Latrobe Valley Regional REHABILITATION STRATEGY

Regional Water Study Synopsis Report
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CONTEXT AND SCOPE

The Latrobe Valley Regional Rehabilitation Strategy (LVRRS) is part of the Victorian Government’s response to the findings of the Hazelwood Mine Fire Inquiry (HMFI), which found significant uncertainties and knowledge gaps surrounding the rehabilitation and closure of the Latrobe Valley’s three brown coal mines.

The HMFI’s Board of Inquiry found that, with the current knowledge available, some form of water body was the most viable rehabilitation option for the coal mine voids, but that many unanswered questions remain concerning the feasibility of the potential mine pit lakes1. The Strategy will address some of these knowledge gaps through technical studies undertaken as part of the Latrobe Valley Regional Rehabilitation Strategy.

The Strategy considers the mines individually and collectively in the context of potential impacts (positive and negative) on the environment, Aboriginal and non-Aboriginal cultural heritage values, infrastructure and land uses in the Latrobe Valley, with a particular focus on water and land stability. The primary objective of rehabilitation is to achieve a safe, stable and sustainable landform for the closed mines.

The Regional Water Study assessed:
1. Potential water availability and use of regional water resources for mine rehabilitation
2. Potential alternative water sources to those currently available to the three mines
3. Potential water quality impacts in water bodies, groundwater and off-site surface waters
4. Potential impacts on aquatic ecosystems and downstream users
5. Scope of likely requirements for long-term regional groundwater monitoring

This synopsis summarises the key findings of the Regional Water Study, covering the following areas:
1. Environmental effects
2. Climate change projections
3. Water supply options
4. Integrated water resource modelling
5. Pit lake water quality modelling
6. Environmental flow recommendations
7. Water availability
8. Water use scenarios
9. Groundwater flux modelling
10. Regional groundwater projections
11. Water-related effects
12. Pit lake modelling
13. Water availability for mine rehabilitation

KEY FINDINGS

1. WATER AVAILABILITY
The Latrobe Valley has experienced dry conditions since 1997, and the LVRRS will need to be able to account for uncertainty around future climate and water availability by planning for a continuation of this drying trend and a drier future.

If the dry conditions currently being experienced in Gippsland continue into the future, there is a risk of impacts if surface water is supplied for mine rehabilitation without conditions that protect other water users and the environment.

- Average inflows since 1997 into the Latrobe River system have declined sharply from pre-1997 levels – from 800 GL/y to 600 GL/y.
- Climate change projections for the region indicate a wide range of possible futures, from very dry (500 GL/y average at 2040) to wet (1,000 GL/y at 2040). The median prediction is a marginal decline to 700 GL/y average by 2040, and 650 GL/y by 2065.
- Water resource modelling indicates that the recent dry period since 1997 could imply different trajectories for future climate:
  - The decline could be ‘on-trend’, following a drying climate projection (i.e. not a drought but the ‘new normal’)
  - The decline could be a drought (temporary), with the possibility of reversion to the long-term average (closer to 800 GL/y) subject to a future possible decline associated with climate change.
- Since 1997, there have been shortfalls in river flows in 15 of 21 years, by up to 67% compared to an average year, after extraction for consumptive uses.

- In three consecutive years (2011–2013) since 1997, inflows significantly exceeded minimum flow needs and consumptive use, indicating that climate and streamflow still has the capacity to deliver good water years, although potentially at a reduced frequency compared to pre-1997 conditions.
- Under long-term average conditions with a median climate change projection, average water availability is likely to be sufficient to allow the mines to fill at a rate limited to current levels of consumptive use for power generation without significantly impacting river function or water security until about 2035, after which water availability may become more limited.
- Under current conditions or a dry climate, average water availability is significantly lower, with a relatively high water availability in which water for rehabilitation could be accommodated.
- Although filling the mine voids with water would pose a significant demand on the Latrobe system, supply of water for this purpose could be feasible if it is accepted that the filling rate is limited to the power stations’ current annual net usage and that filling is restricted or halted under dry conditions to prevent unacceptable impacts on water security, other water users and values including river function and the Lower Latrobe wetlands and Gippsland Lakes.
- New water demands or future growth in the Latrobe Valley could reduce the amount of water available for mine rehabilitation if water availability is limited in the future and new sources of water are not found.

It would take 15 to 30 years to fill each mine pit with water using existing water sources

- Hazelwood has a void volume of 640 GL, and using a combination of groundwater (pumped for stability) and surface water, would take 15 to 20 years to fill without interruption.
- Yallourn has a predicted final void volume of 725 GL at closure (2032), and using the same amount of surface water currently used for power generation plus a supply of surface water equivalent to that supplied to Hazelwood after supply to Hazelwood ceases, would take 20 to 25 years to fill without interruption.
- Loy Yang has a predicted final void volume of 1,420 GL at closure (2048), and at current levels of groundwater and surface water usage would take 25 to 30 years to fill without interruption.
- These timeframes could be extended significantly if filling from surface water sources is delayed due to dry conditions, or shortened if smaller fill volumes are needed or additional water sources come available for use.
Top-up for evaporative losses would be needed to maintain pit lakes

- An external supply of water would be needed to make up for evaporative loss from potential pit lakes in order to maintain the required lake level.
- Under current climate conditions, about 4–6 GL per year per mine void would be needed to maintain water levels, totalling about 15 GL/y for all three mines. This is likely to increase under a drying climate.
- For comparison, over 2017/18, Gippsland Water supplied about 13 GL of water to its residential and non-residential customers (excluding major industry)².

Keeping Hazelwood and Loy Yang dry would require ongoing groundwater pumping

- Keeping these two mine voids empty would require significant ongoing groundwater pumping to maintain the safety and stability of the mine voids. This would likely result in ongoing regional and local ground subsidence.
- Ongoing groundwater pumping is unlikely to be needed at the Yallourn mine, even if it were not to be filled with water, but this could change depending on the final mine void and the rehabilitation approach adopted at the other mines (which could increase groundwater levels in the area of the Yallourn mine).

2. ALTERNATIVE WATER SOURCES

Currently there are no alternative water sources that are considered more feasible than existing water sources for mine rehabilitation, although this may change in the future

- No alternative water sources of suitable quality, volume or comparative cost are currently considered feasible at the present time to assist in mine rehabilitation compared to existing water sources, although this may change in the future.
- Large volumes of water, of more than 5–10 GL/y, would be needed to materially hasten the filling process, although smaller volumes may become more important if mine void filling occurs slowly.
- Source water would need to be of acceptable quality, including low nutrients and dissolved contaminants.
- Treated recycled water from the Eastern Treatment Plant, for example, while potentially offering high volumes (100 GL/y), was found to have unacceptably high nutrient levels, which would result in high treatment costs in addition to the capital and operating costs of a pipeline to the Latrobe Valley.
- Some alternative water sources, such as recycled treated wastewater, may become more feasible or attractive if low water availability in the Latrobe system limits rehabilitation progress significantly.

3. WATER QUALITY

Water quality risks are not significant and are manageable

- No significant sources of potential pollutants were identified in the Hazelwood and Loy Yang mine voids, and no significant water quality risks were identified based on known mine materials at these sites.
- Yallourn has a significant quantity of stockpiled acid sulphate soils in the western mine void, which will act as an ongoing source of acidity unless covered or inundated. The impact of these materials on water quality during filling is expected to be manageable, and once treated, are not expected to have any long-term impact.
- Although no significant water quality risks were identified at a high level, the potential for water quality risks needs to be studied in detail at the end of mining operations based on reliable and representative data.
- Mine water bodies that are not regularly flushed may experience a gradual decline in water quality over time (many decades) due to evaporative concentration of salinity and other accumulated contaminants, but the impact on water quality is not expected to be significant.
- The main factor influencing water quality in the mine voids is the quality of the water used to fill the voids.
- Acceptable water quality objectives are considered to be achievable without ongoing in-pit treatment if the water used to fill the mine voids is of suitable quality.
- Any releases from the pit lakes would need to meet applicable water quality standards, and the final landforms should be configured to allow releases to be ceased or controlled.
- Due to the very low rates of groundwater interaction with the pit lakes and the broadly benign water quality, no significant risk of groundwater quality impacts was identified.

4. ECOLOGICAL IMPLICATIONS

Failure to deliver minimum flow requirements in the Latrobe River would likely result in unacceptable impacts:

- Some Ramsar wetlands at the lower end of the Latrobe River system have undergone significant salinisation in recent years due to insufficient freshwater flushing, caused by a combination of dry conditions, lack of freshwater flows, rising sea level and saline inundation events.
- Updated flow recommendations for the Latrobe River and lower estuary and wetlands quantify the minimum flows needed to maintain sufficiently fresh conditions in the lower reaches of the river, to counter salinisation of the highly valued Ramsar wetlands and other fringing environments of the lower Latrobe River and Lake Wellington.
- Under a drying climate, the physical and ecological function of the river will inevitably change due to a natural decline in inflows, even before any consumptive use.
- The impact of consumptive use, including for rehabilitation, is therefore expected to increase over time under a drying climate.
- Sustained shortfalls in minimum flow requirements are likely to result in ongoing salinisation of previously freshwater wetlands and ecological areas, noting that shortfalls in flows from the Thomson and Macalister rivers also contribute to such impacts in the lower Latrobe estuary and Lake Wellington.

5. GROUNDWATER MONITORING

Existing groundwater monitoring activities appear to be adequate considering the known risks:

- Additional groundwater quality monitoring near the mine pits is expected to be required only if a water quality issue in a pit lake is identified. No such issues are predicted.
- Groundwater drawdown and recovery rates can be adequately monitored using the existing monitoring network if the monitoring bores are maintained in adequate condition and data is made available.
- Potential impacts on other consumptive users of groundwater would need to be assessed if any increase in groundwater pumping rates beyond those required for maintaining stability or extension of pumping duration is proposed.
**TECHNICAL SUMMARY**

1. **ENVIRONMENTAL EFFECTS SCOPING STUDY**

The purpose of this aspect of the study was to:

- understand whether sufficient information is available to assess the potential effects of mine rehabilitation on water-dependent environmental values.
- identify key information gaps that could be realistically filled through the Strategy.
- provide the information needed to plan the remainder of the technical studies.

The potential physical, hydrologic and water quality changes that may occur as a result of mine rehabilitation were assessed, and the processes that may be influenced by these changes (in Gippsland waterways) and water-related ecological assets that are vulnerable to these changes were identified.

**Key outcomes**

- The lower Latrobe estuary and wetlands have experienced significant salinisation impacts in recent years. Understanding the drivers of this process is essential to assess the potential for these impacts to be exacerbated by mine rehabilitation.
- Up-to-date knowledge of environmental flow requirements for the length of the Latrobe River from Lake Narracan to Lake Wellington is essential to assess potential flow-related impacts of mine rehabilitation.
- It is important to investigate the water quality implications of potential cumulative deposition issues arising from toxicants that may be introduced into the mine void.
- It is necessary to further understand the geomorphic processes in the area, specifically changes to erosion processes, sediment supply and geomorphic characteristics of the system.

2. **CLIMATE CHANGE PROJECTIONS**

The purpose of this aspect of the study was to:

- understand potential changes to water availability as a result of climate change and long-term climate variability using the framework and guidelines of the Victorian Climate Initiative.

Any assessment of the viability of water bodies (pit lakes) over the medium to long term, during the rehabilitation (filling) period and into the future, needs to take account of potential changes to water availability as a result of climate change and long-term climate variability (such as periods of prolonged drought). Climate projections were derived for use in modelling rehabilitation scenarios, water sources and fill rates.

**Key outcomes**

- The climate factors recommended by the Victorian Climate Initiative Guidelines\(^3\) (using the empirical downscaling method) at 2040 and 2065 for the climate scenario accepted as being representative of current trends were found to be adequate for projections up to about 2090.
- Rainfall, streamflow, evaporation and temperature factors were provided for the 10% (dry), median and 90% (wet) projections from the set of 42 global climate models considered in the Victorian Climate Initiative in order to inform the range of possible futures.
- Gridded scaling factors were recommended for rainfall, temperature and evaporation while catchment-aggregated change factors were recommended for streamflow. Annual scaling was considered to introduce less uncertainty than seasonal scaling factors, subject to sensitivity analyses.
- It was recommended that the full available climate dataset from 1957 be used to model future scenarios (with climate scaling factors applied), with pre-1975 data scaled to post-1975 conditions to correct for the 1975 step change.
- It was concluded that modelling beyond 2090 is highly uncertain and could be considered only in a very qualitative sense.
- The uncertainty associated with climate change is one of many that impact the Strategy, including changes in consumptive water demand, bushfire risk, and land use-driven changes to streamflow.

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3. WATER SUPPLY OPTIONS FEASIBILITY ASSESSMENT

The purpose of this aspect of the study was to:

• investigate potential water sources, in addition to existing water sources that are being used for power generation, that could be considered for use in mine rehabilitation.

A comprehensive list of ideas for possible alternative water sources was developed through a stakeholder workshop. These ideas were then subjected to a rapid desktop assessment based on potential water volumes, costs, water quality, logistics, infrastructure requirements, timing, availability, regulatory and licensing requirements, and stakeholder planning and integration aspects. Ideas with potential feasibility for mine rehabilitation would then be assessed in more detail in follow-up studies.

The potential sources of water included various sources in the Latrobe system, stormwater, recycled water, wastewater, desalinated water and water from the Victorian water grid.

Key outcomes

• No new or alternative water sources were found to be feasible for mine rehabilitation at this point in time.

• Existing groundwater extraction and supply from the Latrobe River, its tributaries and storages are therefore considered the most feasible source of water, subject to appropriate access arrangements, infrastructure and management constraints.

• New or alternative water sources were found to be comparatively more expensive, too difficult to access, and/or of too small a volume to materially contribute to rehabilitation at this point in time, although this may change in the future with changes in water availability and/or investment in alternative water sources.

• Specific water sources of note include:
  – Recycled water from the Eastern Treatment Plant could potentially provide large volumes (100 GL/y) of reliable flow and is broadly of acceptable quality, but would require significant investment in a pipeline. However, the water’s elevated nutrient levels could potentially present an unacceptable risk for a pit lake. Investment into treatment was considered to be required to reduce this water quality risk to acceptable levels.
  – Water sourced via a connection to the Victorian water grid would compete with urban uses, which are already under significant pressure, and expected to be much more costly than local water sources.
  – Desalinated seawater was considered to be prohibitively expensive, and raw seawater to present significant risks to freshwater groundwater systems and water-dependent ecosystems.
  – Other local recycled water and stormwater streams are considered to be of too small a volume to meaningfully impact regional rehabilitation decisions at the present time, but may become more attractive if water availability becomes more constrained in future.
  – Although the rapid assessment did not reveal any feasible alternative water supply options, a more thorough assessment of specific options could be warranted in future. Such an investigation could include environmental, economic and broader social impacts.
4. INTEGRATED WATER RESOURCE MODELLING SCOPING STUDY

The purpose of this aspect of the study was to:

- understand the requirements and technical constraints for modelling the pit lakes’ interaction with surface water and groundwater.
- develop a framework and approach for completing the modelling studies.

Workshops were held to deliberate on possible approaches and available knowledge. The results of the study were used to develop an implementation or project execution plan as an extension of this task.

Key outcomes

- A proprietary groundwater model maintained by GHD should be used to model groundwater behaviour near and in the pit lakes.
- A regional groundwater model maintained by the Geological Survey of Victoria should be used to model groundwater behaviour on a regional basis.
- The REALM (REsource ALlocation Model) modelling tool should be used to model surface water in the Latrobe River system.
- The near-pit surface and groundwater models can be run separately because surface water extraction is not considered to have a material impact on groundwater, based on a lack of strong interaction between the shallow aquifer system and the deeper regional aquifers.
- The impact on streamflow from groundwater dewatering of deep regional aquifers can be considered by a surface water model. It is expected that losses from streams to groundwater will not change significantly and may not occur for decades or indeed centuries.
- A pit lake model is needed to integrate water from surface water, evaporation and groundwater. The pit lake and surface water models need to synchronise volume and rate data from surface water sources to the pit lakes, and the pit lake model and groundwater model fluxes will need to be reconciled.
- The GoldSim software package should be used to model pit lake filling and water quality evolution.
- The filling of pit lakes should consider solute transport, and the pit lake model can then examine changes in concentration over time. The movement of chemicals in groundwater can be assessed using particle tracking.

5. PIT LAKE WATER QUALITY MODELLING SCOPING STUDY

The purpose of this aspect of the study was to:

- assess geochemical and water-related risks associated with rehabilitation of the three Latrobe Valley mines.
- develop an approach to modelling the three systems based on risk prioritisation.

As part of the study, a technical panel of geochemists toured each of the mines to identify mine domains (e.g. overburden dumps, drains, ash dumps), materials of interest and potential water quality risks based on observation and available knowledge.

Key outcomes

- No significant or unmanageable risks were identified based on an order of magnitude assessment, although each site has specific risks that should be accounted for:
  - Hazelwood is considered to have no significant identified potential for pollution or water quality impacts related to the mineralogy and materials in the mine pit.
  - Yallourn is considered to have no significant contemporary potential for pollution or water quality impacts in the Maryvale and East Fields. However, the site is known to have a stockpile of acid-forming materials (acid sulphate soils) in the legacy Township field pit. These materials will release acidity, which will need to be treated while the void is dry and during any filling process. There are predicted to be no ongoing acid inputs if inundated.
6. ENVIRONMENTAL FLOW RECOMMENDATIONS

The purpose of this aspect of the study was to:

- understand the minimum flow requirements for the Latrobe system as a key input to the assessment of water availability for mine rehabilitation.

The Latrobe River, its tributaries, estuary and wetlands are subject to a highly regulated flow regime as a result of water resource development and water use in the catchment. The study was conducted for the system from Lake Narrogin to Lake Wellington, including the main tributaries (Morwell River, Traralgon Creek, Tyers River and Tanjil River), the Lower Latrobe Wetlands, the Latrobe Estuary and the Thomson Estuary.

The study was conducted using a standard FLOWS method in combination with the Estuary Flows Method (EFAM), which are appropriate for estuarine and wetland areas. The assessment sought to understand the minimum functional flow requirements in reference to water-dependent ecological values using the best available ecologic, hydrologic, hydraulic and geomorphic information.

It built on the previous Latrobe River environmental flow recommendations study completed in 2007 and 2013, which was limited to the freshwater sections of the Latrobe system upstream of the Thomson River confluent.

The Latrobe system was divided into 11 reaches, with flow recommendations derived for the latest methods and an expert process to meet objectives set in reference to the present geomorphology and values of the Latrobe system (which reflect the current flow regime after consumptive extraction).

The flow recommendations were set according to the seasonal timing and minimum duration, magnitude (daily flow volume) and frequency of flow events needed to meet the established objectives. The flow events represent different elements of a natural flow regime, as depicted in Figure 1.

Key outcomes

- Flow recommendations are largely consistent with previous studies, and the new recommendations for additional reaches are consistent with upstream flows.

- The target reach for achieving minimum flows (based on highest water demand) is the reach of river upstream of Rosedale. The total amount of water required to deliver all the flow recommendations for this reach under an average climate scenario is about 560 GL/y.

- If flow recommendations are met for the Latrobe and Thomson rivers, this flow target is expected to achieve sufficiently regular freshwater flushing of the lower Latrobe estuary. Freshwater flushing has been deficient in recent years, resulting in significant salinisation impacts in the estuary and dependent wetlands. Opportunities to improve environmental flow regimes will be explored further through the LVRRS.

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7. WATER AVAILABILITY

The purpose of this aspect of the study was to:

- quantify historical water availability in the Latrobe River system.
- model water availability over the timeframe of mine rehabilitation considering possible climate change futures and long-term climate variability.

This study used the reconstructed unimpacted historic inflows into the Latrobe River (upstream of Rosedale) derived using the Latrobe REsource ALlocation Model (REALM)\(^8\) for 1957 to 2017, with pre-1975 streamflow data scaled to match post-1975 climate conditions. This dataset represents streamflow in the absence of all consumptive water use and farm dams.

To model the potential change in water availability into the future, climate change factors were applied to the long-term inflow average under the wet, median and dry climate scenarios, interpolating the factors between 1995 and 2040, and between 2040 and 2065, and extrapolating the 2040–2065 trend beyond 2065. The sensitivity of the results on the 1995 start date (mid-point of the 1975–2014 Victorian Climate Change Initiative analytical period) for applying incremental climate change (and plausible alternatives) is considered in the findings\(^9\).

Key outcomes

- The historic water availability in the Latrobe system appears to have undergone a step change since 1997 corresponding to a reduction in long-term average flow of about 800 GL/y to an average of about 600 GL/y over the past 20 years (illustrated by the dashed green line in Figure 2).
- The ‘dry climate’ projection based on the post-1997 period, which includes the Millennium Drought, is possibly consistent with the observed step change in the Latrobe system since 1997 (average 600 GL/y).
- This step change (post-1997) and ‘dry climate’ projection could have two possible interpretations – continued drought period and/or drying trend, which makes modelling future scenarios difficult and uncertain. By using a long-term dataset, the drought represents an anomaly and thus modelling intrinsically shows a return to long-term average conditions.
- To overcome this, an analytical approach based on climate statistics was adopted, and the two interpretations considered separately as equally possible climate pathways.
- The results therefore indicate that the possibility of a dry climate needs to be planned for while remaining flexible to the relative opportunities of a possible return to long-term average or wet conditions.
- Under a dry climate, flows in the Latrobe system could decline significantly by 2060 to about 400 GL/y on average. Such a decline would drive an incremental change in character for the Latrobe River system, and would require re-assessment of the minimum environmental flow requirements for the system.

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Figure 1: Notional hydrograph of the terms used to describe the flow regime, and thus flow recommendations, for the environmental flow recommendations study for the Latrobe River, estuary and Lower Latrobe Wetlands.
Figure 2: Total water availability in the Latrobe system (upstream of the Latrobe-Thomson confluence) using historical inflows and climate projections.
8. WATER USE SCENARIOS

The purpose of this aspect of the study was to:

- model filling of the mine voids with water to full and partial levels and fill rates using potentially locally available water sources in order to determine filling timeframes and interactions among the three filling pits and operating power stations.

The key assumptions adopted for the modelling analysis, which would be revisited as part of the analysis supporting any future mine rehabilitation planning, are as follows:

- In order to prevent instability, groundwater pumping continues until stability is achieved and then is slowly ramped down based on mine configuration and known risks. This effectively decouples this analysis of pit filling from groundwater behaviour in the confined aquifers (underlying Hazelwood and Loy Yang) and allows groundwater modelling to be conducted using a simplified groundwater pumping scenario.

- Only existing physical water access arrangements for the three mines and power stations are considered as potential local water sources.

- A supply of surface water, such as that supplied in the past by Gippsland Water for power generation, could be made available to all mine operators in a sequential manner over time.

- Water extraction from the Latrobe River under arrangements similar to the existing arrangements for power generation would be limited to the current level of consumption (i.e. not the full nominal volume of the entitlement or licence). This acknowledges that the effects of current usage are well understood and serves as a benchmark for potential future provision of water for mine rehabilitation.

- Under a full pit lake scenario, top-up to account for evaporative losses would in the first instance be sourced via existing pipelines from the Latrobe River and not local catchments.

Key outcomes

- Water use scenario modelling shows that under the above assumptions, there is no material change to current patterns of water use over the course of rehabilitation, and no undesirable effects due to early closure (i.e. stacking of impacts).

- Evaporation from the pit lakes should be estimated in the first instance using Morton’s shallow lake evaporation, which is available as gridded data in the Latrobe Valley. Evaporation under current conditions is predicted to be of the order of 4–6 GL/y per water body.

- The timeframe for filling of the mine pits under these assumptions is in the range of 15–20, 20–25 and 25–30 years for the Hazelwood, Yallourn and Loy Yang mines, assuming that all mines continue operating to planned closure and there is no interruption of surface water supply (noting that interruption of water supply over these time frames is likely and would result in extension of these timeframes for filling).

9 GROUNDWATER FLUX MODELLING

The purpose of this aspect of the study was to:

- predict the likely movement of groundwater into and out of the mine voids and possible pit lakes in the context of rehabilitation, in order to understand the potential contribution of groundwater to the water balance during and post filling, and the potential for local groundwater contamination or other groundwater impacts.

Key outcomes

- Due to the need to maintain low aquifer pressures (by groundwater pumping) during filling the mine void with water, groundwater seepage is not a material contributor to the filling volume (although pumped groundwater is assumed to be transferred to the mine void during pit filling as a significant proportion of the final lake volume).

- Groundwater fluxes (inward and outward) under a full pit lake scenario are considered to be very small (<0.5 ML/d), in comparison to pit lake volume, and change in direction over time and location in the mine void (both in terms of elevation and pit perimeter) in response to recovery of groundwater pressures.

- The contribution of groundwater seepage to pit lake filling, either losing or gaining, is less than 0.5% of annual fill rates.

- At Hazelwood, due to the low flux rates, it is considered there will be little interaction between the pit lake and groundwater.

- At Hazelwood, net groundwater fluxes into the pit, after recovery of groundwater pressures do not appear sufficient to support a stable pit lake level, meaning that additional water would be required to maintain a stable partial pit lake level (~1 ML/d of inflows versus net evaporative loss of ~11 ML/d).

- The accuracy of modelling is subject to ongoing review; however, given the very small interaction with groundwater, significant error in flux predictions does not materially change the outcomes.

- Similar findings hold for the Yallourn and Loy Yang mines, but would need to be re-evaluated once mining ceases.
10. REGIONAL GROUNDWATER PROJECTIONS

The purpose of this aspect of the study was to:
- predict the recovery and future trajectory of groundwater levels and pressures in the context of mine rehabilitation, climate change and other factors such as offshore oil and gas extraction (which uses significant volumes of groundwater from regional aquifers).

The study provides an understanding of whether regional aquifers are likely to eventually recover to pre-mining levels and identify the need for, and location of, groundwater monitoring.

Key outcomes
- Groundwater pressures in the deep confined aquifers currently pumped by the mines to maintain stability are considered unlikely to fully recover to pre-mining levels on a regional basis due to insufficient recharge under most future climate scenarios.
- The predicted degree of permanent decline depends on the climate scenario used.
- These results potentially have implications for future groundwater management and sustainable yields in the region.
- Whether rehabilitation results in a partial or full pit lake is considered to have no material effect on the recovery of deep groundwater pressures, other than potentially delaying recovery if groundwater pumping continues for an extended period.
- No need for additional groundwater monitoring beyond the existing monitoring network was identified.

11. WATER-RELATED EFFECTS

The purpose of this aspect of the study was to:
- identify the aquatic ecosystem values that could potentially be impacted by mine rehabilitation.
- describe the current condition and existing trajectories of these values.
- determine the potential effects of mine rehabilitation on these ecosystems.
- recommend ways to improve the condition of these ecosystems.

The study considered the system as five mega-habitats, including shallow lakes (Lake Wellington), freshwater wetlands (Sale Common), variably saline wetlands (Heart and Dowd Morasses), Latrobe estuary, Latrobe River and the tributaries. Rehabilitation water use scenarios were used to assess the impacts on the flow regime and thus the potential effects on aquatic ecosystems.

Key outcomes
- The condition of many aquatic ecosystems in the Latrobe system are considered to be in decline. This is especially significant for the end-of-system Ramsar sites, recognised as wetlands of international significance.
- Power generators discharge slightly turbid and saline waters into Morwell River and Traralgon Creek as a result of their operations. The cessation of coal-fired power generation will mean that these tributaries may experience better water quality but a higher frequency of cease-to-flow periods.
- Further reduced freshwater inflows and rising sea levels could increase salinity in Lake Wellington, the Latrobe estuary and fringing wetlands, reducing freshwater habitat.
- Water use for mine rehabilitation, if limited to the current volumes of water use associated with power generation, is considered to have no additional significant effect on the seasonal or total annual flow in the Latrobe system.
- However, under an increasingly drying climate (as indicated by modelling), the total footprint of water take for mine rehabilitation would increase.
- While there is insufficient evidence to draw definite conclusions, the study proposed that continued extraction of water at current levels (without conditions) under a drying climate scenario would likely exacerbate the existing negative impacts on the high value aquatic ecosystems of the Latrobe.
12. PIT LAKE MODELLING

The purpose of this aspect of the study was to:
- develop a fit-for-purpose model that could be used to simulate filling of the mine voids, including water balance and water quality evolution, using the information, parameters and assumptions captured and derived during the Regional Water Study that can be updated in the future.

The model was implemented in GoldSim using a daily timestep, with many options for configuration and testing of rehabilitation parameters such as water sources and fill rates, catchment interception, climate projections and input water quality parameters.

Key outcomes
- The modelling shows that the water quality of the pit lakes is dominated by the quality of water sources used to fill the mine void, and not potential local pollution sources.
- The scenario of a pit lake with ongoing external water input (of suitable quality) and outflow is more likely to achieve and maintain higher water quality.
- Mine water bodies that are not regularly flushed are likely to undergo gradual decline in water quality over time (e.g. 100 years) due to accumulation and evaporative concentration of salinity and potentially other contaminants in supplied water.
- No significant water quality risks were identified at this stage, although this would need to be reassessed at the end of mining operations and consider also the water quality of the proposed water supply.

13. WATER AVAILABILITY FOR MINE REHABILITATION

This aspect of the study integrated the technical studies to:
- understand the implications for mine rehabilitation and the types of decisions that would need to be made to develop the Strategy.

Key outcomes
- Water availability in the Latrobe River system is uncertain given the wide range of possible climate projections, as depicted above in Figure 3.
- In dry periods, water availability can fall significantly short of minimum environmental flow requirements and consumptive usage.
- In wet periods, there are sufficient local water resources to meet all demands including potentially mine rehabilitation.
- The frequency of dry and wet periods is uncertain, and more frequent dry periods could result in limitation to water availability and delays to mine rehabilitation if based on a partial or full pit lake.
Contact us
This report is available at www.water.vic.gov.au/waterways-and-catchments/our-catchments/RWS/
Please visit earthresources.vic.gov.au/projects/lvrrs to learn more about the Latrobe Valley Regional Rehabilitation Strategy or you can contact the project team at lvrrs@ecodev.vic.gov.au