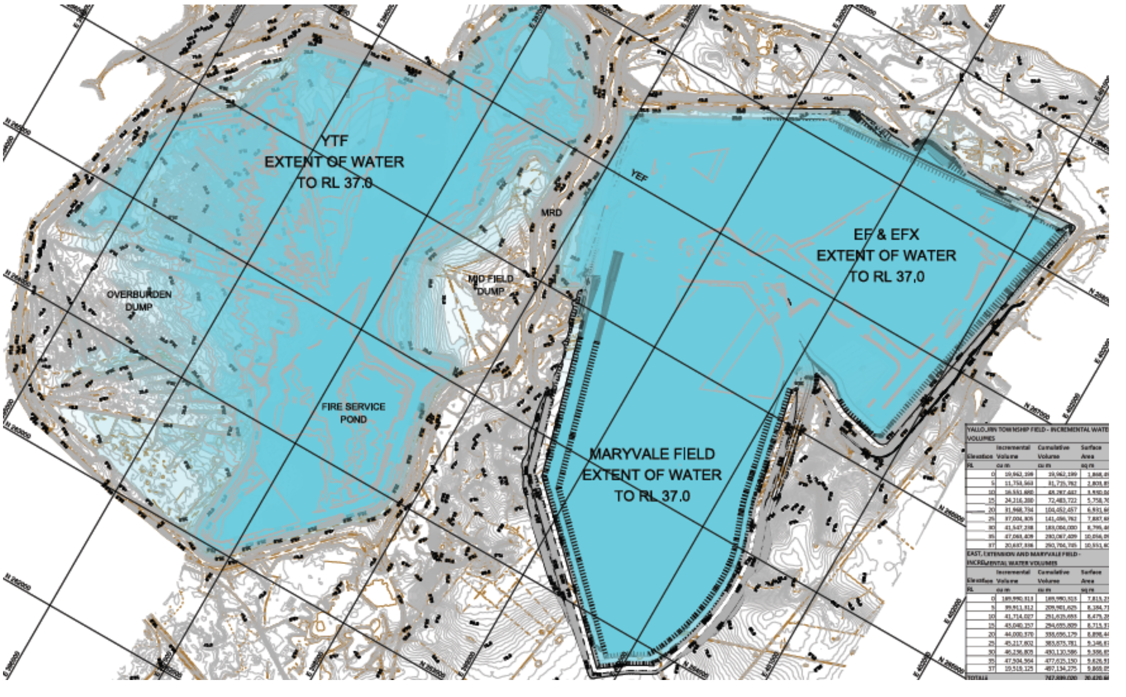
Yallourn Mine

Final Land Rehabilitation

Lake Filling Model

Revision 3



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Chapter 1
Introduction

After completion of mining at Yallourn, there is a requirement to complete the land rehabilitation for its final use post mining. The model favoured by TRUenergy Yallourn is to create a lake system to RL 37, capacity of 748 GL, to meet the requirements of the currently approved Rehabilitation Master Plan. An early commencement option by stopping mine water discharge to the Morwell River would see Township Field inundated with water up to RL 20, to largely neutralize the acid leachate from the overburden dump in that area. A dam wall would prevent water from impeding the Morwell River Diversion (MRD) tunnels at RL 11 whilst maintaining stabilisation of the MRD. This report has determined five scenarios for sources of water filling;

1. natural filling
2. station allocation
3. net station allocation
4. above 90th percentile Latrobe River overflows
5. above 90th percentile Morwell River overflows

Various data analysis and modeling has enabled filling time predictions to be made on the different scenarios of flow and inundation water requirements within the Yallourn Mine.

1.1 Assumptions

The MRD tunnels at RL11 will allow water to flow from Township Field to East/Maryvale Field in the early stages of filling. Once both systems reach RL11 it is assumed that the water bodies will fill simultaneously, therefore becoming one water body. Due to difficulties in modeling the RL and volume relationships of both Township Field and East Field a linear step function has been used instead of a more preferable polynomial function. This said, the linear step function still provides a highly accurate volume function due to mine geometry data being provided at 5m intervals.

The model assumes that filling will begin after full coal production ceases in 2032 with the lake volume being 0 GL at 2032. Various lake capacities can be interpolated from the 2032 scenario depending on changes to the business life and life of the mine. One example of this is given where mining still proceeds through to 2032, yet the volume of the void is decreased to 707 GL.

Chapter 2
Data Collection

2.1 Rainfall

Rainfall in the Yallourn region is somewhat variable and can be difficult to model with great certainty. This said, the Yallourn SEC Bureau of Meteorology site measured rainfall for 41 years whilst Yallourn Mine Fire Service records give another 20 years of data. The average annual rainfall from this data being 859.3mm has been used to forecast the natural runoff upon mine closure.

2.2 Evaporation

In similar respect to rainfall data, evaporation data at the Yallourn SEC BOM site was available until 1986, without the latest history this data may not be a true reflection of the evaporation Yallourn is likely to experience into the future. Therefore, in addition to the Yallourn SEC data, evaporation data has been collected from BOM sites at Blue Rock Reservoir and East Sale with the average annual pan evaporation values being 1278 mm.

When considering a lake scenario, pan evaporation data overstates the actual evaporation which is likely to occur. Because of this a pan coefficient is adopted into the model to more accurately reflect the evaporation from a lake at Yallourn. A pan coefficient of 0.7 is generally considered reasonable for lake evaporation (Srivastava, 2009; Shaw, 2010), therefore 0.7 has been adopted as a pan coefficient in this model. The resultant evaporation used within this model is:

$$E_L = 0.7 * 1278$$
$$= 894.3 \text{ mm}$$

Where E_L is the effective annual lake evaporation.

2.3 Catchment Area

Previous studies from GHD (2005) and HRL (2000) give a vastly smaller catchment area for the Yallourn Mine Final Rehab Lake than the catchment currently assessed by contour data and likely diversions. It is unknown how HRL (2000) derived their catchment area however GHD (2005) used the mining licence boundary as the catchment area. In addition to the mining licence area, runoff from Rifle Range Gully, Old Melbourne Drain, Morwell West Drain North and increased perimeter areas add significant catchment area to the understated area which forms the GHD model. The catchment area for this study is shown in Appendix A.

2.4 Groundwater

TRUenergy Yallourn maintains a Groundwater Extraction Licence for the dewatering of deep aquifers to maintain mine stability. The Licence was granted in 1996 and is valid for 30 years. Under the groundwater Licence, Yallourn Mine currently conducts deep aquifer dewatering in the YEF Mine. For the development of the Maryvale Field, dewatering of the M1A aquifer will be required.

The deep aquifer dewatering volumes extracted by TRUenergy Yallourn are considerably lower than the neighbouring Latrobe Valley brown coal mines.
For the purposes of this study, Deep Aquifer dewatering volumes have been excluded as a potential source of water for the purposes of lake filling.

2.5 Runoff Coefficient

A water balance assumes a closed cycle, therefore:
Inflow – Outflow = Change in Storage

Inflows include:

- Precipitation, P
- Surface Inflows, I_s
- Subsurface Inflows, I_g

Outflows include:

- Stream flow, Q
- Evaporation, E
- Evapotranspiration, ET
- Diversions, D
- Subsurface Outflow, Q_g

Storage may include:

- Surface Storage, S_s
- Soil Moisture Storage, S_{sm}
- Groundwater Storage, S_g

Due to the inflows, outflows and storage characteristics above, the water balance can be expressed mathematically as:

$$(P+I_s+I_g) - (Q+E+ET+D+Q_g) = \Delta S_s + \Delta S_{sm} + \Delta S_g$$

Within this model, inflow is directly related to the amount of precipitation falling within the catchment area whilst outflow considers evaporation and storage refers to the final lake system. It can be seen that other parameters must be considered within the lake model. As the other outflow and storage losses are relatively minor, due to the captive nature of the catchment, it has been assumed that a factor of 0.8 can reflect the other losses and storages within the Maryvale catchment. In contrast, the Township Field catchment covers a vast area of which approximately half can be considered as captive mine area. Due to this, a runoff coefficient for Township Field must be less than Maryvale. This model assumes a runoff coefficient of 0.7 for the Township Field catchment.

Chapter 3
Natural Filling

In determining flow rates and filling times with regard to natural filling, the data collected above and void geometry were utilized. A comparison of the raw data used by this study, GHD (2005) and HRL (2000) is given below.

Table { SEQ Table * ARABIC }: Lake Model Raw Data

Parameter	This Study	GHD (2005)	HRL (2000)
Annual Precipitation (mm)	859.3	796.4	902
Annual Evaporation (mm)	0.7*1278 = 894.3	N/A	950
Annual Groundwater Inflow (m^3)	0	3,804,760	1,576,800
Catchment Area (ha)	3,825	2,500	1,900
Runoff Coefficient	0.7 TF and 0.8 EFMF	0.3	unknown

Comparing the contrasting figures above, the first major impact between this study and the studies of HRL (2000) and GHD (2005) is that this study will not have a limiting lake level due to surface runoff outweighing the effective evaporation. Both the GHD and HRL reports show precipitation being less than evaporation integrated with a smaller catchment area which supports the argument of the lake system reaching an equilibrium lake level. However, by using an average of Yallourn SEC data, in service until 1986, East Sale data which is still a present BOM site, and Blue Rock Reservoir, an average annual evaporation of 1278 mm was used throughout the model. To apply the referenced evaporation figures to a lake scenario the coefficient of 0.7 is applied, this gives an annual evaporation of 894.3mm.

By using the figures shown for this study and corresponding Township and East/Maryvale Field geometry the filling rates with reference to lake RL and volume are given below. This model shows the 748 GL lake system at RL37 in the year 2113 giving a filling time of 81 years using only catchment runoff.

Chapter 4
Additional Filling

In addition to the natural filling sourced by runoff from the catchment area less the effect of evaporation, additional sources of water are available to further supplement the water available to assist in filling the mine void to create a lake system in accordance with our Master Rehabilitation Plan.

These additional sources of water are discussed below where filling rates consider the full mine void of 748 GL.

4.1 Station Bulk Water Entitlement

TRUenergy Yallourn maintains a Bulk Water Entitlement enabling TRUenergy Yallourn to extract water from the Latrobe River to support power station operations. The Bulk Water Entitlement allows TRUenergy Yallourn to extract up to 36,500ML per annum from the Latrobe River. Upon closure of the station, the possibility remains for this water to be retained within the final rehabilitation lake, subject to approval. This scenario allows the lake to reach RL37 within 16 years of filling.

4.2 Net Station Water Entitlement

In similar principle to utilizing the full station water entitlement, a net station entitlement may be approved to achieve a quicker lake filling time. The net station allocation subtracts the EPA licence discharge volume of 18,250ML from the station allocation of 36,500ML giving an additional 18,250ML annually to the rehabilitation lake. This sees the lake filling to RL37 in 27 years (i.e. by 2059).

4.3 Morwell River Overflow

In addition to natural filling of the final rehabilitation lake system, inflows during extreme flood events from the Morwell River could potentially be utilized in achieving a faster lake fill. These scenarios considers allowing 90th percentile overflow from the Morwell River to flow into the lake

Using the past 10 years of instantaneous flow data for the Morwell River the 90th percentile flow was found to be 587ML/day. This model has taken the overflow from any event above 587ML/day and included it within the model. On average the overflow was found to equate to an average annual inflow of 8,838ML which allows the lake system to reach RL37 in 40 years.

4.4 Latrobe River Overflow

In addition to natural filling of the final rehabilitation lake system, inflows during extreme flood events from the Latrobe Rivers could potentially be utilized in achieving a faster lake fill. This scenario considers allowing 90th percentile overflow from the Latrobe River to flow into the lake

Latrobe River overflow was calculated by the same method as the Morwell River overflow; however data was available from 1962 making the Latrobe River data a more reliable source than the Morwell River data which had only 10 years of history. The 90th percentile event from the Latrobe River was found to be 3250.79ML/day which allowed an overflow of 21210.55ML/year. When combined with natural filling, RL 37 would be reached in 24 years.

4.5 RL 20 Dam Wall

In modeling the filling rate of this proposal only Township Field catchment was considered within the natural runoff equation. This sees RL 20 reached within 9 years of natural filling. However, this scenario is unlikely to form the basis of a final rehabilitation lake, its benefit will be enabling storage of wastewater before mining operations cease. In terms of lake water volumes, this provides a 97.9 GL head start, equivalent of an approximately two year shorter filling time when considering the station water combined with natural filling scenario. If only natural filling were to be utilised in lake filling after mine closure, the RL 20 dam wall will provide a filling time 19 years earlier than if beginning the process using only natural fill.

4.6 Comparison of Filling Scenarios

By altering and combining the various sources of inflow into the lake, a range of filling times are tabulated below. In addition, the best case scenario which includes peak flow from the Morwell River, Latrobe River and full station allocation would see the lake fill to RL 37 within 9 years, as opposed to the 11 year fill if the RL 20 dam wall was not to be constructed. It can be seen that filling of the mine void will see Township Field stagnate at RL 11 due to the MRD tunnels and subsequent outflow into East Field. Because of this, the comparison figure shown below will show the filling rate of the East Field void.

Furthermore, modeling of lake filling which considers a mine void of 707 GL has also been completed with results shown in the table below.

Table { SEQ Table * ARABIC }: Filling Times Depending on Source Inflow

Option	Source	Year Filled to RL30, 613GL	Time (years)	Year Filled to RL37, 748GL	Time (years)	Year Filled to RL37, 707GL	Time (years)
1	Natural Fill	2088	56	2113	81	2104	72
2	Natural Fill with: - 90th Percentile MR overflow	2063	31	2072	40	2069	37
3	Natural Fill with: - Station Entitlement	2045	13	2048	16	2047	15
4	Natural Fill with: - Net Station Entitlement	2053	21	2059	27	2057	25
5	Natural Fill: - 90th Percentile LR overflow	2051	19	2056	24	2055	23
6	Natural Fill with: - 90th Percentile MR overflow - Station entitlement	2043	11	2046	14	2045	13
7	Natural Fill with: - 90th Percentile MR overflow - Net Station Entitlement	2048	16	2053	21	2051	19
8	Natural Fill with: - 90th Percentile MR overflow - 90th Percentile LR overflow	2047	15	2051	19	2049	17
9	Natural Fill with: - 90th Percentile MR overflow - 90th Percentile LR overflow - Station Entitlement	2041	9	2043	11	2042	10
10	Natural Fill with: - 90th Percentile MR overflow - 90th Percentile LR overflow - Net Station Entitlement	2043	11	2045	13	2044	12
11	Natural Fill with: - 90th Percentile LR overflow - Station Entitlement	2042	10	2044	12	2043	11
12	Natural Fill with: - 90th Percentile LR overflow - Net Station Entitlement	2044	12	2048	16	2047	15
13	Natural Fill with: - Township Field Dam Wall at RL 20 - -90th Percentile MR overflow - 90th Percentile LR overflow - Station Entitlement	2039	7	2041	9	2040	8

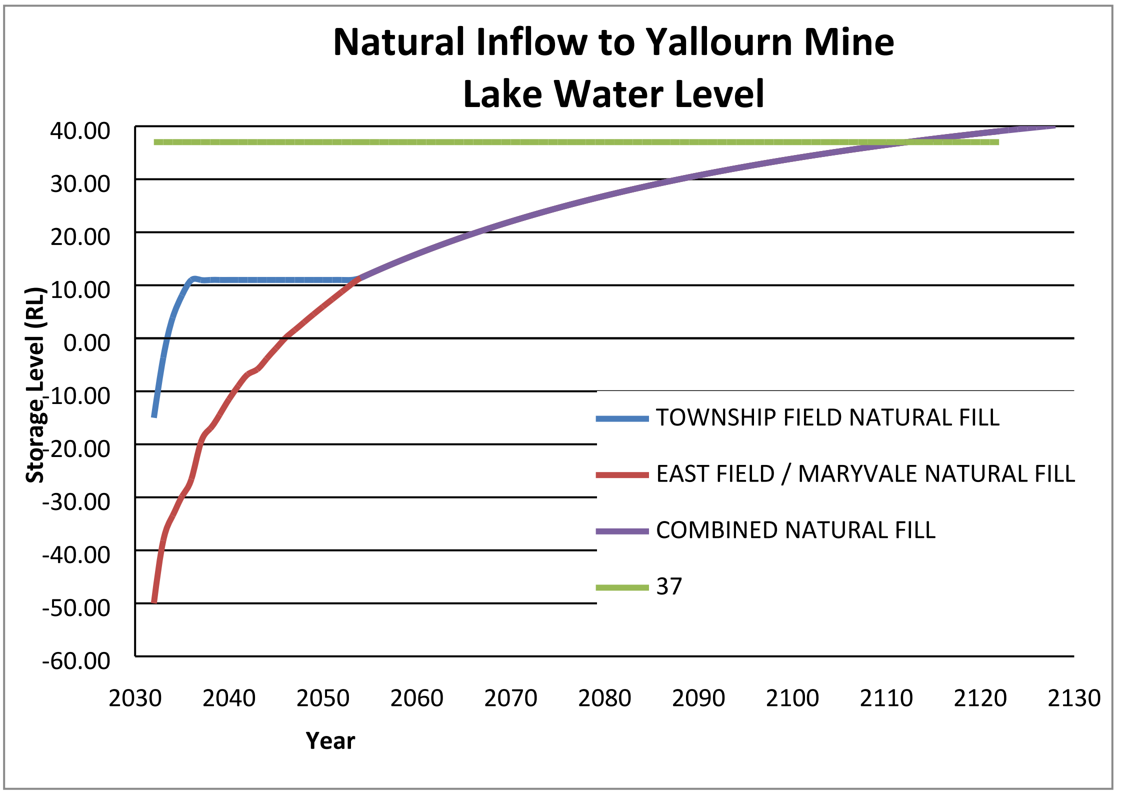

Figure { SEQ Figure * ARABIC }: Filling Model of Yallourn Mine (748GL) with Natural Inflow

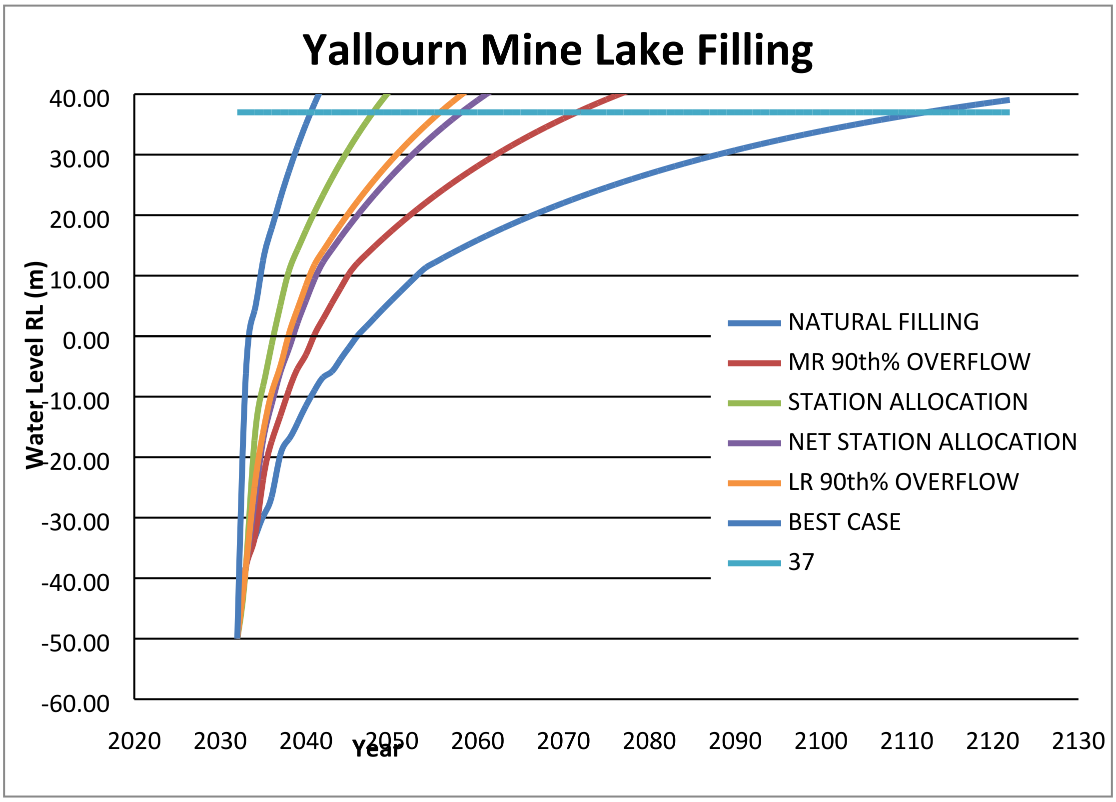

Figure { SEQ Figure * ARABIC }: Filling Model of the East/Maryvale Field Section (748GL) Comparing Different Scenarios

Chapter 5

Conclusion

When considering the volumes of water associated with filling the Yallourn Mine it must be noted that any modeling will contain sensitivities. For example, if average rainfall were to increase by 10mm per year, the result would be a decrease in filling time by three years in the natural filling scenario. The lake filling times provided are considered accurate if average rainfall and evaporation continue in the same trend into the future. This said, using runoff coefficients without greater knowledge of storages and losses, infiltration rates and catchment evapo-transpiration can be prone to errors.

A fundamental finding of this model, based on the data used, demonstrates that an equilibrium lake level will not be reached below RL 37 and that the lake system will therefore overflow, making a spillway to river a necessity. In both the HRL (2000) and GHD (2005) reports an equilibrium level below RL 37 was reached for natural filling. There is now a greater certainty that this will not be the case.

The lake filling rates are dependent on full coal production through to 2032 which gives a lake volume of 748 GL and surface area of 2,042 ha (i.e. RL 37). This compares to approximately 3.6 times the capacity of Blue Rock Lake, which has a capacity of 208 GL and surface area of 873 ha. If full mine life production does not occur, the capacity of the lake would be reduced, therefore resulting in a sooner fill. This ideology is shown through a business plan proposal which sees coal production until 2032, at a reduced volume, giving a void of 707 GL. Other options will be modeled as planning scenarios are developed and data becomes available.

Chapter 6
References

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Appendix A – Catchment Area