Overview of managing groundwater and impacts at Loy Yang open cut.

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Abstract

Groundwater management at Loy Yang coal mine (eastern Victoria) aims to minimise potential impacts by minimising the volume of groundwater extracted and to monitor and assess drawdown and land subsidence impacts. Strategies to minimise extractions include setting drawdown targets for each aquifer calculated from the geological model for a given mine plan and locating pump bores as close as possible to where the drawdown is required within operational and geotechnical constraints. Routine assessment of aquifer properties and connectivity across structural features also assist in locating pump bores. Placement of overburden within the mine reduces groundwater pumping requirements and is an important factor in mine rehabilitation planning to stabilise the mine floor. Groundwater monitoring and modeling on a local and basin scale is used to predict future drawdown and subsidence impacts. A local-scale Loy Yang model is nested within the basin model to assess short-term depressurisation requirements and long-term mine rehabilitation planning and subsidence estimates for environmental and engineering purposes.

Keywords: mine depressurisations, groundwater management

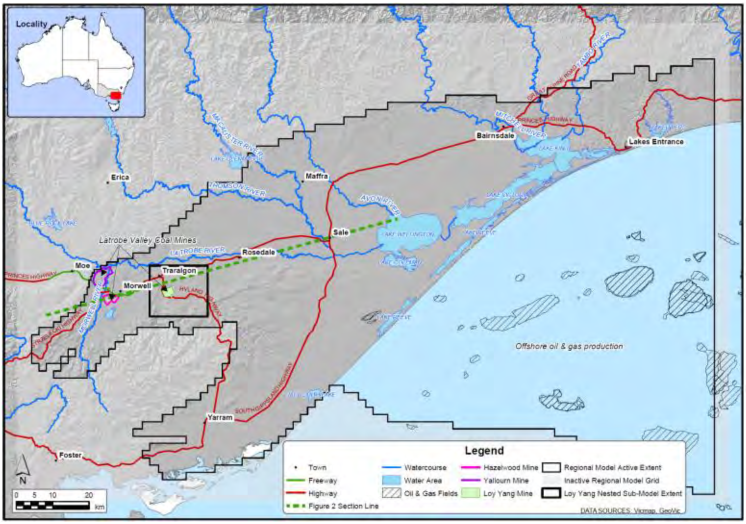
Introduction

Loy Yang Power operates a brown coal mine to supply to the 3,250 MW Loy Yang A and B power stations. Loy Yang Mine is located south of Traralgon in the Latrobe Valley in the western onshore part of the Gippsland Basin (eastern Victoria) as shown in Figure 1. To maintain stable geotechnical conditions it is necessary to depressurise the major aquifers beneath the mine floor.

Three broad aquifer systems based on the geological formations occur in the region (Figure 2):

- An upper unconfined to semi-confined shallow aquifer system (SAS) within the Recent alluvium, Haunted Hill and Yallourn Formations. The SAS occurs throughout most of the Gippsland Basin and in many areas provides low-yielding domestic and agricultural supplies.
- In the western part of the Gippsland Basin the Mid-Tertiary Morwell Formation sediments form a generally confined aquifer system (MFAS) consisting of interbedded sands and clays between coal seams and minor fractured basalts. The MFAS extends eastward to the marginal marine barrier sand sequence of the Balook Formation. Groundwater is extracted from the MFAS as part of mining operations at Yallourn, Hazelwood and Loy Yang mines, and for domestic and agricultural activities in the eastern Latrobe Valley.

- The Lower Tertiary aquifer system (TFAS) extends across the entire Gippsland Basin and onshore consists of interbedded sands, clays, coals and basalts (M2, Traralgon Aquifers) and offshore consists of interbedded sandstones, mudstone, coals, and basalts (Latrobe Group Aquifers). Onshore, groundwater is extracted from this aquifer system as part of coal mining, operations at Loy Yang and Hazelwood Mines, for agricultural and industrial supplies in the southern Gippsland Basin, and offshore for oil and gas production activities (Figure 1).



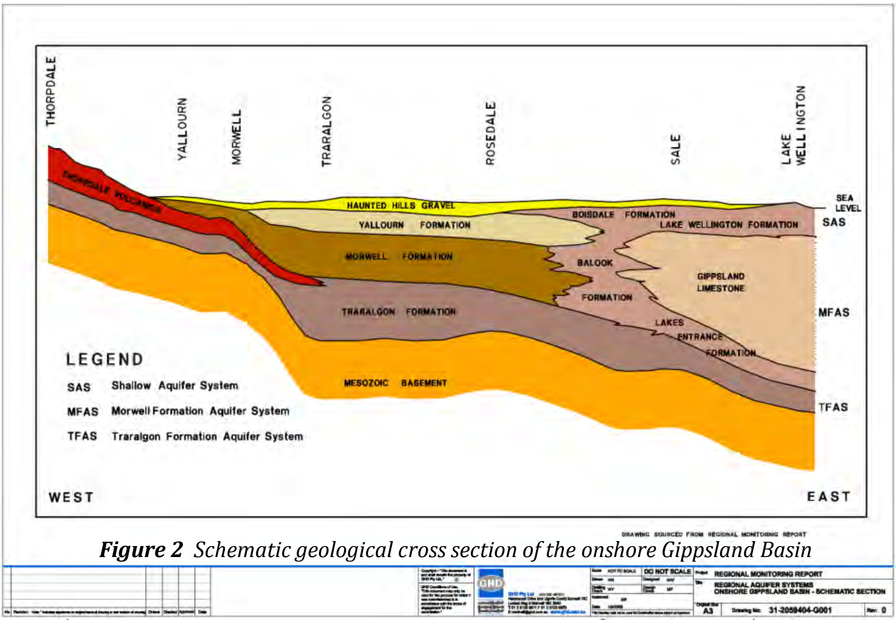


Figure 2 *Schematic geological cross section of the onshore Gippsland Basin*

Managing Groundwater at Loy Yang Mine

The pump bore network consist of 5 TFAS pump bores, 3 which extract from the Upper Traralgon aquifer sand along the northern batters and 2 from the Mid Traralgon Aquifer in the western part of the mine. Traralgon aquifer flows are of the order of 350 to 450 L/s depending on the number of bores operational. Typically around 7 to 10 MFAS (M2C) pump bores are required to achieve the drawdown necessary for the current base of mine development (-103 mAHD) and annual flow rates are in the order of 80 – 120 L/s. The lower permeability M2B aquifer has been depressurised in the past via pump bores but is now unconfined and exposed in the base of mine and groundwater levels are managed via sumps and the drainage systems.

Loy Yang implements strategies aimed at minimising the volume of groundwater pumped from the underlying aquifers and therefore minimising depressurisation-associated impacts while maintaining mine floor stability. These strategies include:

Setting depressurisation targets for each aquifer system

Mine depressurisation is required to lower pressures in the aquifers in coordination with the mine development to maintain stable geotechnical conditions. Target levels are set for the Traralgon and M2C aquifers such that aquifer pressures are maintained below critical levels to provide a safety buffer in the case of a short-term loss of pumping capacity. The critical levels for each aquifer are a function of the mine grade and sediments overlying the aquifers, and are calculated using the MINCOM geological model based on the thickness and density of the overlying sediments. Assessment of risks associated with pumping outages is used to set the buffer between the critical and target levels (GHD-LYP 2005). This takes into account observed and modelled responses to pumping outages, spare pump and spare bore capacity and operational constraints such as the time taken to replace failed pumps and sheared bores. To assess aquifer pressures relative to target levels, a network of groundwater monitoring bores are established across the mine and aquifer pressures are compared to target levels each month or more frequently if required due to pumping outages.

Optimising pump bore locations

This is achieved by locating pump bores as close as possible to where the drawdown is required within operational and geotechnical constraints. Future depressurisation requirements are assessed annually using the geological model for the coming 1 year and 5 years to determine the magnitude and location of required drawdown for each aquifer. The geological model is also used to assess thickness and distribution of the various sand units. These isopachs, along with grain size distribution data, allow optimal locations to be selected. Review of structural mapping and groundwater monitoring responses to pump commissioning and outages particularly, ahead of the mine development, allows for discontinuities in the aquifer to be identified and accounted for in the depressurisation system planning. This strategy is particularly important for the M2C aquifer which is more variable in thickness and permeability. In comparison the high permeability and flatter potentiometric surface of the TFAS allows these pump bores to effectively depressurise future mining areas from behind the active mining areas. As the TFAS pump bores are significantly more expensive, they are drilled at locations on permanent batters following mine development to reduce the risk of casing failure from excavation-related ground movement.

Placement of Overburden within Mine Void

In the short-term, placement of overburden in the base of mine areas results in the target level for the aquifers under the overburden to be raised and bores decommissioned. This in effect allows the depressurisation pumping network to migrate to the east with the active mining areas. The bore decommissioning is planned in accordance with the internal dump development. Internal overburden dumping is an important factor in long-term mine rehabilitation to stabilise the mine floor. Figure 3 shows the increase in target levels associated with the dump development.

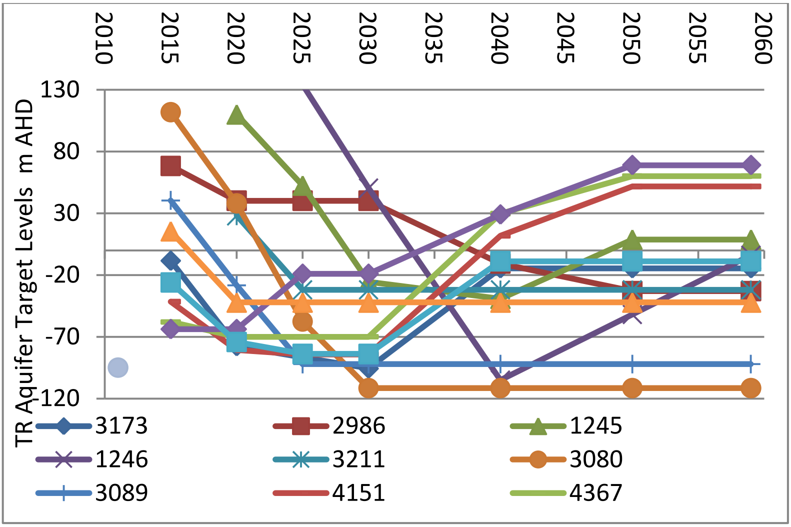


Figure 3 *Predicted Traralgon Aquifer target levels*

Groundwater Collection System

Aquifer water is used in the power station to reduce the volume of water purchased from external surface water storages. A groundwater collection system typically delivers over 95% of pumped groundwater to the main pump station of which around 90% of the 10-14GL/yr is pumped to the power station. Flows within the collection system are monitored via flow meters on the pump station and bores via a telemetry system.

Assessing and Managing Mine Depressurisation Impacts

Groundwater modelling on a local and basin scale is used to predict future drawdown and subsidence impacts. In collaboration with International Power and

TruEnergy, Loy Yang Power undertakes a regional groundwater monitoring and assessment program which includes:

- Maintenance and monitoring of a groundwater monitoring network which extends across the Latrobe Valley to Sale to assess the cumulative impact of aquifer depressurisation associated with the Latrobe Valley mining operations. The monitoring bore network provides data on groundwater levels in the major regional aquifers, the annual rate of change in groundwater levels, and the extent of aquifer depressurisation impacts;
- Surveying and maintenance of a network of regional land level survey markers to provide data on the natural surface response to aquifer depressurisation.
- A modelling program including predictions of cumulative drawdowns and associated subsidence.

GHD currently maintain two groundwater models which include the Loy Yang area. A regional-scale groundwater model of the Latrobe Valley and Gippsland Basin has been progressively developed based on previous investigations including Jansen et al (2003) by International Power, TruEnergy and Loy Yang Power. Nested within the regional model is a detailed model of the Loy Yang mine. The models were recently migrated to the MODFLOW-NWT code (Niswonger et al 2011) to address cell drying and rewetting issues to more reliably predict mine closure recovery heads in close proximity to the Loy Yang mine. The 'nesting' process was undertaken using the Telescopic Mesh Refinement (TMR) function within the Groundwater Vistas software which automatically extracts boundary conditions for the smaller sub-model from the main model. In addition to ensuring consistency between the two models this means that any drawdown effects in the regional model are represented as declining groundwater levels along the sub-model boundary. The MODFLOW Lake (LAK3) package (Merritt and Konikow 2000) was used to simulate the post-mine closure pit lake recovery water balance and predict lake water levels. Subsidence was modelled using the MODFLOW SUB package (Hoffman et al 2003) and was calibrated using selected ground level surveys, some of which were installed in the 1950's prior to commencement of large-scale TFAS depressurisation.

The Loy Yang MODFLOW model assesses if the planned depressurisation program will achieve the required drawdowns based on the excavation plans for the coming 5 years. It is also used to assess the recovery of groundwater levels following bore decommissioning relative to the increase in target levels associated with the development of the internal overburden dump.

The model is also used to assist long-term mine rehabilitation planning. This includes assessing post closure recovery of groundwater levels relative to the filling of the mine void and resultant increase in target levels. The model allows for water balance modeling of the mine void to be integrated with the groundwater and surface water inputs over time. Subsidence modeling is also completed to provide final subsidence predictions for engineering designs such as the future

Princes Highway bypass to the north of Loy Yang and environmental studies associated with Traralgon Creek.

Conclusion

Strategies to minimise extractions include setting drawdown targets for each aquifer system below critical levels taking into account aquifer responses to pumping outages, spare pump bore capacity and operational constraints such as the time required to replace failed pumps and sheared bores. Pump bores are located as close as possible to where the drawdown is required within operational and ground movement constraints. Groundwater monitoring in active mining areas and ahead of development is required to demonstrate that drawdown targets are met, and to assess aquifer connectivity across structural features. Placement of overburden within the mine reduces groundwater pumping requirements and is an important factor in mine rehabilitation planning to stabilise the mine floor.

Groundwater monitoring and modelling on a local and basin scale is completed to predict future drawdown and subsidence impacts. In collaboration with International Power and TruEnergy who operate other mines in the Latrobe Valley, a groundwater model of the Gippsland basin has been developed to assess cumulative future drawdowns and subsidence impacts. A local-scale Loy Yang model is nested within the basin model to assess volume, location and timing of groundwater extractions to produce the required drawdowns. Longer-term applications include mine rehabilitation planning and subsidence predictions beyond the mine crest for input into engineering designs.

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