ANNEXURE N
LOY YANG MINE REHABILITATION MINE LAKE WATER BALANCE MODELLING

AGL.0001.001.0198

GHD

AGL Loy Yang

Loy Yang Mine Rehabilitation

Mine Lake Water Balance Modelling

March 2015

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Background

A water balance assessment of the Loy Yang Mine final mine void has been undertaken to estimate the time required to fill the void, and at what level the lake would stabilise in the long term currently modelled at 200 years after mine closure. This study builds on the water balance assessments undertaken in 2011, 2006 and 2004 as part of the Loy Yang Mine Rehabilitation Plan (GHD 2011; GHD 2006; GHD, 2004).

The filling rate of the lake impacts on the post mining aquifer depressurisation requirements as aquifer pressures need to be maintained below weight balances as the lake fills. A lake level of RL-22.5 m AHD is estimated to be the highest level at the key bore locations required to achieve a weight balance pressures of RL+20m which is considered to represent the long term TR aquifer recovery level. At lake levels above RL-22.5m AHD, the risk of floor heave is considered low and active groundwater management is not likely to be required. The maximum lake level of RL-22.5 is based on the Whole of Life (WOL) mine development plan and recent internal dump plan modifications including placement of additional material for fire protection against the northern batters in the Minniedale Dome area as discussed in *Long term Aquifer Depressurisation Assessment* (GHD 2015a).

One limitation of the long term depressurisation assessment is that has been completed at key bores rather than spatially. Key bores which extend to the Traralgon aquifer were used so there is good geological control and a high level of confidence in the weight balance level estimates at these locations. The bores have been selected to provide good coverage across the mine area including the critical deeper mine areas and structural highs and are considered to be representative of the range of 2059 weight balance and floor stability lake levels. However to improve the confidence in the results, further modelling of these levels spatially across the mine area could be considered in future studies.

2. Model Setup

A number of REALM (Resource Allocation Model) models have been configured to simulate the mine lake water balance for a combination of inflow scenarios and climatic conditions to provide an indication of the variation in the lake water level over time. The models were configured with a monthly time step for a 200 year simulation period post mine closure (2060 – 2260).

The Stochastic Climate Library was used to generate a 200 year monthly rainfall and evaporation time-series, derived from the gauge Morwell Mail Centre (85062).

The water balance modelling was assessed using the final mine void shape from the *"Revised Whole of Life Mine Plan – 2011"*, with the internal dump shape from the *"August 2014 option for maximising dumping against the northern batters"*.

See Appendix A and Appendix B for further details on REALM model inputs and configuration.

2.1 Contributions to inflows

Contributions to inflow to the mine lake are discussed below.

Runoff from maximised catchment

Rainfall runoff from the catchment that naturally drains towards the mine void above the mine lake surface area (maximised catchment), calculated using the equation below:

$$Runoff = (Maximised\ Catchment\ Area - Surface\ Area\ of\ Lake) \times Rainfall \times Runoff\ Coefficient \times Climate\ Coefficient$$

Assuming a maximised catchment area of 3687 Ha, a runoff coefficient of 0.3 and the corresponding climate coefficient for rainfall (refer to Table 9 in Appendix A). Maximising the catchment would be achieved capturing flows from Sheepwash Creek and other waterways which naturally flow towards the mine void. It

Runoff from minimised catchment

Rainfall runoff from a catchment limited to the area of the mine void (minimised catchment) above the mine lake surface area, calculated using the equation below:

$$Runoff = (Minimised\ Catchment\ Area - Surface\ Area\ of\ Lake) \times Rainfall \times Runoff\ Coefficient \times Climate\ Coefficient$$

Assuming a minimised catchment area of 2115 Ha, a runoff coefficient of 0.3 and the corresponding climate coefficient for rainfall (refer to Table 9 in Appendix A). Minimising the catchment would be achieved by diverting flows from Sheepwash Creek and other waterways within the mining licence area, and flood flows from Traralgon Creek, away from the mine void.

Traralgon Creek flood flows

Traralgon Creek flood flows diverted to the mine void, assuming a flow of 4 GL/year (10% of the mean annual flow) uniformly distributed at a monthly time-step, using the equation below:

$$Traralgon\ Creek\ Flood\ Flows = {}^{4}/_{12} \times Climate\ Coefficient$$

For the corresponding climate coefficient for streamflow (refer to Table 9 in Appendix A).

9.8 GL/yr Groundwater extraction for 10 years

Groundwater extractions at a rate of 9.8 GL/yr over the first ten years post mine closure, uniformly distributed at a monthly time-step. This groundwater extraction scenario was selected as it is simulated in the WOL post-closure mine recovery model documented in *Loy Yang Groundwater Modelling – Long Term Mine Plan* (GHD, 2015) and is considered a reasonable estimate of post mining pumping requirements as discussed in Section 4.1.4.

15 GL/yr groundwater extractions

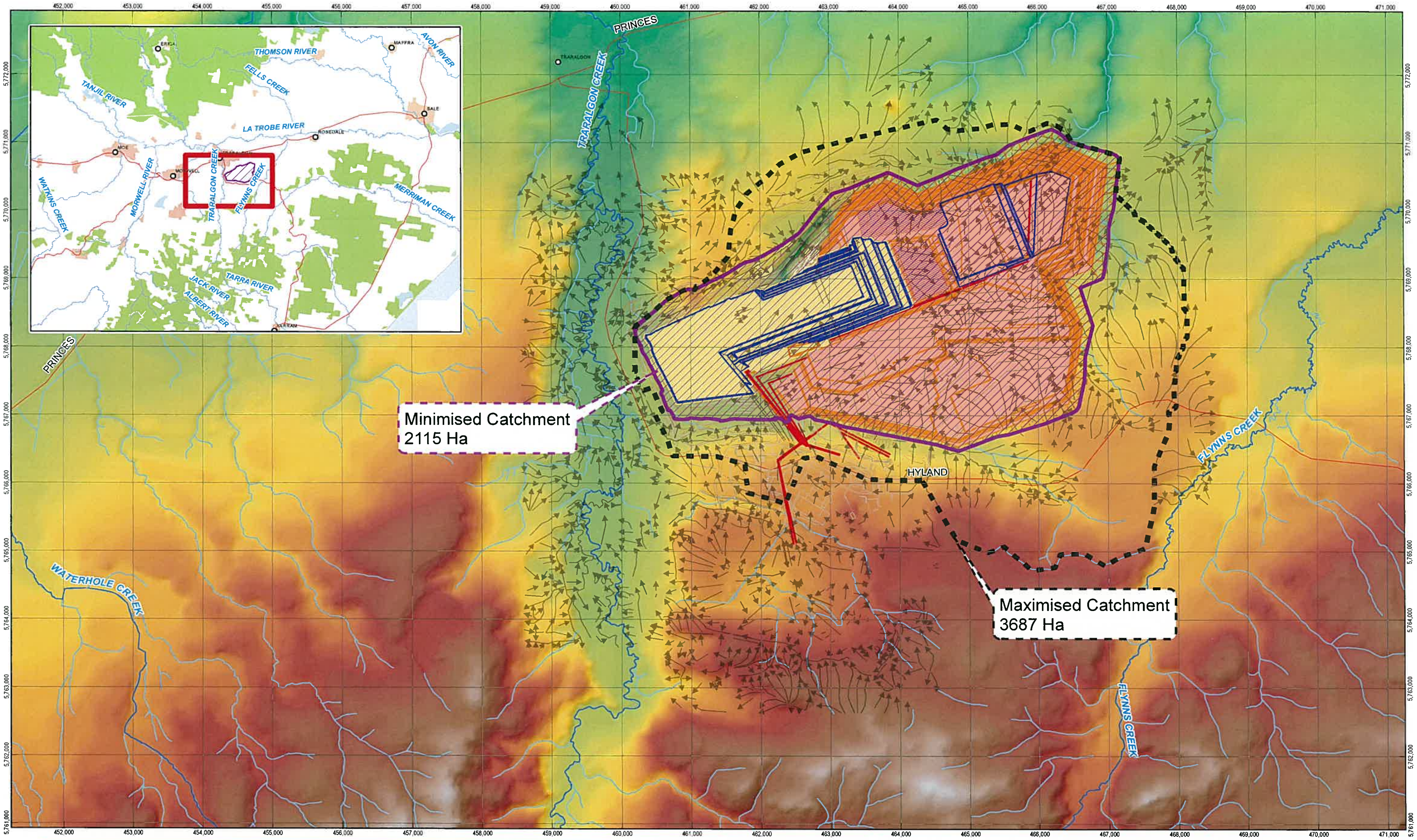
Groundwater extractions at a rate of 15 GL/yr diverted to the mine lake until lake level reaches the maximum stable level mine of RL-22.5 m AHD, uniformly distributed at a monthly time-step.

40 GL/yr Bulk Entitlement

Bulk Entitlement flows of 40 GL/yr diverted to the mine lake until lake level reaches the maximum stable level mine of RL-22.5 m AHD, uniformly distributed at a monthly time-step.

Groundwater Seepage

The relationship between groundwater seepage into the mine lake (ML/month) and the mine lake water level for the four climatic conditions were estimated by simulating the transient groundwater model for Loy Yang mine recovery period (2059 – 2455). It is noted that the groundwater seepage inflows were scaled by a factor of 50% for the Yallourn Interseam and the M2B Aquifer, as the predicted pit inflows were considered to be too high compared to known aquifer conditions in these interseams. Refer to GHD (2015) for further details on the groundwater modelling and Table 15 in Appendix A for the groundwater seepage rating tables for the four climatic conditions.



AGL Loy Yang Pty Ltd
Loy Yang Rehabilitation and Closure Strategy

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Mine Lake Water Balance Modelling
Surface Water Catchments

Figure 1

G:\31\1141815\GIS\Maps\Deliverables\311141815_REALMWaterBalance.mxd

Data source: GHD, Whole of Life Mine Plan, 2012. GHD, Minimised and Maximised Catchments, 2014. SMEC, Drainage Flow Lines, 2014. DEPI, VicMap, 2014. Created by:adrummond

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2.2 Model Scenarios

Six scenarios were developed using combinations of the inflow sources discussed above, and are summarised in Table 1.

Table 1 Mine Lake Inflow Scenarios

Scenario	Mine lake level below -22.5 mAHD	Mine lake level above -22.5 mAHD
1	40 GL/yr of Bulk Entitlement flows 15 GL/yr of groundwater extraction 4 GL/yr (multiplied by climate factor) flood flows from Traralgon Creek Runoff from a maximised catchment Groundwater seepage	Runoff from a minimised catchment Groundwater seepage
2	40 GL/yr of Bulk Entitlement flows 15 GL/yr of groundwater extraction Runoff from a maximised catchment Groundwater seepage	Runoff from a minimised catchment Groundwater seepage
3	15 GL/yr of groundwater extraction 4 GL/yr (multiplied by climate factor) flood flows from Traralgon Creek Runoff from a maximised catchment Groundwater seepage	Runoff from a minimised catchment Groundwater seepage
4	15 GL/yr of groundwater extraction Runoff from a maximised catchment Groundwater seepage	Runoff from a minimised catchment Groundwater seepage
5	9.8 GL/yr groundwater extraction for 10 years Runoff from a maximised catchment Groundwater seepage	Runoff from a minimised catchment Groundwater seepage
6	Runoff from a maximised catchment Groundwater seepage	Runoff from a minimised catchment Groundwater seepage

These six scenarios were simulated for four climatic conditions (historical, wet, median and dry) on mean annual runoff at 2060 (2°C global warming) and corresponding changes in rainfall and potential evapotranspiration (PET) for the Latrobe River catchment (DSE, 2011). These scenarios are based on work undertaken by the CSIRO as part of the SEACI research program, and are consistent with the median warming scenario under the "A1B" emission scenario developed by the IPCC. Refer to Table 9 in Appendix A for climate change factors applied in the REALM modelling.

These scenarios are generally consistent with the scenarios simulated in GHD (2011), with the following key differences:

- The stable lake level after which active depressurisation and groundwater pumping is not required has increased from RL -27m (GHD, 2011) to RL -22.5m based on the revised mine void and weight balance calculations.
- The minimised catchment runoff is activated in this study when the lake level reaches the stable level of RL -22.5m, whereas the previous study (GHD, 2011) assumed that the lake level would stabilise in the long term at RL -10m.

- Scenarios 1 and 3 have been modified in this study to only simulate flood flows from the Traralgon Creek until the stable lake level of RL -22.5m is reached, whereas the previous study (GHD, 2011) simulated flood flows from the Traralgon Creek for the full modelling period.
- Scenario 5 has been modified to simulate a constant groundwater extraction rate of 9.8 GL/yr for the first ten years post-mine closure, instead of a reducing rate of groundwater extractions for the first seven years post-mine closure, to align with the scenario simulated in the post-closure mine recovery model documented in *Loy Yang Groundwater Modelling – Long Term Mine Plan* (GHD, 2015).
- Scenario 6 has been modified to include groundwater seepage into the mine void, whereas the previous study (GHD, 2011) did not include groundwater seepage in this scenario.

It is also important to note that the previous study (GHD, 2011) simulated the mine void configuration adopted in the 2004 study (GHD, 2004) for Scenarios 1 and 2, and a combination of the mine void configuration from the 2006 study (GHD, 2006) and the 2004 study (GHD, 2004) for Scenarios 3, 4, 5 and 6.

3. Model Results

Figure 2, Figure 3, Figure 4 and Figure 5 show the model results for all six scenarios for the historical, wet, median and dry climate change scenarios (respectively). Appendix C contains plots of the lake level over time for each of the four climatic conditions for each scenario, as well as the results from the 2011 study (GHD, 2011). It is important to consider the modifications to scenarios between the two studies, as outlined in Section 2.2 when comparing the results.

Table 2 summarises the number of years (rounded to the nearest 5 years) for the mine lake to reach the stable water level of RL -22.5 m AHD for the six scenarios under the four climatic conditions. By diverting 15 GL/yr of groundwater extractions and Bulk Entitlement surface waters into the mine void (Scenarios 1 and 2), the time required to fill the void to RL -22.5 m AHD is substantially reduced compared with the runoff only option (Scenario 6).

Table 2 Years to reach stable lake water level of RL -22.5 m AHD

Climate	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Historical	10	10	20	25	55	65
Wet	10	10	20	25	60	70
Median	10	10	25	25	65	75
Dry	10	10	25	30	75	85

Table 3 summarises the lake level (m AHD) after 200 years of simulation for the six scenarios under the four climate change projections, rounded to the nearest meter. The results indicate that the lake level will be between 13 and 5 m AHD under the historical climatic conditions for the six inflow scenarios, and between -8 and -11 m AHD under the dry climatic conditions.

Table 3 Lake water level after 200 years (m AHD)

Climate	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Historical	13	13	11	10	7	5
Wet	4	4	3	3	1	0
Median	0	0	-1	-1	-3	-4
Dry	-8	-8	-8	-8	-10	-11

Figure 2 Loy Yang Lake Water Balance - Historical Climate Scenarios

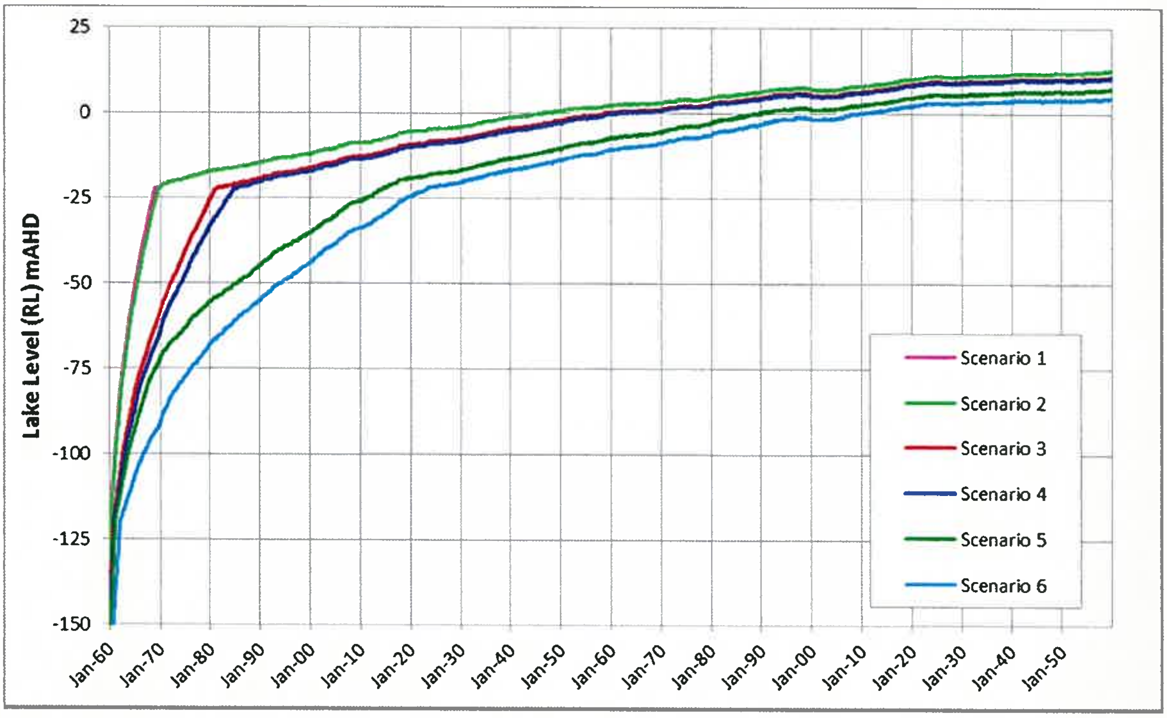


Figure 3 Loy Yang Lake Water Balance - Wet Climate Scenarios

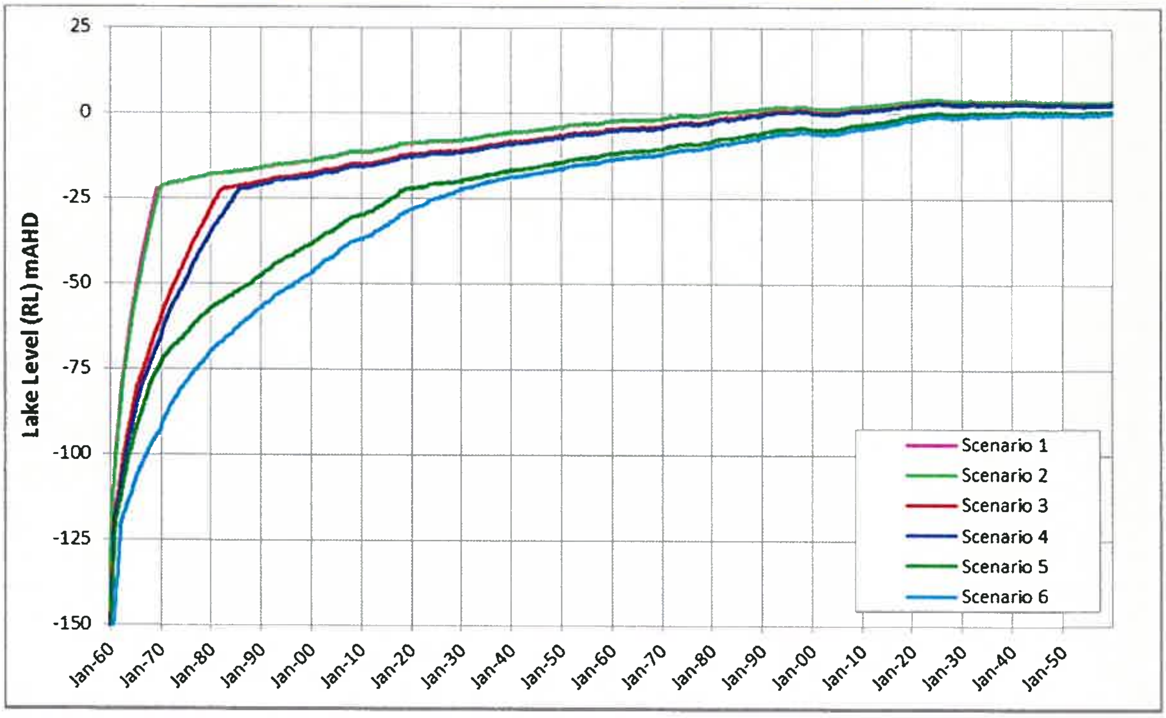


Figure 4 Loy Yang Lake Water Balance - Median Climate Scenarios

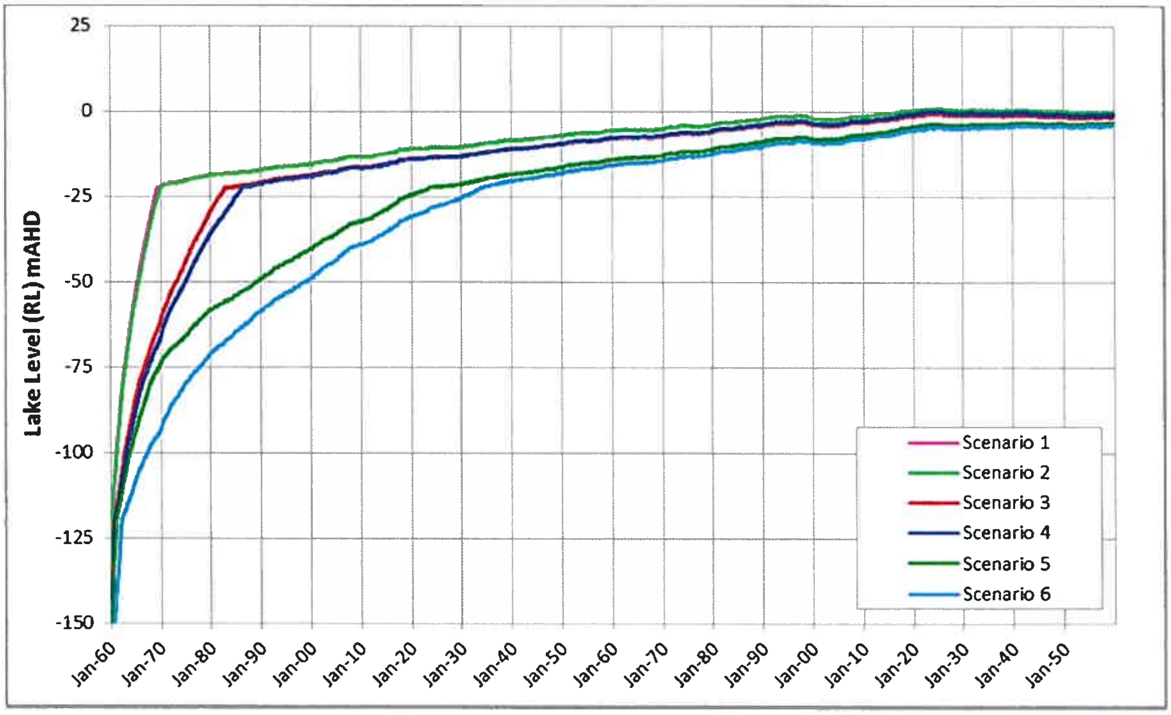
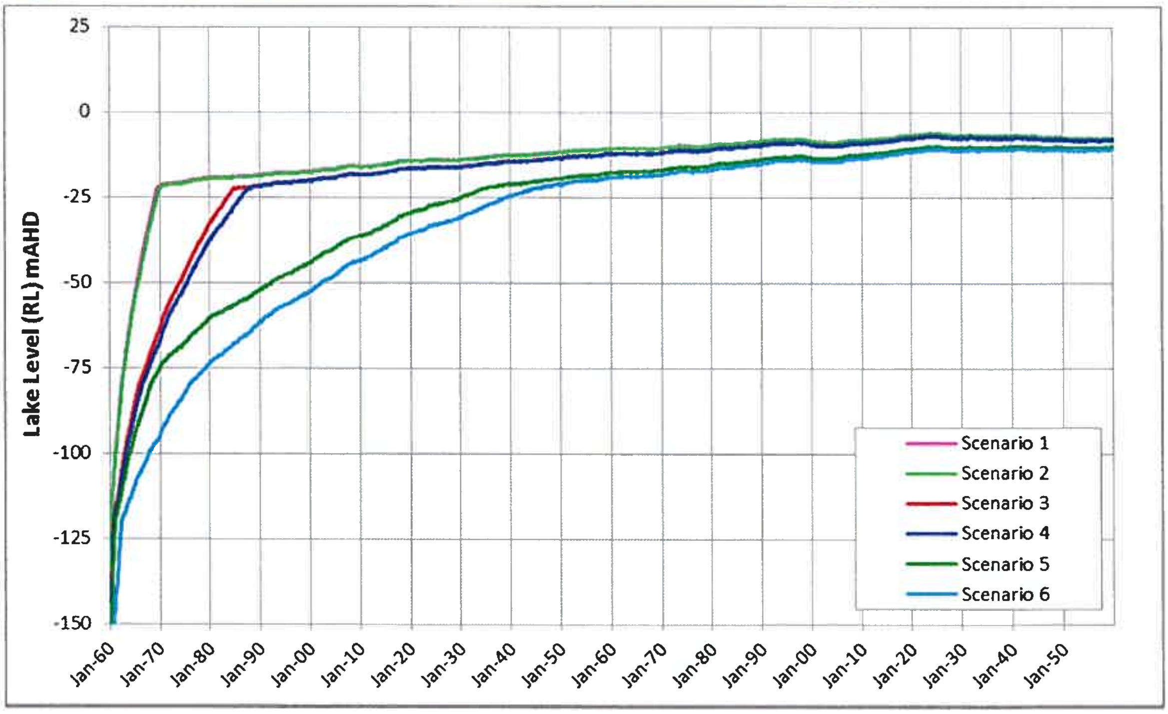


Figure 5 Loy Yang Lake Water Balance - Dry Climate Scenarios



4. Potential Water Sources

4.1 Likelihood of accessing future potential water sources

4.1.1 Traralgon Creek Flood Flows

Traralgon Creek is located within the middle reaches of Latrobe River catchment, and has a catchment area of 190 km^2. Traralgon Creek is a gauged catchment, with daily streamflow recorded from 1960 at gauge 226023 (Traralgon Creek at Traralgon). Traralgon Creek has a mean flow of 41 GL per annum with a mean flow over the winter period (June to October inclusive) of 26 GL.

Based on the 2004 sustainable diversion limit (SDL) assessment (DEPI, 2004), there is potentially up to 1,600 ML/yr available within the Traralgon Creek catchment, as a winter period (June to October inclusive) diversion. We recognise that the lower part of the catchment has a higher level of extractions, and therefore, any further impacts on flow regimes are more likely to impact upon the lower reach compared to the upper reaches of the catchment.

From this preliminary assessment, there is a low likelihood of accessing the required 4,000 ML/y from this creek. Further studies may need to be conducted in consultation with Southern Rural Water to establish the current availability of water and demonstrating that accessing the required water does not impact on existing users and the environment.

An application for a licence to take and use surface water and to operate works would need to be submitted to the licencing authority (Southern Rural Water) to access water from this stream, as a requirement under sections 51 and 67 of the Water Act. The process required to obtain a licence includes an initial discussions with Southern Rural Water to discuss the licencing needs, and submitting the application form including all supporting documentation (i.e. copies of land title(s) and accompanying maps where works are located and where the water is to be used).

4.1.2 Runoff from maximised and minimised catchments

The minimised catchment is assumed to be 2115 Ha and is limited to the area of the mine void above the mine lake surface. Minimising the catchment would be achieved by diverting flows from Sheepwash Creek and other waterways within the mining licence area, and flood flows from Traralgon Creek, away from the mine void.

The maximised catchment is assumed to be 3687 Ha and is limited to the area in proximity to the mine void where natural drainage flows. Maximising the catchment would be achieved by diverting overland flows, and flows from Sheepwash Creek and other waterways within the mining licence area, towards the mine void.

Diverting runoff from the minimised and maximised catchments requires the same approval process discussed above for the diversion of Traralgon Creek Flood Flows (Section 4.1.1). Further studies may need to be conducted in consultation with Southern Rural Water to establish the current availability of water and demonstrating that accessing the required water does not impact on existing users and the environment.

4.1.3 Bulk Entitlement

AGL Loy Yang Partnership currently holds a Bulk Entitlement (Latrobe – Loy Yang A) which was endorsed 25th March 1996. This entitles Loy Yang to access up to an annual total of 40,000 ML from a combination of Blue Rock Reservoir and Lake Narracan under a capacity share arrangement. Loy Yang has access to a 16.4% share of the total storage capacity and inflow of Blue Rock Reservoir and 32.8% share of capacity and 24.5 % share of inflow to Lake Narracan.

The water sharing arrangements defined in the Bulk Entitlement were developed based on the historical water usage practices and the inherent water use patterns. Apart from the defined shares, there doesn't appear to be any limitations described in the Bulk Entitlement to access this water related to pre- or post-mining operations. However, it would be expected that if the pattern of usage was to substantially change then this may impact on the reliability on the availability of water to Loy Yang and other users compared to historical practices. This could prompt a revisit of the Bulk Entitlement water sharing arrangements.

Further discussion with DEPI are recommended to confirm Loy Yang's rights under the Bulk Entitlement.

The ability to access 40 GL each and every year is affected by actual climate sequences, in particular drought periods. Very low water availability was evident during the Millennium Drought. Sensitivity analysis indicated that a 75% reduction in the availability of water under the Bulk Entitlement results in an extra 8 years before the threshold water level is reached.

4.1.4 Groundwater

Loy Yang Mine has been issued a 30 year extraction licence with total groundwater allocations of 15 to 20 GL/year, largely from the Traralgon Formation aquifer. This licence is valid until the end of June 2026. A new groundwater extraction licence would be expected to be issued prior to this date and it is uncertain at this stage if this would be for a further 30 year period or longer including the closure period after 2060.

Post mining groundwater pumping requirements are dependent on the rate of recovery in Traralgon Aquifer pressure relative to the rate of void filling. At the end of mining, the closer Traralgon Aquifer target levels are to aquifer pressures the greater monitoring and management requirements will be during the void filling phase to maintain stable floor condition until the lake levels reached RL-22m. To increase Traralgon Aquifer target level at mine closure placement of additional overburden in the future drainage area, on the crest of Minniedale Dome and on some areas in Block 3 such s LY2976 is required. Alternatively higher final mine grades in these locations would also increase Traralgon Aquifer target level at mine closure. Increasing the Traralgon Aquifer target levels at mine closure also has the advantage that it would lower the stable lake level from RL-22.5 m and therefore reduce the time period where management of Traralgon Aquifer pressures is required.

The results show the rate of groundwater extractions used to fill the mine void is important factor influencing the time until the stable lake level of RL-22.5 m is reached. The two rates used and the approximate post mining groundwater extractions are shown in Table 4. As a comparisons, total groundwater extractions to June 2014 at Loy Yang are approximately 233 GL of which 73% (170 GL) is sourced from the Traralgon Aquifer.

Table 4 Approximate post mining groundwater extractions

Scenario		Lower Bound
1 and 2	15 GL/year for 10 years	150 GL
3 and 4	15 GL/year for 20 to 25 years	300 to 375 GL
5	10 GL/year for 10 years	100 GL

Groundwater modelling reported in GHD 2015 indicates that with the current WOL mine plan post mining depressurisation is likely to be required to prevent Traralgon Aquifer target levels being exceeded during the initial phase of void filling. Modelling indicates and extraction rate of just under 10 GL/yr for 10 years is sufficient to prevent the majority of target levels being exceeded.

It is feasible to assume that some post mining depressurisation would be licenced and the volumes adopted for scenario 5 are considered to represent the lower range of possible future allocations and therefore more likely to be licenced. Higher allocations may be possible but there is greater uncertainty associated with these being licenced. Placement of additional overburden in critical locations would reduce the overall risk of floor instability and period of active groundwater management and would also be beneficial from the resource management perspective as would reduce the total volume of post mining groundwater extractions required.

4.2 Sensitivity Assessment

A sensitivity analysis was conducted to provide an indication of the variation in the long-term lake water level and time to reach the stable lake water level, based on the uncertainty of future water availability and the uncertainty of modelling parameters. The uncertainty of each inflow component has been classified as high, moderate or low, and assigned a lower and upper bound of what is expected to be reasonably available (Table 5). It is noted that the modelled Traralgon Creek flood flows of 4 GL/yr are beyond what is expected to be reasonably available, based on the 2004 sustainable diversion limit (SDL) assessment (DEPI, 2004) which indicates that there is potentially only up to 1.6 GL/yr available within the Traralgon Creek catchment, as a winter period (June to October inclusive) diversion.

The upper and lower bounds for runoff from a maximised and minimised catchment were estimated considering the runoff coefficient ranging between 0.2 and 0.4.

The six scenarios were simulated by adjusting the lower and upper bound of each expected inflow systematically, as summarised in Table 5, for the historical climate condition.

Table 5 Upper and lower bound of inflow components

Inflow	Uncertainty of water availability	Lower Bound	Modelled	Upper Bound
40 GL/yr Bulk Entitlement	High – dependant on climatic sequences	10 GL/yr	40 GL/yr	40 GL/yr
15 GL/yr groundwater extractions	Moderate – dependant on groundwater licencing	5 GL/yr	15 GL/yr	25 GL/yr
9.8 GL/yr groundwater extraction for 10 years	Moderate – dependant on groundwater licencing	5 GL/yr	9.8 GL/yr	25 GL/yr
Traralgon Creek flood flows	High – dependant on climatic sequences and surface water licencing	0.5 GL/yr	4 GL/yr	1.6 GL/yr
Groundwater Seepage	Moderate – uncertainty from groundwater modelling results	-25% change to seepage relationship	Seepage relationship from groundwater model	+25% change to seepage relationship
Runoff from a maximised catchments	High – dependant on climatic sequences and surface water licencing	0.2 runoff coefficient	0.3 runoff coefficient	0.4 runoff coefficient
Runoff from a minimised catchment	High – dependant on climatic sequences and surface water licencing	0.2 runoff coefficient	0.3 runoff coefficient	0.4 runoff coefficient

Table 6 summarises the modelled range in the lake water level after 200 years under the historical climate condition, estimated by adjusting the corresponding inflow parameter to the upper and lower bounds listed in Table 5. Table 7 summarises the modelled range of years to reach the stable lake water level of RL-22.5 mAHD under the historical climate condition, estimated by adjusting the corresponding inflow parameter to the upper and lower bounds listed in Table 5. The results presented in Table 6 indicate that the long-term lake water level is relatively insensitive to changes in the Bulk Entitlement, groundwater extraction rates and Traralgon Creek flood flows. This is primarily due to these inflow sources only being utilised when the mine lake water level is below the stable level of -22.5 mAHD. The results presented in Table 7 indicate that the number of years to reach the stable lake water level of -22.5 is relatively sensitive to changes to these inflow parameters.

The results presented in Table 6 indicate that the long-term lake water level is relatively sensitive to changes in the groundwater seepage estimates and runoff from the minimised catchment. This is primarily due to these inflow sources being utilised when the mine lake water level is above the stable level of -22.5 mAHD. The results presented in Table 7 indicate that the number of years to reach the stable lake water level of -22.5 is relatively insensitive to changes to these inflow parameters.

Table 6 Sensitivity Assessment: Range of lake water level after 200 years (m AHD)

Inflow	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
40 GL/yr Bulk Entitlement	11.5 - 12.6	11.1 - 12.6				
15 GL/yr groundwater extractions	12.4 - 12.8	12.2 - 12.7	9.4 - 11.5	8.6 - 11.1		
9.8 GL/yr groundwater extraction for 10 years					6.5 - 8.8	
Traralgon Creek flood flows	12.6 - 12.6		10.4 - 10.4			
Groundwater Seepage	8.9 - 18.2	8.8 - 18.1	7.5 - 15.2	7.2 - 14.8	4.1 - 10.2	3.3 - 9.2
Runoff from a maximised catchments	12.6 - 12.6	12.5 - 12.5	10.4 - 10.4	6.6 - 10.1		
Runoff from a minimised catchment	8.2 - 17.9	8.2 - 17.8	6.8 - 15.3	6.6 - 14.7	3.9 - 10.1	1.5 - 7.3

Table 7 Sensitivity Assessment: Range of years to reach stable lake water level of RL -22.5mAHD

Inflow	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
40 GL/yr Bulk Entitlement	9 - 16	10 - 18				
15 GL/yr groundwater extractions	8 - 11	8 - 11	16 - 33	18 - 42		
9.8 GL/yr groundwater extraction for 10 years					41 - 58	
Traralgon Creek flood flows	9 - 9		23 - 23			
Groundwater Seepage	9 - 9	10 - 10	21 - 22	24 - 26	51 - 58	58 - 69
Runoff from a maximised catchments	9 - 9	10 - 10	23 - 23	28 - 25		
Runoff from a minimised catchment	9 - 9	10 - 10	21 - 21	25 - 25	54 - 54	63 - 63

5. Conclusions

5.1 Conclusions

The modelling results indicate that diverting the full Bulk Entitlement allocation of 40 GL/year to the mine void (scenarios 1 and 2) results in the shortest time for the lake to reach stabilisation timeframe of approximately 10 years. However, the likelihood of accessing the full Bulk Entitlement post mine closure is unknown at this stage and could potential be affected by actual climate sequences, in particular during drought periods so their is some uncertainty associated with relying on this allocation for mine closure planning.

Inclusion of Traralgon Creek flows is the difference between scenarios 3 and 4 and not considered significant making around a 5 year difference in reaching RL-22.5 m. The modelled Traralgon Creek flood flows of 4 GL/yr are beyond what is expected to be available which is potentially up to 1.6 GL/yr as a winter period diversion.

The groundwater extraction volumes used in scenarios 4 and 5 are likely to represent the range of possible future post mining groundwater extractions. Scenario 4 with groundwater inflows of 15 GL/y effectively represents extension of the current licenced extractions for an additional 25 to 30 years after mine closures and is considered as an optimistic "best case" scenario. The licensing of post mine closure extractions has not been addressed to date by the regulators and there is uncertainty as to how it will be approached. Under scenario 4, lake levels 200 years after closure are modelled to range from RL +10 to -8 m AHD and take between 25 to 30 years to reach the stable level of RL-22.5 m depending on the climate option adopted (Table 8).

Scenario 5 with groundwater extractions of 9.8 GL/y for 10 years is considered to have a higher probability to be licenced and is a conservative approach for mine closure planning. Under scenario 5 lake levels are modelled to range from RL +7 to -10 m AHD after 200 years and take between 55 to 75 years to reach the stable level of RL-22.5 m depending on the climate option adopted. This increases to 65 to 85 years with lake levels after 200 years of RL+5 to RL-10 using "worst case" scenario 6 assumptions of catchment runoff and groundwater seepage only to the mine void.

Table 8 Summary of void filling modelling results

Scenario	Years to RL -22.5 m	Lake Level (mAHD) at 2260
4 - Best case	25 to 30	+10 to -8
5 - Likely case	55 to 75	+7 to -10
6 - Worst Case	65 to 85	5 to -11

The modelled the lake levels after 200 years for the likely, best and worst case scenarios all achieve or are greater than the assumed level of RL-10 m as adopted in the current Mine Rehabilitation Plan. The results also indicate that once RL-22.5 m lake level is reached, management of the catchment area can be used to influence the long term final lake level.

It is noted that the lake level of RL-22.5 m AHD required for long term stability is based on the WOL mine plan. To manage the uncertainty associated with the future water sources particularly licencing of bulk entitlements and groundwater extractions, modifications to the WOL mine plan could be considered at key locations to reduce the maximum stable lake level from RL-22. These modifications could include increasing the final mine grade and placement of addition overburden at selected locations thereby reducing stable lake level and void filling period to when it is reached. For example assuming scenario 5, if the stable lake level is reduced to around RL-37 m the void filling period when groundwater management may be required is between 35 and 45 m depending on the climate option adopted, a reduction of 20 to 30 years.

6. References

DSE (2011) Guidelines for the Development of a Water Supply Demand Strategy (Version 2), ISBN 978-1-74287-388-6 (online). August 2011.

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GHD (2015) Loy Yang Groundwater Modelling – Long Term Mine Plan. Report 31/11584/15/235556 prepared for AGL Loy Yang, March 2015.

GHD (2015a) Long Term Aquifer Depressurisation Assessment. Report 31/11589/15/222197 prepared for AGL Loy Yang, in preparation.

Appendices

Appendix A – REALM model inputs

Table 9 Climate change factors (DSE, 2011)

Impact	Historic	Wet	Median	Dry
Runoff (% change)	1	0.86	0.53	0.34
Rainfall (% change)	1	0.96	0.93	0.85
PET (%change)	1	1.05	1.07	1.05

Table 10 2014 Study: Loy Yang Mine Volume vs. Lake Stage rating table

2014 Mine Volume (ML)	2014 Stage (mAHD)
0	-160
20,078	-120
77,931	-100
159,847	-80
285,706	-60
449,434	-40
642,233	-20
885,932	0
1,224,330	20
1,782,212	50

Table 11 2011 Study: Loy Yang Mine Volume vs. Lake Stage rating table (Scenarios 1 – 2 only)

2011 Study (Scenarios 1 – 2) Mine Volume (ML)	2011 Study (Scenarios 1 – 2) Stage (mAHD)
0	-135
41,443	-120
131,573	-100
238,656	-80
362,123	-60
530,464	-40
724,126	-20
977,565	0
1,222,029	20
1,583,954	40

Table 12 2011 Study: Loy Yang Mine Volume vs. Lake Stage rating table (Scenarios 3 – 6 only)

2011 Study (Scenarios 3 – 6) Mine Volume (ML)	2011 Study (Scenarios 3 – 6) Stage (mAHD)
0	-135
17,800	-120
74,900	-100
151,390	-80
257,730	-60
440,250	-40
648,140	-20
914,710	0
1,238,870	20
1,600,630	40

Figure 6 Loy Yang Mine Volume vs. Lake water level rating curve

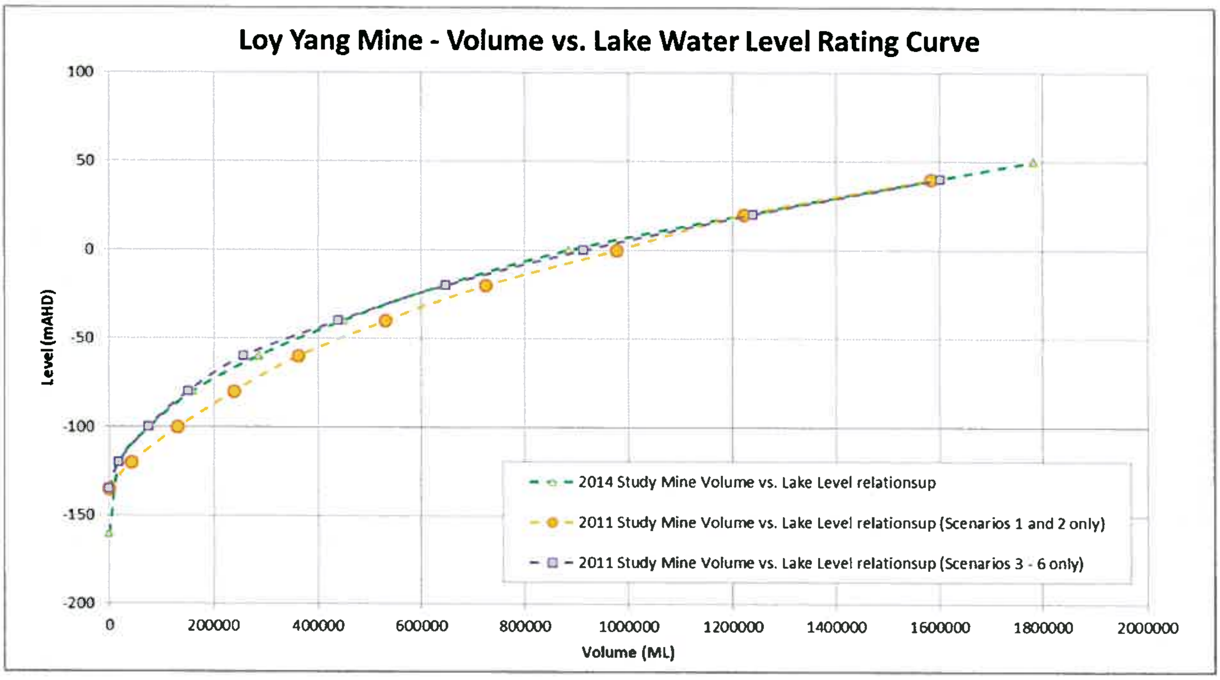


Table 13 2014 Study: Loy Yang Mine Volume vs. Area rating table

2014 Study - Mine Volume (ML)	2014 Study - Mine Area (HA)
0	0
32,585	269
95,018	351
217,210	635
364,019	824
696,143	1,108
816,212	1,325
965,110	1,659
1,224,331	1,784
1,782,212	1,957

Table 14 2011 Study: Loy Yang Mine Volume vs. Lake Stage rating table

2011 Study - Mine Volume (ML)	2011 Study - Mine Area (HA)
0	0
41,443	389
131,573	497
238,656	578
362,123	670
530,464	900
724,126	1,081
977,565	1,423
1,222,029	1,769
1,583,954	1,855

Figure 7 Loy Yang Mine Volume vs. Area rating curve

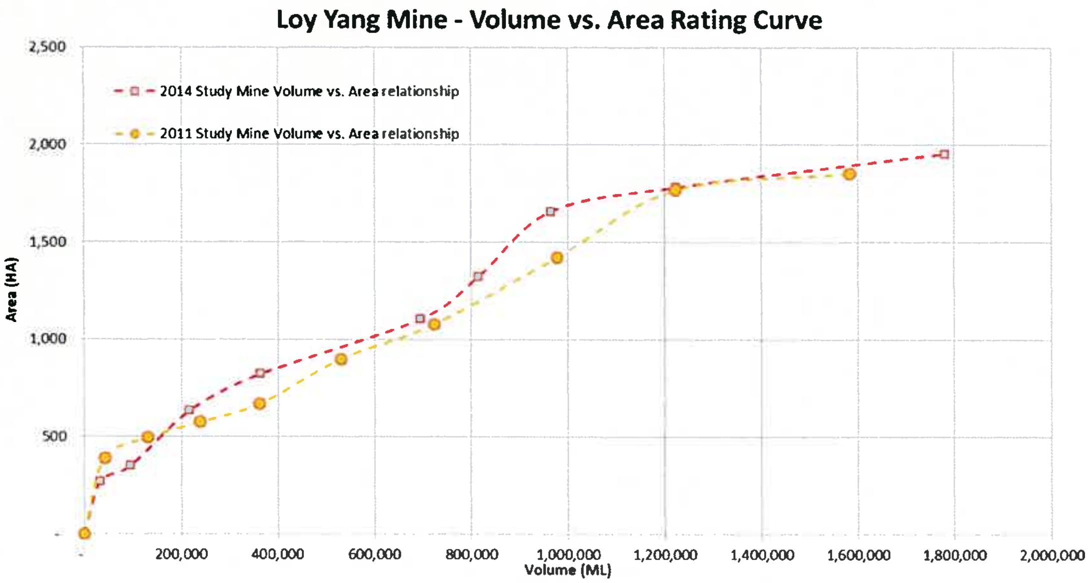


Table 15 2014 Study: Groundwater Seepage Mine Lake Inflows (kL/month)

Lake water level (mAHD)	Historical climatic condition	Wet climatic condition	Median climatic condition	Dry climatic condition
-155	405,720	404,414	403,771	402,562
-140	396,857	395,156	394,464	392,991
-125	376,628	374,345	373,403	371,440
-110	357,099	355,251	354,576	352,414
-95	341,107	338,371	337,073	334,391
-80	314,973	311,290	309,833	306,357
-65	280,619	278,126	277,421	274,525
-50	248,181	243,496	241,230	235,650
-35	205,865	199,943	197,177	189,704
-20	164,897	164,276	165,005	148,501
-5	141,072	142,405	138,674	107,539
10	125,347	120,533	112,343	66,577

Note – these relationships were established by simulating the Loy Yang mine recovery groundwater model over the period 2059 – 2455 for the four climatic conditions (GHD, 2015).

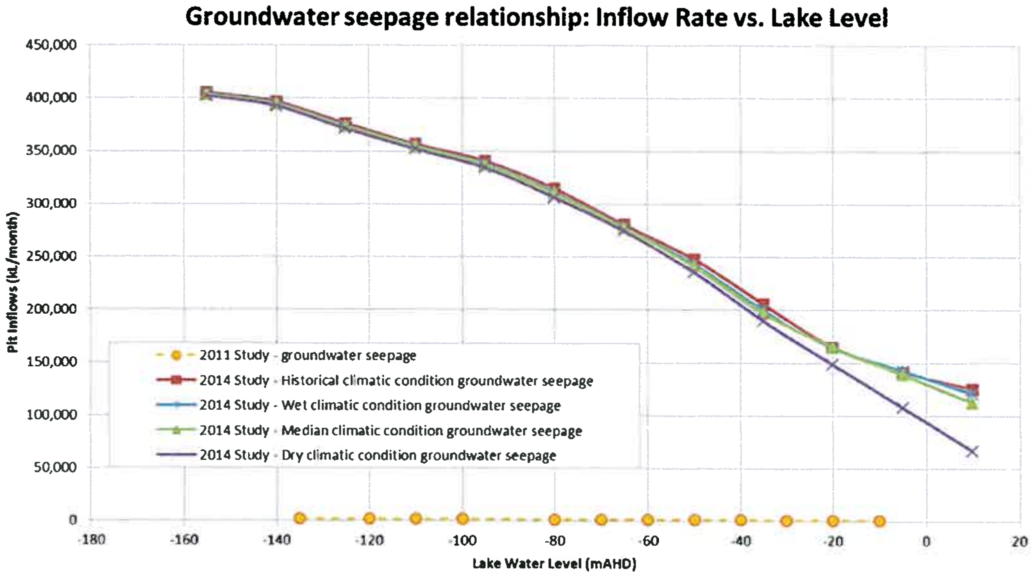
Table 16 2011 Study: Groundwater Seepage Mine Lake Inflows (kL/month)

Lake water level (mAHD)	Groundwater seepage mine (kL / month)
-10	980
-20	1109
-30	1238
-40	1367
-50	1496
-60	1625
-70	1754
-80	1883
-100	2141
-110	2270
-120	2399
-135	2593

Note – the groundwater seepage relationship applied in the 2011 study was not estimated from groundwater modelling.

Note – the groundwater seepage inflows are entered into REALM as kL/month, and are converted into ML/month in the model.

Figure 8 Groundwater seepage relationship: Inflow rate vs. lake water level



Appendix B – REALM model configuration

Figure 9 REALM System configuration

REALM SYS file key changes

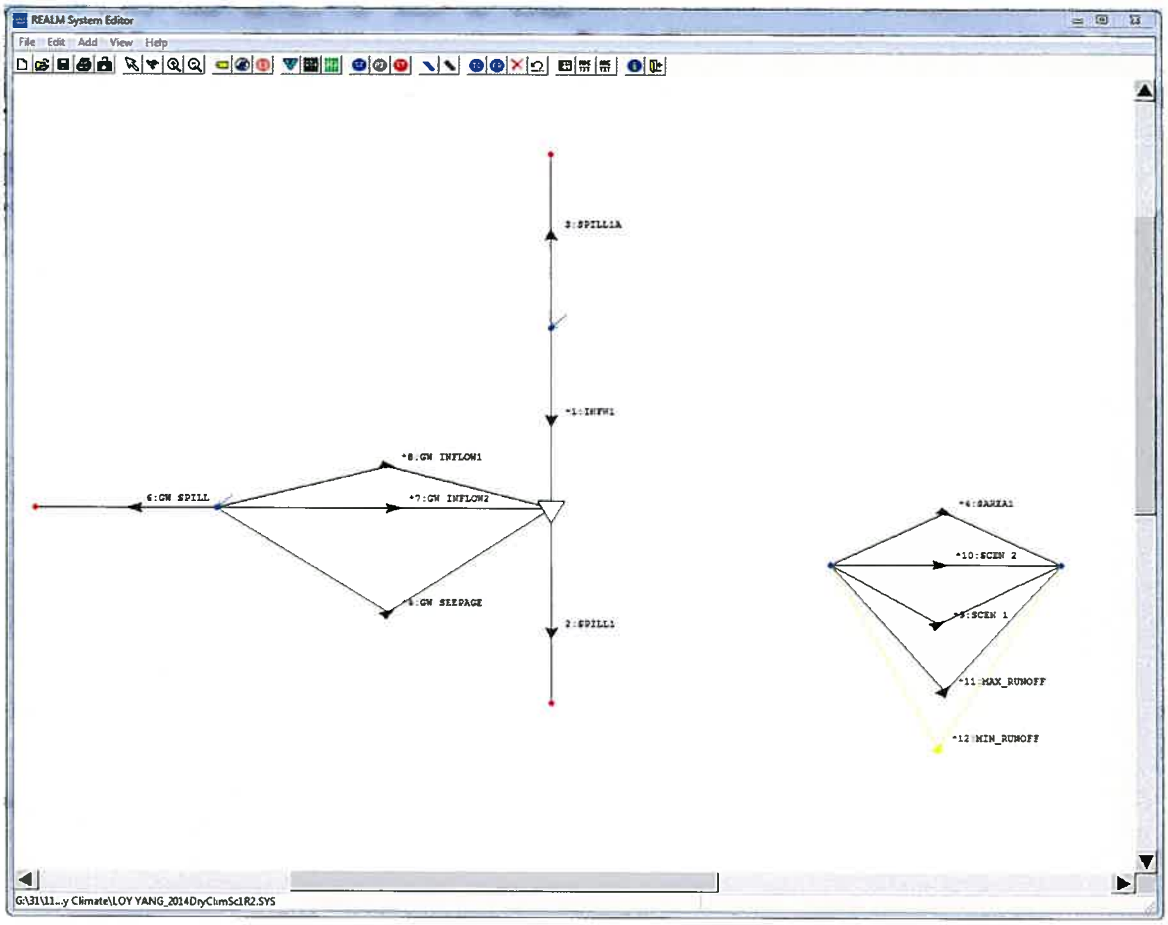
Historical climatic conditions

Dry climatic conditions

Median climatic conditions

Wet climatic conditions

Figure 9 REALM System configuration



REALM SYS file key changes

Key changes to the system file include:

- Addition of the minimised catchment area calculation for mine lake RL above -22.5 m. Calculation arcs added are carrier 11 and carrier 12. Minimum catchment 2115 Ha is based on the 2014 mine void area at +50 mAHD.
- Modified the maximum catchment area based on revised spatial mapping from 3800 Ha to 3687 Ha.
- Modified the calculation for Traralgon Creek flood flows (Scenarios 1 and 3) to be diverted into the mine lake void up to mine lake level of -22.5 mAHD, and switched off when the mine lake level is above -22.5 mAHD

Historical climatic conditions

- System file configured with the historical climate condition groundwater seepage rating table (Carrier 10)
- The historical climate factors for rainfall and potential evapotranspiration are applied to the inflow and demand files
- The historical climate factor for streamflow is applied to the Traralgon Creek flood flows in Carrier 8 for Scenarios 1 and 3.

File Path: G:\31\1158414\Technical\WB\2014\Historic Climate

Scenario number	Log file	SYS file	Inflow	Demand
1	H1r2.log	LOY YANG_2014HistClimSc1R2.SYS	200_Yr_INFW.prn	200_Yr_DEM.prn
2	H2r2.log	LOY YANG_2014HistClimSc2R2.SYS		
3	H3r2.log	LOY YANG_2014HistClimSc3R2.SYS		
4	H4r2.log	LOY YANG_2014HistClimSc4R2.SYS		
5	H5r2.log	LOY YANG_2014HistClimSc5R2.SYS		
6	H6r2.log	LOY YANG_2014HistClimSc6R2.SYS		

Dry climatic conditions

- System file configured with the dry climate condition groundwater seepage rating table (Carrier 10)
- The dry climate factors for rainfall and potential evapotranspiration are applied to the inflow and demand files
- The dry climate factor for streamflow is applied to the Traralgon Creek flood flows in Carrier 8 for Scenarios 1 and 3.

File Path: G:\31\1158414\Technical\WB\2014\Dry Climate

Scenario number	Log file	SYS file	Inflow	Demand
1	D1r2.log	LOY YANG_2014DryClimSc1R2.SYS	200_Yr_DEM_DryCC.prn	200_Yr_DEM_DryCC.prn
2	D2r2.log	LOY YANG_2014DryClimSc2R2.SYS		
3	D3r2.log	LOY YANG_2014DryClimSc3R2.SYS		
4	D4r2.log	LOY YANG_2014DryClimSc4R2.SYS		
5	D5r2.log	LOY YANG_2014DryClimSc5R2.SYS		
6	D6r2.log	LOY YANG_2014DryClimSc6R2.SYS		

Median climatic conditions

- System file configured with the median climate condition groundwater seepage rating table (Carrier 10)
- The median climate factors for rainfall and potential evapotranspiration are applied to the inflow and demand files
- The median climate factor for streamflow is applied to the Traralgon Creek flood flows in Carrier 8 for Scenarios 1 and 3.

File Path: G:\31\1158414\Technical\WB\2014\Median Climate

Scenario number	Log file	SYS file	Inflow	Demand
1	M1r2.log	LOY YANG_2014MedClimSc1R2.SYS	200_Yr_DEM_MedCC.prn	200_Yr_DEM_MedCC.prn
2	M2r2.log	LOY YANG_2014MedClimSc2R2.SYS		
3	M3r2.log	LOY YANG_2014MedClimSc3R2.SYS		
4	M4r2.log	LOY YANG_2014MedClimSc4R2.SYS		
5	M5r2.log	LOY YANG_2014MedClimSc5R2.SYS		
6	M6r2.log	LOY YANG_2014MedClimSc6R2.SYS		

Wet climatic conditions

- System file configured with the wet climate condition groundwater seepage rating table (Carrier 10)
- The wet climate factors for rainfall and potential evapotranspiration are applied to the inflow and demand files
- The wet climate factor for streamflow is applied to the Traralgon Creek flood flows in Carrier 8 for Scenarios 1 and 3.

File path: G:\31\1158414\Technical\WB\2014\Wet Climate

Scenario number	Log file	SYS file	Inflow	Demand
1	W1r2.log	LOY YANG_2014WetClimSc1R2.SYS	200_Yr_DEM_WetCC.prn	200_Yr_DEM_WetCC.prn
2	W2r2.log	LOY YANG_2014WetClimSc2R2.SYS		
3	W3r2.log	LOY YANG_2014WetClimSc3R2.SYS		
4	W4r2.log	LOY YANG_2014WetClimSc4R2.SYS		
5	W5r2.log	LOY YANG_2014WetClimSc5R2.SYS		
6	D6r2.log	LOY YANG_2014WetClimSc6R2.SYS		

Appendix C – REALM model results

Figure 10 Lake water balance modelling results – Scenario 1

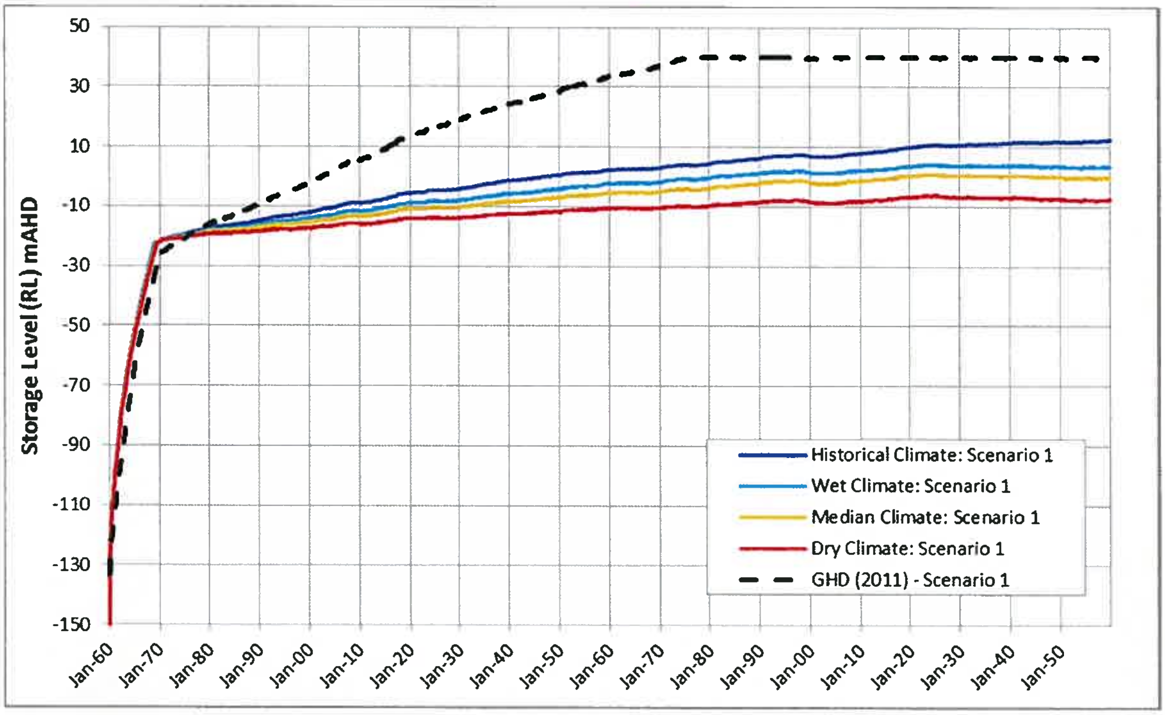


Figure 11 Lake water balance modelling results – Scenario 2

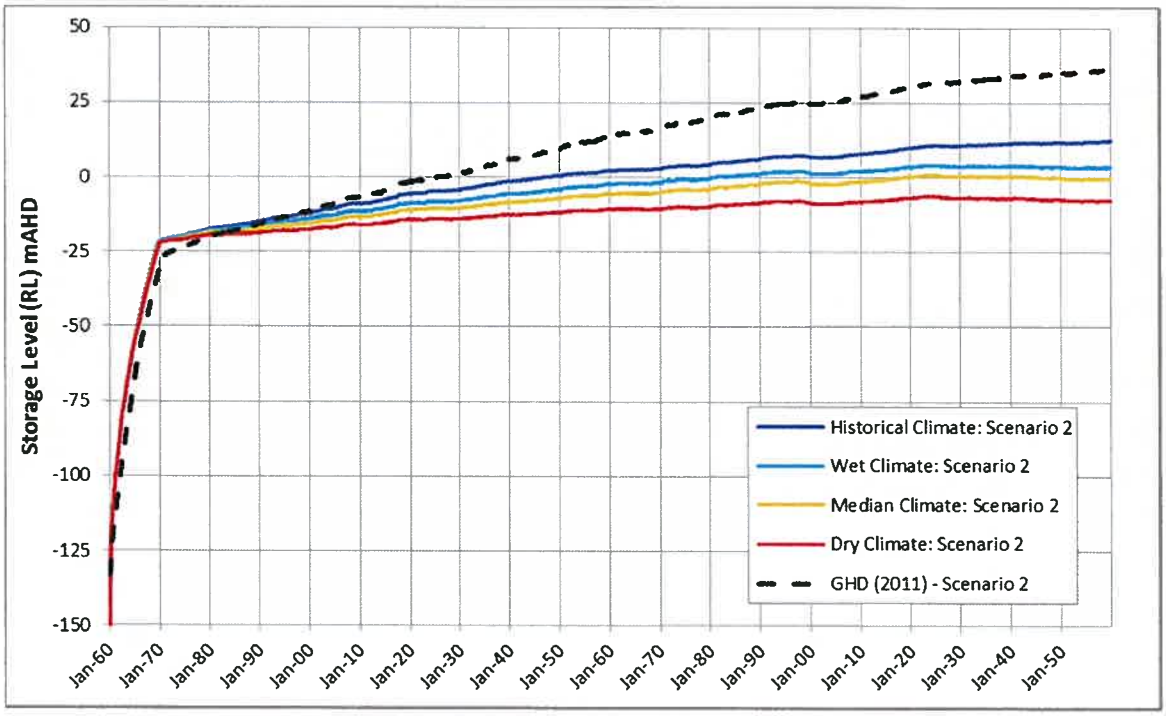


Figure 12 Lake water balance modelling results – Scenario 3

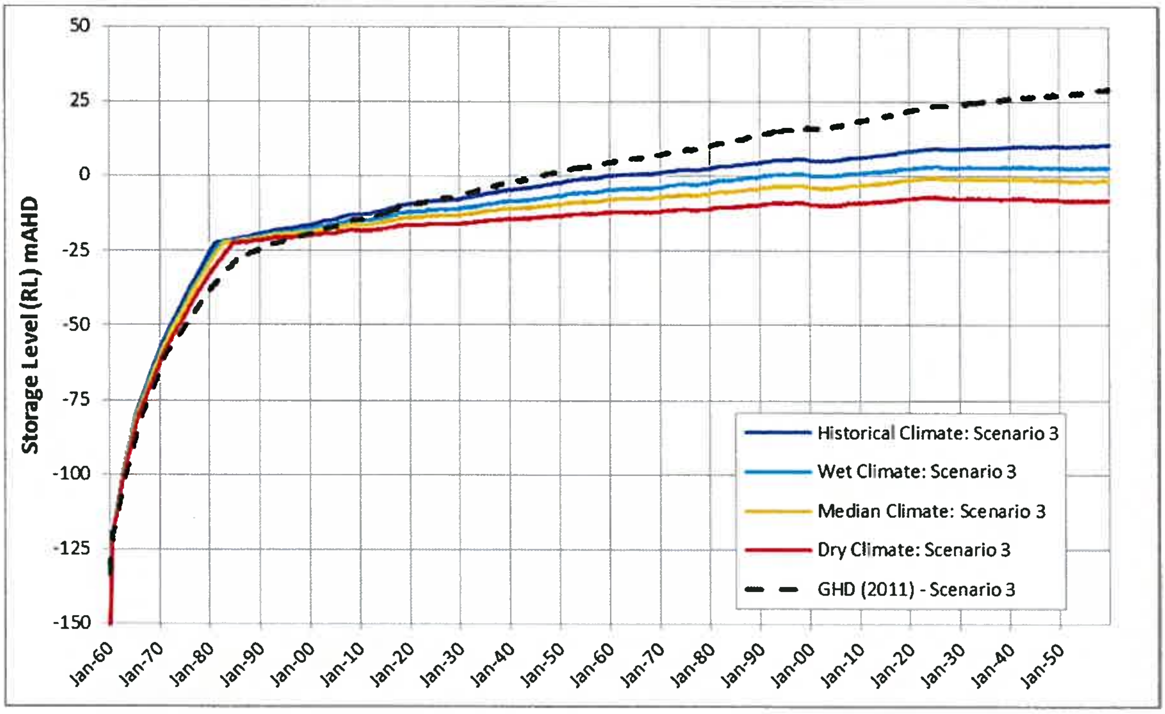


Figure 13 Lake water balance modelling results – Scenario 4

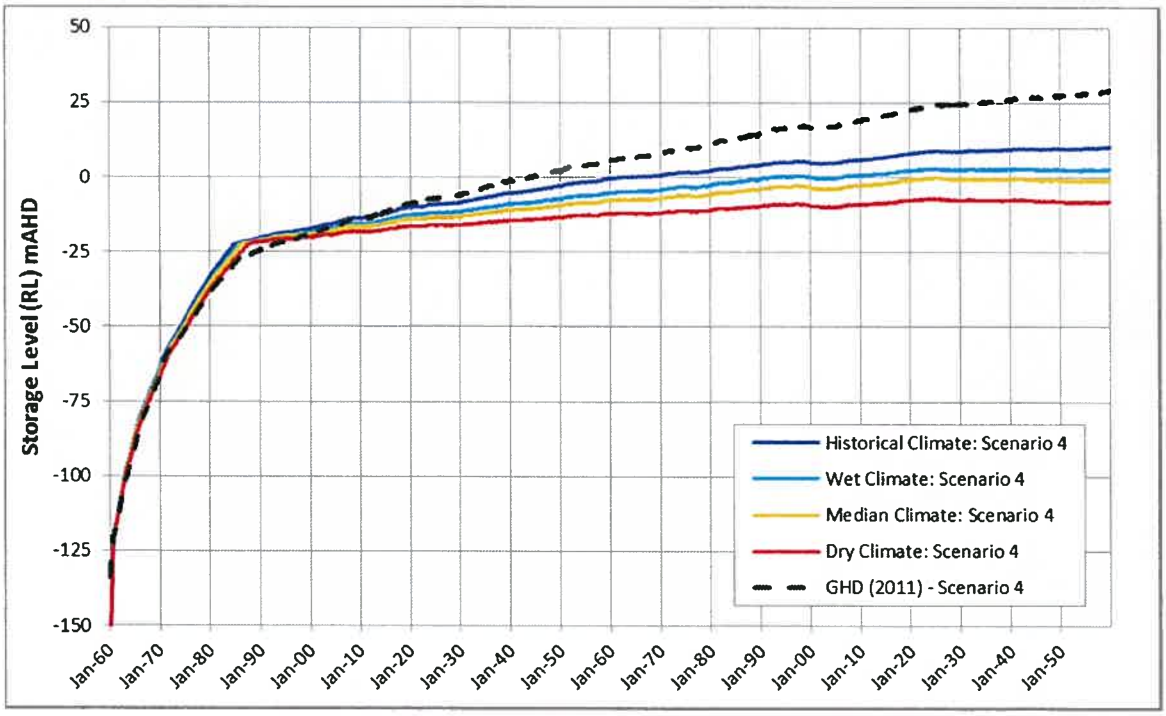


Figure 14 Lake water balance modelling results – Scenario 5

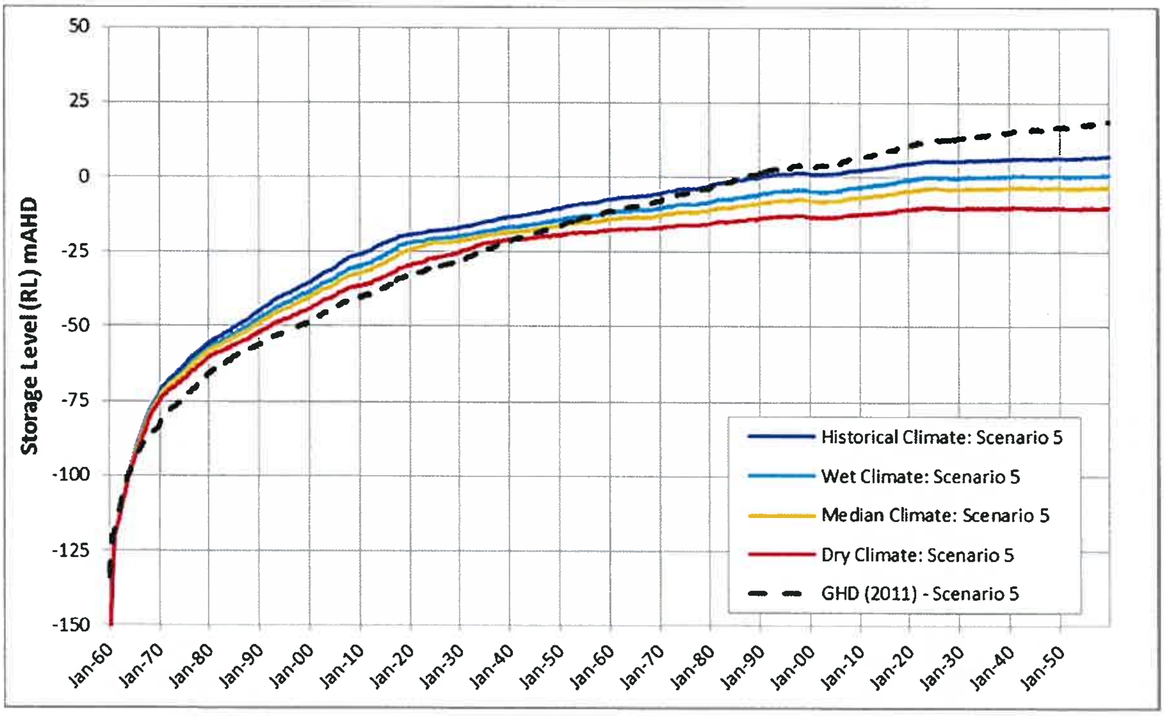
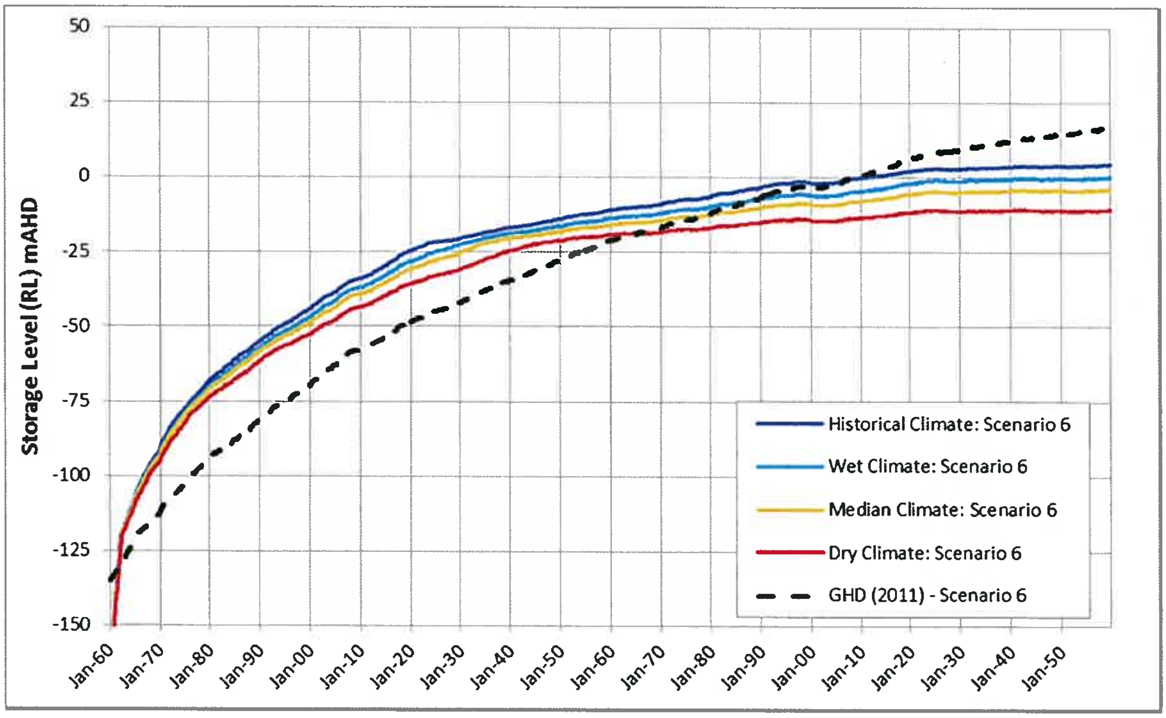


Figure 15 Lake water balance modelling results – Scenario 6



This *Loy Yang Mine Rehabilitation – Mine Lake Water Balance Modelling report* (Report) has been prepared by GHD Pty Ltd (GHD) for AGL Loy Yang Pty Ltd (AGL Loy Yang) under AGL Loy Yang Order No 20010030 "Provision of Mine Planning, Earth Sciences and Associated Services", and associated Modifications as at the date of this Report (the Contract). The Contract, and relevant sections in this report, provide a list of the information relied upon in preparing this report, and any limitations/assumptions made. This report may only be used/relied upon by AGL Loy Yang

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