gigalitres a year in 2035–2038
- draining 25 gigalitres of water from the Hazelwood Pondage
- allowing runoff from the Hazelwood Pondage catchment to be directed into the pit.[131]

Climate variability was accounted for by a range of catchment runoff volumes with an average volume of 8.38 gigalitres a year used in the final scenario.[132] Based on a fill volume of 117 gigalitres to a weight balance depth of RL -20m, cumulative fill time scenarios were modelled, as shown in Table 7. It is noted that the final lake has an intended fill volume of approximately 750 gigalitres.

Table 7. Hazelwood mine modelled fill times for a weight balance pit lake (RL -20m, 117 GL) post-closure[133]

Scenario		Years to fill
A	Natural fill only	> 200
B	(A) + groundwater pumping	200
C	(B) + 25 GL from Hazelwood Pondage	160
D	(C) + catchment runoff from Hazelwood Pondage	7

LOY YANG MINE

AGL Loy Yang engaged GHD to complete a water balance assessment of the final mine pit as part of its 2015 work plan variation.[134] The modelling used six scenarios combining natural fill with a combination of:

- groundwater pumping (either 9.8 gigalitres a year for 10 years or 15 gigalitres a year until the lake reaches weight balance level of RL -22.5m)
- Loy Yang A power station's bulk entitlement (40 gigalitres a year)
- diversion of Traralgon Creek flood flows (4 gigalitres a year).[135]

Four simulated climatic conditions (historic, wet, median and dry) were considered, but they only influenced those scenarios that are heavily reliant on natural fill (scenarios A and B as shown in Table 8).[136] Based on a 'median climatic conditions' scenario and a fill volume of approximately 700 gigalitres[137] to a weight balance depth of RL -22.5m, the following fill times were calculated for each combination of water sources (Table 8).

Table 8. Loy Yang mine modelled fill times for a weight balance pit lake (RL -22.5m, 700 GL) post-closure[138]

Scenario		Years to fill
A	Natural fill only	75
B	(A) + 9.8 GL/yr groundwater pumping	65
C	(A) + 15 GL/yr groundwater pumping	25
D	(C) + 4 GL/yr flood flows from Traralgon Creek	25
E	(C) + 40 GL/yr bulk entitlement	10
	(E) + groundwater pumping, flood flows & bulk entitlement	10

For each mine, it is possible that, if evaporation exceeds inflows, an ongoing top up of water may be required once the lakes are filled to the desired weight balance or stability levels. The additional amount of water required will largely depend on whether there is flow through from another water source. Professor Mackay told the Board that the 'reasonably large catchment' around the Yallourn mine may bring it up 'fairly close to river level', which would enable it to be connected to the rivers.[139]

However this is an area of uncertainty, as discussed further below.[140] The Jacobs options report notes that, based on current indications of mine closure dates, the Latrobe Valley mines (in particular the Yallourn and Hazelwood mines) are likely to be filling their pits at the same time, which could also impact water availability.[141]

6.4.3 ACCESS TO WATER ALLOCATIONS

The mines currently have access to groundwater by licences with Southern Rural Water, by the power stations accessing water through bulk entitlements, and water supply agreements with Gippsland Water. The allocations are summarised in Table 9 (and detailed in Part 4 of this report). It should be noted that currently the mines do not use their full groundwater licence allocations.[142]

Table 9. Current water allocations to the Latrobe Valley mines and power stations by licence type[143]

Site	Amount (GL/year) as at 2016			
	Groundwater licence[144]	Bulk entitlement[145]	Water supply agreement[146]	Total
Yallourn mine	3.285	-	-	3.285
Yallourn power station	-	36.5	2.2	38.7
Hazelwood mine	22.484	-	-	22.484
Hazelwood power station	-	-	14	14
Loy Yang mine	19.996	-	-	19.996
Loy Yang A power station	-	40	3	43
Loy Yang B power station	-	20	1.5	21.5

The Board heard that, for a variety of reasons, it is unclear whether the mines will be able to use their existing water allocations and the allocations to the power stations, for rehabilitation and filling the lakes.

The three groundwater licences expire in 2025.[147] The objective of each licence is 'to allow the efficient depressurising of the...open cut mine while minimising adverse impacts on the Gippsland Groundwater Basin.'[148] This means that the licence allows the mine operators to dewater the mine to release pressure from the aquifers underlying the mine floor. Condition 2 of each licence states that the licensee is authorised to 'take and use groundwater to facilitate mining for coal and generation of electrical energy and purposes incidental thereto.' Condition 5 states the licence applies only on land for which the licence is held.[149]

Bulk entitlements do not expire.[150] They are issued to the relevant power generation companies associated with the three mines, and are tied to the purpose of operating the power station.[151] Similarly, as stated by Mr David Mawer, Managing Director of Gippsland Water, the water supply agreements between Gippsland Water and the power stations 'do not extend to the mine rehabilitation process' and 'end when the power generating entity ceases operating.'[152]

Southern Rural Water, the licensing authority for AGL Loy Yang's groundwater licence, recently raised these issues with the Mining Regulator. In a letter dated 24 August 2015, in relation to the 2015 Loy Yang work plan variation, Southern Rural Water advises the Mining Regulator that '[c]urrent Licences do not allow for ongoing depressurisation after the term of the licence. In addition [the] current Bulk Entitlement from the Latrobe system does not allow water use for mine flooding'.[153]

AGL Loy Yang commissioned a report from GHD as part of its 2015 work plan variation application. In the report, GHD expresses concerns about the ability of the mine operators to use their existing water allocations to fill the mines post-closure.[154]

AGL Loy Yang submitted that 'there is no rational reason why the [water] authorities would refuse to provide AGL with a continuing entitlement to fill its mine if it was in the net interests of the community of Victoria to provide access to that water.'[155]

6.4.4 AVAILABILITY OF WATER

The Board heard that a key state policy, the 2011 *Gippsland Region Sustainable Water Strategy* (Sustainable Water Strategy) provides that '[c]urrent rehabilitation plans for open-cut coal mines involve flooding them to create artificial lakes. However, this is not considered to be an entirely viable option any longer because there is insufficient water to fill most of the mines.'[156]

Action 6.8 of the Sustainable Water Strategy tasks the Department of Primary Industries (now DEDJTR) with reviewing the groundwater and surface water impacts of mine rehabilitation strategies, in partnership with the Department of Sustainability and Environment (now the Department of Environment, Land, Water and Planning (DELWP)), the Environment Protection Authority (EPA), and the mine operators.[157] However, the Board heard that Action 6.8 has not been progressed by any of the parties, despite its implications for mine rehabilitation.[158] This issue is discussed further in Part 10 of this report.

Similar concerns have been raised elsewhere, including by the Technical Review Board in a letter to the Minister for Energy and Resources, dated 2 February 2011. This letter states that 'the current Yallourn Mine rehabilitation strategy of flooding the mine has been shown to be not feasible because of insufficient water.'[159]

The 24 August 2015 letter from Southern Rural Water to the Mining Regulator in relation to the Loy Yang work plan variation states that '[t]here are a significant number of risks related to the long-term availability of water for mine void filling and potential consequent impacts on regional water resources to achieve the proposed mine rehabilitation which are not addressed in the Plan'.[160]

Southern Rural Water concludes this letter with the observation that the assessment of water availability for filling the mines 'should be undertaken well in advance of closure such that risk mitigation methods can be identified and incorporated into the closure strategy.' The letter also notes that Southern Rural Water was advised by DELWP that a meeting between them 'to discuss the amendment [to the work plan] and potential implication for water management is essential.' In the letter, Southern Rural Water expresses the hope that the meeting with DELWP could occur prior to any further correspondence with AGL Loy Yang.[161]

In evidence to the Board, Dr Sharon Davis, Executive Director of the Water Resources Division, Water and Catchments Group at DELWP, agreed that the meeting to discuss the implications of using large volumes of water to fill the mine pits in the future was essential, and that DELWP had received advice from Southern Rural Water to this effect in two emails.[162] The Board was informed that this 'essential' meeting has not occurred and, as at 9 December 2015, had not been scheduled.[163] Dr Davis could not assist the Board to understand why this was the case.[164]

DELWP and Southern Rural Water have confirmed in evidence to the Board that it is not clear to them, and they have not determined, whether any or all of the mines would be able to acquire the water they need to fill the mine pits.[165] Other than the Mining Regulator's referral of the 2015 Loy Yang work plan variation to Southern Rural Water, it appears that the water authorities have not been asked this question.[166]

Even if existing bulk entitlements are available for mine filling, it is unclear what quantity of water will be available at the time it is needed. Each entitlement is limited by a percentage share of the water storage (at Blue Rock Reservoir and Lake Narracan), and by the water flow (from Tanjil River at Blue Rock Reservoir and the Latrobe River at Lake Narracan).[167]

GDF Suez cautioned the Board against placing too much reliance on the concern expressed in the Sustainable Water Strategy about the availability of water for filling the mines. In oral submissions before the Board, counsel for GDF Suez described Action 6.8 in the Sustainable Water Strategy as no more than a 'thought bubble.'[168]

EnergyAustralia also submitted that the Board should not place much weight on the Sustainable Water Strategy document, but for somewhat different reasons.[169] EnergyAustralia submitted that the authors of the document express 'no concluded view' about water availability and assume that the Hazelwood and Loy Yang mines will be 'filled entirely with water.'[170] EnergyAustralia further submitted that neither the authors of the Sustainable Water Strategy, nor the water authority representatives who gave evidence to the Board, had considered the studies that it commissioned in response to Condition 7 of the 2011 Yallourn work plan variation.[171] It submitted that these studies included 'evidence…that water in the required volumes is expected to be available'.[172]

However, in oral submissions to the Inquiry, counsel for EnergyAustralia accepted that accessibility to water is a 'principal unknown.'[173]

Environment Victoria submitted that it may be more likely that water will be allocated to AGL Loy Yang to fill a lake that is of beneficial use to the public (as was planned under its 1997 work plan), rather than a 'private dam' (as planned under its 2015 work plan variation).[174]

6.5 WATER QUALITY

Term of Reference 9(c) requires the Board to consider 'whether, and to what extent, the option would create a stable landform and minimise long-term environmental degradation'. The Board heard that the key concern in terms of environmental degradation is water quality, of both the pit lake and the surrounding waterways.[175]

6.5.1 CLOSED AND INTERCONNECTED SYSTEMS

Water quality was identified as an area requiring management at the Yallourn, Hazelwood and Loy Yang mines.[176] Professor Mackay told the Board that he 'would not expect either Loy Yang or Hazelwood to have water levels which would allow a direct movement of water over land back into the river system. They will be enclosed lakes and their primary discharges if left to nature will be evaporation.'[177]

This is known as a 'closed system'. In its assessment of the 2015 Loy Yang work plan variation, Southern Rural Water states that 'there are significant risks related to groundwater management' inherent in the proposed pit lake at the Loy Yang mine, including 'the maintenance of water quality given exposed coal batters'; a 'closed system water environment for many years of filling'; and 'potential risks to groundwater quality through interconnection between the pit lake and aquifers exposed within the mine void.'[178] Southern Rural Water observed that these issues are not addressed in the 2015 Loy Yang work plan variation.[179]

The Yallourn mine's rehabilitation plan, however, proposes a higher lake level, which would allow it to be connected to the Morwell and Latrobe Rivers, providing a 'flushing' effect as the water passes through.[180] This is known as 'flow through' or an interconnected system. Professor Mackay advised the Board that it is 'definitely' less likely that water quality issues will develop where there is flow through but also noted that, with respect to the Yallourn mine, the desirability of connecting the pit lake to the river system to create flow through is 'yet to be determined.'[181] The Board was advised by Mr Mether of water quality studies completed at the Yallourn mine, which conclude that '[t]he diversion of fresh river flows is identified as having several advantages, principally through neutralising salinity and acidification.'[182]

The Board also heard that there are specific considerations regarding water quality associated with flow through. The Jacobs options report notes that for the Yallourn mine:

> Water quality in the pit water body will be key to addressing long term risks. Given the proximity to surface water (the [Latrobe and Morwell] rivers) and considering that limited groundwater is pumped from the mine at present, it is likely that the water body in the final landform will require inflow from surface water in the long-term to maintain required water quality.[183]

Dr McCullough gave evidence that flow through can create 'a number of dangers both for the lake and also for the river and for users of both of those entities.'[184] In part, this is because 'flow through may create new liabilities associated with contamination of the river downstream with [acid mine drainage] from the pit lake. Risks include increased acidity, metal/metalloid, nitrate and ammonia concentrations'.[185]

Mr Mawer expressed similar concerns when asked by counsel for EnergyAustralia 'if the proposed lake were interconnected with the Latrobe River and the Morwell River and the Morwell River Diversion, would that alleviate concerns about stagnancy of water?' He replied: 'No' and explained that he would need information about 'the porous nature of the surface contact between the existing mine and the water', as well as other details.[186]

6.5.2 PREDICTING WATER QUALITY

Dr von Bismarck gave evidence regarding the difficulties faced in Germany in predicting water quality when connecting pit lakes to river systems. He told the Board that the Joint-Governmental-Agency he heads was aware that there would be an effect on the groundwater quality when the overburden dumps were penetrated by groundwater during filling, because of the overburden's chemical composition. The Agency undertook modelling for each mine.[187] Dr von Bismarck told the Board that the rise in iron hydroxide content in the groundwater 'occurred earlier and more intensely than the hydrogeological model calculations had predicted and is entering the river system in some areas.'[188] Measures to reduce the iron hydroxide content in the groundwater and river system have now been implemented.[189] Figure 28 shows water contaminated by iron hydroxide from previously rehabilitated overburden dumps in the Lusatia river system.[190]

Figure 28. Iron hydroxide in the Lusatia river system, Germany 2013[191]

6.5.3 ADDRESSING WATER QUALITY ISSUES

It was indicated to the Board that solutions to address water quality issues is an area that requires further investigation.[192] Mr Rieniets advised the Board that 'a lot of work' needs to be done to better understand water quality issues, and that AGL Loy Yang is committed to doing this, but that it is too early to say what that work will entail.[193] Mr Faithful indicated that GDF Suez would make a similar commitment to consider the viability of the pit lake option from a water quality perspective in its proposed 2016 work plan variation.[194]

Mr Mether stated that EnergyAustralia has commissioned a range of investigations, which 'demonstrate that water quality outcomes for flooded lakes in the Latrobe Valley will generally depend on the quality of water inflows, the nature and extent of the void to be filled, and interconnectedness to other water systems',[195] and that interconnection with nearby rivers would be 'beneficial' to the quality of the lake water.[196]

Mr Ross McGowan, Executive Director of the Mining Regulator, noted that this issue had been addressed in Condition 7.1 of the 2015 Loy Yang work plan variation, which requires AGL Loy Yang to conduct a water resources risk assessment, and which states:

> The Water Resources Risk Assessment must be to the satisfaction of the Department Head. The Water Resources Risk Assessment must, as a minimum:
>
> a. Include local catchment and regional assessment of risks to surface water and groundwater resources, and natural ecosystem services; and
>
> b. Be undertaken in accordance with Action 6.8 of the Gippsland Region Sustainable Water Strategy.[197]

Condition 7.1 is discussed further in Part 10.3.2.

As with stability, the cost of monitoring water quality in the pit lakes is unknown, and represents an uncertainty in the assessment of rehabilitation liability for each mine.[198] Dr von Bismarck told the Inquiry that he anticipated having to monitor water quality in the German lakes for a significant length of time and that the cost of this would be substantial.[199]

6.6 PROGRESSIVE REHABILITATION

Term of Reference 9(d) requires the Board to consider 'whether, and to what extent, the option would ensure that progressive rehabilitation is carried out as required by the Mineral Resources Act.'

6.6.1 DEFINITIONS AND CRITERIA

As a starting point to addressing this Term of Reference, the Board considered the requirements of 'progressive rehabilitation' under the Mineral Resources Act. The term is not defined in either the Act or the Mineral Industries Regulations. Schedule 15 of the Mineral Industries Regulations requires mine operators to include proposals for both progressive and final rehabilitation in their work plans. The Act specifies that a licensee must, as far as practicable, complete rehabilitation during the period of the licence.[200]

There are advisory guidelines, but no specific criteria by which rehabilitation progress is measured by the Mining Regulator.[201] Further, there is no prescribed timeline for rehabilitation during the licence period; instead, mine operators propose timelines as part of the work plan approval process.[202]

DEDJTR's rehabilitation guidelines state that progressive rehabilitation plans should detail the rehabilitation works, including their sequence and timing.[203] The Hazelwood mine rehabilitation plan contains milestones for progressive rehabilitation; however, in his evidence, Mr Wilson noted that confusion had arisen between the Mining Regulator and GDF Suez about expectations with respect to those milestones.[204] Mr Faithful stated that GDF Suez would be happy to have the Mining Regulator set performance criteria for progressive rehabilitation 'providing that it's done in a practical and measured fashion and it's not dictated to us but it's working with us'.[205]

Despite the requirements contained in the rehabilitation guidelines, Mr Wilson stated that the Loy Yang and Yallourn mines' rehabilitation plans do not currently include milestones.[206] Mr Mether indicated that EnergyAustralia already produced six-monthly milestone reports to the Mining Regulator and that he would be '[h]appy to have milestones in line with our rehabilitation plans.'[207]

Mr Rieniets disagreed with Mr Wilson's statement that milestones are not already in the AGL Loy Yang rehabilitation plan. He told the Board that 'I think it's quite clear in our work plan on the stage plan shows quite clearly the staging of rehabilitation at AGL Loy Yang. So I think the milestones are there already right up until closure showing which areas will be rehabilitated by when.'[208]

The Board also heard that it is unclear to the mine operators what the State considers to be progressive rehabilitation. This was apparent during the Inquiry's public hearings when mine operators were questioned on their reporting of progressive rehabilitation costs. As part of their mining licence conditions, licensees are required to submit an Annual Activity and Expenditure Return (Annual Return) to the Mining Regulator that includes an estimate of their rehabilitation liability—that is, how much they estimate it will cost to successfully complete their rehabilitation in accordance with their approved work plan. They are also required to report on how much had been spent in that financial year on progressive rehabilitation.[209]

Each mine operator noted that the expenditure it recorded in its Annual Return for 2014–15 did not accurately reflect its full expenditure on what it considered to be progressive rehabilitation.[210] There was uncertainty regarding whether aspects categorised under operational costs, such as moving overburden onto the pit floor, were seen as rehabilitation costs for the purposes of the Annual Return, despite this work 'serving a rehabilitation end goal'.[211] Mr Mether told the Board that he had been in discussions with the Mining Regulator over the past 12 months to better understand this issue.[212]

6.6.2 IMPACT OF THE PIT LAKE OPTION ON PROGRESSIVE REHABILITATION

Ms Unger outlined the benefits of effective progressive rehabilitation as including 'fire risk reduction, dust suppression, trialling final rehabilitation concepts and building community and regulatory confidence.'[213]

The Board heard evidence about the extent to which the pit lake option could ensure that progressive rehabilitation is undertaken. The Jacobs options report states that progressive rehabilitation is possible with the pit lake option, and notes that the mine operators have been progressively rehabilitating the mine sites under their existing plans.[214] Jacobs also states that the rate of progressive rehabilitation undertaken during the mine's life will be a key factor in determining timeframes for achieving the final pit lake.[215]

The joint expert report records that the approved rehabilitation plans of the Latrobe Valley mines 'do not deal adequately with the complex stability issues' that impact progressive rehabilitation.[216]

The mine operators' evidence to the Board summarise their rehabilitation plans, including the progressive rehabilitation that they undertake. The primary focus of each rehabilitation plan is assessing stability, moving infrastructure, changing batter angles, adding overburden, conducting rehabilitation trials, and revegetating the area.[217] The mine operators identified a range of operational issues that limit their ability to undertake progressive rehabilitation, including the location of critical mining infrastructure such as conveyors, ash and overburden dumps, transport routes, power lines, pumping stations and fire services, dams, and bores.[218] Such infrastructure needs to be operational 24 hours a day, seven days a week, in order to continually supply coal to the power stations.[219] In addition, as Professor Galvin identified, the availability of suitable quantities of overburden can limit how much material can be placed in the mine pit.[220]

Professor Galvin gave evidence to the Inquiry that the Technical Review Board 'believes that there is scope to increase the rate of rehabilitation of exposed coal faces, albeit at an additional cost impost. The issues are complex but not insurmountable.'[221] The mine operators acknowledged that there could always be more progressive rehabilitation, where there are no constraints.[222] Jacobs also identified fire risk as an area that could be addressed through additional progressive rehabilitation.[223]

6.6.3 RESEARCH AND MONITORING

Ms Unger emphasised the benefits of trials and monitoring as a component of progressive rehabilitation, as they provide a 'feedback mechanism' for mine operators to systematically review their work.[224] The benefits of research into stability and other areas related to progressive rehabilitation were reinforced by Mr Rieniets, who stated that at the Loy Yang mine, '[p]rogressive rehabilitation plans have evolved over the life of the project based on learnings from rehabilitation trials, improved understanding of geotechnical and hydrogeological factors and changing community expectations.'[225] Adjunct Professor Sullivan also referred to trials that have taken place and are planned at the Loy Yang mine.[226]

6.6.4 IMPACTS OF PROGRESSIVE REHABILITATION ON FINAL LANDFORM OPTIONS

The Board heard that decisions regarding progressive rehabilitation can have major impacts on the final landform options available to the mine operators—at a certain point the decisions made regarding progressive rehabilitation will limit what is possible for final landforms, due to physical limitations or potential risks. Dr McCullough described this as a 'Rubicon moment'—when an option is 'irretrievably lost due to mining design or other achievements.'[227] Mr Clinton Rodda, Managing Director of Southern Rural Water, provided the example of dumping overburden in the mine pits as part of rehabilitation efforts, as such dumping may affect water quality in the long-term.[228]

6.6.5 IMPACTS OF PROGRESSIVE REHABILITATION ON FIRE SERVICES

The issue of in-pit fixed fire services was also discussed in relation to progressive rehabilitation, and the potential risks of removing fire services during operations.[229] Professor Galvin recognised that the fixed fire services limit the amount of progressive rehabilitation the mine operators can undertake, but noted that the rate of rehabilitation could be increased.[230] In a letter to the Mining Regulator reviewing the draft 2015 Loy Yang work variation, Professor Galvin made the following observations about AGL Loy Yang's planned fire mitigation plans:

> It seems that the proponent has no intention of reducing the fire fuel load on the northern batters until the final rehabilitation is carried out at the completion of Stage C mining in about a decade's time. The presence of a range of mining and other infrastructure on this batter has been put forward as the reason for this delay. Notwithstanding this, the proponent still claims to be undertaking progressive rehabilitation. The matter does not appear to have been independently tested to date from both technical and risk management perspectives.[231]

6.7 TIMEFRAME

Term of Reference 9(e) requires the Board to consider the estimated timeframe for implementing the rehabilitation option. In considering this issue, it is necessary to first establish how the end point of that timeframe will be measured—that is, how to determine that implementation of the rehabilitation option has been successful.

6.7.1 CLOSURE CRITERIA

Ms Unger told the Board of Inquiry that 'timeframes around the end of the life of a project are very unclear.'[232] Counsel Assisting submitted that one of the difficulties in establishing timeframes is that there are no clear criteria to indicate whether rehabilitation has been successful.[233] The Board heard that establishing closure criteria is complex. Adjunct Professor Sullivan noted that there are 'very, very many parts to this mine rehabilitation aspect,' including safety, stability, water quality, erosion and revegetation, among others.[234]

Ms Unger told the Board that without criteria to determine whether rehabilitation has been successful 'there's no step-wise process of necessarily getting to an end point and there is no way of signing off on that end point. There must be mechanisms for agreement that they have been met. Without those mechanisms, it's not clear who is deciding when it's been done.'[235]

Adjunct Professor Sullivan advised the Board that, as each mine has unique features and settings, each mine requires separate criteria against which to assess completion of rehabilitation.[236] He suggested that the success criteria for stability could potentially be at 'a much lower level' for the Loy Yang mine than the other mines, because it is further from infrastructure and residences than the other mines.[237] Likewise, the unique characteristics of the Yallourn mine have meant the potential for impacts on stability relating to floor heave are relatively minor.[238] Reflecting this, each of the mine operators has developed its own set of rehabilitation goals and objectives in its rehabilitation plan.[239] These are discussed further in Part 5.2 of this report.

Dr McCullough stated to the Board that 'the importance of developing closure criteria for pit lakes early in the planning process cannot be overstated, because all mine closure design and mitigation should be directed toward meeting these criteria.'[240]

The need for clear closure criteria that are developed early and are 'fully integrated into the life of mine planning' is reflected in the Western Australian *Guidelines for preparing mine closure plans.*[241] The guidelines state that closure criteria 'usually include post-closure environmental outcomes together with measurement tools, and where applicable, final landform designs and construction specifications.'[242]

However, it was also suggested to the Board that closure criteria should be considered 'preliminary' and flexible to change over time. Dr McCullough told the Board that '[a] lot can happen in three decades.'[243] He stated that if fixed criteria are established now, 'people who are not even born who will live with those rehabilitated mines would be being influenced by criteria that they had no say in.'[244]

The issue of rehabilitation bonds, which is considered in Parts 7 to 9 of this report, is closely related to closure criteria. Section 82(1)(b) of the Mineral Resources Act provides that a bond must be returned to a licensee only when the Minister is satisfied that 'rehabilitation is likely to be successful.'[245]

6.7.2 IMPACTS ON TIMEFRAMES

As already outlined in this Part, there are many factors that can influence rehabilitation timeframes. These factors can impact upon both the activity that needs to be done and its timing. For example, the water modelling conducted by the mine operators highlights the range in potential fill times based on combinations of water sources. Areas of regulatory uncertainty also impact timeframes, such as the absence of clear definitions of 'safe' and 'stable', as this will make it difficult to establish what constitutes a long-term successful rehabilitation outcome.

It was suggested to the Board that the rehabilitation plans themselves needed to allow for this uncertainty. Mr Rieniets explained that 'a rehabilitation plan needs to have flexibility to go longer or shorter.'[246] Professor Mackay noted that it was important that plans 'allow for an extended period of monitoring and maintenance in order to effectively manage both expected and unexpected changes to conditions.'[247]

6.8 IMPACT ON CURRENT REHABILITATION PLANS

Term of Reference 9(g) requires the Board to consider the impact of the rehabilitation option on any current rehabilitation plans for each mine.

The Jacobs options report notes that significant changes to the mines' work plans will require a work plan variation under the Mineral Resources Act, and can result in increased 'operational and cost burdens' to mine operators.[248] Jacobs considered the extent to which the two pit lake options that it identified as viable vary from the mines' current plans, and found:

- Yallourn mine—the pit lake landform option 'requires some amendment to the existing work plan (e.g. inclusion of programmed maintenance of cover/capping, including monitoring or top up to mitigate fire risk).' The partial backfill below the water table option 'aligns most closely with the current work plan.'[249]
- Hazelwood mine—the pit lake option will require 'some changes' to the current work plan, and the partial backfill below the water table option 'aligns most closely with the current work plan.'[250]
- Loy Yang mine—the pit lake option will require 'some changes' to the current work plan, and the partial backfill below the water table option 'aligns most closely with the current work plan.'[251]

The Jacobs options report records that the other four unviable landform options are not supported at all by the current work plans for all three mines, and would have significant impacts on progressive rehabilitation efforts.[252]

6.9 FUTURE BENEFICIAL USE

Term of Reference 9(h) directs the Board to consider whether, and to what extent, the rehabilitation option would impact the future beneficial use of land areas impacted by the mines. As discussed in Part 5 of this report, the landform dictates the final land uses that are possible within the constraints of safety, stability and sustainability.

6.9.1 COMMUNITY VISION

The Board sought feedback from the Latrobe Valley community about its vision for final land use, through community consultation sessions held on 4 and 5 August 2015 in Traralgon and Morwell, and by inviting written submissions. A range of organisations also provided submissions to the Inquiry.

Members of the community articulated a desire for the mine sites to become an asset for the community, by supporting employment, tourism opportunities, and recreational uses, or by creating an attractive landscape and habitat for native flora and fauna.[253] The community identified the following potential final land uses:

- vegetation—aquaculture, silviculture, agriculture, wetlands, and wildlife conservation
- passive recreation—lakes, gardens, walking tracks, hiking, camping and hot springs and so on
- active recreation—extreme sports, hang-gliding, playing fields, mud racing, speedboat/dingy racing and golf
- nature reserve
- heritage or cultural parks, including interpretive centres and art galleries
- waste management—landfill, recycling, recovery and salvage
- flood retention structures or water storage
- technology industries or a rocket/satellite launching pad
- education, training and research (for example, a Cooperative Research Centre for low emissions technology, carbon capture and storage or alternative coal uses)
- power generation from non-coal sources—bioenergy, hydroelectricity, wind and solar.[254]

6.9.2 FINAL LAND USE OPTIONS

Jacobs assessed the impact of the pit lake option on multiple land uses. It found that, in general terms, a pit lake option could potentially support the uses, described in Table 10 with the caveat that this was not an assessment of viability for each of the Latrobe Valley mine sites.

Table 10. Potential final land uses for the pit lake and partial backfill below the water table options[255]

Land use	Pit lake	Partial backfill below the water table
Conservation and natural environment	✓	✓
Production from dryland agriculture and plantations		✓
Production from irrigated agriculture and plantations		✓
Residential		✓
Manufacturing and industrial		✓
Mining (future)		✓
Services (parklands, education, sport and/or cultural facilities)	✓	✓
Hydro electricity generation	✓	
Solar electricity generation	✓	✓
Lake – intensive use	✓	✓
Lake – production	✓	✓
Reservoir	✓	✓
Wetland – conservation	✓	✓

Land uses less likely to be available under the pit lake option include waste treatment, disposal and recycling; bioenergy electricity generation; and wind electricity generation.[256] Jacobs noted that these land uses are not necessarily impossible, but they are improbable due to the 'significant financial, human and physical resources' required for successful implementation (such as additional materials, water or enabling infrastructure such as roads and utilities).[257]

The ability to create different landforms could, at a later date, result in different final land uses. Mr Hoxley considered that, 'lining the voids and leaving them open has been ruled out through our study because of some of the technical difficulties,' but that these difficulties may be solved over time.[258] In his opinion, 'often a lot of those constraints come down to the cost that people will bear.'[259] According to Dr McCullough, it is possible (though very unlikely) that the results of studies will show a pit lake is not desirable.[260] He noted that there is no reason at this stage to take an option that requires dewatering in perpetuity off the table.[261]

6.9.3 CURRENT FINAL LAND USE PLANS

The mine operators have identified potential land uses for the rehabilitated pit lakes and surrounding areas.

EnergyAustralia has identified conservation, grazing, recreation, forestry, drainage corridors and/or industrial uses as potential final land uses for the rehabilitated Yallourn mine site under the pit lake option.[262] EnergyAustralia submitted that the Yallourn pit lake option could provide a flood, drought and fire resource if and when required, and could be a water source for future industry.[263]

GDF Suez has identified grazing, conservation zones, recreation (active/passive), forestry (open woodland/plantation), and/or various watercourses and wetlands, as potential final land uses for the Hazelwood mine.[264] However, Mr Faithful told the Board that GDF Suez is 'still working through' whether or not it intends, as part of its proposed 2016 work plan variation, to allow public access to the Hazelwood mine site after closure.[265]

As outlined in Part 4 of this report, Loy Yang's 1997 rehabilitation plan identified community recreation as a potential final land use, along with grazing.[266] The 2015 Loy Yang work plan variation only specifies that the rehabilitated site will be suitable for agricultural uses, and that public access to the lake is not intended. Under the heading 'End Use Concept', the approved rehabilitation plan states that 'it is AGL's intention that the land will remain in private ownership at the completion of mining.'[267] Adjunct Professor Sullivan told the Board that 'more detailed engineering may well show that [the lake] can come back into public access of some more limited form', but that he did not know when this might be achieved.[268]

The Board heard that the level of uncertainty about the Loy Yang mine's final land use is related to concerns around safety.[269] The mine operators, State and experts agreed that extensive research and trials are needed to settle on a final land use, and that rehabilitation plans need to be flexible enough to incorporate changes that result from that research.[270]

Mr Rieniets accepted that AGL Loy Yang's intention not to provide for public access to the site under the recent work plan variation, was not actively communicated to the broader community prior to the approval of the variation.[271] This issue is discussed further in Part 10 of this report.

Ms Unger noted that community engagement regarding both progressive rehabilitation of the mines and the final land use is required throughout the mine's life. She explained that it was important that the community is involved in decision-making, and that knowledge is shared, so that locals understand what can be done with each mine site.[272]

6.10 COST

Term of Reference 9(f) requires the Board to consider the estimated cost of the rehabilitation option. The issue of cost is inextricably linked to the assessment of mine operators' liabilities in relation to rehabilitation, which will be discussed in Part 7 of this report. This section briefly discusses the costs relative to other options, and the factors that could impact those costs in the future.

In Jacobs' assessment of viable landforms, the four options deemed unviable (full backfill, partial backfill above the water table, lined void, and rehabilitated void) were assessed as having high costs compared to the pit lake and partial backfill below the water table options, collectively referred to as the 'pit lake option' in this report. The difference in the cost of these options is due to the need for additional overburden, clay cover and/or groundwater management.[273] The costs of the pit lake and partial backfill below the water table options were assessed as being roughly the same.[274]

Considering the similarity of the pit lake option to the mines' current rehabilitation plans, the rehabilitation liabilities that mine operators report in their Annual Returns provide an indication of the cost of the pit lake option. The estimated rehabilitation costs in Annual Returns are calculated on the mines' current footprint, and take into account any progressive rehabilitation completed to date using existing infrastructure and equipment.[275] The mine operators' 2014–15 reports provide the following cost estimates for rehabilitation:

- Yallourn mine—between $46 million and $91 million[276]
- Hazelwood mine—$73.4 million[277]
- Loy Yang mine—$53.7 million[278]

The rehabilitation liability assessment contained in the Loy Yang mine's Annual Return for 2014–15 reflects the estimated costs to implement the 1997 work plan. Subsequently, the 2015 Loy Yang work plan variation was approved. GHD developed a revised cost model based on the work plan variation, which estimated the rehabilitation liability as $112 million. The model is only indicative, as it is based on a series of assumptions that are yet to be validated through detailed technical assessments.[279]

DEDJTR provided the Board with rehabilitation cost estimates developed by AECOM, an independent consultancy. AECOM calculated third party costings based on early closure, meaning that estimates reflect how much it would cost for an agency, other than the mine operator, to undertake rehabilitation now (as opposed to at the end of the mine's life), without the mine operators' infrastructure or personnel. [280] The costings include decommissioning infrastructure, capping ash ponds, earthworks to establish final landforms, revegetation, lake filling, management costs, and post-closure maintenance and monitoring. Significant uncertainties are considered as 'risk costs'—these relate to batter failures, groundwater and surface water quality, coal fires, and securing and maintaining lake water levels.[281] AECOM estimated the cost of rehabilitation undertaken by a third party as follows:

- Yallourn mine—between $167 million and $262 million[282]
- Hazelwood mine—between $264 million and $357 million[283]
- Loy Yang mine—between $221 million and $319 million[284]

The differences in the two sets of estimates and their adequacy are discussed further in Part 7 of this report.

The Jacobs options report states that significant changes to the current rehabilitation plans could have financial implications for mine operators.[285]

Dr von Bismarck told the Inquiry that factors such as monitoring could have significant cost implications for mine rehabilitation, particularly if it involves long timeframes.[286] He estimated that the cost of monitoring water quality and stability in the German rehabilitated mines would be in the vicinity of 'several million Euros.'[287]

6.11 KNOWLEDGE GAPS

As has been highlighted throughout this Part, the Board heard repeatedly from the mine operators, experts and other stakeholders that many areas relevant to rehabilitation require significant research. This will include translating existing knowledge from other settings, while recognising the unique settings and features of each mine.[288]

The Board was urged by several witnesses to ensure that relevant research is conducted in the short-term, so that key uncertainties are addressed, and decisions made now (such as those related to progressive rehabilitation or final landform) are not based on flawed knowledge.[289]

Some of the areas relevant to rehabilitation that were identified during the Inquiry as requiring further research and trials, include the following:

STABILITY

- The role of batter angles in geotechnical stability, and the effect of batter angles and profile on the erosion of overburden cover.[290]
- The role and optimal depth of overburden cover in terms of geotechnical stability and erosion, specific to each mine and/or batter.[291]
- The implications of the changing water level during lake filling on mine stability.[292]
- The development of 'hazard maps' that identify infrastructure in close proximity to the mines and the risks posed to that infrastructure by ground movements caused by mining activity.[293]
- The lifespan of horizontal bores and alternative methods for ongoing batter drainage in the rehabilitated mine.[294]
- The potential for wave action to erode batters.[295]

GROUNDWATER

- Long-term geological changes, including the interactions between ground movements and groundwater pressure, and the development of hazards such as sinkholes that can take a long time to become apparent.[296]
- The impacts of ceasing aquifer dewatering in one mine on the dewatering needs of the other mines, and the recovered aquifer levels at which mine stability should be tested.[297]
- The impacts of batter instability below the surface of the lake.[298]

WATER MODELLING

- The availability of water for timely flooding of the mine pits.[299]
- Impacts of climate change on the water balance.[300]
- Site-specific climate data from the predicted lake surface level to inform water balance modelling.[301]
- Lake fill rates and impacts on stability and the broader water system (including impacts of simultaneous pit filling).[302]

WATER QUALITY

- The implications of the changing water level during lake filling on water quality.[303]
- Long-term pit water quality.[304]
- Site-specific climate data from the predicted lake surface level to inform water quality modelling.[305]
- Impacts of interconnected pit lakes on the hydrology and water quality of nearby waterways.[306]
- The role of flow through from the rivers in pit lake and river water quality and its broader environmental impacts.[307]
- The use of power station fly ash waste in rehabilitation, and the impacts on the environment, erosion and revegetation.[308]
- Monitoring existing contaminants on the mine sites, such as fuels and other chemicals.[309]
- The risk of algal blooms in pit lakes, and management strategies if required.[310]

OTHER ENVIRONMENTAL AND VEGETATION ISSUES

- The viability of rehabilitated sites as wildlife habitats.[311]
- Selection and trialing of vegetation, including vegetation around the edges of the lakes.[312]
- The potential for wave action to impact wildlife habitats and amenity.[313]

FIRE RISK

- Fire risk management in the short, medium and long-term and its links with progressive rehabilitation.[314]
- The role and optimal depth of overburden cover to address fire risk, specific to each mine. [315]
- Other approaches to protecting coal batters from fire risk other than overburden cover.[316]

OTHER

- Alternative final land use options.[317]
- Social and economic effects of closure and the proposed final land uses of the site.[318]
- Strategies to remove barriers to progressive rehabilitation, such as fire services and other infrastructure.[319]
- Timelines for long-term maintenance and monitoring of aspects such as stability and water quality.[320]

The Board heard that some of this work has already commenced. Mr Mether said that EnergyAustralia is addressing many of these issues: '[T]hey've been dealt with starting 20 years ago and we continue to improve our models and our planning.'[321] Mr Faithful agreed that this was also the case at the Hazelwood mine.[322]

However an important research project, the State's Batter Stability Project at the Yallourn mine, has been delayed.[323] The Board was told that contractual issues between the State, EnergyAustralia and the research group (GHERG) have played a role in this delay. [324] Professor Galvin described the Project as just the start in resolving knowledge gaps, and agreed that the length of time it was taking to commence was frustrating. According to Professor Galvin:

> The bottom line is simple. Government is not the place to undertake research. This project has got caught up with all the bureaucracy, all the lawyers in the government department who don't understand research…The solution is had that project gone to a research institute it would have been finished by now. So, with government's best intentions, that project then should have been handed over to a professional research facility.[325]

Professor Galvin added that because of the delay, the Yallourn mine had to continue operations on the batter that was originally selected for the research, meaning that the 'site has now lost some of its value.'[326] Professor Mackay indicated that the commencement of the Batter Stability Project was 'very close',[327] with Mr Wilson advising that field work was expected to be completed by 30 June 2016.[328]

6.12 BOARD'S DISCUSSION AND CONCLUSIONS

In this section, the Board comments on the evidence outlined above, and articulates its findings relevant to criteria in Term of Reference 9.

6.12.1 FIRE RISK

The Board is cognisant of the importance of responding to Term of Reference 9(a), considering the substantial health, social, economic and environmental impacts of the 2014 Hazelwood mine fire. As the 2014 fire demonstrated, uncovered coal represents a serious fire risk to the mines, which can impact critical infrastructure and the communities situated next to the mines.

The proposed rehabilitation option of a pit lake presents benefits for fire prevention in the long-term, as covering the coal with water undoubtedly decreases fire risk.

The Board also recognises that the uncertainties relating to the management of fire risks mean that research, trials and adequate resources must be directed towards resolving these issues. This is of particular importance to the Board in the short and medium-term, considering the risks associated with worked out batters being exposed during mine operations and while lakes are filling. It is apparent that with each mine there will be years, and possibly decades, in which batters that will eventually be underwater, remain uncovered.

Ongoing monitoring and fire services will be vital throughout the entire period the pits are filling. Based on the evidence before the Board, it is not clear what the cost or practicalities are of maintaining these fire services post-mining. It is also unclear whether any detailed consideration has been given to these issues by anyone—regulators (including WorkSafe which shares the responsibility for regulating mine fires with the Mining Regulator) or mine operators. Alternative options, such as additional covering of exposed batters below the planned waterline during lake filling, need to be considered.

The Board heard divergent opinions about the optimal overburden depth for fire prevention, which is also relevant to stability issues. This will also require further investigation, so that the risks of overburden cracking or eroding are minimised over time, as far as is practicable and without unnecessarily onerous cost implications for the mine operators. In its report on the closure of the Anglesea mine (Hazelwood Mine Fire Inquiry Report 2015/2016 – Volume I), the Board found that the necessary depth of overburden for fire prevention purposes may depend on the nature of the overburden used—for example, the percentage of clay it contains.[329] This is a matter that should also be examined in the Latrobe Valley.

The Board is concerned that the mine operators see fire services infrastructure as an impediment to progressive rehabilitation. This is discussed in Part 6.12.5.

Term of Reference 9(a) requires consideration of the cost of the pit lake option relative to the cost of other fire prevention measures. The difficulties in costing the pit lake option are examined in the Board's consideration of Term of Reference 9(f). There is little, if any, evidence before the Board about the costs of alternative fire prevention measures, largely because the work on identifying such alternatives has not been done.

6.12.2 STABILITY

The Board recognises that the issue of mine stability is fundamental to the Terms of Reference for this Inquiry, as it is a core objective of rehabilitation. The beneficial use of rehabilitated land, particularly land that will be accessed by the community or is in close proximity to communities and infrastructure, is based on a presumption that the final landform will be stable. Instability can have significant ongoing implications, as has been seen in recent events at the Yallourn and Hazelwood mines.

At this time, the evidence presented does not allow the Board to make an evaluation of the viability of the pit lake option for any of the mines from a stability perspective. The numerous uncertainties regarding stability lead the Board to conclude that this is clearly an area that requires significant investment and investigation. The GHD report cited by EnergyAustralia is consistent with the rest of the evidence before the Board in this regard, in that it highlights the amount of work that remains to be done in assessing stability issues at the Yallourn mine.

It appears to the Board that without clear definitions and criteria for 'safe' and 'stable', there is no way to assess whether mine rehabilitation has been successful. This is a critical area for resolution by the Mining Regulator, mine operators and relevant experts.

Studies must be conducted into groundwater management; optimal fill rates; the impact of submerging batters; batter angles; levels of overburden for backfilling and batter cover; wave erosion; and requirements of ongoing maintenance and monitoring. The results of these studies will have significant implications for the mines' rehabilitation plans and final costs.

The Board affirms the commitment of the Mining Regulator, the mine operators and the research groups to progress the Batter Stability Project at the Yallourn mine and the Loy Yang mine rehabilitation trials. What constitutes long-term stability is a fundamental issue that must be resolved in the short-term to inform successful progressive and final rehabilitation of the mines.

6.12.3 SOURCING WATER

The Board considers that the issue of sourcing water is key to the viability of the pit lake options. Based on the evidence before the Board and having regard to the submissions of the parties, the Board accepts that it is not at all clear that sufficient water will be available to any of the mines for the purpose of rehabilitation, in terms of both using existing water allocations and the quantity of water available in the water system at the time the mines are scheduled to be filled.

Prolonged years of drought combined with water restrictions, extreme weather events and a greater awareness of climate change have dramatically influenced society's views and expectations on current and future water usage. The original concept of all three coal mines being flooded with water to create artificial lakes may not be viable in light of changing environmental and regulatory constraints. This plan needs to be revisited, as recommended by the Sustainable Water Strategy.

It is not the task of this Board to interpret the conditions or scope of various water licences and entitlements. It is sufficient for present purposes to note that there is a real question about whether a licence with a limited life that was granted 'to facilitate mining for coal and generation of electrical energy and purposes incidental thereto' would authorise use of water to fill the former mine after mining and power generation has ceased. The Board notes the view of the administering authority (Southern Rural Water) that 'current licences do not allow for ongoing depressurisation after the term of the licence.'[330] Until this issue is addressed, there are significant uncertainties about access to water, and therefore the viability of the pit lake option.

The Board is conscious that at various times the three mine operators will be filling the mine pits concurrently. At this point in time, the mine operators are not using their full water allocations under their groundwater licences, despite this being proposed under the rehabilitation plans for the Yallourn and Loy Yang mines. This means that the impacts on the water system of the full use of those allocations (assuming they are available) are unknown, and could be significant for the region. Further, if water is available under the current allocations but at a cost, or only over a certain period of time, this may impact the viability of this option as compared with others.

Based on the evidence of Professor Mackay, the Board acknowledges that the setting of the Yallourn mine means that it has a natural advantage in terms of accessing water that is not enjoyed by the other two mines. Whether the pit lake can be connected to the nearby waterways is, of course, another 'unknown' at the present time.

As with the other issues relevant to this Part, without certainty around this issue, it is difficult for the Board to determine Terms of Reference 9(f) and 9(i), other than to confirm that without reliable sources of water, the pit lake option will be unviable and unsustainable. The uncertainty in this area is a limitation of the option, particularly due to the volumes of water, the timeframes, and the potential for external factors to influence availability of water.

6.12.4 WATER QUALITY

In considering rehabilitation options, the Board recognises the importance of water quality, both in terms of its environmental effects, and its impact on the potential final land use. If water quality is unable to be maintained in one or more of the pits, the public will not be able to access those lakes for recreational use.

The Board heard evidence about the possible effects of flooding the mines on water quality. As was the case with the evidence about stability, sourcing water, fire risk and other issues, the Board considers that there are many important unanswered questions concerning water quality, within the proposed lakes and in external groundwater and river systems.

It is not presently clear how water quality will be maintained in each of the proposed pit lakes, nor the cost implications of both answering this question and maintaining required quality levels.

While the Board acknowledges that the prospect of the Yallourn mine successfully maintaining water quality is greater than for the other two mines (due to the potential for flow through), it is clear that further studies and trials will be required in order to determine if, and how, all of the pit lakes can be made safe from a water quality perspective. The Board notes that whether ongoing maintenance of water quality is needed is dependent on the end use of the pit lakes. The proposal for a recreational lake at the Yallourn mine, while providing the most benefit to the community, may also be the most challenging to achieve.

Due to these factors, it is not possible to make an assessment about the viability of the pit lake option as it relates to water quality for any of the mines.

6.12.5 PROGRESSIVE REHABILITATION

The Board recognises the importance of progressive rehabilitation throughout the operational life of a mine, to both reducing fire risk and to ensuring that final rehabilitation is achievable within an acceptable timeframe. It is clear to the Board that the rate and type of progressive rehabilitation that occurs now can greatly impact these timeframes for the rehabilitation process, as well as the associated costs.

Progressive rehabilitation was discussed throughout the hearings, and the Board is concerned that there was no clear agreement on its definition. The Board's view is that progressive rehabilitation must be seen as broader than moving overburden, changing batter angles and revegetation. It should include a focus on short, medium and long-term risk reduction, as well as research, trials, and building community and regulatory confidence.

The confusion that each mine operator expressed around progressive rehabilitation costs and operational costs is an indication that there is no consistently held view on what progressive rehabilitation entails. Considering that progressive rehabilitation is a requirement of the Mineral Resources Act, the Board believes that it would be of benefit to both the Mining Regulator and the mine operators if the scope of progressive rehabilitation was clarified, and associated criteria established in the short-term.

The Board considers research and trials to be essential components of progressive rehabilitation. The knowledge gained through this process will increase the likelihood that rehabilitation is effective and sustainable. Building certainty regarding what will work in each mine prior to closure will allow the mine operators to refine their rehabilitation plans, more accurately predict timeframes and costs, and clearly communicate their plans to the community. This communication and the physical evidence of trials, will build the community's confidence in the ability of the mine operators to achieve these plans.

The Board recognises that while a pit lake may be the most viable option at this time, this could change due to shifting expectations and knowledge—but by that point progressive rehabilitation choices could have eliminated any alternative as a possibility. The Board notes Dr McCullough's concept of a 'Rubicon moment', that is, that flexibility in progressive rehabilitation must be maintained wherever possible, so that no decisions are made that unwittingly restrict the mines from achieving the best possible final landform and land use.

The presence of fire services infrastructure has been cited by the mine operators as a barrier to greater progressive rehabilitation. The Board notes Professor Galvin's advice, and the mine operators' agreement, that more could be done to address this apparent obstacle to rehabilitation. The Board reiterates that identifying solutions to this issue must be a short-term focus of the mine operators and the Mining Regulator. The risk involved in not undertaking progressive rehabilitation (including further fire risk) must be a key consideration, particularly considering batters will be exposed while each lake is filling and will therefore pose a fire risk over a number of years.

The Board concludes that the pit lake option cannot be seen to 'ensure' progressive rehabilitation in a literal sense any more than any other long-term option. Instead, the mine operators must ensure that it is undertaken, overseen by the Mining Regulator, and that any barriers to its implementation are addressed. There are obvious short-term benefits to undertaking progressive rehabilitation from a knowledge, confidence and risk management perspective, as well as benefits in the medium and long-term to refine and enhance planning and provide a basis for successful final rehabilitation.

To ensure that the rate of progressive rehabilitation increases, the Board recommends that the Mining Regulator develops milestones within the mine operators' progressive rehabilitation plans. This will provide clear guidance for mine operators about the expectations for each mine, and achieving the milestones will build regulatory and community confidence.

The Board recommends that the State increase the rate of progressive rehabilitation by developing milestones within the mines' progressive rehabilitation plans in consultation with the mine operators and the Technical Review Board, and require the successful achievement of the milestones.

The Board recommends that the mine operators increase the rate of progressive rehabilitation by achieving milestones within the mines' progressive rehabilitation plans, as set by the Mining Regulator under the previous recommendation.

6.12.6 TIMEFRAME

Without some level of certainty around what constitutes safe, stable and non-polluting closure criteria, it is difficult for a meaningful assessment to be made of the estimated timeframe for the implementation of the pit lake option.

One measure of closure might be whether the landform can be used as planned. However, as discussed, there is uncertainty regarding what this land use may be. Further, public access can change what is considered acceptable in terms of water quality and stability. Without a clear understanding of the intended use and the associated acceptance criteria, it is impossible to predict a timeframe for implementation.

It is clear is that there is currently no way to measure 'successful' rehabilitation. The Board does not consider the achievement of the weight balance lake level as a marker of successful implementation, particularly considering all that it has heard about the importance of timeframes for ongoing maintenance and monitoring—the estimates of which have ranged from decades to in perpetuity. The timeframes provided by mine operators in their lake modelling scenarios should be seen as distinct from rehabilitation timeframes.

Considering the complexity and enormity of the rehabilitation undertaking for the Latrobe Valley mines, it is perplexing to the Board that the Mining Regulator has not established mine closure planning principles from which operators could develop clear closure criteria. The development of these criteria was recommended by many of the experts, and it seems evident to the Board that this would have benefits to both the mine operators and the State in clarifying expectations and reaching optimal outcomes. The obvious links to rehabilitation bonds provide an added impetus to establishing closure criteria in the short-term.

The Board also acknowledges the need for flexibility in closure criteria, to reflect changing knowledge and expectations about rehabilitation in the future.

Another consideration in relation to timeframes is that rehabilitation will be occurring, to a large degree, at the same time across the three mines. As discussed above, this could lead to problems with groundwater management, access and availability of water and backfill material, and access to labour, equipment and other materials. The Board accepts the evidence of Jacobs that the potential for this or any of the above factors to extend timeframes will have significant implications on the costs of rehabilitation.

While there are many factors that will affect how long closure will take, it is clear that resolving the question about sourcing water may significantly change the estimated timeframe for filling each pit. The identification of appropriate monitoring and maintenance requirements and water quality standards will also be key.

6.12.7 IMPACT ON CURRENT REHABILITATION PLANS

The Board notes Jacobs' advice that the two pit lake options align relatively closely to the mine operators' current work plans. The Board recognises that some changes may be required to the work plans to ensure the landforms are achieved. This finding is consistent with the evidence the Board has heard regarding the many uncertainties and gaps in the current work plans, which require clarification.

6.12.8 FUTURE BENEFICIAL USE

The Board recognises the importance of final land uses that see the mine sites become assets to the community, particularly during the transition period after mining ceases. The Board is grateful to the Latrobe Valley community for its engagement and insights on this issue, and is conscious of the implications of its findings relevant to this Term of Reference.

Many of the options suggested by community members require landforms other than the pit lake option. For example, a golf course would require a greater area of relatively flat land (potentially a fully backfilled or partially backfilled above the water table landform option), and waste management would require a lined void landform. The Board accepts the evidence of the experts that the creation of safe, stable and non-polluting landforms is a fundamentally important component of mine rehabilitation, and based on the current level of knowledge, this will be best achieved by the pit lake option.

Unfortunately, it is not possible to adequately assess the viability of potential land uses due to the lack of clarity about whether or not implementing the pit lake option will impact the future stability and water quality of the lake and surrounding area. The ability of the public to safely access the rehabilitated sites will be affected by elements such as water quality, stability (for example, an unstable landform could potentially result in block sliding and batter collapse), and erosion controls (for example, if rip rap is deemed necessary, it would mean that people couldn't access the lakes easily, as rocks would be placed along the water line). These issues limit potential land uses, as was outlined in Jacobs' evidence. The final assessment depends on matters presently unknown, and a premature assessment could have ramifications for the community's safety and the land's amenity in the future.

What was clear throughout the Inquiry, however, was that the community is eager to be engaged in the process of identifying potential land uses and developing a vision for the future. The mines have been integral to the Latrobe Valley's landscape, economy and history over the past century, and the rehabilitated sites have the potential to be similarly integrated. The Board believes that the community should have an active role in developing a vision for the mines post-closure. To date the community has been almost entirely excluded from this process. While a definitive assessment of the mines' final land use cannot be made now, the conversation between mine operators, the community and the State must be ongoing and meaningful.

The Board is concerned that changes to the mines' work plans that affect the community are not the subject of public discussion. The 2015 Loy Yang work plan variation is a clear example of where adequate community engagement has not occurred. The community has anticipated that the site will be accessible to the public for recreational use after the mine's closure; however this is no longer the case. This example highlights the need for ongoing community engagement, and is discussed further in Part 10 of this report.

6.12.9 COST

The Board accepts Jacobs' assessment that at this stage the pit lake option appears to be the least expensive of the available options. However, uncertainty regarding a wide range of issues relevant to rehabilitation means that it is not possible for the Board to definitively assess the cost of the pit lake option for each mine. The Board considers it highly likely that the estimated costs of rehabilitation will change over time, as further research and trials are undertaken, and community and regulatory expectations are defined.

As outlined in each of the previous sections, rehabilitation costs will depend on a range of factors, such as stability, sourcing water, water quality, fire risk reduction, and the planned future beneficial use of the site—all of which, to greater or lesser degrees, are uncertain or unknown at this time. Some factors could greatly influence overall costs, such as the length of time it takes to fill the pits with water, optimal batter angles, or the need for rip rap or additional overburden. More certainty in these areas will provide more accurate cost estimates.

While the Board is unable to provide a definitive cost assessment, this does not mean it is impossible for the mine operators or the Mining Regulator to estimate rehabilitation costs. The Board sees this assessment as critical to effective rehabilitation planning and oversight.

Ultimately, it is clear that the complexities and uncertainties regarding mine rehabilitation make it a costly endeavour. There are risks to both the mines and the community more broadly if costs are not adequately forecast and budgeted for. Failure to accurately account for the costs of rehabilitation creates the possibility that the responsibility for undertaking rehabilitation will default to the State—a situation that the rehabilitation bond system aims to avoid. The Board has concerns about the current systems and practices regarding liability assessments as they relate to rehabilitation bonds under Term of Reference 10 of this Inquiry. These concerns are discussed in Parts 7 and 8 of this report.

6.12.10 KNOWLEDGE GAPS

Undertaking research to ensure effective rehabilitation of the mine sites is clearly a priority. The Board strongly agrees that research and trials must be conducted in the short-term wherever possible. The Board encourages the mine operators to prioritise research and trials within their rehabilitation plans, so that the issues that require resolution prior to mine closure (particularly around stability, sourcing water, water quality and fire risk) are thoroughly investigated, and where possible resolved.

The Board recommends that the mine operators, in consultation with the Mining Regulator and relevant research bodies and experts, develop an integrated research plan that identifies common research areas and priorities for the next 10 years. The plan should be reviewed every three years to reflect updated priorities and areas of uncertainty. The list of research topics identified in Part 6.11 can be used as a starting point for discussion. This will enable the mine operators to plan future joint research projects and co-funding opportunities, as well as identify areas in which knowledge can be shared and duplication minimised.

Funding this and other mine-specific rehabilitation research should be part of mine operators' expenditure on progressive rehabilitation, and should be reflected in the mine operators' Annual Returns as such.

> The Board recommends that by 31 December 2016, the mine operators develop an integrated research plan that identifies common research areas and priorities for the next 10 years, to be reviewed every three years. The plan should be developed in consultation with the Mining Regulator and relevant agencies, research bodies and experts. The list of research topics identified in Part 6.11 can be used as a starting point for discussion. The Latrobe Valley Mine Rehabilitation Commissioner and Latrobe Valley Mine Rehabilitation Authority should promote and coordinate this research (see the recommendations in Part 11).

6.12.11 FINAL COMMENTS

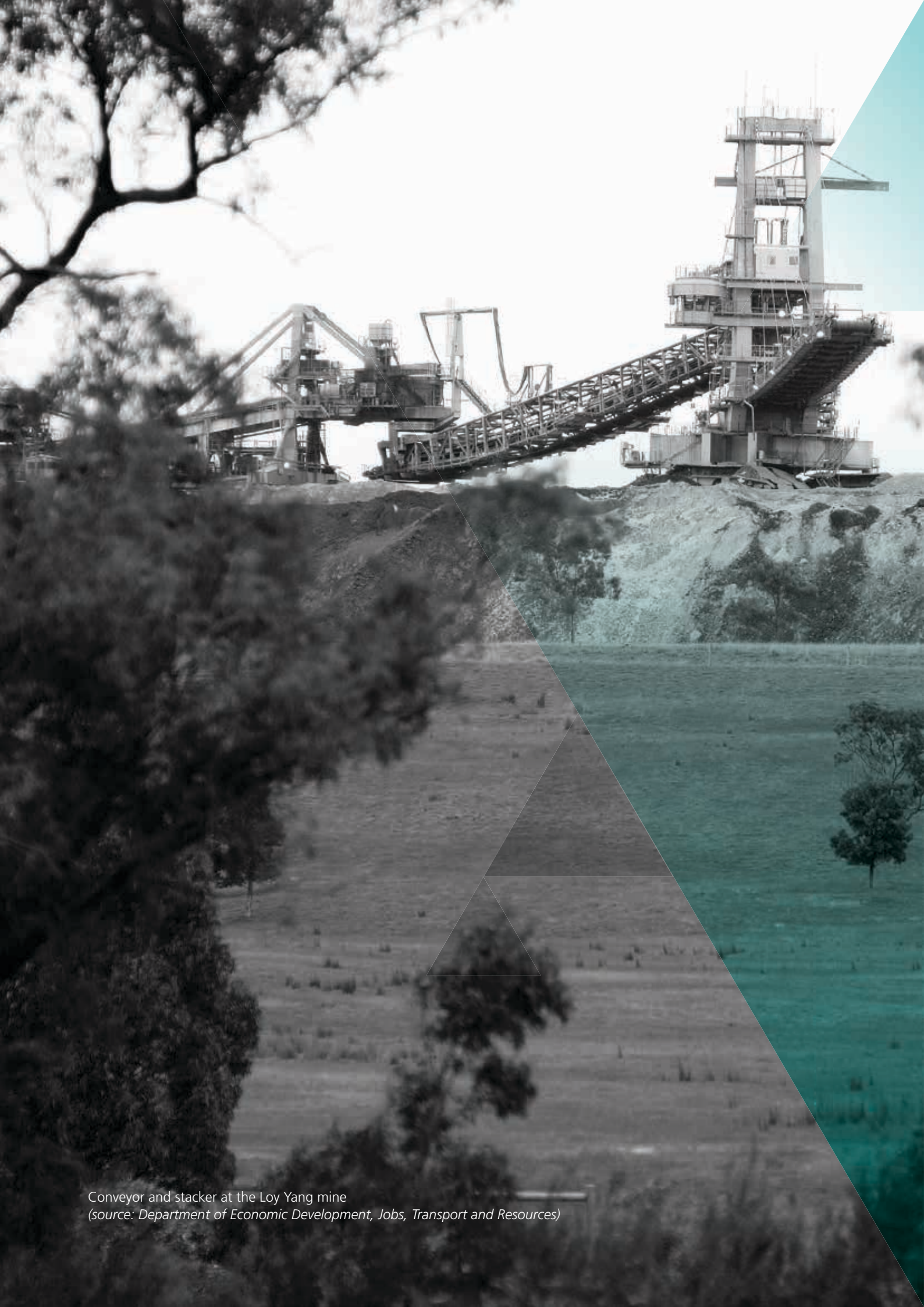
Given the evidence before the Board, it is not presently possible to provide a definitive evaluation of rehabilitation options, in particular the pit lake option, against the criteria set out in Term of Reference 9.

The Board heard that there are many gaps in current knowledge of the technical issues related to mine rehabilitation, such as fire risk mitigation, mine stability, groundwater management, water availability, and water quality, at both a regional and mine-specific level. Therefore, while the Board acknowledges that the pit lake option is currently the most viable rehabilitation option, considerable further investigation is required, as new knowledge could result in an alternative preferred option.

The Board considers that the evidence provided during the Inquiry regarding Terms of Reference 8 and 9 represents an important step towards creating certainty around a range of issues that impact mine rehabilitation, and will be a valuable resource for the mine operators and the Mining Regulator.

As highlighted in this discussion, there are significant barriers and limitations to the regulation, planning and implementation of mine rehabilitation in the Latrobe Valley. Term of Reference 12 directs the Board to consider 'any other matter that is reasonably incidental' to the Inquiry's Terms of Reference. These practical limitations and uncertainties are evidently reasonably incidental to the issue of mine rehabilitation options. Therefore, in Parts 10 and 11 of this report, the Board considers a number of factors that need to be taken into account when implementing rehabilitation options, as well as changes that are necessary to ensure that rehabilitation is successful for the mine operators, the Mining Regulator, the residents of the Latrobe Valley and the broader community.

Source: Department of Economic Development, Jobs, Transport and Resources



Conveyor and stacker at the Loy Yang mine
(source: Department of Economic Development, Jobs, Transport and Resources)