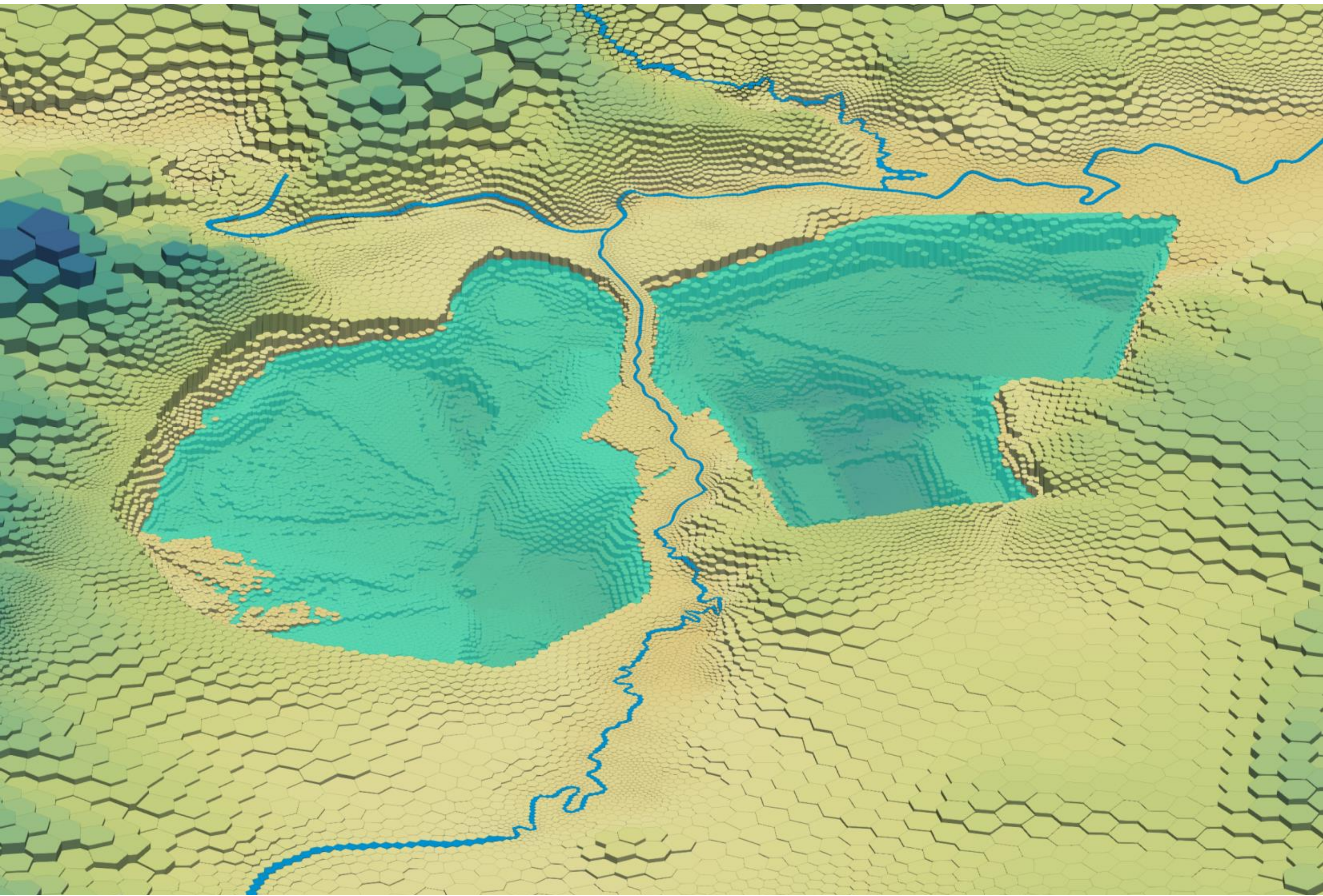
Yallourn Rehabilitation Hydrogeological Modelling

Numerical Groundwater Model – Rehabilitation Scenario Modelling Report

EnergyAustralia Yallourn Pty Ltd

15 May 2025

→ **The Power of Commitment**



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1. Introduction

1.1 Background

EnergyAustralia Yallourn (EAY) is planning for the closure and rehabilitation of the Yallourn Mine in mid-2028. The mine is located in the Latrobe Valley approximately 150 km east of Melbourne. The planned rehabilitation of the mine will involve filling of the mine void to form a pit lake, marking an important hydrogeological transition from the operational phase (involving the excavation of coal and aquifer depressurisation) to the post-mining phase (when the groundwater system reaches a new dynamic equilibrium with respect to the final pit lake level and prevailing climate conditions).

GHD has been engaged by EAY to undertake numerical groundwater modelling of the Yallourn Mine, to support its rehabilitation planning. The overarching objective of the modelling is to quantify potential changes to groundwater levels and quantity that may arise from the proposed rehabilitation, particularly those associated with the changes made to the groundwater extraction regime and the interaction between the pit lake and groundwater systems (during and after filling). Outputs from the numerical groundwater model are required to inform the aquifer depressurisation program (to ensure safe mining and rehabilitation conditions), pit water balance and water quality modelling (based on the volumes of pit water that may be lost to and gained from the groundwater systems) and potential changes to the shallow groundwater regime arising from the presence of a full pit lake (and how this may influence interactions with the surface water systems and ecosystems that are depended on these interactions).

1.2 Purpose of this report

The purpose of this report is to provide detailed descriptions of the rehabilitation scenario modelling undertaken for the Yallourn Mine, including the model scenario assumptions, model setup and model outputs used to quantify the hydrogeological effects of turning the existing mine voids into a pit lake. Due to the complex and multi-disciplinary nature of rehabilitation, the outputs generated from groundwater modelling are required in formats suitable for informing other relevant technical studies on ground stability, pit lake water balance and groundwater impacts on sensitive receptors such as groundwater dependent ecosystems. The key model outputs required for the mine rehabilitation studies are:

- Time series of fluxes exchanged between the groundwater and pit lake systems during and after filling. The fluxes are used to estimate the volumes of water and solutes (mass) gained and lost by the pit lake due to interactions with the groundwater system, providing necessary information to enable more detailed pit lake water balance and quality modelling using GoldSim (in addition to hydrodynamic modelling).
- Piezometric head changes in confined aquifers, both spatially (as contours) and temporally (as time series hydrographs), to inform aquifer depressurisation (pumping) effects on weight balance and ground stability.
- Shallow groundwater level changes, to inform potential effects on surface water-groundwater interactions, groundwater dependent ecosystems and infrastructure such as roads.

The numerical groundwater modelling described in this report is an outcome of a staged modelling process that has been undertaken in a manner consistent with the recommendations of the Australian Groundwater Modelling Guidelines (AGMG, Barnett et al, 2012). The rehabilitation scenario results are underpinned by the hydrogeological conceptual model and detailed construction and calibration exercise undertaken prior to the predictive modelling stage (with independent peer reviews completed at the key stages). For this reason, and to avoid unnecessary duplication of the significant body of work already completed, this report and findings detailed within it should be reviewed in conjunction with the following two key reports:

- GHD (2023), Yallourn Rehabilitation Hydrogeological Modelling; Hydrogeological Conceptual Model
- GHD (2025), Yallourn Rehabilitation Hydrogeological Modelling; Numerical Groundwater Model - Design, Construction and Calibration Report.

1.3 Model expectations and limitations

GHD (2025) outlines the expectations and limitations of groundwater modelling, particularly those associated with the scale of the project and the challenges for mathematical models to accurately simulate the highly complex physical systems (often informed by finite observations and data points). Uncertainty is therefore inherent with the modelling and the findings presented in this report should be considered within this context.

With respect to rehabilitation scenario modelling, it is important to note the requirement for the model to provide predictions over a long time horizon in excess of 100 years as the aquifer depressurisation is ceased and the hydrogeological system recovers and forms a new dynamic equilibrium with respect to the rehabilitated pit lake (and under changing climate condition). The recovery will tend towards a condition similar to that pre-mining except where the hydrogeological system has been modified by the presence of the pit lake and future climate. While there is some uncertainty in the pre-mining groundwater levels, the significant aquifer depressurisation effects have been monitored over many decades and the calibration of the groundwater model to this data, adds a level of confidence in the predictions of long term recovery.

As discussed in GHD (2025), the model confidence level classification of the AGMG is fundamentally underpinned by the quality of data used to inform the model design and calibration, and whether the magnitude of historical stresses is similar to that of the future with periods of historical observations that are comparable to those of the predictive timeframe. For the Yallourn Mine, the magnitude of hydrogeological stress of historical mining is significant and is comparable to the expected magnitude of recovery (effectively a reversal of the depressurisation). The length of predictive simulation is also not excessive relative to the length of calibration (more than 60 years). However, there are some limitations with the model calibration performance and uncertainties are associated with the simulation of a future pit lake that cannot be reduced from calibration to historical observations. For this reason, GHD (2025) considered a confidence level classification of 2 with some attributes of 3 to be appropriate, indicative of a moderate to high confidence level.

The uncertainty analysis guideline recently updated by the Independent Expert Scientific Committee (IESC) suggests the confidence level classification of the AGMG should be replaced by more effective uncertainty analysis techniques (Peeters and Middlemis, 2023). A detailed uncertainty analysis is part of the future modelling scope subject to ongoing data collection and review, with the uncertainty quantification techniques to be informed by the model calibration and findings of rehabilitation scenarios detailed in this report.

2. Conceptual overview of mine rehabilitation effects on groundwater

The Yallourn Mine consists of two large open cut voids separated by the Morwell River Diversion (MRD) in the middle. Mining is currently planned to continue until mid-2028, with the extension of the existing void to the south (over an area referred to as Maryvale Field). The surface of the final void supplied by EAY indicates the lowest elevation of the mine floor will be around –58 mAHD, located approximately at the centre of the east void, with the floor elevation raised locally by the placement of internal overburden dumps. Depressurisation of the confined M1A Interseam will be maintained via pumping bores during and after mining to ensure a safe and stable condition.

The preferred mine rehabilitation option will involve filling of the two mine voids with water to form a full pit lake. The sources of water for the filling would include direct rainfall, runoff from external and internal (in-pit) catchments, groundwater seepage from pit walls, pumped groundwater from aquifer depressurisation, flood flows and external supplies. The filling would initially result in the formation of two separate pit lakes with different starting water levels due to the presence of in-pit water features such as the Fire Service Pond. The two pit lakes will become connected when the lake level in one of the pit lakes reaches the elevation of the conveyor tunnels (located below the MRD), resulting in the transfer of water from one lake to another until both lakes reach the same level and rise as one connected lake. The proposed final lake level is 37 mAHD.

Groundwater levels in hydrostratigraphic units (HSUs) will change due to the effects of aquifer depressurisation, both locally at the Yallourn Mine and regionally due to the extraction of groundwater at the neighbouring Hazelwood and Loy Yang mines. As the pit lake is formed, the groundwater levels will also be modified at the mine due to the interaction between the lake and the groundwater system. During filling, the groundwater levels in the HSUs below the mine floor will be maintained lower than the pit lake level by groundwater extraction. This would create a downward vertical hydraulic gradient that would result in some leakage of water out from the pit lake, causing the underlying groundwater levels to rise locally. The pit lake will also receive groundwater seepage from the pit walls, where shallow groundwater naturally discharges at elevations above the lake level. As the water level of the pit lake continues to increase over time, the groundwater levels would also rise in parallel albeit at a reduced rate depending on the balance between the rate of leakage from the pit lake and the rate of removal of groundwater by pumping from below. The ongoing aquifer depressurisation by pumping would ensure the groundwater levels in the HSUs below the mine floor would remain lower than the pit lake level during filling, creating a low point in the piezometric (aquifer pressure) surface relative to the surrounding area. This implies that most of the pit water (and solutes contained within it) leaking into the underlying HSUs would be retained within the mine area or ultimately captured by the pumping bores.

When the pit lake reaches the full lake level of 37 mAHD, the weight of water above the mine floor becomes sufficient to counter the predicted maximum upward aquifer pressure, rendering ongoing depressurisation unnecessary for achieving the weight balance in the long term. At this point, the groundwater extraction can be ceased, initiating the recovery of the aquifer pressure. The groundwater levels would be expected to initially rise rapidly as the aquifer storage is replenished by groundwater flow from the broader area under steep hydraulic gradients created by prior pumping. The rate of recovery would reduce progressively over time as the hydraulic gradients (and the rate of groundwater flow towards the mine) reduces, leading to a long period of post-filling stabilisation. As discussed in GHD (2023), the confined aquifers below the floor of the mine were likely to have been sub-artesian to artesian with the pre-mining groundwater levels estimated to be in the range of 50 to 60 mAHD. Although the future climate condition is unknown (and expected to be different from that of the past), it is highly likely that the groundwater levels in the confined aquifer would ultimately recover to levels above the 37 mAHD pit lake level. This means the pit lake would act as a local sink to the groundwater system over the long term, with seepage of small quantities of groundwater occurring under the influence of small upward vertical hydraulic gradients.

The conceptual model for the hydrogeological changes expected during and after rehabilitation is described in GHD (2023), using regional hydrogeological cross-sections. Additional and more locally refined schematic hydrogeological cross-sections are presented in this section to set the context for the detailed model results and discussions provided in the subsequent sections of the report. When reviewing these cross-sections (and the outputs of the modelling), it is important to note that only some of the HSUs are exposed in the mine and would directly interact with the pit lake. The rate and direction of fluxes exchanged with the pit lake would also depend on the groundwater levels and material properties of each HSU, with different groundwater levels or piezometric surfaces forming in different units. This concept is demonstrated schematically in Figure 1 below, showing groundwater rising to different levels in bores constructed within different HSUs (focusing on the surficial and interseam layers that act as aquifers/zones of preferential groundwater flow, separated by intervening low hydraulic conductivity coal layers). In this example, the groundwater level decreases with depth, which indicates a downward vertical hydraulic gradient (and downward groundwater flow).

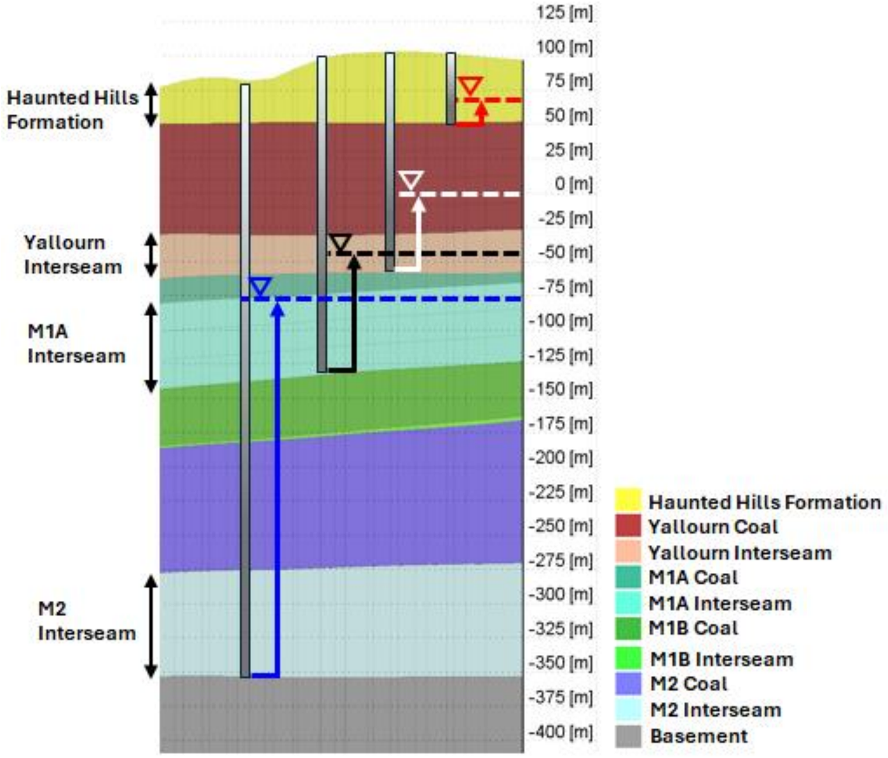


Figure 1 ***Relationship between hydrostratigraphic units and current groundwater levels***

Figure 3 is a schematic (vertically exaggerated) cross-section across the two mine voids (in northeast to southwest orientation) showing the relationship between the pit lake level and groundwater levels in the key HSUs when the lake level is at 11 mAHD (an approximate elevation of the conveyor tunnels, when the two pit lakes become hydraulically connected). The two mine voids are referred to as the Yallourn Township Field (YTF) void in the west and Yallourn East Field (YEF) void in the east, for simplicity. Arrows are used to show the directions of expected flow, with larger arrows used to indicate preferential flows in the horizontal direction towards the pumping bore (M4203) in the M1A Interseam and regionally towards the Hazelwood Mine (due to pumping in the deep M2 Interseam). Smaller arrows in the vertical direction indicates flow out from the pit lake and flow across the layers due to the downward vertical hydraulic gradient (with the rate of flow limited by the low hydraulic conductivity of the Yallourn Interseam and M1 Coal). The phreatic surface (water table) in the Haunted Hills Formation is maintained by rainfall recharge at ground surface and is largely unaffected by the pumping in the M1 Interseam due the presence of the thick Yallourn Coal. Shallow groundwater from the Haunted Hills Formation discharges into the pit lake.

Figure 4 is the conceptualisation of the post-rehabilitation condition along the same cross-section, when the groundwater system has reached dynamic equilibrium with respect to the full pit lake. The groundwater levels in the confined aquifers (interseams) are expected to recover towards the pre-mining level, above the final lake level. This would result in small upward vertical flows into the pit lake, with the lake forming a sink in the regional groundwater system.

The changes to the hydrogeological regimes expected during and after filling are further demonstrated using a localised north to south cross-section through the YEF void. The cross-section runs through the deepest point of the mine, where the Yallourn Interseam interacts directly with the pit lake and the piezometric surface becomes locally elevated due to the absence of Yallourn Coal/overburden dump to limit hydraulic connection (see Figure 5, when the lake level is at 0 mAHD, before the in-pit pumping bore N6899 is decommissioned). Also shown in the cross-section is the presence of the regionally significant Haunted Hill Fault/Yallourn Monocline acting as a hydraulic barrier. Figure 6 shows the conceptualisation of the post-rehabilitation condition along the same cross-section. The final pit lake level is shown to be above the base of the Haunted Hills Formation in an area adjacent to the northern batters. This is expected to result in re-saturation of the Haunted Hills Formation where shallow groundwater has been previously drained by the mine, leading to the restoration of the water table to a condition similar to the natural state prior to mining.

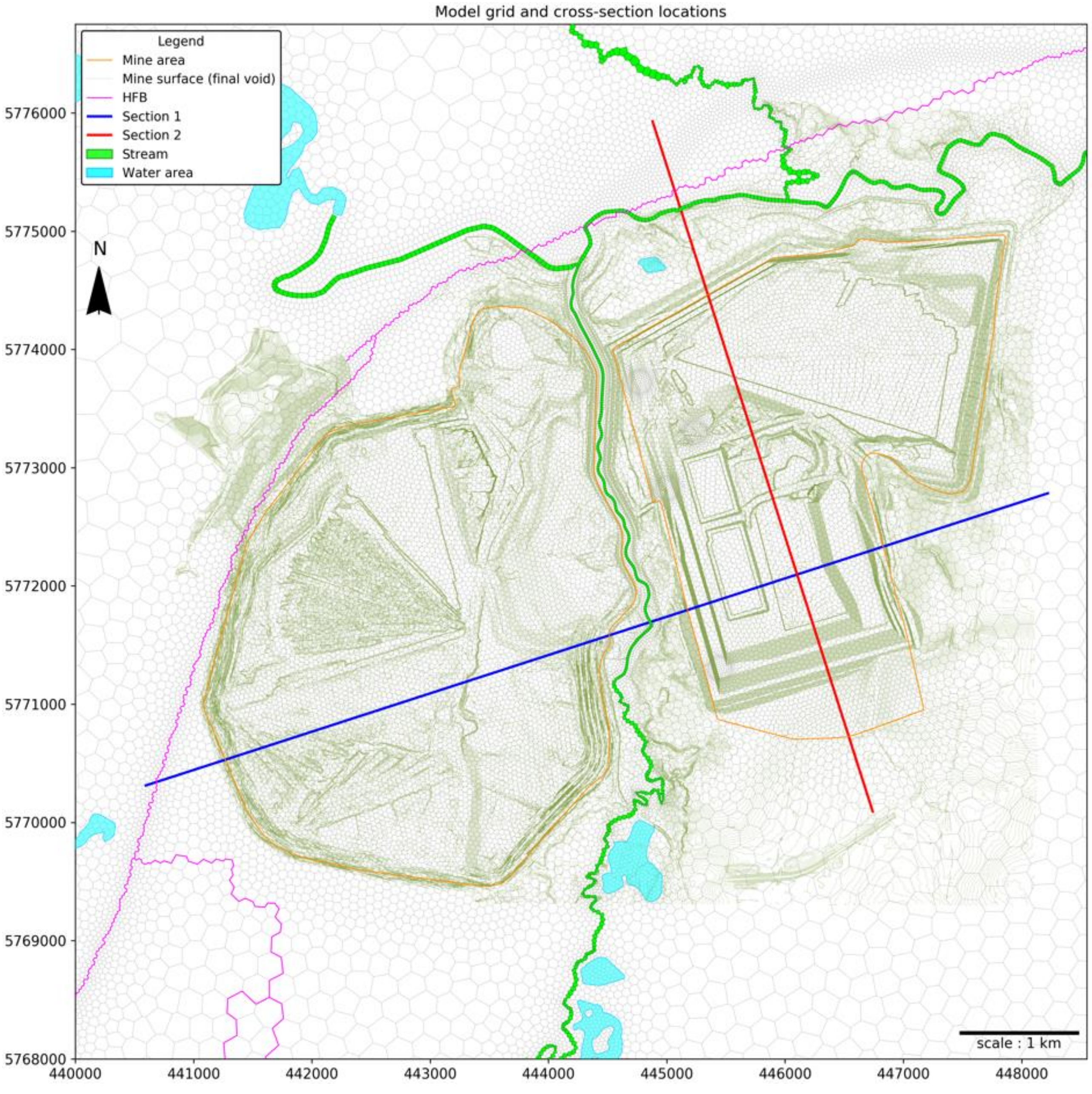


Figure 2 ***Schematic cross-section locations***

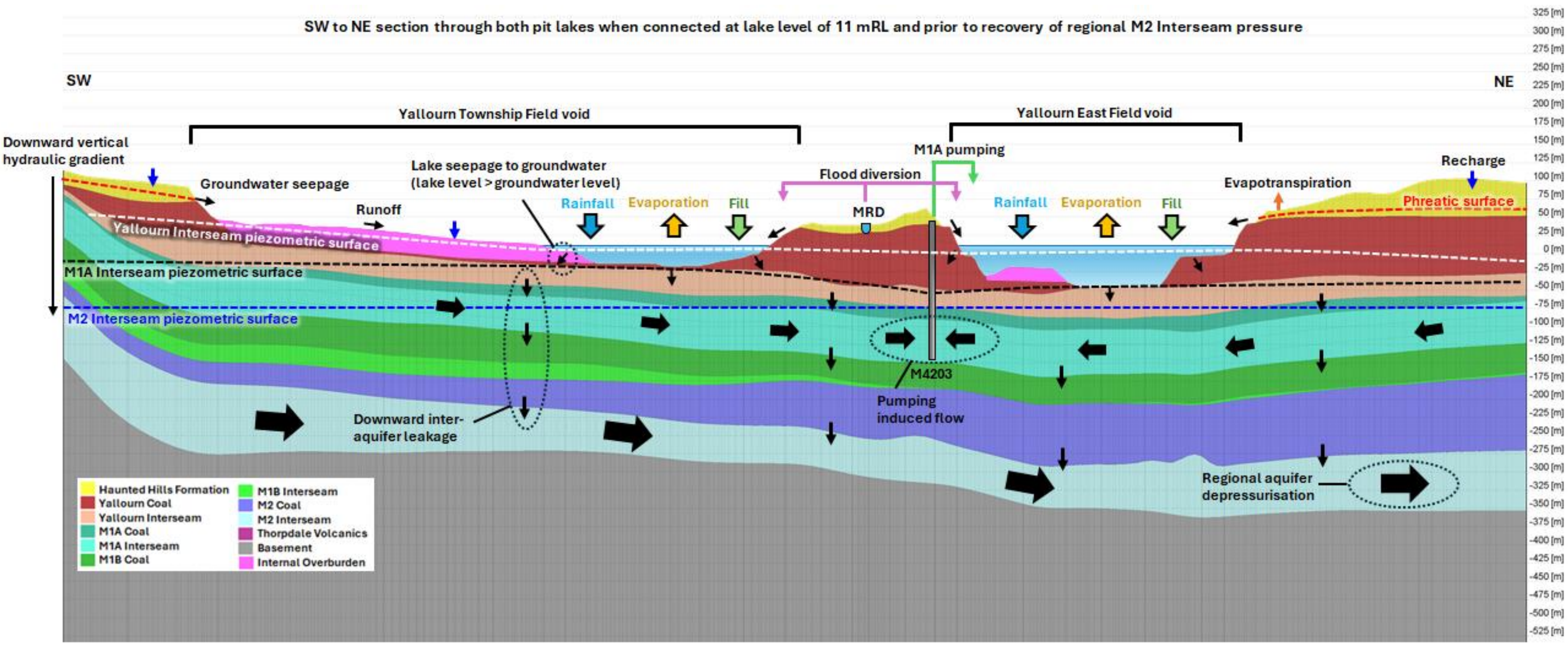


Figure 3 *Section 1 - schematic SW to NE hydrogeological section at 11 mRL lake level*

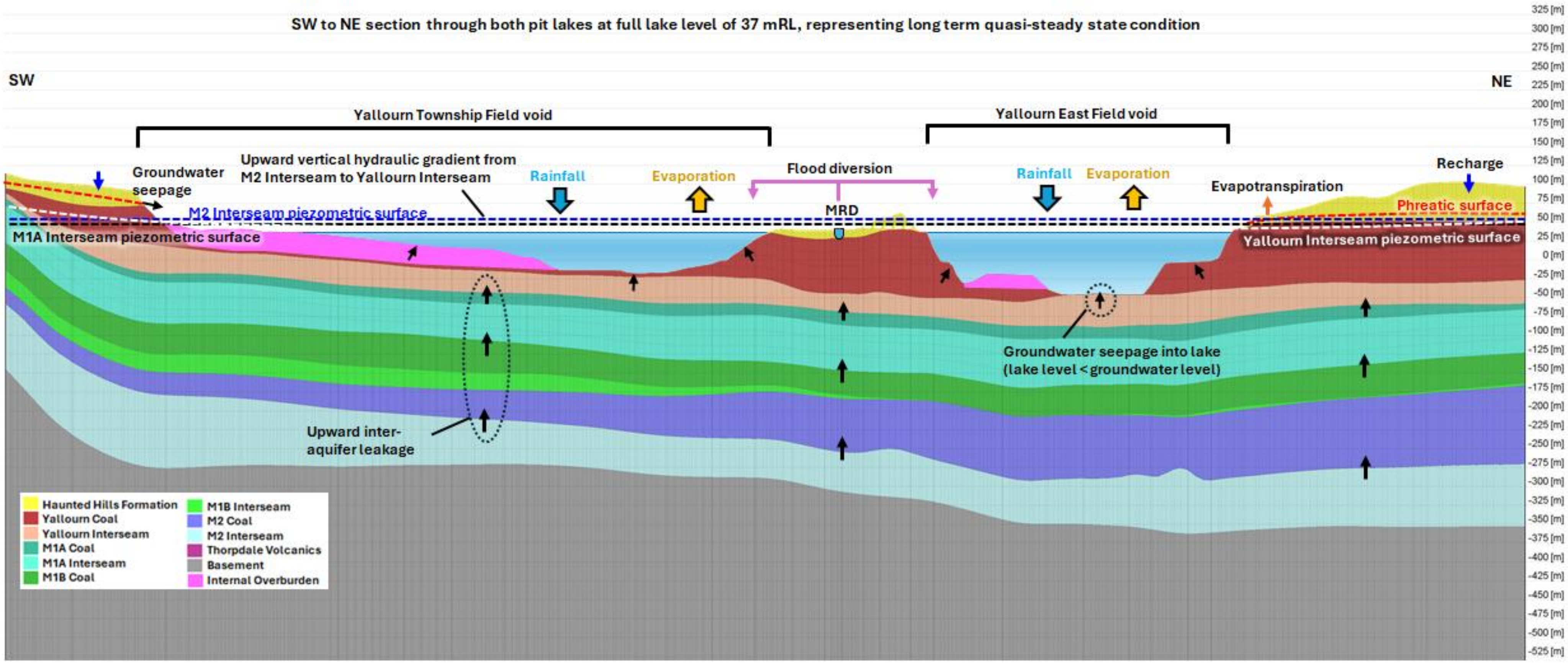


Figure 4 Section 1 - schematic SW to NE hydrogeological section at 37 mRL lake level

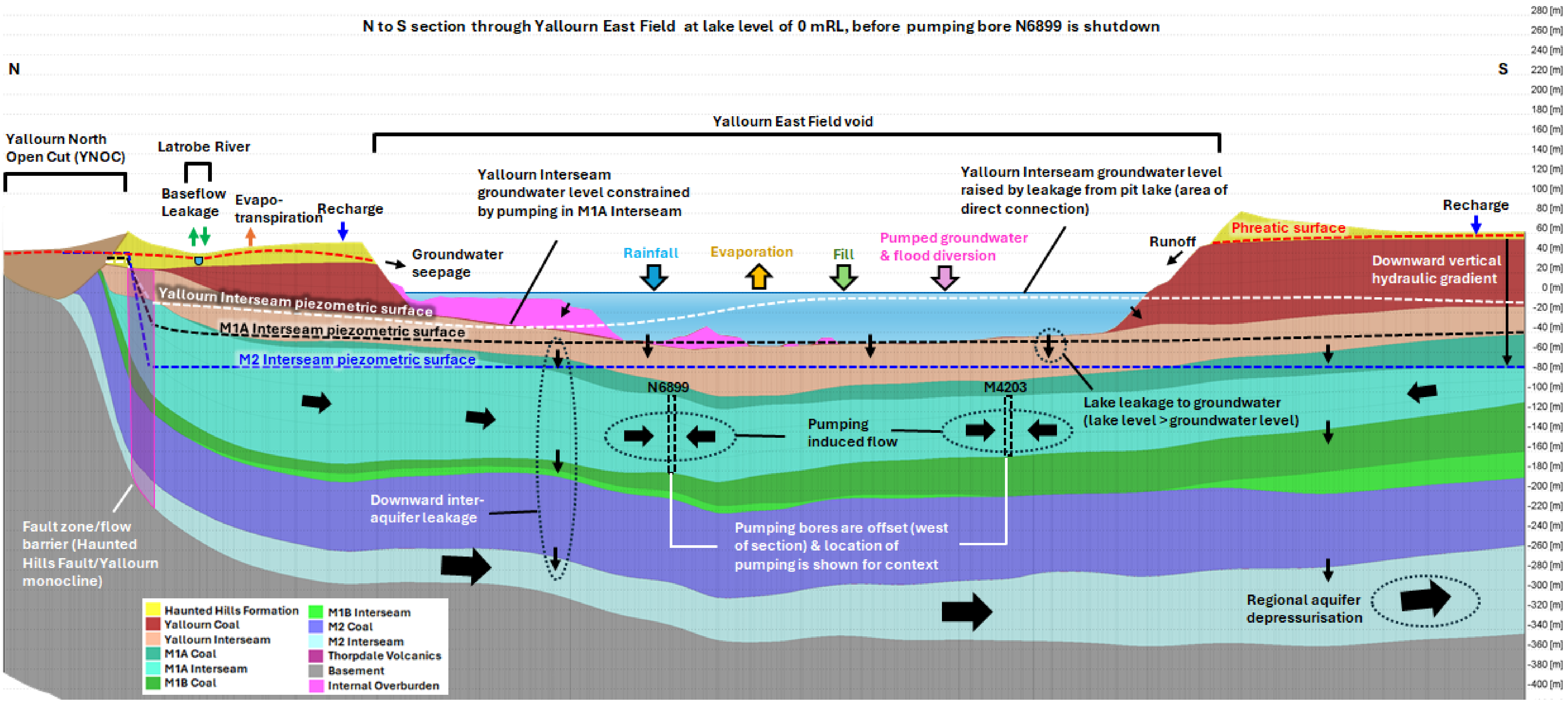


Figure 5 Section 2 - schematic N to S hydrogeological section at 11 mRL lake level

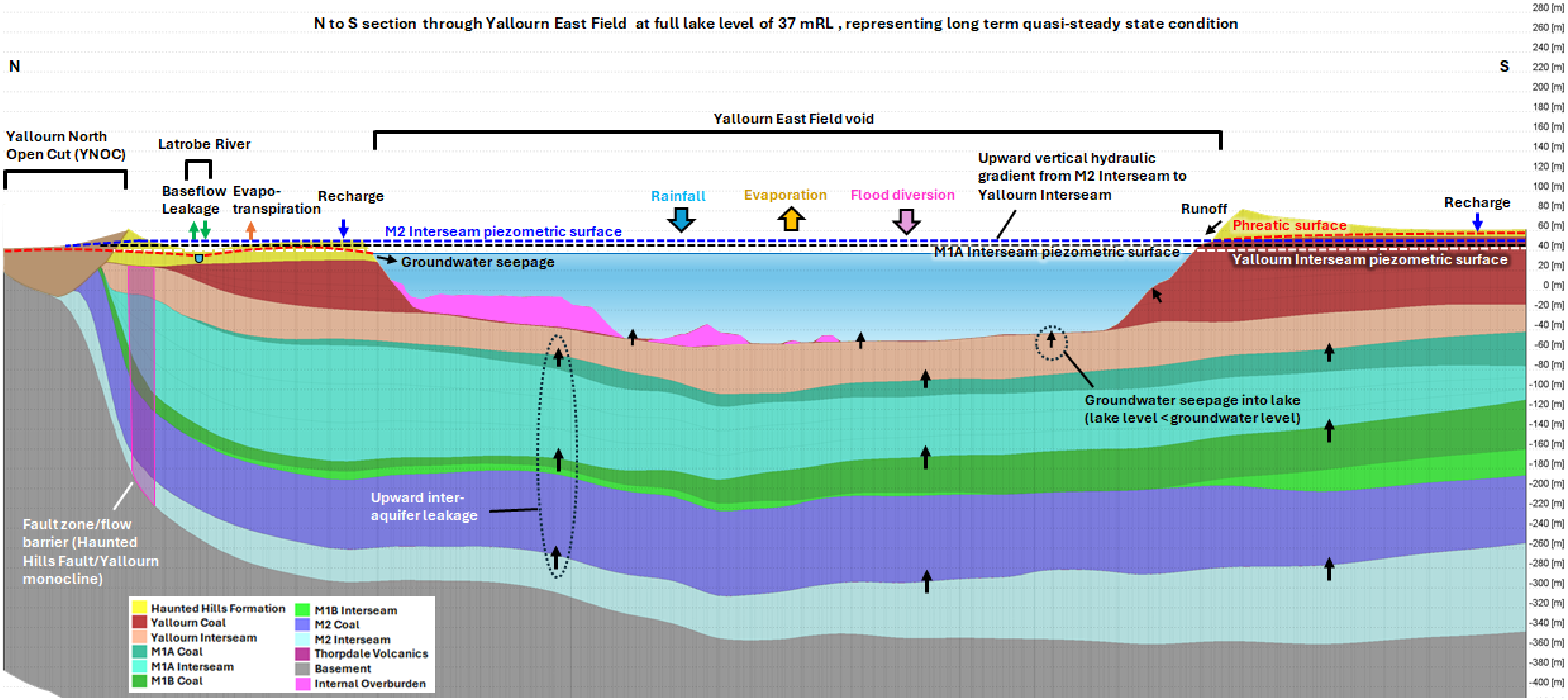


Figure 6 Section 2 - schematic N to S hydrogeological section at 37 mRL lake level

3. Rehabilitation model set up

3.1 Rehabilitation scenarios

Two predictive modelling scenarios are considered for quantifying potential groundwater changes during and after rehabilitation:

– **Base Case scenario**, which represents the maintenance of the final mine void without active filling from external water sources. In this case, water accumulating within the mine void is limited to rainfall, runoff and retention of pumped groundwater (due to the requirement for ongoing pumping to maintain floor stability). The scenario is intended to assess the mine water balance and hydrogeological conditions in the absence of external water sources to fill the void, necessitating ongoing maintenance and aquifer depressurisation in perpetuity to ensure a stable condition.

– **Preferred Filling scenario**, which involves active filling of the final mine void to form a full pit lake at RL 37 mAHD, using a combination of natural and external sources of water. It represents EAY's preferred rehabilitation scenario, designed to achieve a safe and stable landform in the most efficient and effective manner. The scenario assumes diversion of flood waters or high flows from the Morwell River, to reduce the filling time. Once the full pit lake is formed, groundwater pumping can be ceased to allow the confined aquifer pressure to recover. The pit lake would be maintained at RL 37 mAHD post-filling, using top up water as necessary.

In the context of groundwater modelling, the Base Case scenario provides a hydrogeological baseline that can be used to quantify the incremental effects of active filling i.e. how the hydrogeological conditions would change in response to the full pit lake, relative to ongoing maintenance of the final void. There are also variations of the filling scenario that are under consideration by EAY (e.g. with and without flood flows); however, these differences are not material to the quantification of hydrogeological effects that would occur gradually over time in response to the rising water level in the mine void and aquifer depressurisation caused by pumping from below. For this reason, only one preferred filling scenario is assessed and presented in this report.

For both scenarios, mining is assumed to continue to 2028 and the period of rehabilitation is assumed to commence in 2029. Due to antecedent hydrogeological effects, the numerical modelling is required to simulate the progression of mining, aquifer depressurisation, material property changes and climate up to the end of 2028, before the effects of rehabilitation can be simulated. As described in GHD (2025), the model calibration and verification has been completed up to the end of 2023. For this reason, the predictive modelling period commences in 2024, with the effect of future mining simulated up to the end of 2028 and rehabilitation thereafter. The predictive simulation period is 104 years (4 years of mining followed by 100 years of rehabilitation simulation), commencing in 2024 and ending in 2128. Quarterly stress periods are used to capture seasonal variability, as per the model calibration, resulting in 20 stress periods from 2024 to end 2028 (for the mining period) and 400 stress periods from 2029 to end 2128 (for the rehabilitation period).

While not the focus of this study, the cumulative effects of regionally significant aquifer depressurisation from the neighbouring Hazelwood and Loy Yang mines have been taken into consideration through adjustments of model boundary conditions, using the outputs from the most current (2024) version of GHD's Latrobe Valley Regional Groundwater Model (refer to GHD, 2025 for the descriptions of this approach). For the purpose of the modelling, the aquifer depressurisation is assumed to cease at the end of 2035 and 2061 at Hazelwood and Loy Yang respectively, leading to the recovery of the piezometric heads in the deep confined M2 interseam. This allows the changes to the inter-aquifer fluxes at the deeper level to be simulated appropriately.

3.2 Future climate

The climate condition assumed for the future influences the computation of recharge, evapotranspiration and stream flow (the volume of surface water available to interact with the groundwater system). For the rehabilitation scenario modelling, a synthetic future climate sequence has been generated by re-sampling the historical climate data and scaling this in accordance with the climate change factors recommended in Victorian Government's climate change guidelines (DEWLP, 2020). The climate sequence has been generated using a deterministic approach in which the climate data from the historical reference period are repeated back-to-back to construct the future climate (with the climate change factors subsequently applied to scale the climate data). This is consistent with the approach previously adopted for the Latrobe Valley Regional Rehabilitation Strategy (LVRRS) and is considered best suited for groundwater modelling, due to the long model run time and pre-processing efforts required in generating the necessary model input files (rendering the alternative approach based on many stochastically generated climate sequences not practical).

In accordance with the DELWP (2020) guidelines, the historical climate data from the post-1975 reference period (from Jan 1975 to end of December 2023) have been extracted and repeated as necessary over the 104-year predictive simulation period (with January 2024 aligned with January 1975). The guidelines provide projections of percentage changes for key climate parameters such as average annual rainfall, potential evapotranspiration and runoff under three climate change conditions (low, medium and high impact). The percentage changes (or scaling factors) for each of the three climate change conditions are provided for years 2040 and 2065, under two emission scenarios referred to as high Representative Concentration Pathway (RCP) 8.5 and low RCP 4.5. The RCP 8.5 percentage changes are considered more conservative and have been adopted in this study, consistent with the assumptions for other rehabilitation technical studies.

The percentage changes can be used to linearly scale the climate parameters up to year 2040 and then up to 2065. Where model simulation periods extend beyond 2065, the guidelines indicate the scaling factors can be linearly extended up to year 2075. Beyond 2075, the scaling factors are assumed to be time constant as further linear extrapolation results in climate conditions that are considered extreme (particularly when RCP 8.5 emission scenario is assumed and the climate data already includes extended dry periods such as the Millennium Drought). Figure 7 shows the projected percentage changes in rainfall and potential evapotranspiration (PET) applied to this project, based on the guideline values for the Latrobe River basin. For the rehabilitation scenarios described in this report, the medium climate change projection has been adopted.

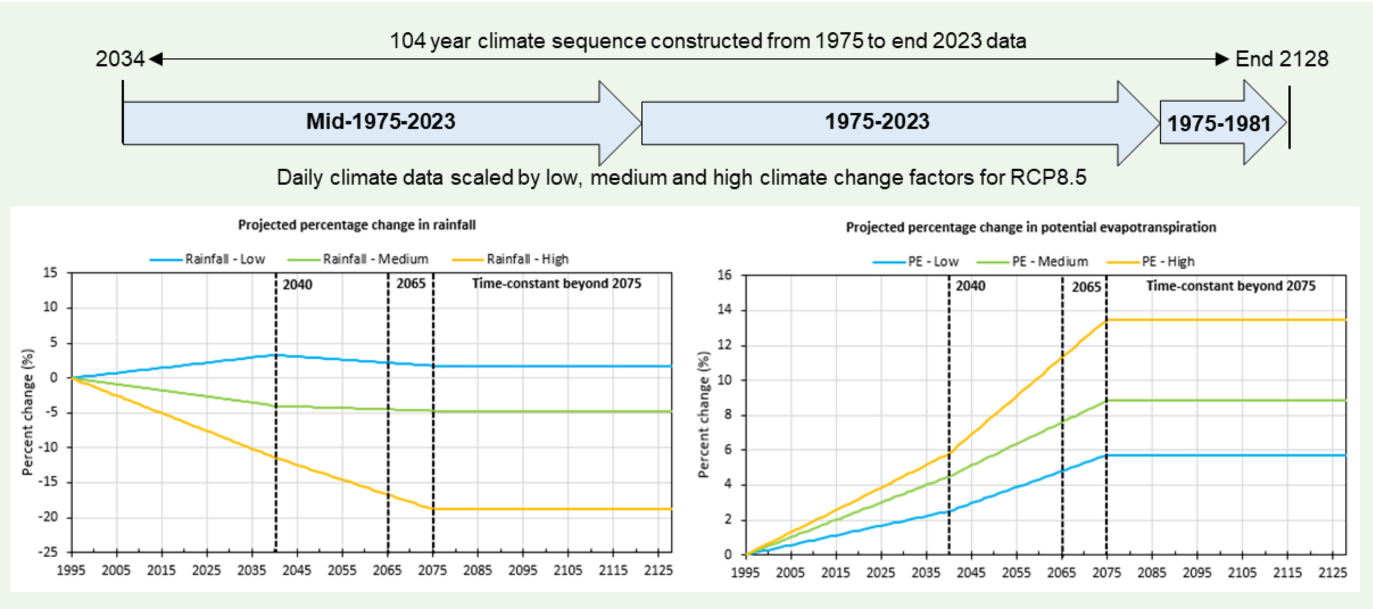


Figure 7 Climate sequence and climate change factors

The synthetic daily climate data are provided as inputs to the PRMS model to generate the necessary recharge, evapotranspiration and runoff outputs for parameterising the model boundary conditions. The climate data are also used to simulate direct rainfall and evaporation to and from the surface of the pit lake, as well as runoff derived from external and internal catchments. These are described further in Section 3.3 below.

3.3 Model boundary conditions

3.3.1 Recharge, evapotranspiration and stream boundary conditions

The distributed physical-process-based hydrological model PRMS has been used to generate spatially and temporally varying recharge, evapotranspiration and runoff, using daily rainfall and potential evapotranspiration (PET) inputs from a total of 18 Bureau of Meteorology (BoM) weather stations located within and in the vicinity of the model domain. This approach is consistent with that adopted for the calibration period, which is described in detail in GHD (2025). The key difference is that the historical daily climate data at each of the18 BoM stations have been replaced by synthetic future climate data with scaling applied for the three climate change projections. Figure 8 provides an example of the model-wide annualised recharge and unused PET (groundwater evapotranspiration) computed by PRMS, showing the difference between the unscaled and scaled outputs (for the medium climate change projection used for the rehabilitation scenario modelling).

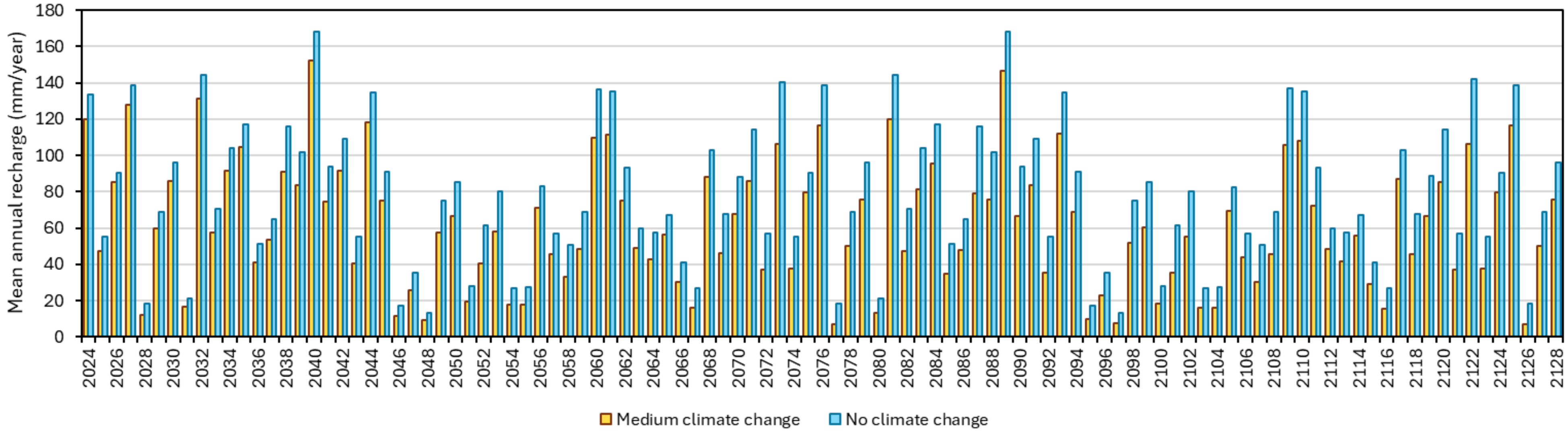
The spatial differences in recharge and unused PET for the different climate change conditions are also demonstrated in Figure 9 and Figure 10 respectively, using maps of long term average values calculated from 2075 to 2122 (when the climate change factors are maintained as time-constant values). These maps are based on the PRMS grid and the computed recharge and evapotranspiration values are subsequently interpolated to the unstructured grid of the USG-Transport model (see GHD, 2025 for more detail). The medium climate change projection shows recharge and unused PET values that are approximately average of the low and high climate change projections (the two extreme bounds)

Recharge over the footprint of the mine void is locally adjusted once the mining ceases and the Lake (LAK) package is activated to simulate the retention of water/filling of the mine void (from 2029 onwards). This is undertaken to better account for the condition of the exposed mine floor and is further discussed in Section 4.2.3.

The runoffs generated within the PRMS model domain are apportioned to the relevant segments of the stream (SFR) boundary condition. Gauged flow data are also used to feed flow into the upstream segment of the stream boundary condition to simulate the contribution of flow accumulated from upstream of the groundwater model domain (GHD, 2025). As per the climate data, post-1975 gauged flow data are extracted and repeated back to back (with gaps in the flow record filled based on a simple rainfall-runoff regression analysis). For each climate change condition, the runoff climate change scaling factors from the guidelines are used to adjust the flow rates in a similar manner to the rainfall and evapotranspiration data.

The component of inflow into the Latrobe River is based on the gauged flow data downstream of the intake point, which already accounts for the volume of water removed for the mining operation. For the Base Case, this operational take is no longer required and hence a nominal flow volume of 25 giga litres (GL) per year has been added to the inflow data from 2029 to maintain realistic flow volumes (to correct for the typical operational water take, which ranged from 21 to around 33 GL/year). For the Preferred Filling scenario, the same flow correction has been applied once the pit lake reaches the full lake level of RL 37 mAHD and water take is no longer required for filling.

The return flow to the MRD for the future mining period (2024 to 2028) uses a time-constant value of 40 mega litre (ML) per day, based on the typical flow rate over the last 10 years (as supplied by EAY). This is applied to the relevant segment of the SFR boundary condition, as per the calibration period. Once the mining ceases, surplus flow is assumed to be either retained within the mine void (Base Case) or added to the lake water balance (Preferred Filling scenario). For this reason, no further return flow is added to the stream segment from 2029 onwards. For the Preferred Filling scenario, the diversion of flood waters/high flows into the pit lake is simulated by removing the equivalent volume from an upstream segment of the MRD (as negative flows). The return flows and flow takes from the industries further upstream of the mine (including flood flows for the filling of the Hazelwood Mine) are incorporated based on the data from the Latrobe Valley Regional Groundwater Model (LVRGM, which is maintained by GHD and used for licensing and rehabilitation planning).



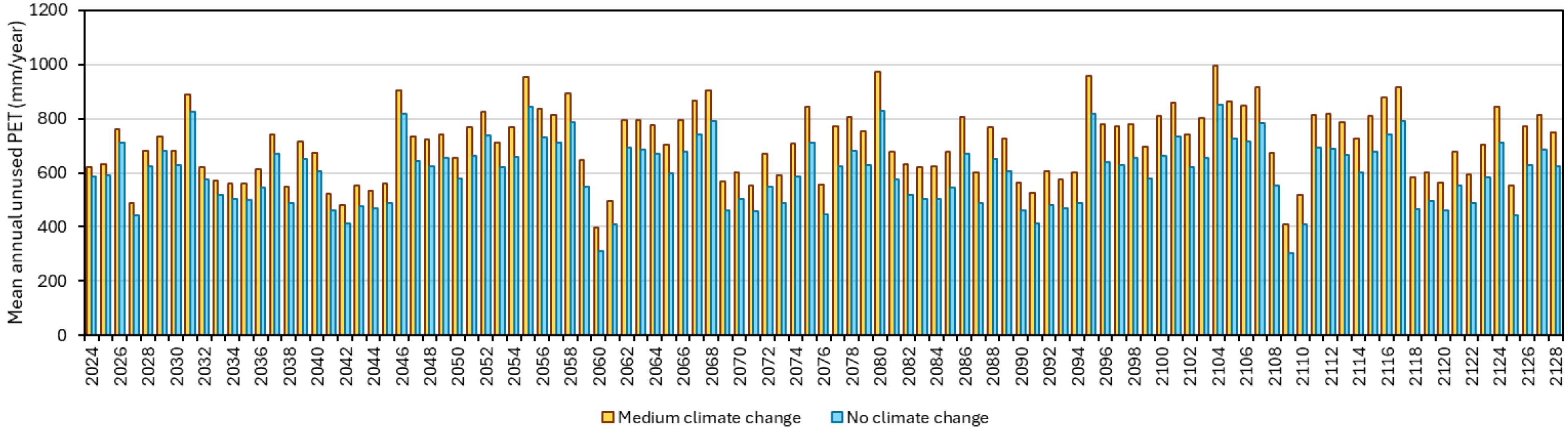


Figure 8 *Annualised model-wide recharge and unused PET*

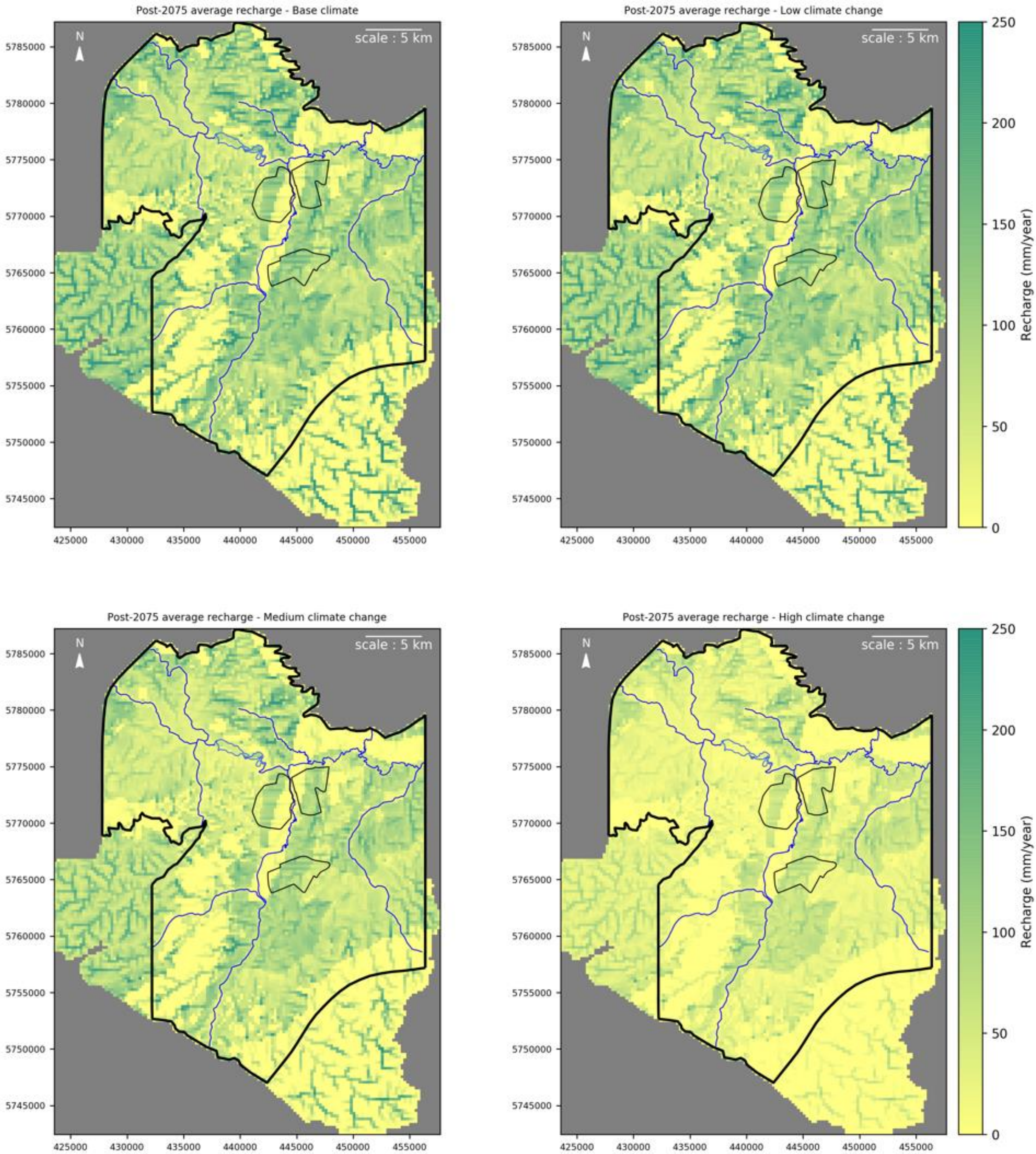


Figure 9 Effects of climate change on long term average recharge

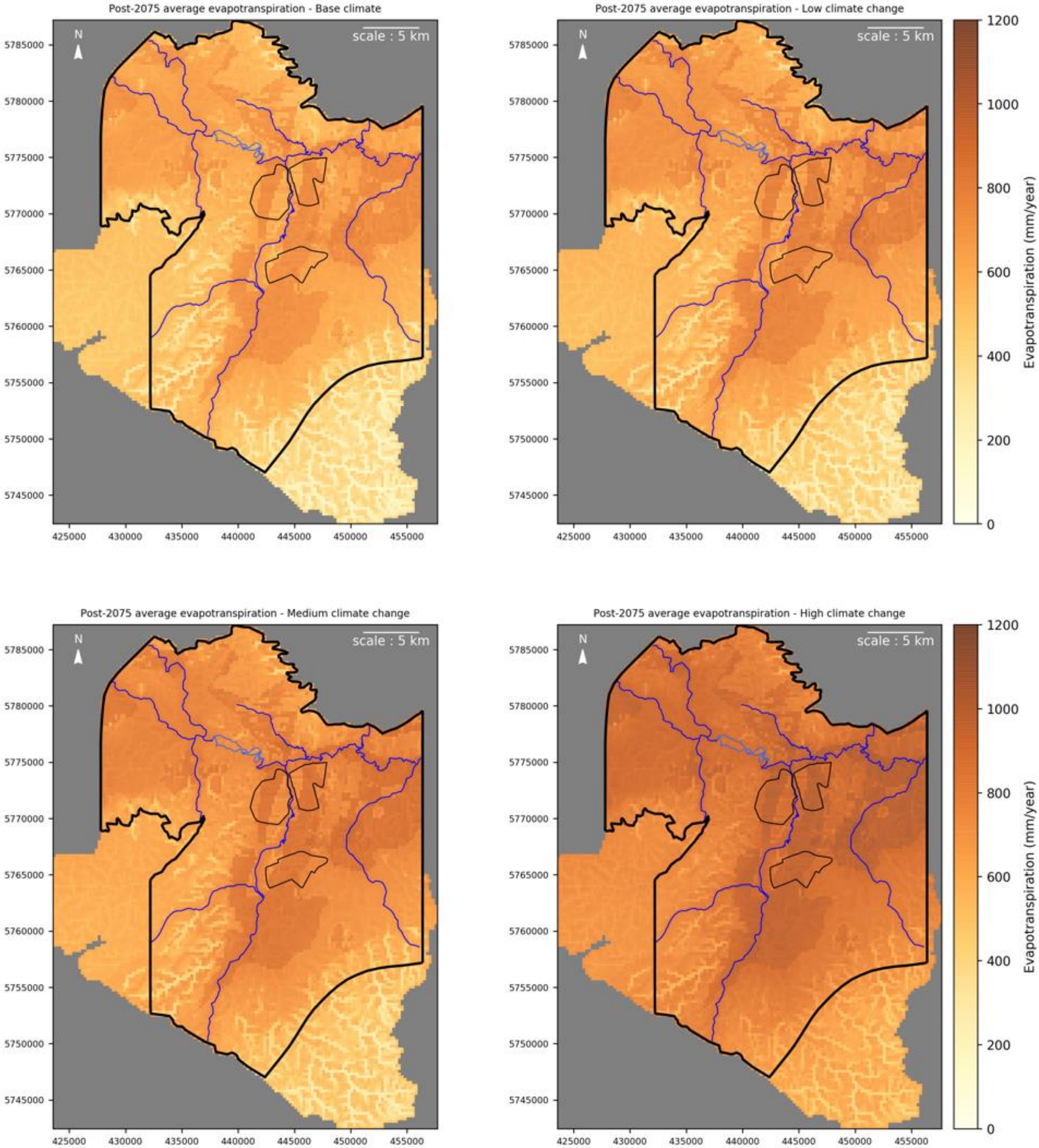


Figure 10 ***Effects of climate change on long term average evapotranspiration***

3.3.2 Drain boundary condition

The Drain (DRN) package is used to simulate the excavation of overburden and coal until mining ceases in 2028. The progression of mining is simulated based on linear interpolation of DRN elevations from 2024 to 2028, using the surface of the final mine void supplied by EAY. Figure 11 compares the elevation of the DRN cells (mine floor) mapped to the model grid at the end of calibration (2023) and mining (2028), showing the changes over the remainder of the active mining period. The final DRN elevation includes additional areas of internal overburden dumps, where the DRN elevation has been shifted up from the original mine floor to represent the placement of overburden. For each DRN cell, a conductance value of 100 m^2/d is applied, high enough to fully drain the cells to the specified DRN elevations. The DRN cells within the mine void are deleted where the River (RIV) boundary condition is used to simulate the presence of in-pit water features. The DRN cells are fully deactivated at the Yallourn Mine and replaced by the Lake boundary condition from 2029 onwards (see Section 3.3.4).

As per the calibration period, the DRN boundary condition is also used to simulate the hydraulic head changes at the Hazelwood Mine, to incorporate the cumulative effect of the regionally significant aquifer depressurisation and subsequent recovery following rehabilitation (when groundwater extraction is ceased at the Hazelwood Mine). This has been achieved by extracting the time-series of hydraulic heads from the relevant model layers of the LVRGM (within the footprint of the Hazelwood Mine) and assigning these to model layers 1 to 17 using DRN cells. The LVRGM currently assumes the aquifer depressurisation would continue at the Hazelwood Mine until the end of 2035, with the recovery of the confined aquifer pressures occurring thereafter.

3.3.3 River boundary condition

The River (RIV) package is used to simulate the water features within and outside of the mine void. The in-pit water features are simulated based on their expected water levels supplied by EAY, which are summarised in Table 1. These are assigned from 2024 to end of 2028 (using time-varying RIV stage) and deactivated in 2029 when the Lake boundary condition is activated to simulate the mine void (see Section 3.3.4).

Time-constant RIV stages are assumed for the ex-pit (regional) water features that include Blue Lagoon, Lake Narracan, Witts Gully Reservoir, Pine Gully Reservoir, Morwell River wetlands and APM lagoon and aeration pond, based on the values adopted for the model calibration period (see GHD, 2025). The exception is the Hazelwood Cooling Pond (HCP), which is deactivated in 2029 based on the estimated timing of emptying of the pond (as currently incorporated into the LVRGM).

As per the calibration period, the RIV conductance value for each RIV cell is calculated from the cross-sectional cell area, assuming a RIV bed thickness of 0.1 m and the calibrated bed hydraulic conductivity values.

Table 1 Estimated RIV stage for in-pit water features

	2024	2025	2026	2027	2028
Township Lake	-2.7 mAHD	-2.7 mAHD	-2.7 mAHD	-2.7 mAHD	-2.7 mAHD
Fire Service Pond	-6 mAHD	-6 mAHD	-5 mAHD	-4 mAHD	-4 mAHD
Floc Pond	4 mAHD	4 mAHD	4 mAHD	4 mAHD	4 mAHD
NE Pond	-27 mAHD	-27 mAHD	-24 mAHD	-20 mAHD	-15 mAHD
East Field Sump *	-44.5 mAHD	-49 mAHD	-49 mAHD	-49 mAHD	-49 mAHD
Maryvale Field Sump	-47.5 mAHD	-47.5 mAHD	-47.5 mAHD	-47.5 mAHD	-47.5 mAHD

* Lower and half of upper sump is expected to be filled with internal overburden dump by early 2026

The RIV boundary condition is also used in the Preferred Filling scenario to simulate the part of the lake surface that would spill out beyond the boundary of the mine void (adjacent to the East Field northern batters, between the mine and Latrobe River). The RIV boundary condition is used in preference to the LAK boundary condition as the latter would create a void for the entire thickness of layer 1 cells while in reality the over-topping of lake water would lead to ponding above ground surface, which is better represented by the RIV boundary condition. This is further explained schematically in Section 3.3.4 (refer to Figure 14).

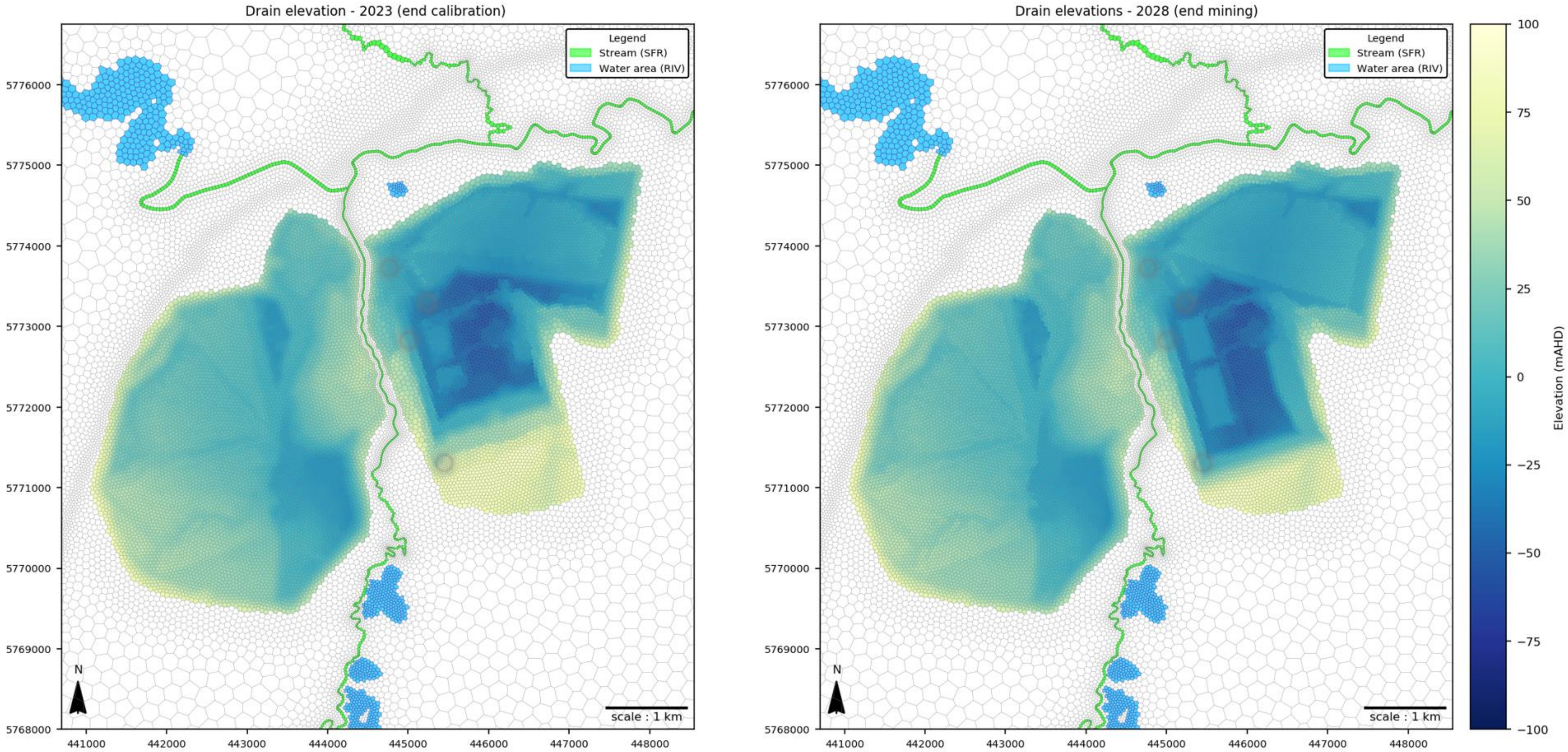


Figure 11 Yallourn mine drain elevation – 2023 and 2028

3.3.4 Lake boundary condition

The retention of water in the mine void and the formation of a full pit lake are simulated using the Lake (LAK) package. The advantage of the LAK package over head-dependent flux boundaries such as the river (RIV) package is that the lake stage (in this case, pit water level) is computed based on accurate accounting of the lake water balance and stage – storage relationship, ensuring the interaction between the lake and groundwater systems is consistent with the components of flow into and out of the lake.

The LAK package of the USG-Transport code considers lakes as volumes of space within the model grid composed of inactive cells extending down from the upper surface of the grid (with the modelled lake bottom within any vertically stacked column of cells defined by the bottom of the lowest cell). The LAK cells have been mapped using the final mine void, with the bottom (lowest) LAK cells assigned to a layer containing cells whose bottom elevation is closest to the final mine floor elevation. This results in a staircase representation of lake bathymetry across the top five model layers, with connections defined between the LAK cells and the adjacent aquifer cells in horizontal as well as vertical directions (to allow fluxes to be exchanged between the LAK and aquifer cells in both directions, as shown in Figure 14). The LAK cells are grouped into two lakes, referred as Yallourn Township Field (YTF) lake to the west and Yallourn East Field (YEF) lake to the east. The extent of the LAK cells and how this varies with depth through the model layers is shown in Figure 12. Also shown in the figure are the locations of adjacent aquifer cells that are horizontally connected to the LAK cells in each layer. Figure 13 is a 3d image the model grid with the LAK cells removed, to show the adjacent aquifer cells (and the corresponding model layer) that are connected to the LAK cells. The lake bed leakance value is set equal to the RIV bed conductance values used for in-pit water features for consistency (noting that lake fluxes are more sensitive to the hydraulic conductivity of the adjacent aquifer cells than the bed leakance term).

The water level simulated within each lake depends on the water balance and stage-storage relationship (defined by the elevation and volume of LAK cells). The components of water balance include rainfall, evaporation, run-off and anthropogenic water source (referred to as ‘withdrawal’ in the LAK package). Runoffs for the deterministic climate sequence have been generated by RGS Environmental and these are assigned to the LAK package to ensure consistency with the method adopted for the GoldSim pit lake water balance modelling. The runoffs consider external and internal (pit) catchment areas, with the latter reducing over time as the lake level rises. Rainfall and evaporation (Morton’s lake PET) are sourced from the SILO point dataset from a location corresponding to the centre of the YTF lake. The total rainfall and evaporation fluxes are dynamically adjusted by the LAK package based on the lake surface area that changes over time. The withdrawal term is used to represent a combined inflow from the pumped groundwater, external surface water source and flood volumes (using negative values to add flow to the lake). The flood volumes are sourced from the hydrological modelling undertaken by Alluvium, based on a deterministic climate sequence (which are applied to the preferred filling scenario only).

The YTF and YEF lakes are simulated as two separate lakes to account for the different initial stage and filling rates (due to differences in run-offs and pit geometry). The initial water levels are based on the expected final water levels of in-pit water features at the end of mining (-4 and -45 mAHD for the YTF and YEF lakes, respectively). When the lake level reaches RL 11 mAHD, the two pit lakes become hydraulically connected via conveyor tunnels, allowing flow to move from one lake to another until both lakes reach the same level and begin to rise as one connected lake system. This effect has been simulated in the LAK package by representing the YEF lake as a sub-lake of the YTF lake, with a sill elevation set at RL 11 mAHD to allow flow to spill into the YEF lake until the two lakes merge (coalesce). Both the run-offs and flood volumes have been supplied separately for the two lakes and applied to the LAK package accordingly. The pumped groundwater (1 to 1.5 GL/year) is added to the YEF lake and filling from the external water source is split evenly across the two pit lakes.

The lake stage is maintained constant once RL 37 mAHD is reached by assigning a nominal fill rate with a spill point included to allow removal of surplus water. This is achieved by creating a diversion to an isolated stream (SFR) segment, with a stream bed elevation set equal to the target lake level to allow flow to be removed from the lake (and model) water balance without affecting the flow in the stream network. The source of top up water is yet to be confirmed (groundwater pumping has not been assumed for top up in this report).

Although there are simplifications and limitations with the LAK package, comparison of lake stages generated from the USG-Transport model and GoldSim model shows generally consistent results (with slight differences mostly limited to the early time data when the rate of filling is most sensitive to the accuracy of the stage-storage relationship).

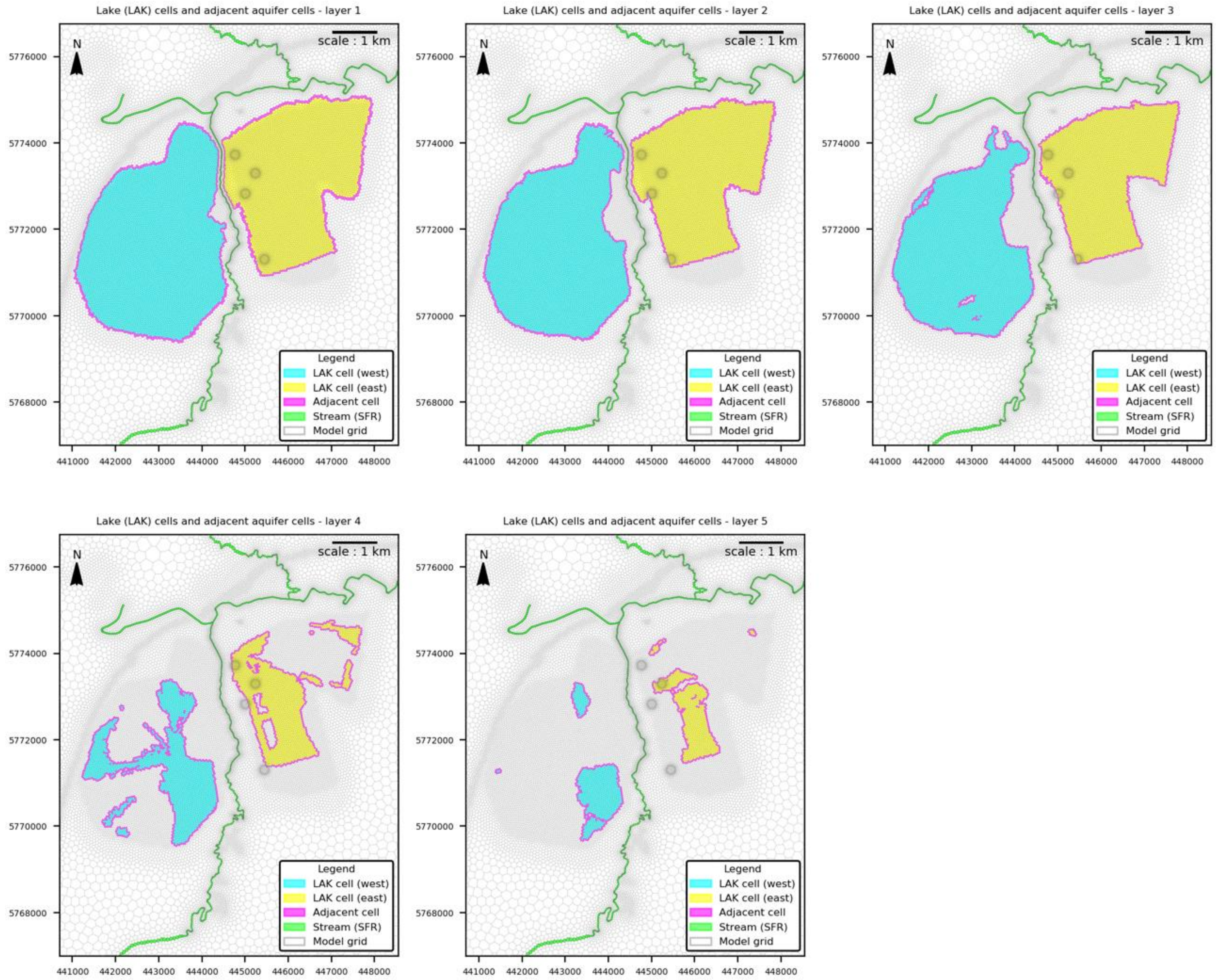


Figure 12 ***Lake and adjacent aquifer cells***

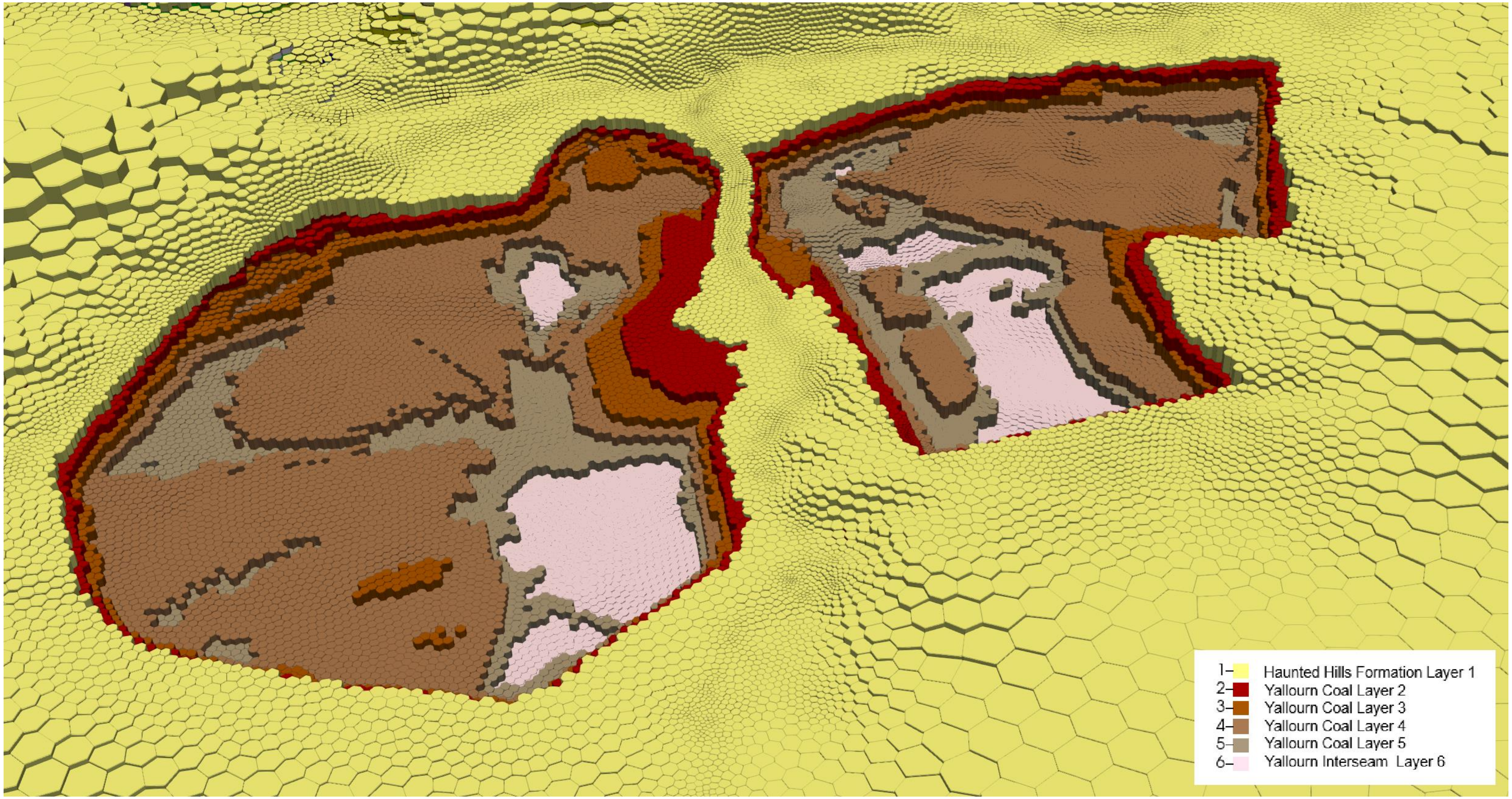


Figure 13 ***3d view of model grid with lake cells removed (vertically exaggerated)***

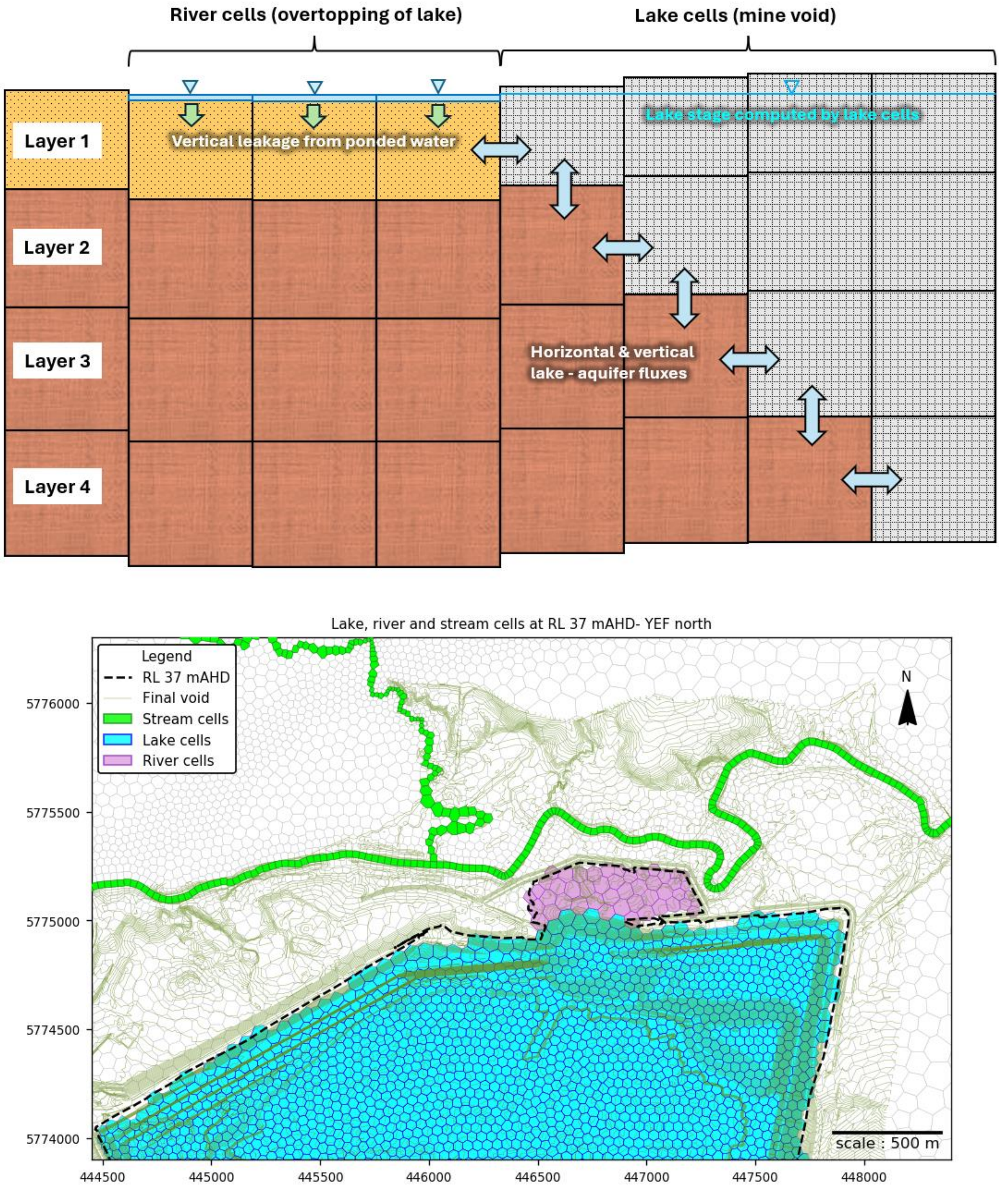


Figure 14 ***LAK and RIV boundary conditions north of YEF northern batters***

3.3.5 Well boundary condition

The Well (WEL) package is used to simulate the extraction of groundwater by pumping bores at the Yallourn Mine, YNOC and for other non-mining uses. Groundwater extraction at the mine is based on EAY's projected extraction schedule to the end of mining, which includes pumping at total rates of 1 to 1.3 GL/year from three pumping bores (N5056, N6899 and M4203) to the end of 2025, reducing to two pumping bores thereafter (N6899 and M4203). For the rehabilitation scenario (from 2029 onwards), a nominal pumping rate of 1.5 GL/year is assumed until the water level in the YEF lake reaches 0 mAHD and bore N6899 is decommissioned. At this point, the pumping is continued from bore M4203 at a reduced rate of 1 GL/year until the final lake level of RL 37 mAHD is reached.

For the YNOC, a time-constant pumping rate of 5.5 ML per month has been distributed to 10 pumping bores (with the rates for each pumping bore adjusted based on their capacity). For other non-mining uses, seasonally adjusted average extraction rates have been assumed.

3.3.6 General head boundary condition

The General Head Boundary (GHB) package is used to simulate the throughflow of groundwater across the model boundaries (outer edges of the model), as per the calibration period (as detailed in GHD, 2025). For the boundaries that adopt time-varying GHB heads, these were extracted from the LVRGM (2024 version) to simulate the influence of regional confined aquifer depressurisation changes (primarily in response to the depressurisation and subsequent rehabilitation of the Loy Yang Mine).

3.4 Material properties

The Time-Variant Materials (TVM) package is used to simulate the transient material property changes of the Yallourn Coal layers (model layers 2 to 5), consistent with the calibration model (GHD, 2025). The material property changes derived from the calibration period are applied at the start of the predictive simulation in 2024 to simulate the fracturing of coal and placement of internal overburden dumps from historical mining. The zones of material property changes are slightly extended at the end of 2028, to simulate the effect of future fracturing and overburden dumping from the extension of the mine (based on the final mine void).

3.5 Summary of rehabilitation model set up

A graphical summary of the model set up for running the rehabilitation scenarios is provided in Figure 15, showing the relationship between the various input data sources and the boundary conditions (packages) used to simulate the relevant hydrogeological processes. Also included in the figure are key output data generated by the model and linkage with other external models, such as the GoldSim model developed by RGS Environmental which is used to simulate the pit water balance and water quality in more details. The outputs are described further in Section 4.

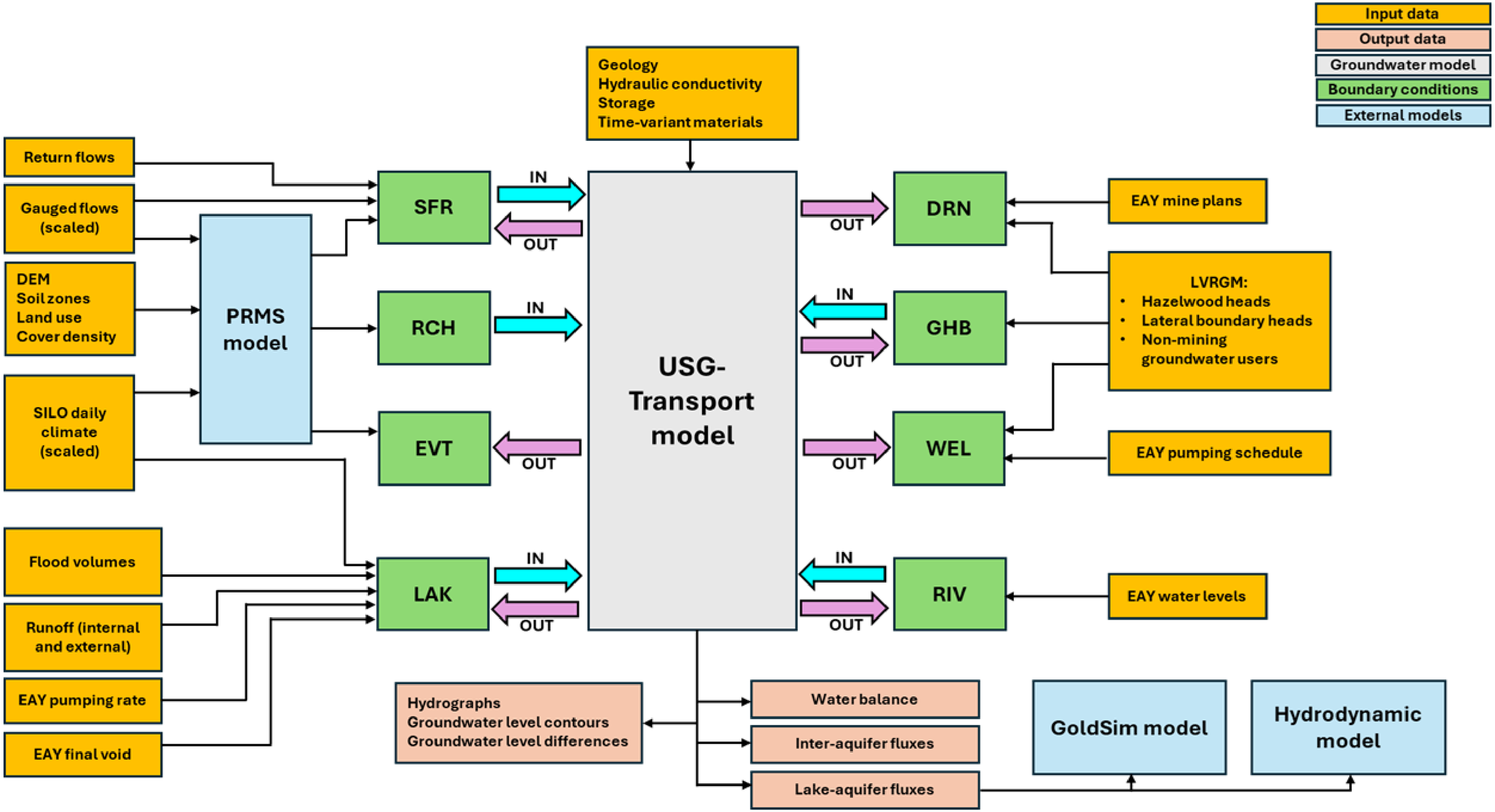


Figure 15 *Graphical summary of model set up*

4. Rehabilitation scenario results

4.1 Overview

This section presents the outputs of the rehabilitation scenario modelling. The outputs are presented and described for the Base Case scenario first, followed by the Preferred Filling scenario. These outputs include hydrographs (time series) and maps of lake and groundwater levels and fluxes, specifically:

– Hydrographs of predicted lake levels (stage), plotted separately for the YTF and YEF lakes.
– Hydrographs of groundwater levels in the key aquifers (interseams), using average groundwater levels calculated over the area of the YTF and YEF lakes and at selected locations of interest outside of the lakes.
– Contours maps of predicted groundwater levels and differences (changes relatively to the pre-filling condition) in the confined aquifers (Yallourn Interseam and M1A Interseam) and how these vary over time.
– Contour maps of shallow groundwater level changes in the Haunted Hills Formation, focusing on the area between the YEF northern batters and Latrobe River.
– Time series charts of groundwater fluxes exchanged between the pit lake and groundwater systems and how these vary in response to changes in lake stage and groundwater levels.
– Maps of lake fluxes, showing the spatial differences in the magnitude and direction (to/from lake) of fluxes exchanged between the pit lake and adjacent aquifer cells, and how these vary over time.
– Time series charts of inter-aquifer fluxes, representing the throughflow of groundwater entering and leaving the Yallourn and M1A Interseams vertically.

The above outputs are presented in Sections 4.2 for the Base Case and Section 4.3 for the Preferred Filling scenario, assuming the medium climate change projection (50th percentile projection) for all climate inputs.

4.2 Base Case results

4.2.1 Lake stage and groundwater level hydrographs

Hydrographs of the simulated lake stage for the Base Case are presented in Figure 16 (from 2029, when the retention of water is assumed to commence). Also included in the figure are the hydrographs of average groundwater levels calculated over the footprint of the YTF and YEF lakes (for the key aquifer/interseam units), showing the overall trends.

The lake stage in the YTF lake is predicted to reach RL 11 mAHD by around 2045, leading to transfer of flow into the YEF lake via the conveyor tunnels. The lake stage in the YTF lake is predicted to remain below RL 11 mAHD, reaching around 2 mAHD by the end of the rehabilitation simulation period (end of 2128). As a result, the lake stage in the YTF lake is maintained at around 11 mAHD with minor fluctuations in response to seasonal differences in runoff, rainfall and evaporation.

The groundwater levels in the Yallourn Interseam are sensitive to the lake stage and the effect of aquifer depressurisation in the underlying M1A Interseam (leading to downward leakage). The groundwater levels are generally constant below the YTF lake due to the lake stage remaining at RL 11 mAHD while the groundwater level in the YEF lake slowly rises with the lake stage. For both lakes the average groundwater level remains below the lake stage due to the downward leakage into the underlying layers caused by the extraction of groundwater from the M1A Interseam (offsetting a portion of leakage out from the lakes that would otherwise cause the groundwater level to equilibrate with the lake stage). The effect of groundwater extraction can be seen by the much lower groundwater level in the M1A Interseam, which declines gradually due to pumping at 1.5 GL/year (slightly higher than the historical average of 1 to 1.3 GL/year) followed by a slight rebound in 2087 when the pumping rate is reduced to 1 GL/year (when the lake stage in YEF reaches RL 0 mAHD and bore N6899 is assumed to be decommissioned). The groundwater level in the M1A Interseam continues to rise in line with the increasing lake stage, with a small upward vertical flux from the recovery of aquifer pressure in the deep M2 Interseam. The groundwater level trends in the M2 Interseam reflect the effects of regionally significant aquifer depressurisation and subsequent rehabilitation at the Hazelwood and Loy Yang mines, which are simulated in the model using the outputs from the LVRGM.

Spatial differences in the groundwater level trends (and how they vary with depth) are further demonstrated in Figure 17 and Figure 18 using hydrographs of key model layers at selected locations outside of the mine void/pit lake. The figure also includes a map of the final mine surface, showing differences in the floor elevation (low areas are at or close to the top of the Yallourn Interseam). The hydrographs are presented for the full simulation period, from 1960 before the aquifer depressurisation program commenced at Hazelwood, to the end of 2128 (100 years since the start of rehabilitation at Yallourn). This places the predicted groundwater level changes during and after rehabilitation within the context of the historical depressurisation effects and pre-mining condition (and how the predicted far future groundwater levels compare with the past condition prior to mining). The gaps in the layer 1 (Haunted Hills Formation) hydrographs indicate periods when the simulated water table drops below the layer bottom and cells become dry.

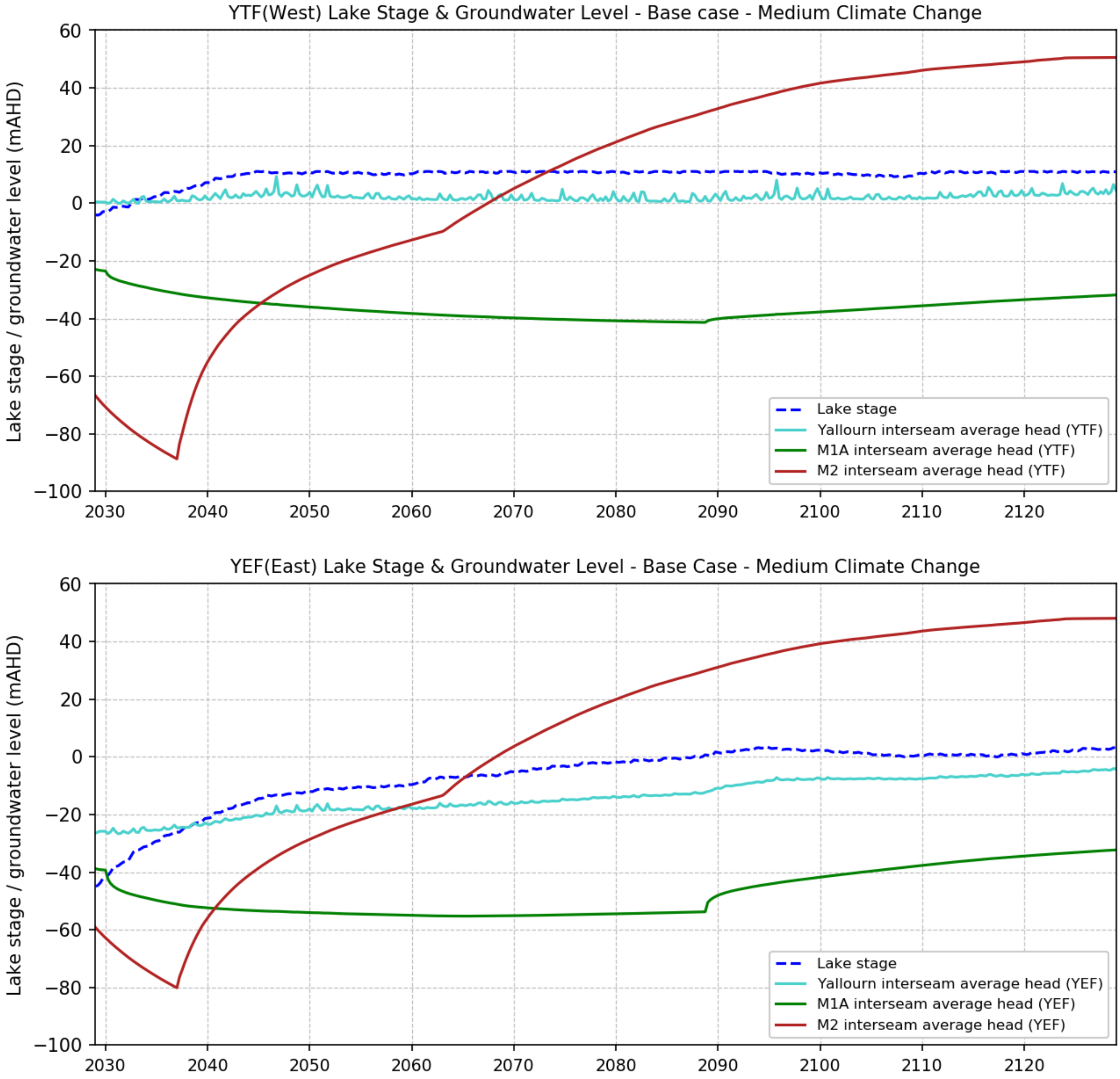


Figure 16 ***Lake stage and average groundwater level hydrographs – Base Case***

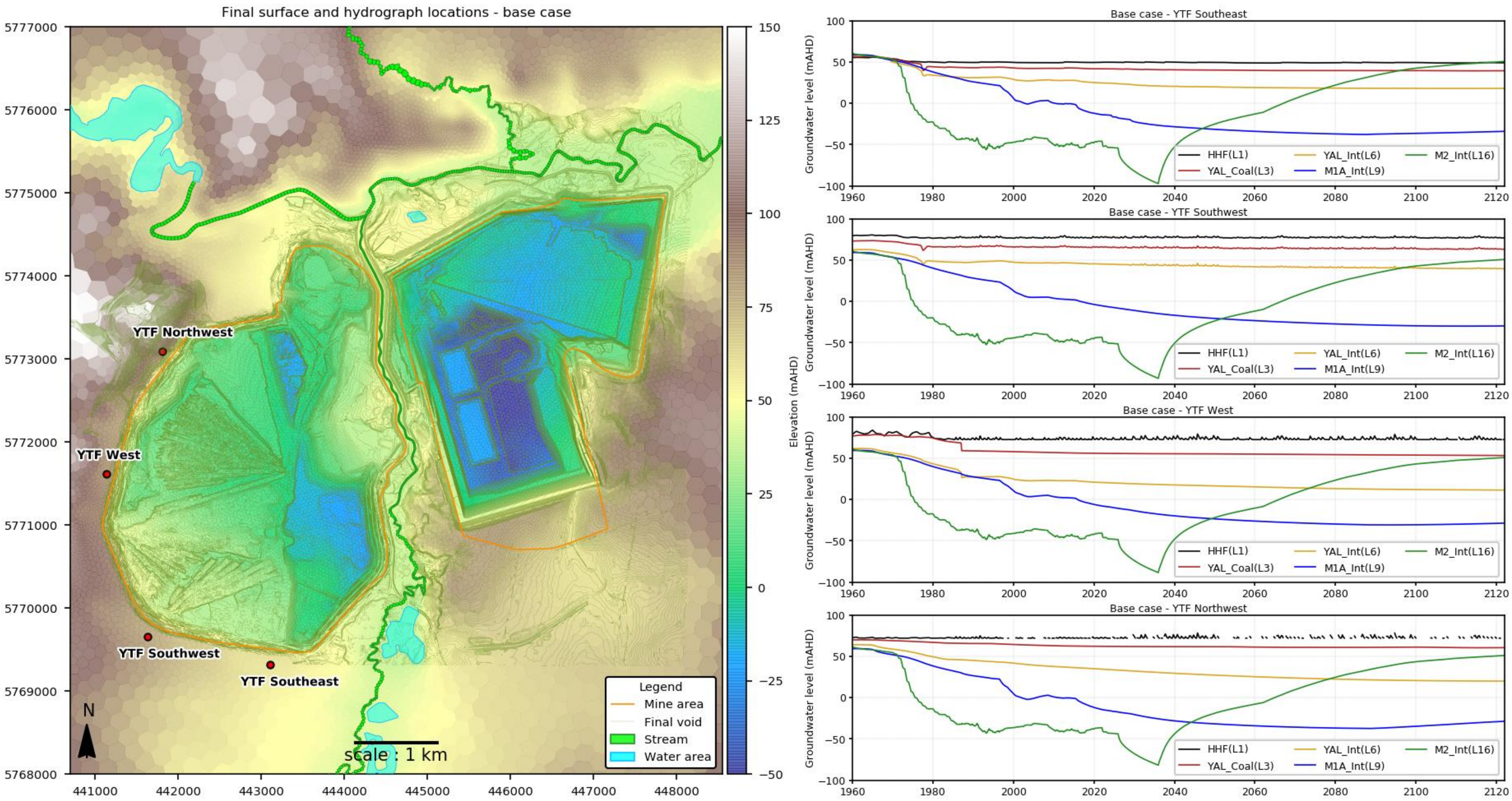


Figure 17 *Base Case hydrographs at selected locations outside of mine void – YTF*

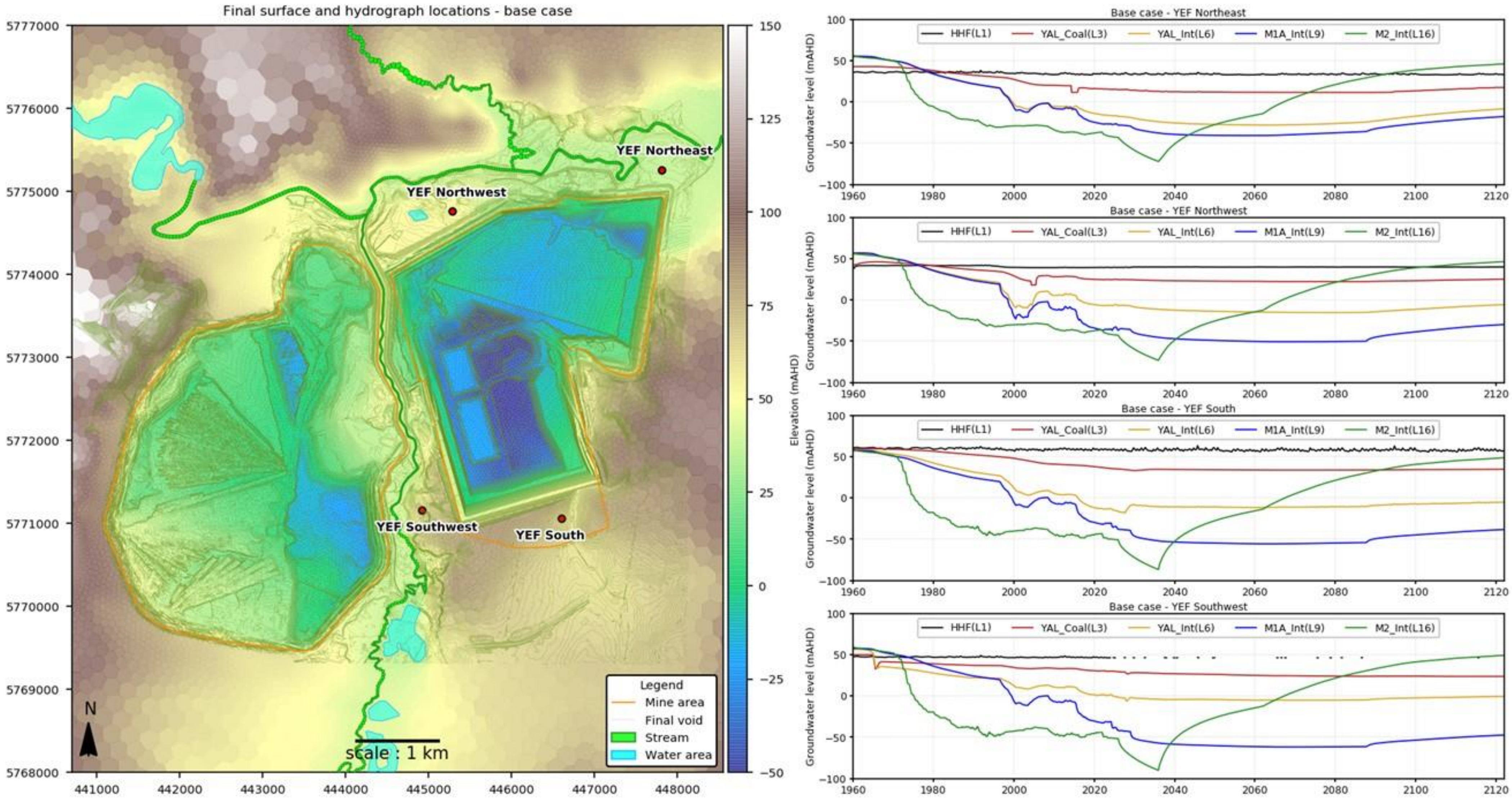


Figure 18 ***Base Case hydrographs at selected locations outside of mine void – YEF***

4.2.2 Groundwater level contours

The contours of simulated groundwater levels in the Yallourn Interseam are presented in Figure 19, every ten years from 2030 to 2080 to show changes over time during rehabilitation. Figure 20 presents the groundwater level difference plots for the same time periods, calculated by subtracting the groundwater levels for each time period from the pre-filling groundwater levels simulated at the end of mining (end of 2028). Positive difference indicates lowering of the groundwater levels (for example, due to pumping) and the negative difference indicates the rising of the groundwater levels (for example, due to leakage from the lakes). Also shown in each figure is the location of the Horizontal Flow Barrier (HFB) used to simulate the flow barrier effect of the Haunted Hills Fault/Yallourn Monocline and dry cells where the modelled groundwater levels are below the bottom of the Yallourn Interseam.

The groundwater level and difference contour plots show areas of rising groundwater level (negative groundwater level differences) centred on the deepest parts of the mine where the Yallourn Interseam is in close proximity to/exposed in the mine floor, resulting in hydraulic connection with water retained in the mine void. The deepest parts are also where pit water is collected and accumulated first, leading to leakage into the Yallourn Interseam. The areas of rising groundwater level become larger over time as the lake level rises, with the groundwater level reaching 30 m above the pre-filling level in the YEF lake by year 2080. The groundwater level away from the deepest parts of the mine is generally falling albeit by a smaller amount (around 5 m but reaching up to around 15 m adjacent to the Haunted Hills Fault). This is due to the ongoing aquifer depressurisation in the underlying M1A Interseam, leading to net downward leakage in areas where the Yallourn Interseam is less connected to the pit lake (due to the thickness of the overlying Yallourn Coal) or further away from the point of leakage (where leakage of lake water is insufficient to offset the downward leakage due to pumping from below). There is an area in the MRD South, between the two lakes where the groundwater level is rising, that shows little groundwater level difference. This is because the downward leakage from the M1A depressurisation in this area is locally balanced by the leakage from the two adjacent pit lakes, leading to little change in groundwater level since the start of filling.

The effect of ongoing pumping from the M1A Interseam can be seen in the groundwater level and difference contours of this unit, shown in Figure 21 and Figure 22. Also included in the figures is the location of two pumping bores used to maintain the necessary aquifer depressurisation. The contour maps show the cone of depressurisation radiating from the two pumping bores, which increases over time (until 2087, when pumping bore N6899 is decommissioning as the lake stage reaches RL 0 mAHD, leading to local recovery around this bore).

The contours of groundwater levels for the Haunted Hills Formation are not presented for the Base Case as there is very little discernible change over time due to the pit lake remaining below the base of the Haunted Hills Formation with shallow groundwater continuing to drain into the mine void. In this case, the changes over time are entirely due to climate with minor natural seasonal variations. The interaction with the shallow groundwater system becomes important for the Preferred Filling scenario when a full pit lake is formed. This is discussed further in Section 4.3.2.

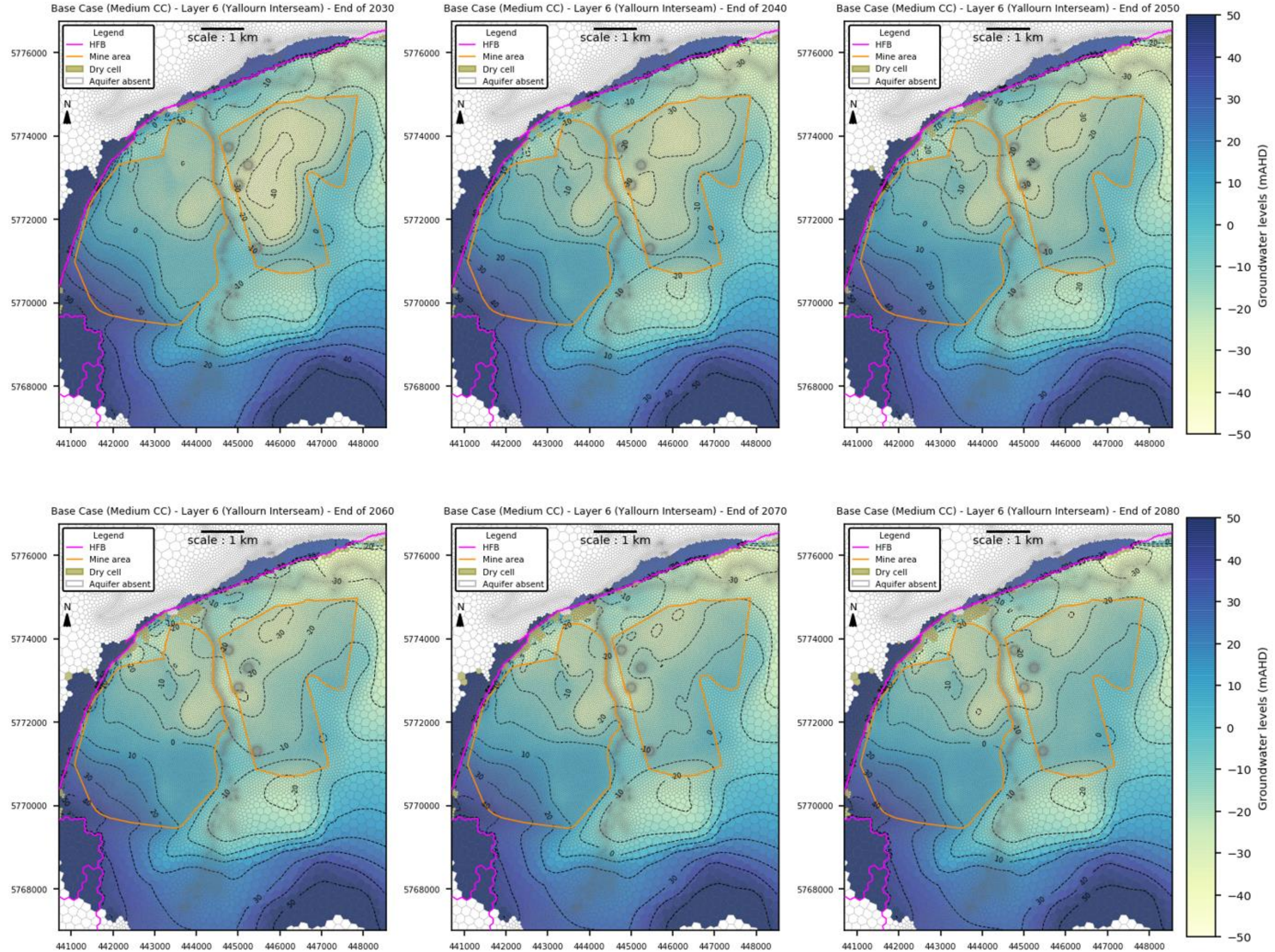


Figure 19 ***Base Case Yallourn Interseam groundwater level contours***

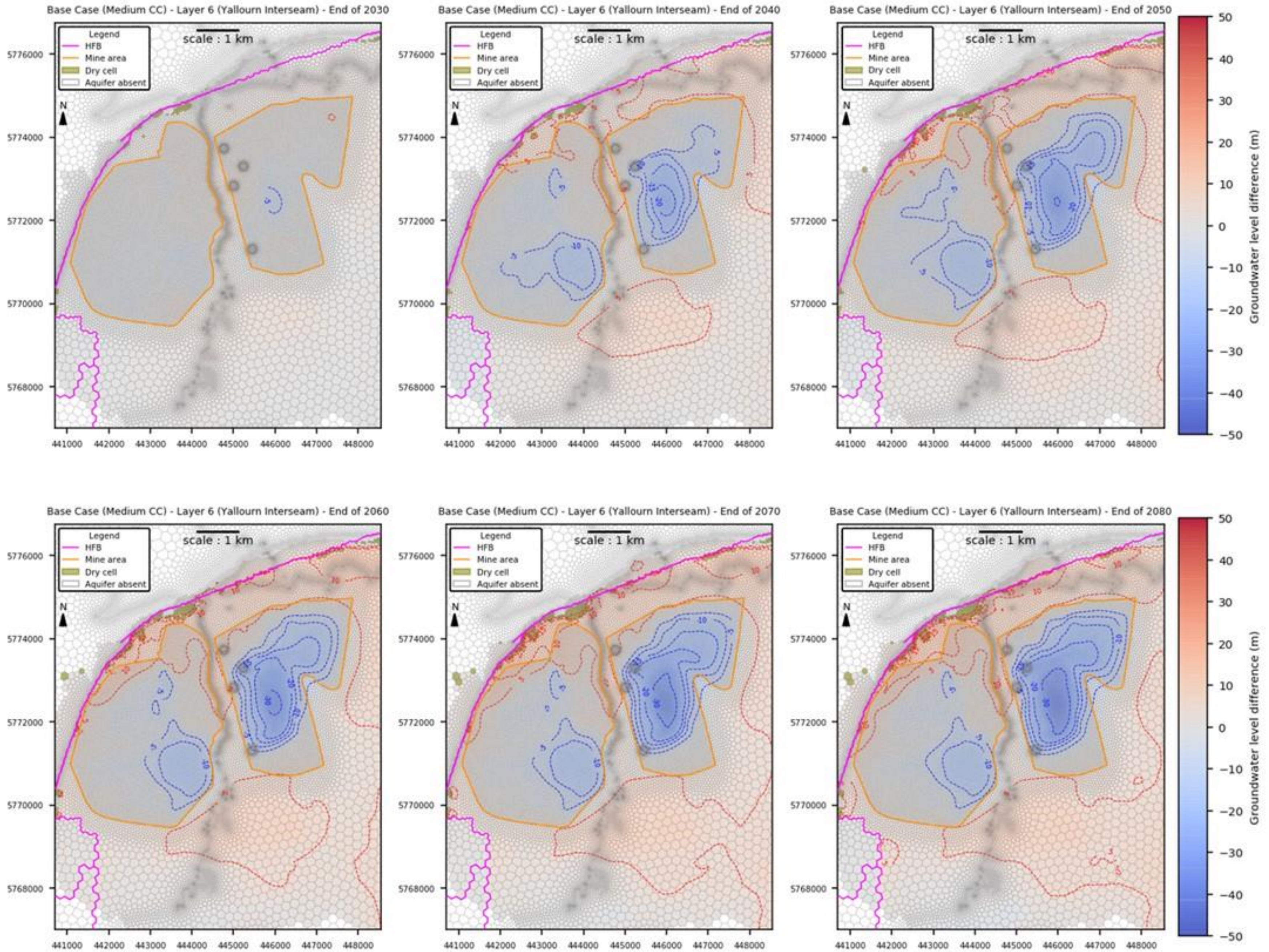


Figure 20 Base Case Yallourn Interseam groundwater level difference contours

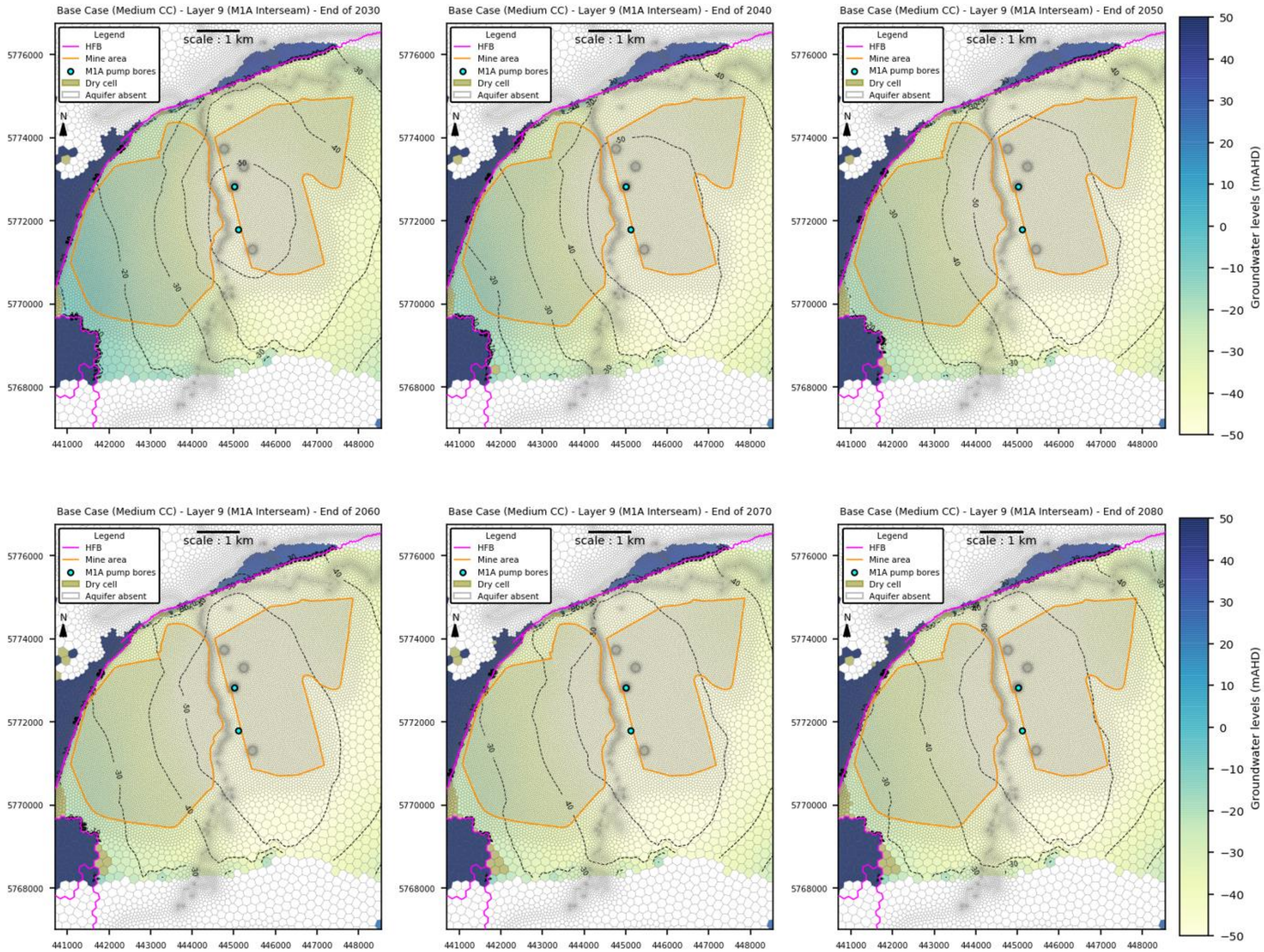


Figure 21 *Base Case M1A Interseam groundwater level contours*

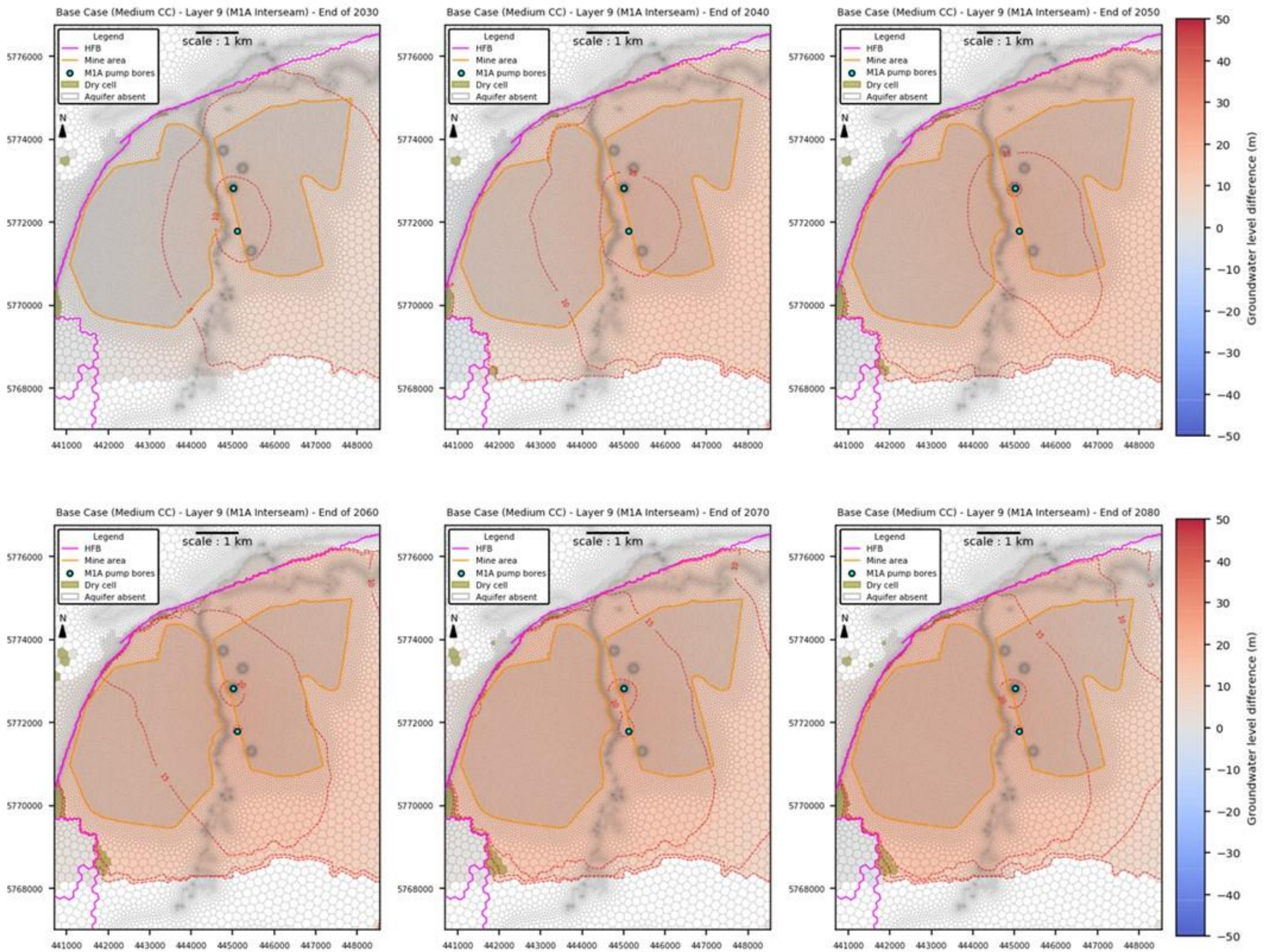


Figure 22 ***Base Case M1A Interseam groundwater level difference contours***

4.2.3 Lake-aquifer flux charts

The fluxes exchanged between the pit lakes and the adjacent groundwater system are computed by the LAK package, based on the volumes of groundwater gained from each aquifer cell connected to the LAK cell (when the piezometric heads are higher than the pit lake level) and the volume of pit water lost to the aquifer cells (when the pit lake level is higher than the piezometric heads). The magnitude and direction of fluxes exchanged between the two connected systems vary over time, due to changes to the lake level and piezometric heads in response to filling and pumping.

Charts of fluxes exchanged between the pit lake and adjacent aquifers for the Base Case are plotted separately for the YTF lake in Figure 23 and YEF lake in Figure 24. Each figure includes two plots, showing the simulated fluxes into the pit lake from the groundwater system (top plot) and from the pit lake into the groundwater system (bottom plot). The fluxes are computed for each hydrostratigraphic unit (HSU) connected with the pit lake, which includes the Haunted Hills Formation (layer 1), Yallourn Coal (combined fluxes from layers 2 to 5) and Yallourn Interseam (layer 6, connected to the lake cells vertically only). The M1A Interseam is confined by the overlying M1 Coal and does not directly interact with the pit lake i.e. fluxes to and from this deep confined aquifer must pass through the intervening M1 Coal and Yallourn Interseam. The fluxes are presented as continuous time series since the start of filling in 2029, using a logarithmic scale to account for the large variations in fluxes associated with the different HSUs. To assist with the interpretation of the fluxes, each plot also includes hydrographs of the simulated lake stage and average groundwater level in the Yallourn and M1A Interseams (as shown in Figure 16).

The charts indicate that seepage of lake water into the Yallourn Coal and Yallourn Interseam initially increases as the lake stage rises, before plateauing as the lake stage stabilises at around RL 11 mAHD in YTF and RL 0 mAHD in YEF (occurring much later, in 2087). The Yallourn Coal lake seepage is much greater than the Yallourn Interseam seepage due to the much larger area of direct connection with the lakes.

Seepage of groundwater into the lakes occurs from model layers that remain above the lake stage, primarily from the Haunted Hills Formation (which is replenished by recharge) and to a lesser extent from the Yallourn Coal. Groundwater seepage from the Yallourn Interseam is negligible (orders of magnitude less) and reduces to zero in the YEF lake as the lake level becomes greater than the groundwater level across the entire area of connection. Groundwater seepage from the Yallourn Coal in the YTF lake shows a wide range of seasonal fluctuations due to a large area of exposed lake floor that receives direct recharge. As discussed in Section 3.3.1, direct recharge to the exposed coal has been adjusted to account for ground conditions that are very different to the natural ground surface used to estimate diffuse recharge. In this case, recharge derived from the PRMS model has been reduced by half to assign a recharge rate that is considered more consistent with the material properties of coal, resulting in groundwater seepage rates that are approximately equal to the range of seepage rates estimated from the horizontal drain holes i.e. 0.4 to 0.6 GL/year from the Yallourn Coal, as discussed in GHD (2025).

Table 2 Base Case lake-aquifer flux summary

HSU	YTF (West)			YEF (East)		
	Min (m^3/d)	Max (m^3/d)	Average (m^3/d)	Min (m^3/d)	Max (m^3/d)	Average (m^3/d)
Groundwater fluxes						
HHF	978.14	4749.04	1725.99	1762.62	5207.51	2625.59
Y.Coal	70.18	2665.06	379.94	133.68	997.8	263.4
Y.Interseam	0.09	7.84	0.37	0	45.67	0.88
Lake fluxes						
HHF	0	0	0	0	0	0
Y.Coal	16.83	151.62	95.74	4.47	214.64	125.12
Y.Interseam	19.76	58.74	51.62	0.01	49.97	35.7

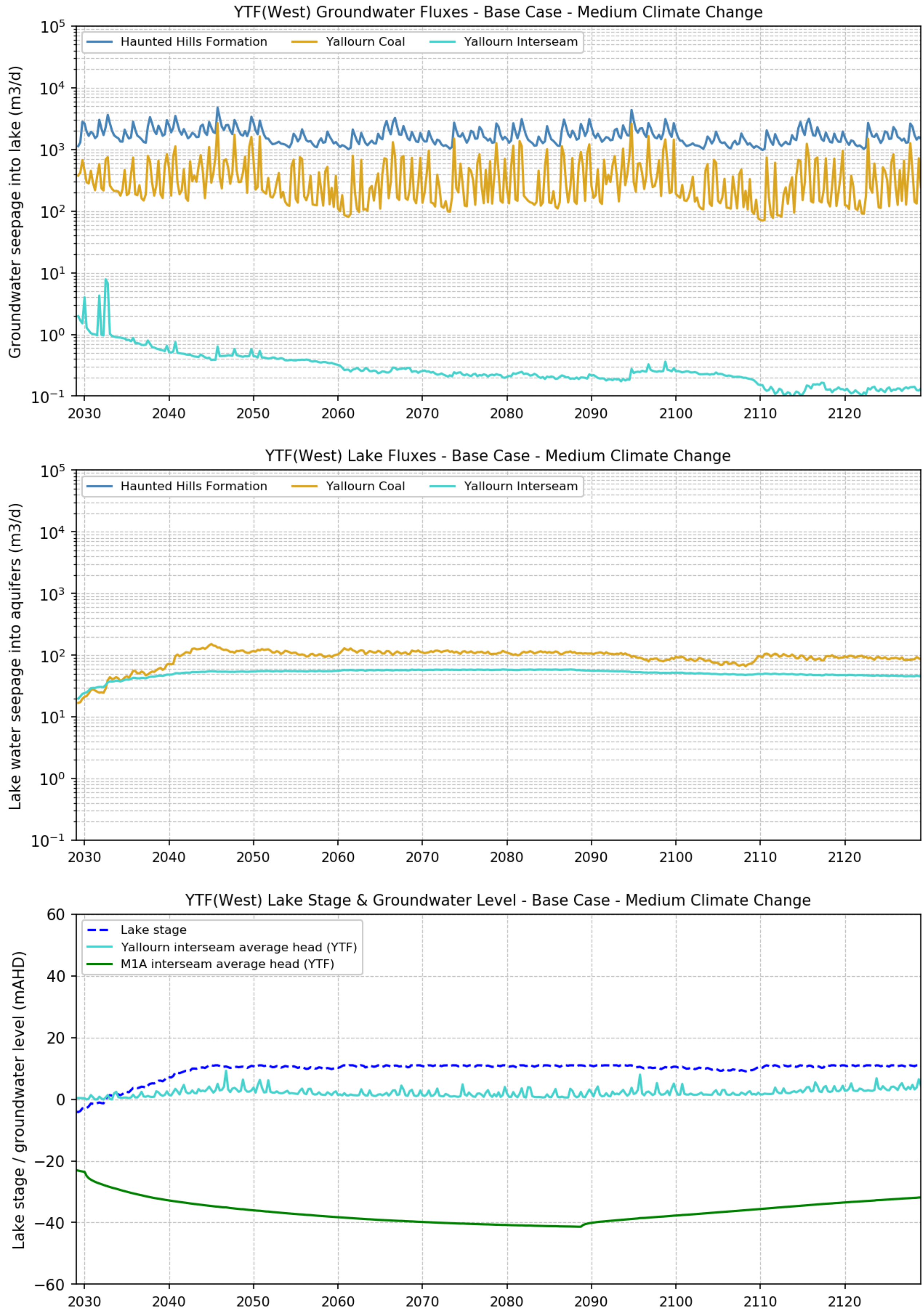


Figure 23 ***Base case lake – groundwater fluxes for YTF***

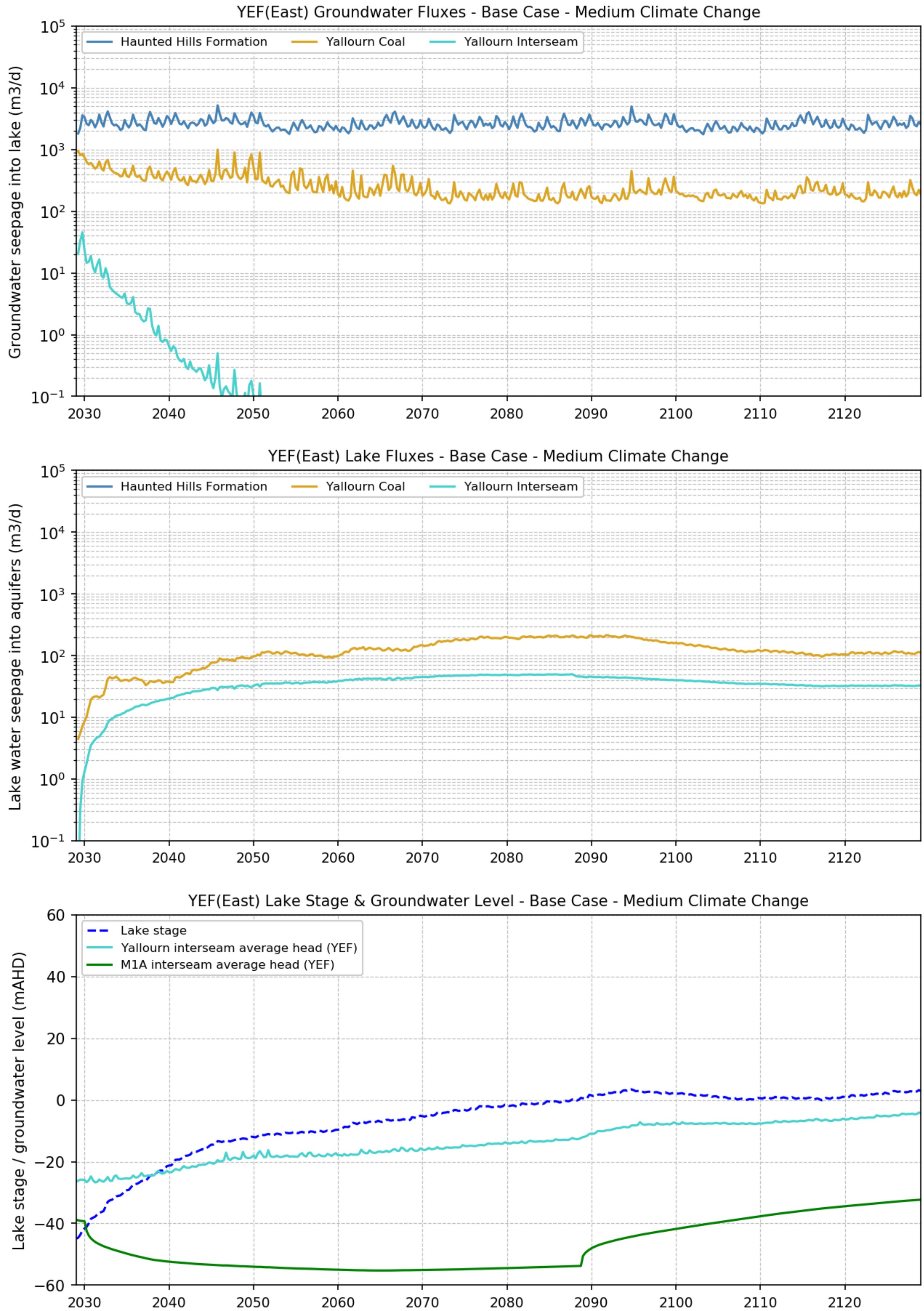


Figure 24 ***Base case lake – groundwater fluxes for YEF***

4.2.4 Lake-aquifer flux maps

The spatial distribution of fluxes exchanged between the LAK and aquifer cells is presented using maps of fluxes calculated for each LAK-aquifer cell connection and projecting this information onto a 2d grid. As the bottom LAK cells can receive fluxes from the adjacent aquifer cells in horizontal as well as vertical directions, total fluxes have been calculated for each LAK-aquifer cell connection by summing the fluxes from both directions. To account for the different surface areas of the cells in the unstructured grid, the total fluxes have been converted to normalised fluxes (expressed per unit surface area of each cell). Positive fluxes indicate fluxes gained by the aquifer cells (seepage out from the LAK cells) and negative fluxes indicate fluxes lost by the aquifer cells (groundwater seepage into the lake). To show changes in flux distribution over time, average fluxes have been calculated and presented every five years from 2030 to 2050 and then every ten years to 2070, followed by every 20 years to 2110. A logarithmic scale is used due to orders of magnitude differences in fluxes from different model layers/HSUs.

The LAK-aquifer flux maps included in Figure 25 and Figure 26 show the extent and magnitude of positive fluxes increasing over time as the lake level rises, resulting in more leakage of lake water. In the early stages of the filling, the area of negative fluxes in the YTF (west) lake also increases (from 2030 to 2050). This is due to the water table in the Yallourn Coal rising with the lake level, leading to the phreatic surface intersecting the floor of the lake at higher levels (leading to seepage of groundwater above the lake level). Cells along the perimeter of the mine voids show large negative fluxes, representing seepage of groundwater from the Haunted Hills Formation. This is maintained by recharge and is unaffected by the filling of the mine voids due to the lake level remaining below the base of the Haunted Hills Formation (model layer 1).

4.2.5 Inter-aquifer fluxes

Inter-aquifer fluxes refer to the transfer of flux from one model layer to another, in the vertical direction. During lake filling, vertical fluxes would occur from the Yallourn Coal down to the M1A Interseam due to the downward hydraulic gradient created by the rising lake level and the pumping within the M1A Interseam. A series of flux charts showing the vertical fluxes entering the top and leaving from the bottom of the Yallourn Interseam and M1A Interseam are included in Appendix A. For the MA1 Interseam, which consists of three model layers, the flux entering from the top is calculated using the top of model layer 8 and flux leaving the bottom is calculated using the bottom of layer 10. The fluxes are total vertical fluxes calculated over the footprint of the YTF and YEF voids (defined by the extent of the LAK boundary condition, as shown in Figure 12).

The charts show that for the Base Case, the flux entering the top of the Yallourn Interseam is similar to that leaving from the bottom. This means most of the flow entering from above due to the leakage of lake water is ultimately transferred to the M1A Coal layer below. In the YEF area, the flux leaving from the bottom shows a decrease in 2087, corresponding to the reduction in the pumping rate, which is more pronounced than the flux entering from above due to the proximity to the effect of pumping from below.

The vertical flux entering the top of the M1A Interseam is similar to the vertical flux leaving the bottom of the Yallourn Interseam, however the flux leaving the bottom of the M1A Interseam is much lower due to the capturing of the flux by the pumping within this aquifer. This means changes in vertical fluxes due to leakage of lake water is ultimately captured by the pumping within the M1A Interseam, which creates a local sink in the groundwater system.

It is important to note that while changes in aquifer pressure can lead to rapid changes in fluxes (due to the compressibility of aquifer and elastic storage changes), the transport of solutes contained within groundwater would occur at a much slower rate due to the tortuosity of the granular structures and the movement of solutes through inter-connected pore spaces (representing much longer flow paths). The travel time can also be further delayed due to chemical reactions (such as retardation due to sorption) along the flow paths. This means the increase in vertical fluxes into the Yallourn Interseam and the M1A Interseam are not necessarily indicative of the arrival of solutes from the pit lake.

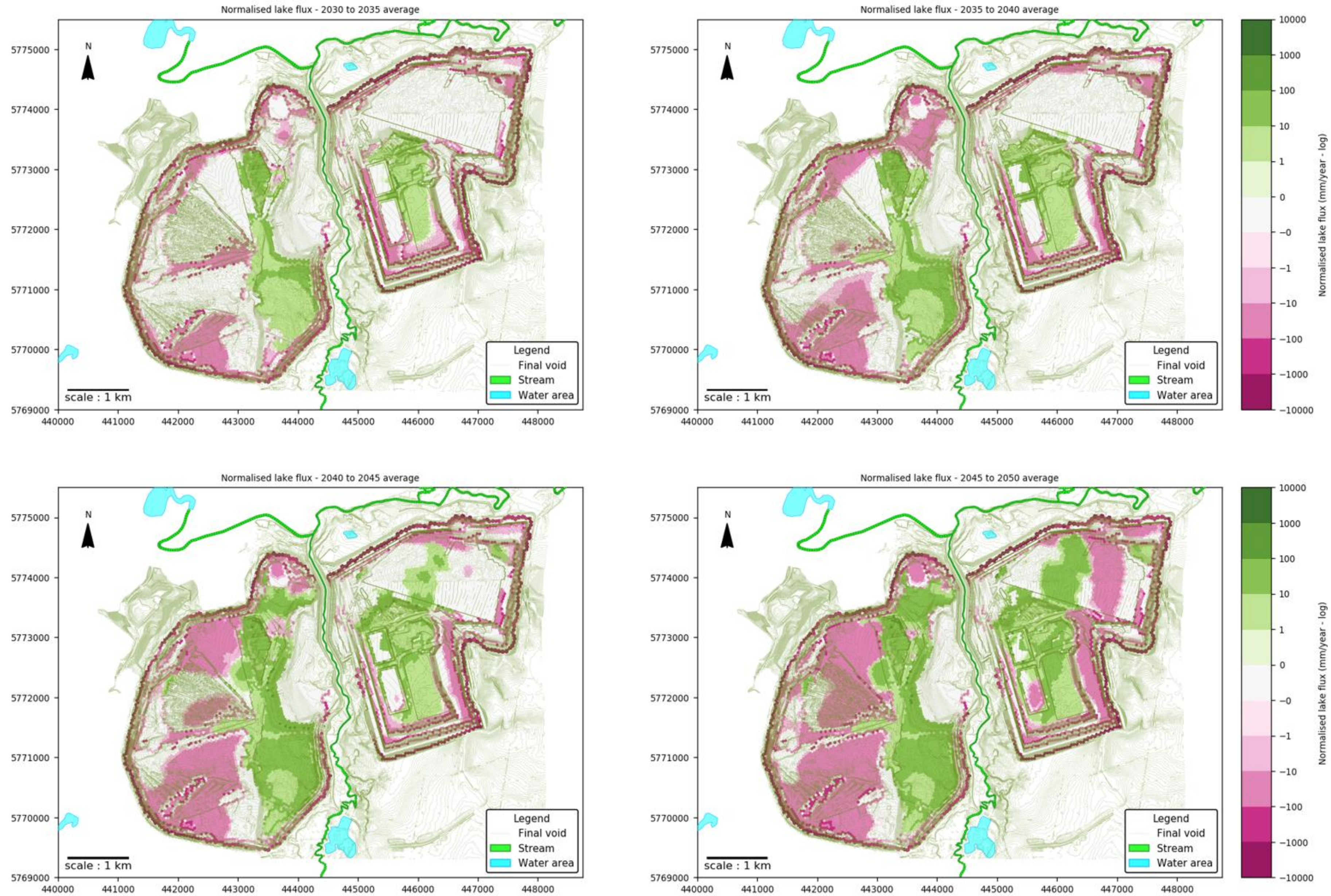


Figure 25 *Base Case lake-aquifer flux map – 2030 to 2050*

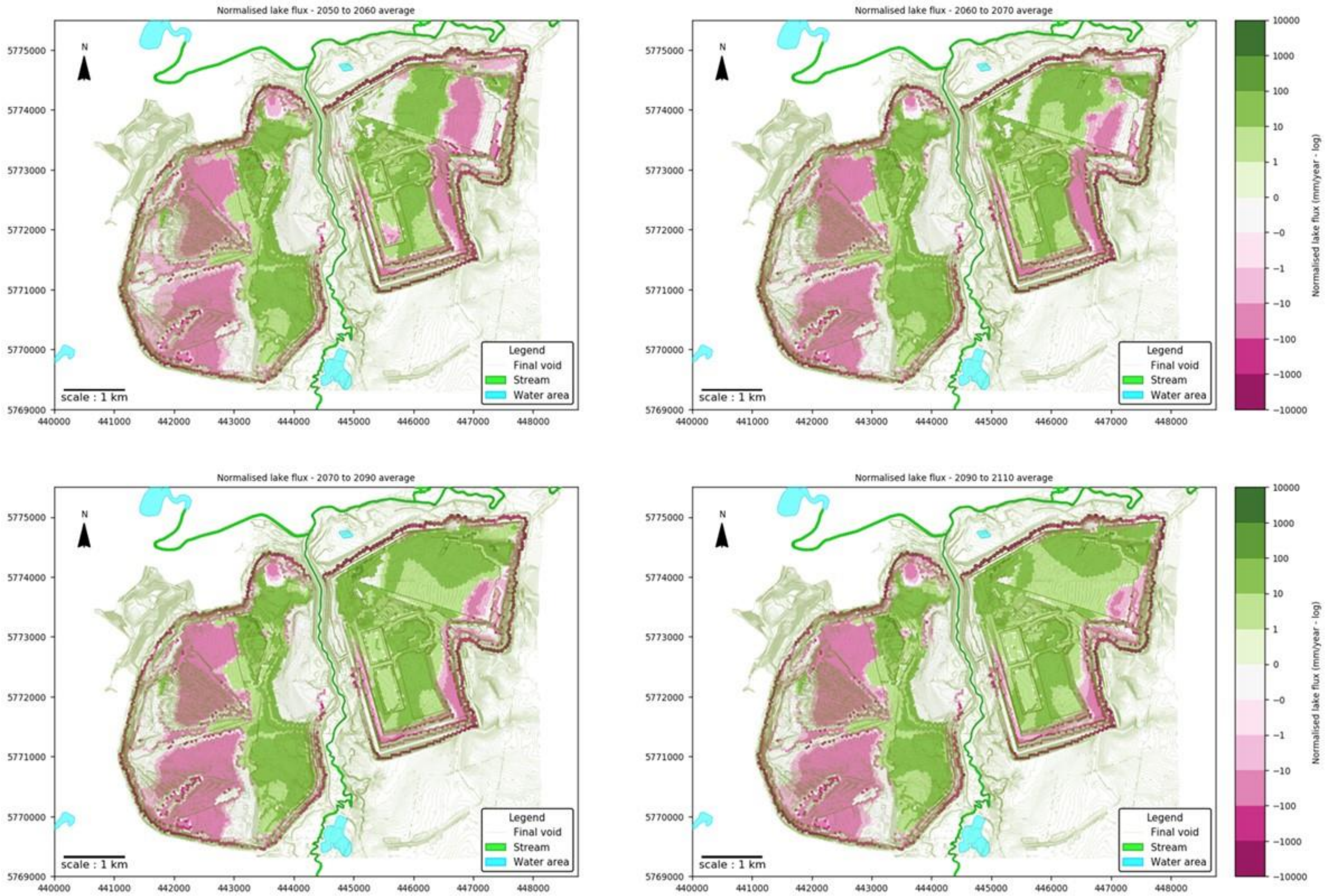


Figure 26 ***Base Case lake-aquifer flux map – 2050 to 2110***

4.2.6 Water balance

Table 3 below summarises the cumulative water balance and average volumetric fluxes for the rehabilitation simulation period (from January 2029 to end of December 2128) for the entire model domain. The "In" components refer to flows entering the model i.e. fluxes gained by the aquifer and the "Out" components refer to flows leaving the model. For the Base Case scenario, the out flow from the lake boundary is larger than the inflow, meaning more groundwater is discharging into the pit lake than that gained from leakage of lake water. Note that the "Lake" boundary condition is only applied at the Yallourn Mine whereas all other boundary conditions/water balance components are for the entire model domain e.g. the "Stream" and "River" boundary conditions represents the network of major rivers and water bodies distributed across the entire model domain respectively, which account for larger components of the total water balance than the pit lake under the Base Case scenario.

Table 3 Base Case modelled water balance

Component	Transient cumulative (ML)		Transient average rate (ML/d)	
	In	Out	In	Out
Recharge	4,559,189	0	123	0
Evapotranspiration	0	4,240,125	0	124
Drain	0	376,761	0	10
Well	0	178,264	0	4.9
River	830,396	388,443	23	11
Stream	88,817	1,085,537	2.4	30
Lake	11,258	181,509	0.3	5
GHB	2,119,818	767,836	59	21
Storage	3,742,482	4,133,449	113	113
Total	**11,351,961**	**11,351,925**	**319**	**319**

The cumulative mass balance error as well as the maximum mass balance error for any given time step for the entire rehabilitation simulation period is less than 0.001 %, well below the 1 % threshold recommended by the Australian Groundwater Modelling Guidelines.

4.3 Preferred Filling scenario results

4.3.1 Lake stage and groundwater level hydrographs

Hydrographs of the simulated lake stage for the Preferred Filling scenario are presented in Figure 27, along with the hydrographs of average groundwater levels calculated over the footprint of the YTF and YEF lakes. The lake stage in the YTF lake is predicted to reach RL 11 mAHD by around 2032, approximately 13 years earlier than the Base Case, leading to transfer of flow into the YEF lake via the conveyor tunnels. The lake stage in the YTF lake is predicted to reach RL 11 mAHD towards the end of 2037, after which the lake stage in both lakes rise together as one connected pit lake. The final lake stage of RL 37 mAHD is predicted to reach towards the end of 2052.

The groundwater levels in the Yallourn Interseam rise with the lake stage albeit at a reduced rate due to the effect of aquifer depressurisation in the underlying M1A Interseam (leading to downward leakage). The groundwater levels in the M1A Interseam are maintained low by ongoing pumping during filling, creating vertical head differences between the Yallourn Interseam that are much larger than those of the Base Case. The groundwater levels show a sharp recovery in 2034 when the lake stage reaches RL 0 mAHD in the YEF lake and the pumping rate is reduced to 1 GL/year as bore N6899 is decommissioned. The groundwater levels in the M1A Interseam begin to slowly rise from 2034 onwards due to the reduced pumping rate and the increase in leakage from the pit lake caused by the rising lake stage (leading to higher groundwater levels and fluxes from the Yallourn Interseam). When the lake stage reaches RL 37 mAHD in 2052, pumping is ceased in the M1A Interseam, resulting in a rapid recovery of the groundwater level. The rate of recovery in the M1A Interseam increases slightly from 2080 due to the delayed effect of the faster rate of recovery simulated in the deeper M2 Interseam from around 2063 (with the delay caused by the vertical separation between the two interseams and the resistance to flow due to the thick M2 and M1B Coal layers).

The groundwater levels in the Yallourn Interseam and the M1A Interseam are predicted to exceed the lake stage by 2100, around 48 years after the pit lake becomes full. The rate of recovery becomes progressively slower as the hydraulic gradient (the difference between the lake stage and surrounding groundwater levels) is reduced over time. The simulated groundwater levels begin to stabilise towards the end of the rehabilitation simulation period, with a net upward vertical hydraulic gradient from the M2 Interseam to the pit lake. This means the pit lake is predicted to ultimately become a groundwater sink as the confined aquifer pressure is restored, leading to small groundwater inflows.

Hydrographs of the key model layers at selected locations outside of the mine void/pit lake are shown in Figure 28 and Figure 29. The hydrographs show the post-rehabilitation groundwater levels recovering towards their pre-mining levels, although the far future levels are generally lower due to the drier future climate (medium climate change projection) and the presence of the pit lake that acts as a local sink (locally depressing the piezometric surface). The influence of the pit lake can also be seen in the upward vertical hydraulic gradient of the post-rehabilitation groundwater levels, which is more pronounced than that of the pre-mining condition (reflecting upward flows of groundwater into the pit lake).

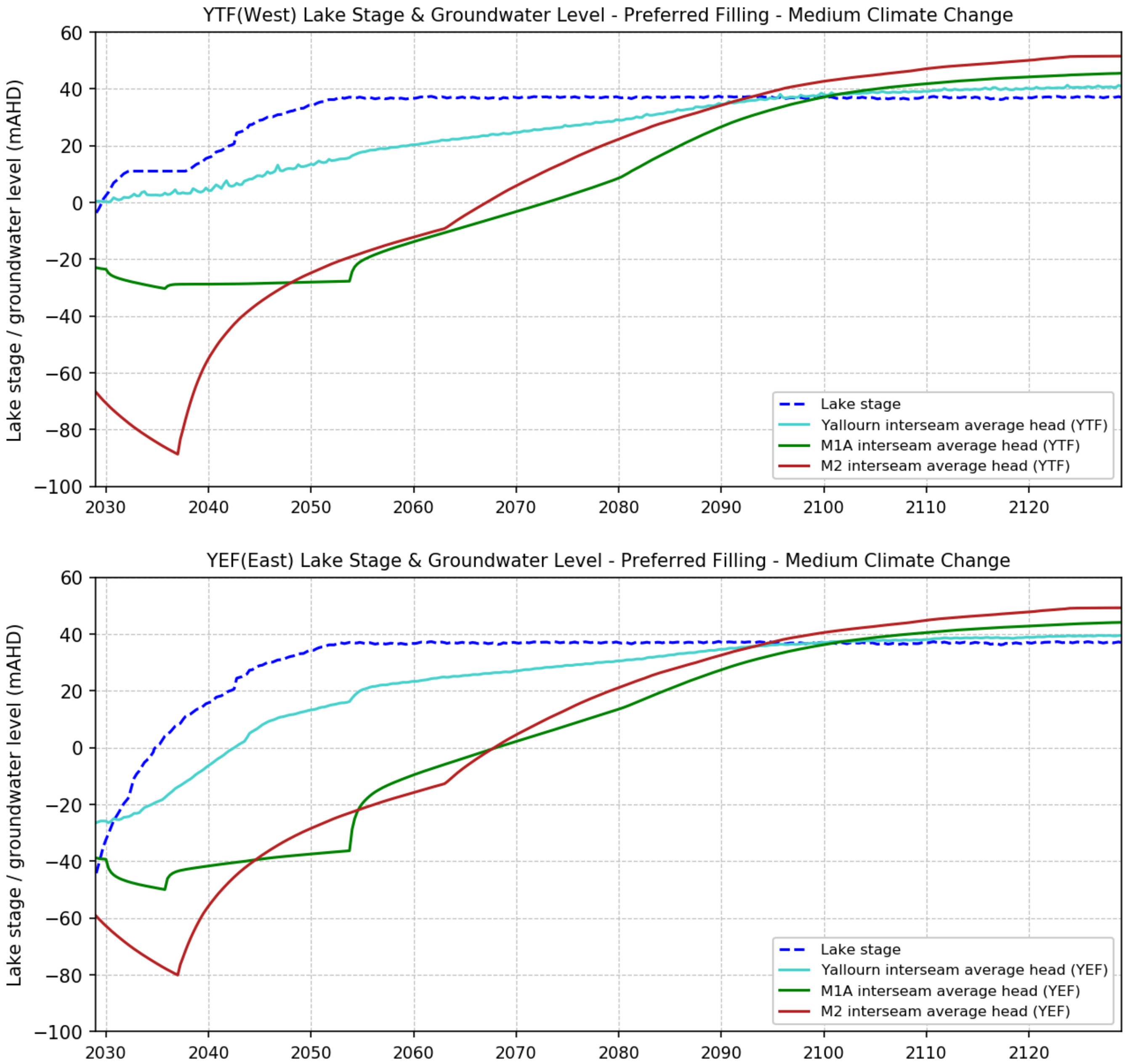


Figure 27 ***Lake stage and average groundwater level hydrographs – Preferred Filling scenario***

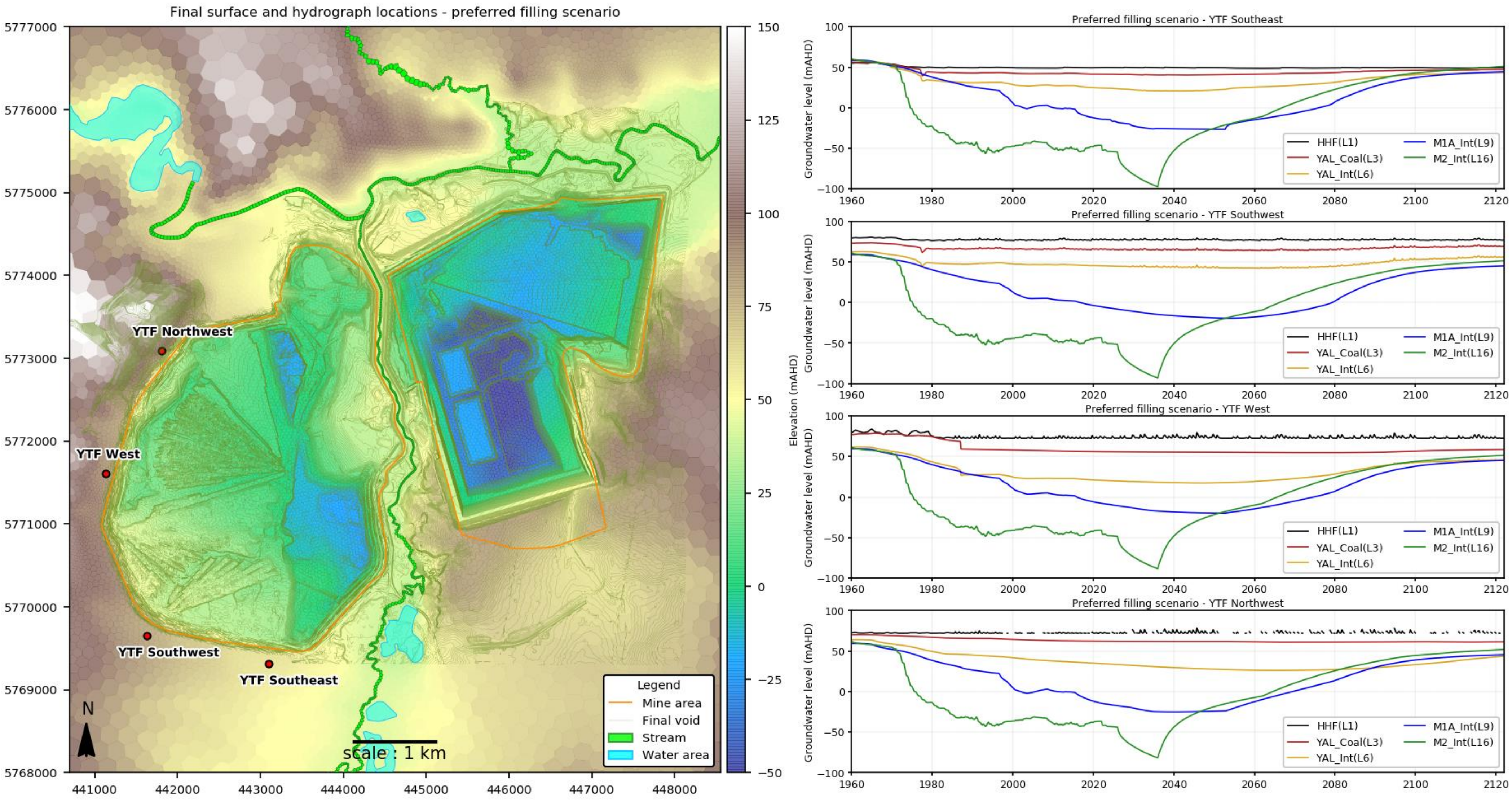


Figure 28 ***Preferred Filling hydrographs at selected locations outside of mine void – YTF***

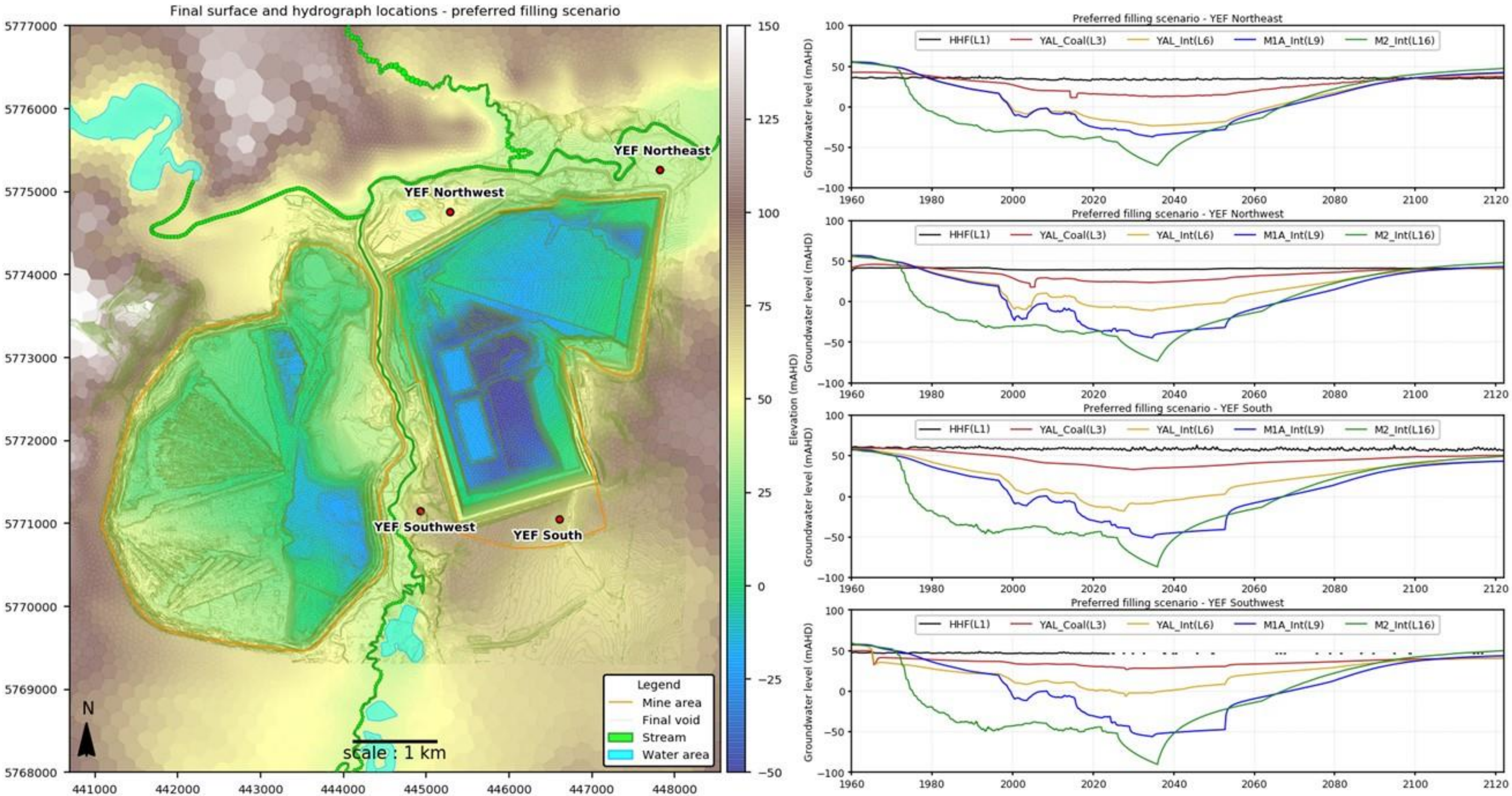


Figure 29 ***Preferred Filling hydrographs at selected locations outside of mine void – YEF***

4.3.2 Groundwater level contours

The contours of simulated groundwater levels and groundwater level differences for the Yallourn Interseam are presented in Figure 30 and Figure 31, respectively. The groundwater levels are rising over time, with the area of higher groundwater levels (negative differences) becoming progressively larger with the rising lake stage. Compared to the Base Case, the areas of lower groundwater levels (outside the mine void) show much smaller positive differences due to the higher lake stage and larger leakage rates that offsets the drainage effect of pumping in the M1A Interseam. Figure 31 shows that the groundwater levels in the Yallourn Interseam are predicted be more than 50 m higher than the pre-filling condition across the YEF lake by the end of 2080.

The groundwater level and difference contours of the M1A Interseam are shown in Figure 32 and Figure 33, respectively. The cone of depression can be seen in the groundwater level contours up to the end of 2050, centred on the pumping bores. The groundwater level difference plot shows a local recovery (negative contours) around bore N6899 (the northern pumping bore) in 2040 and 2050, following the shutdown of this bore in 2034 when the YEF lake reaches RL 0 mAHD. The groundwater level and difference contours show a net recovery across the mine and the surrounding areas from 2060 onwards due to the cessation of pumping in 2052. Similar to the Yallourn Interseam, the groundwater level in the M1A Interseam is predicted be more than 50 m higher than the pre-filling condition across the YEF lake by the end of 2080.

The final lake level of RL 37 mAHD is locally above the base of the Haunted Hills Formation, leading to the re-saturation of this aquifer where it has been previously drained by the presence of the mine void. Figure 34 is a plot of the base of the Haunted Hills Formation, highlighting areas adjacent to the mine void where the elevation is below 37 mAHD and there is the potential for direct hydraulic connections with the pit lake. In particular, the area to the north and northeast of the YEF northern batters is of particular interest due to the spilling of the lake water (as shown in Figure 14), proximity to the Latrobe River and infrastructure such as Latrobe Road and the presence of potential groundwater dependent ecosystems within the floodplain.

To demonstrate the effect of the full pit lake on shallow groundwater levels in this area, a contour map of depth to groundwater is presented in Figure 35, calculated by subtracting the modelled water table from ground surface (using the most accurate LIDAR dataset supplied by EAY). The figure compares the depth to groundwater contours for the Base Case, when the lake stage is below the base of the Haunted Hills Formation, and the Preferred Filling scenario when the full pit lake is formed. The modelled water table has been extracted from a dry period in the future, so the effect of the full pit lake is easily discernible. The figure shows areas of shallow groundwater increasing in the Preferred Filling scenario, particularly to the north where the lake level spills out. This effect is more clearly demonstrated in Figure 36, which highlights areas where the modelled water table is at ground surface (referred to as areas of “shallow water table” in the figure). The figure shows an increase in the area of shallow water table to the northeast (under the Preferred Filling scenario), including parts of Latrobe Road that is located along the northeast edge of the pit lake. The figure also shows wider extents of shallow water table along the Latrobe River under the Preferred Filling scenario, due to the higher water table resulting from the overtopping of the lake.

It is important to note that Figure 35 and Figure 36 have been generated by resampling the LIDAR and modelled water table using a 10 m grid. Because the water table is derived from a model with a much coarser grid, it does not account for the effects of subtle variabilities in topography that exist in the high resolution LIDAR dataset. Near surface controls on the water table (such as soil evaporation and capillary effects) are also simplified in the groundwater model, which means the areas of shallow water table presented in Figure 36 could be overestimated or may not, in reality, lead to surface expressions of groundwater (such as water logging). The model also simulates a broad area of shallow water table to the northeast of the mine under the Base Case, indicating the potential for a very shallow water table to already exist in this area in the absence of a full pit lake. Although there are no bores in this area to verify the model outputs, the presence of a shallow water table is considered plausible under the existing condition due to the sharp break in topography and low-lying nature of the Latrobe River floodplain. It is possible that the slightly wider extent of the shallow water table predicted under the Preferred Filling scenario is more representative of the natural hydrogeological condition of the floodplain, before it was locally drained by the mine void. While further monitoring and investigations would be necessary to improve the understanding of shallow groundwater dynamics in this area, some engineering controls (such as drainage structures) may become necessary in the future to constrain the water table along Latrobe Road.

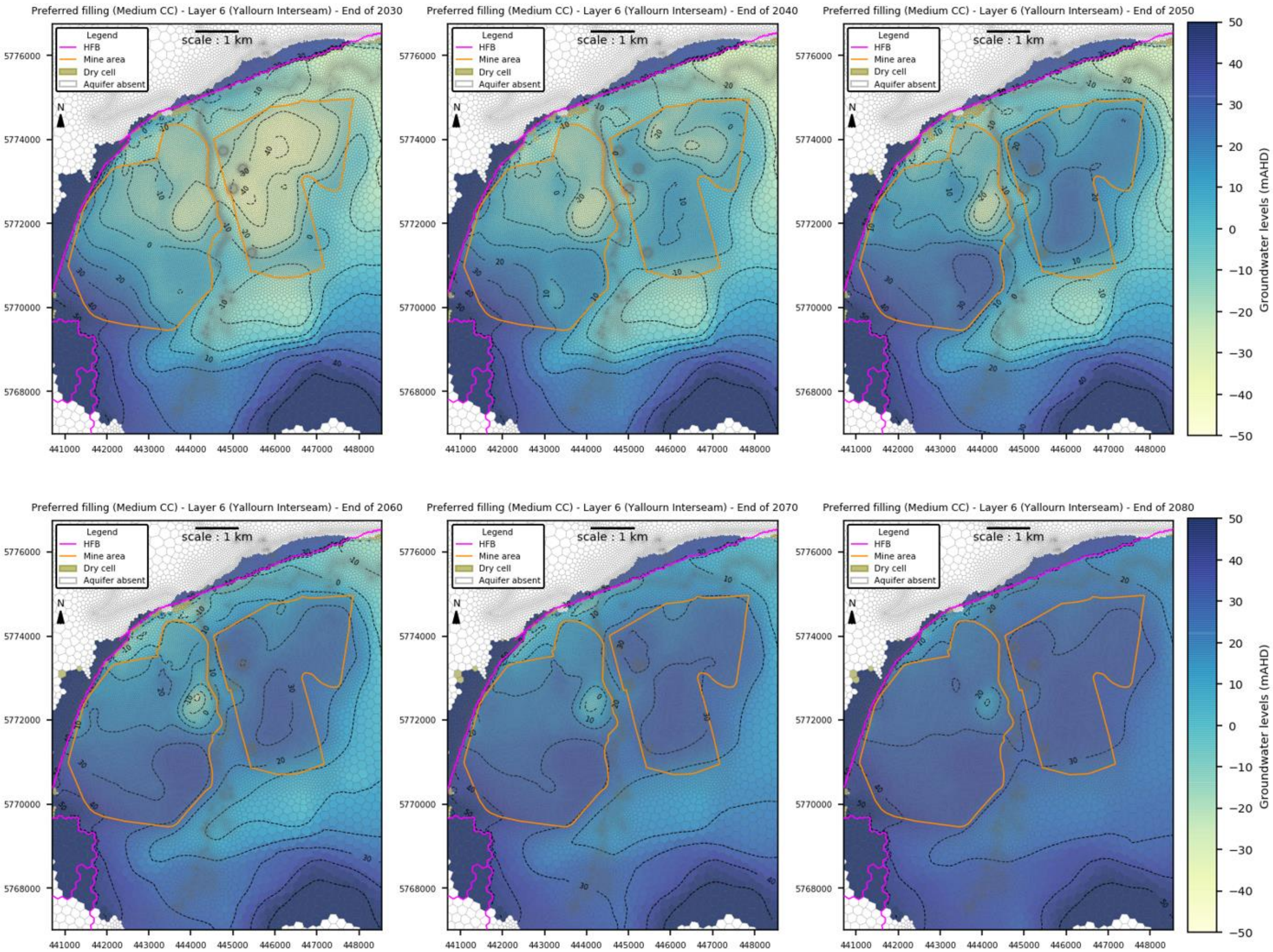


Figure 30 ***Preferred Filling Yallourn Interseam groundwater level contours***

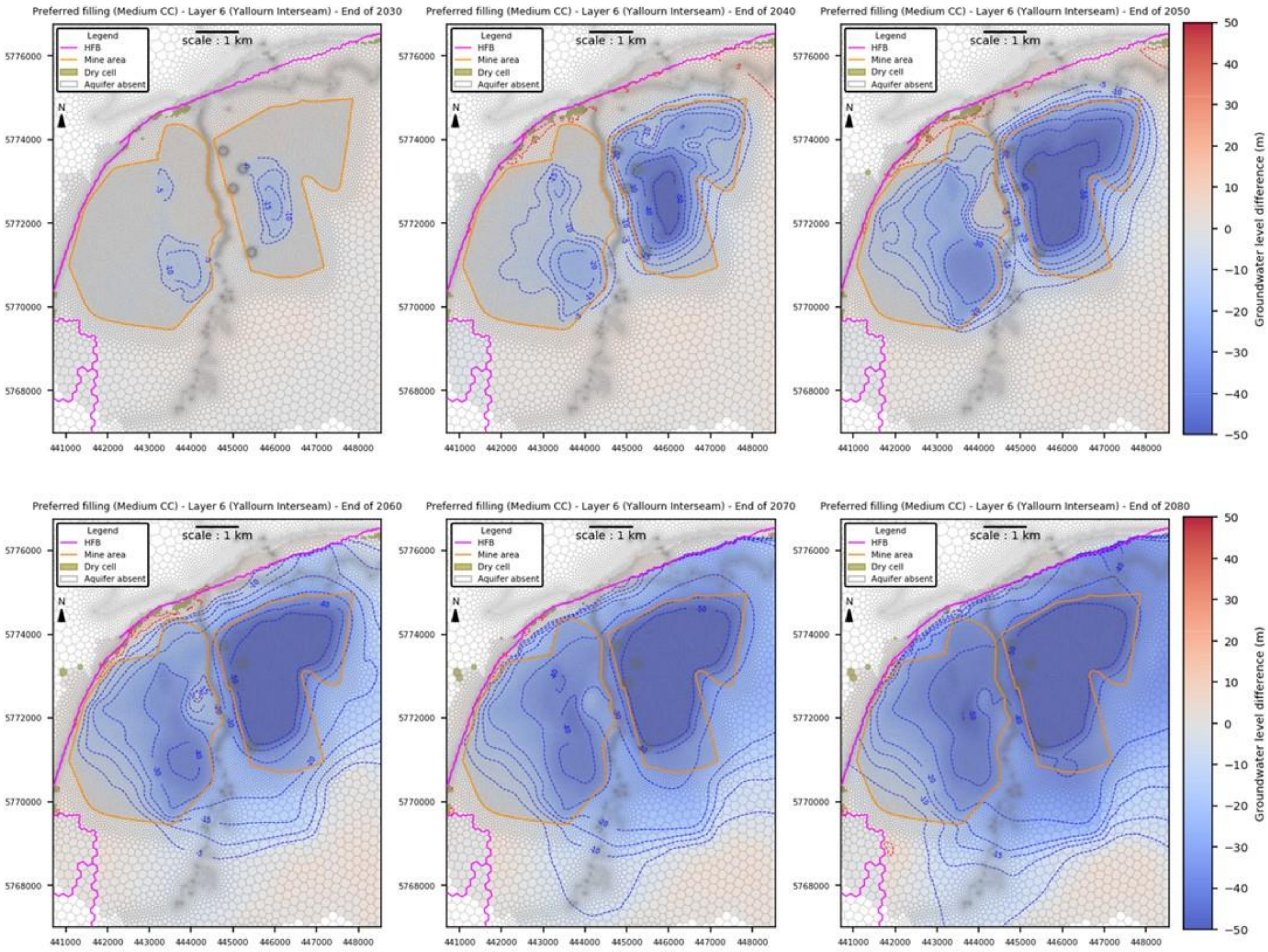


Figure 31 *Preferred Filling Yallourn Interseam groundwater level difference contours*

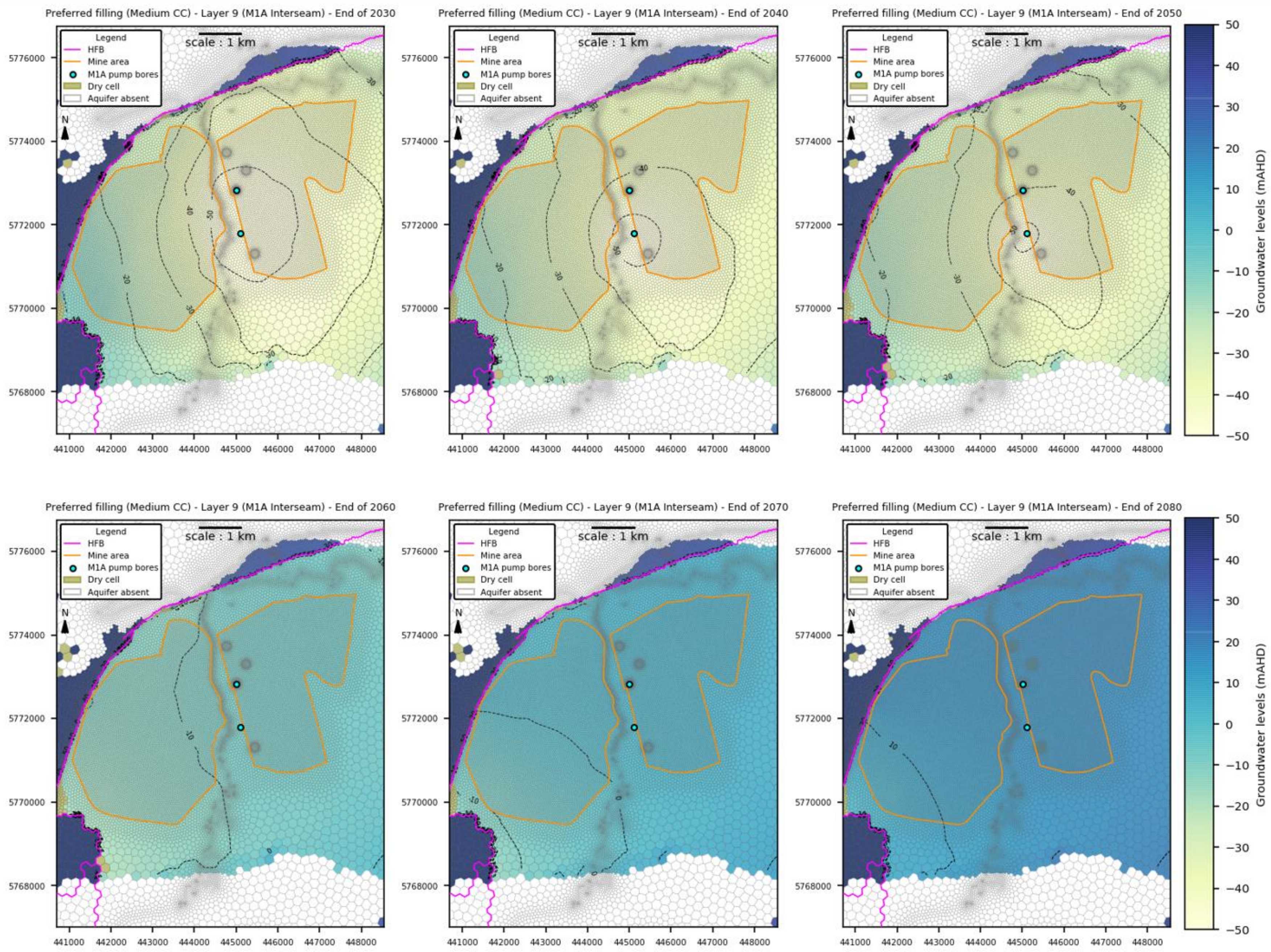


Figure 32 ***Preferred Filling M1A Interseam groundwater level contours***

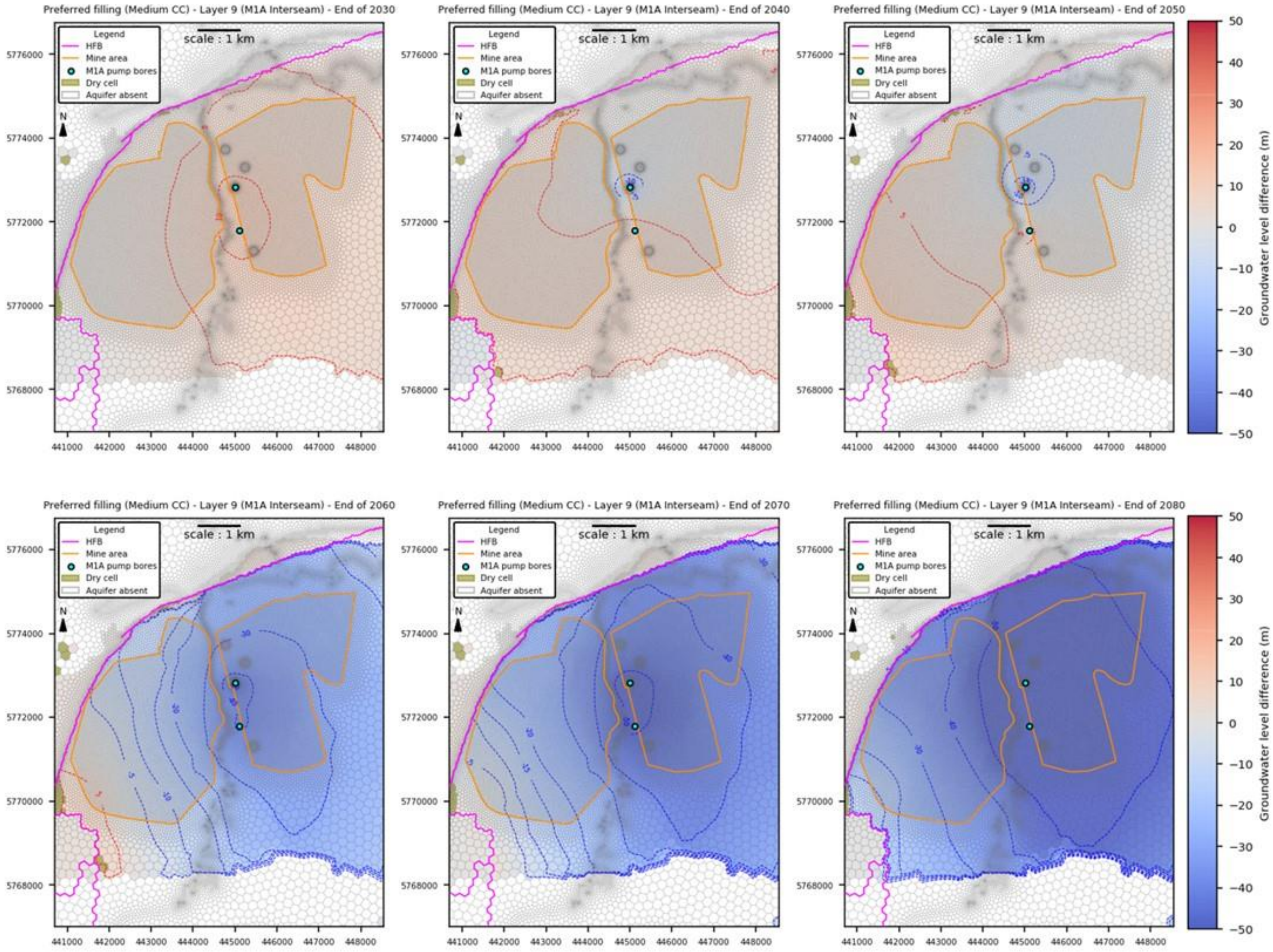


Figure 33 ***Preferred Filling M1A Interseam groundwater level difference contours***

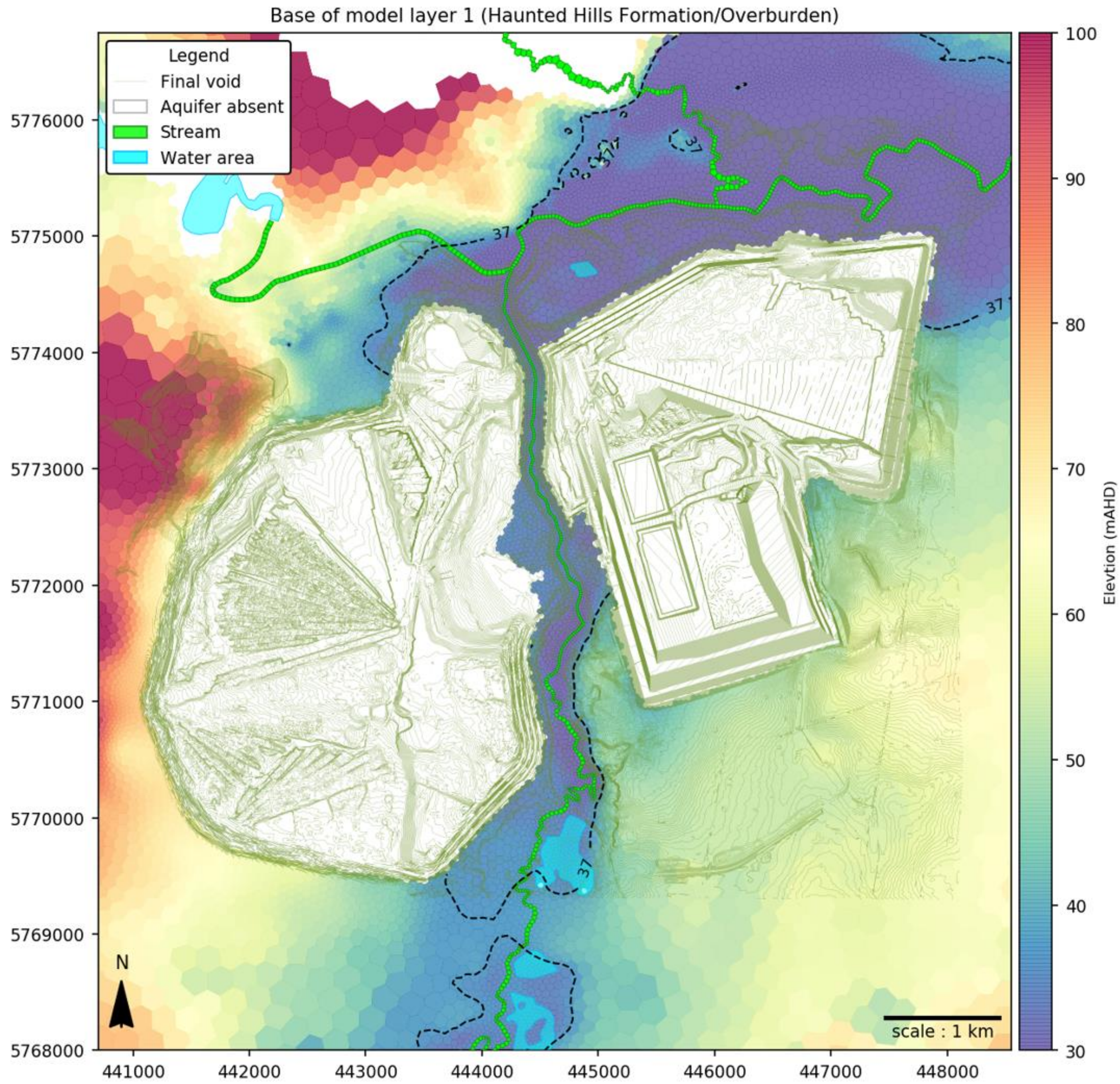


Figure 34 ***Haunted Hills Formation bottom and RL 37 mAHD contour***

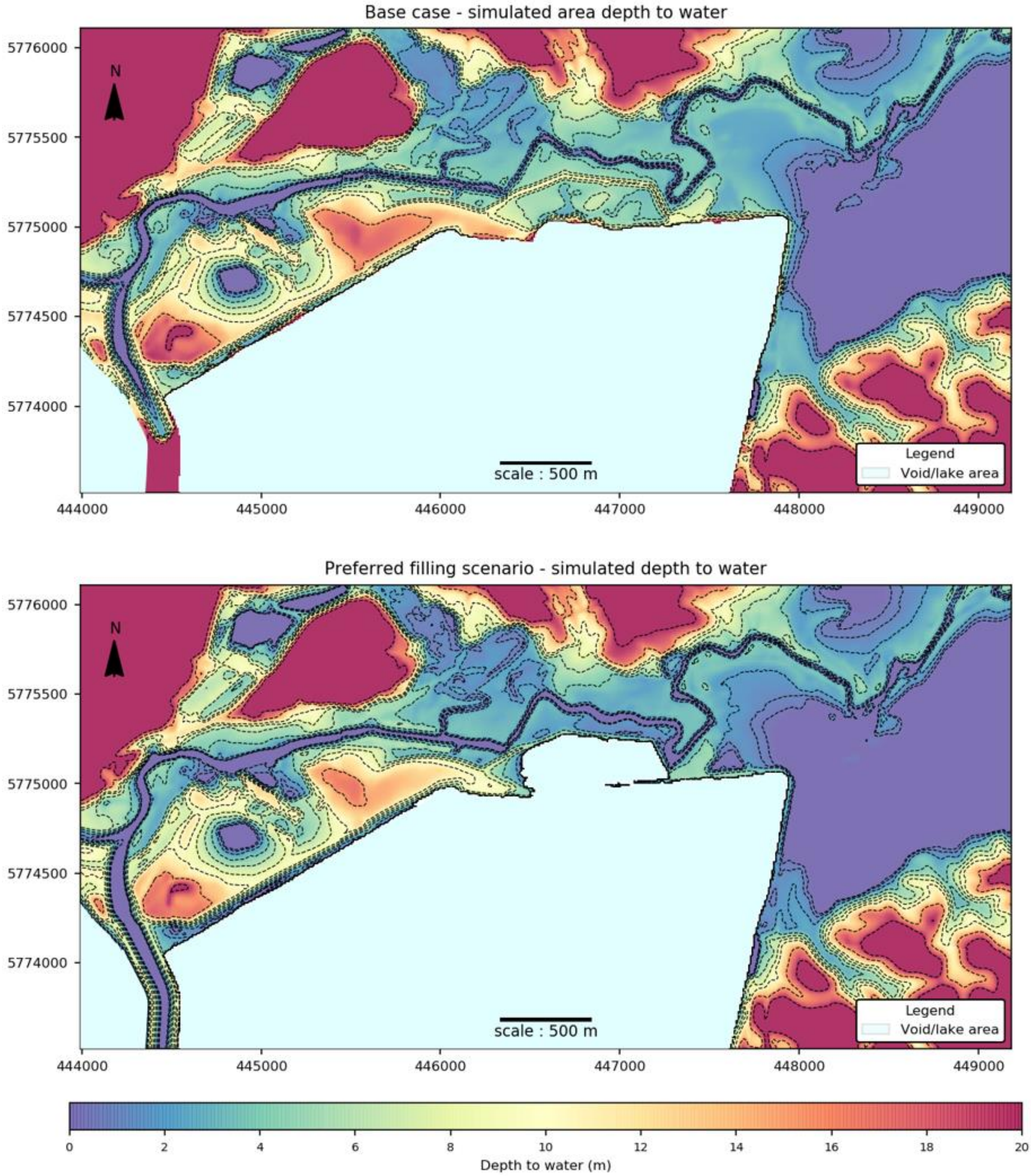


Figure 35 Simulated depth to groundwater – Base Case and Preferred Filling scenario

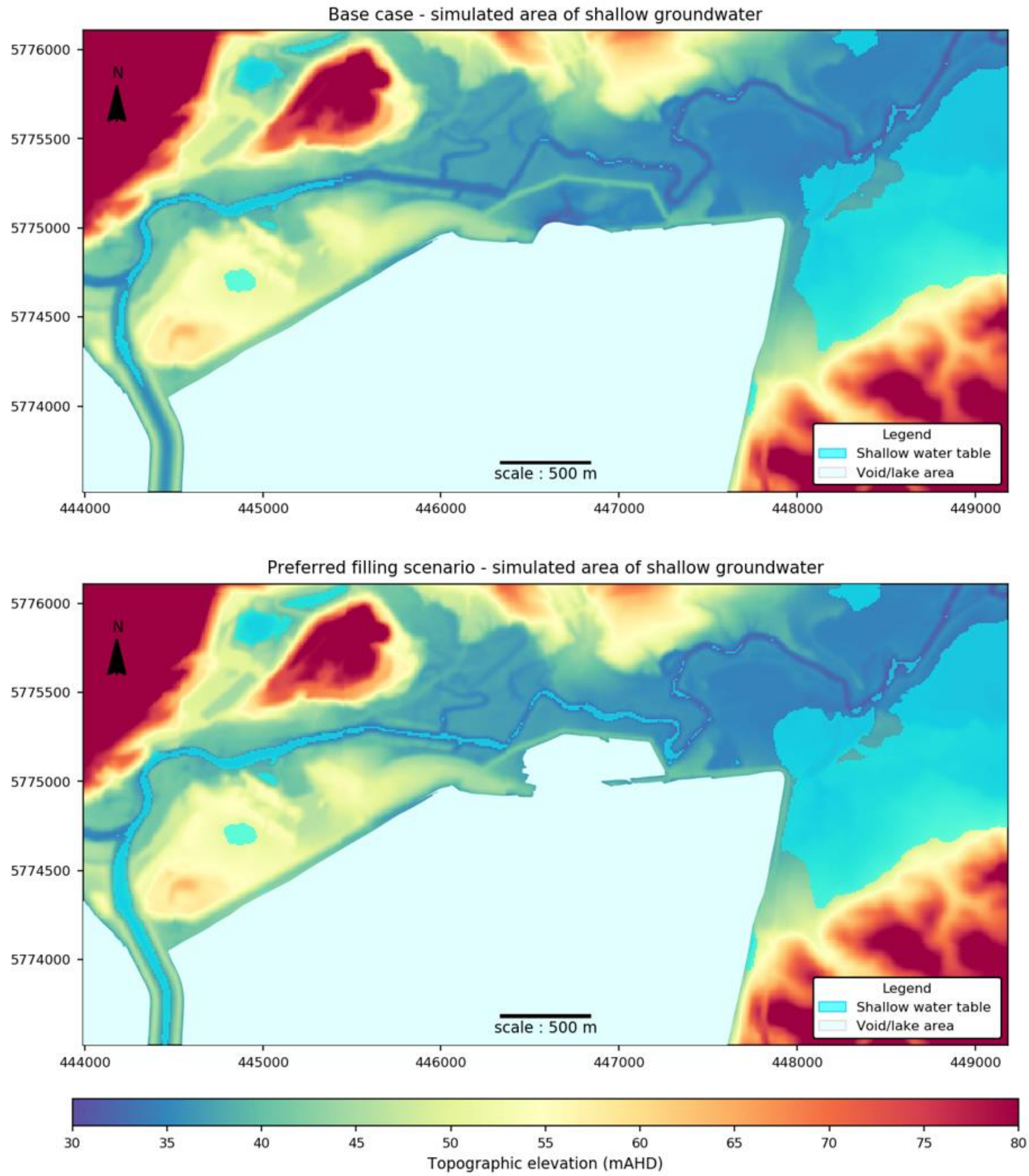


Figure 36 Simulated shallow groundwater areas – Base Case and Preferred Filling scenario

4.3.3 Lake-aquifer flux charts

Charts of fluxes exchanged between the pit lake and adjacent aquifers for the Preferred Filling scenario are plotted for the YTF lake in Figure 37 and YEF lake in Figure 38, using the outputs from the LAK package.

Compared to the Base Case, the higher lake stage and the faster rate of filling of the Preferred Filling scenario result in much larger fluxes of lake water entering the groundwater system primarily via the Yallourn Coal and Yallourn Interseam. The leakage of lake water into the Haunted Hills Formation occurs from around 2049 in the YTF lake and slightly earlier in the YEF (from 2048) as the lake stage rises above the base of the Haunted Hills Formation exposed in the mine batters. The leakage of lake water begins to reduce once the full pit lake is formed in 2052 and the groundwater levels begin to recover following the cessation of pumping. The leakage of lake water into the Yallourn Coal and Yallourn Interseam eventually reduces to zero as the groundwater levels recover to higher elevations than the final lake stage (RL 37 mAHD). The leakage of lake water into the Haunted Hills Formation remains higher in the YEF lake compared to the YTF, particularly along the northern batters.

Seepage of groundwater into the lakes occurs primarily from the Haunted Hills Formation and the Yallourn Coal. The Yallourn Coal seepage decreases during filling, as the lake stage rises, and slightly recovers post-rehabilitation as the lake stage stabilises and the groundwater level becomes higher (topped up by recharge from above). Groundwater seepage from the Yallourn Interseam is predicted to be minor, reducing to zero by 2040 and increasing from around 2095 when the Yallourn Interseam groundwater level begins to exceed the lake stage.

Table 4 provides a summary of fluxes computed by the LAK package for the Preferred Filling scenario. Also included in the table are the leakage rates from the RIV cells used to simulate the overtopping of the lake adjacent to the YEF northern batters. These fluxes are larger than the fluxes into the Haunted Hills Formation computed by the LAK package, which is expected as the RIV cells represent flooding and full saturation of the Haunted Hills Formation over a large area (in contrast, the LAK fluxes are limited to partially saturated Haunted Hills Formation exposed along the mine perimeter, where the cell bottom is below the final lake stage)[1].

Table 4 Preferred Filling scenario lake-aquifer flux summary

HSU	YTF (West)			YEF (East)		
	Min (m^3/d)	Max (m^3/d)	Average (m^3/d)	Min (m^3/d)	Max (m^3/d)	Average (m^3/d)
Groundwater fluxes						
HHF	926.67	4756.54	1730.04	1164.3	5077.68	2120.77
Y.Coal	22.93	928.11	170.31	18.6	927.57	116.63
Y.Interseam	0	9.21	1.88	0	17.83	1.58
Lake fluxes						
HHF	0	40.74	9.47	0	394.55	143.77
Y.Coal	0	767.63	235.33	0	1307.45	241.52
Y.Interseam	0	75.41	28.28	0	69.08	23.8
River fluxes						
HHF	0	0	0	74.74	2135.68	1104.95
Y.Coal	0	0	0	0	0	0
Y.Interseam	0	0	0	0	0	0

[1] If the RIV cells were removed, the LAK fluxes would increase because the difference between the head in the adjacent aquifer cells and lake stage in the LAK cells would be greater without the RIV cells to top up the water table; however, the fluxes would be limited across the perimeter of the mine void, which would underestimate the flux from the flooding of the cells over a larger area, which is better simulated using the RIV cells.

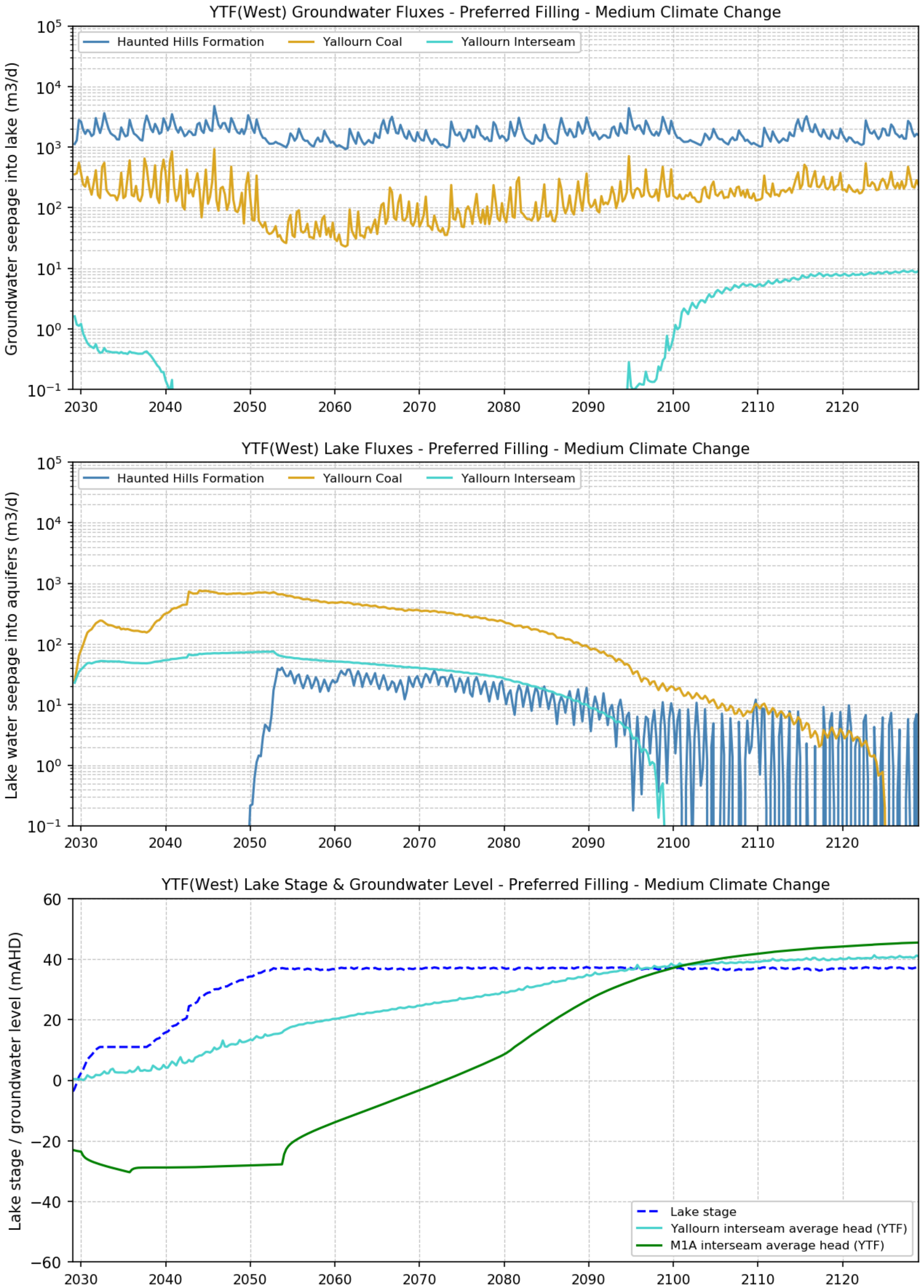


Figure 37 *Preferred Filling scenario lake – groundwater fluxes for YTF*

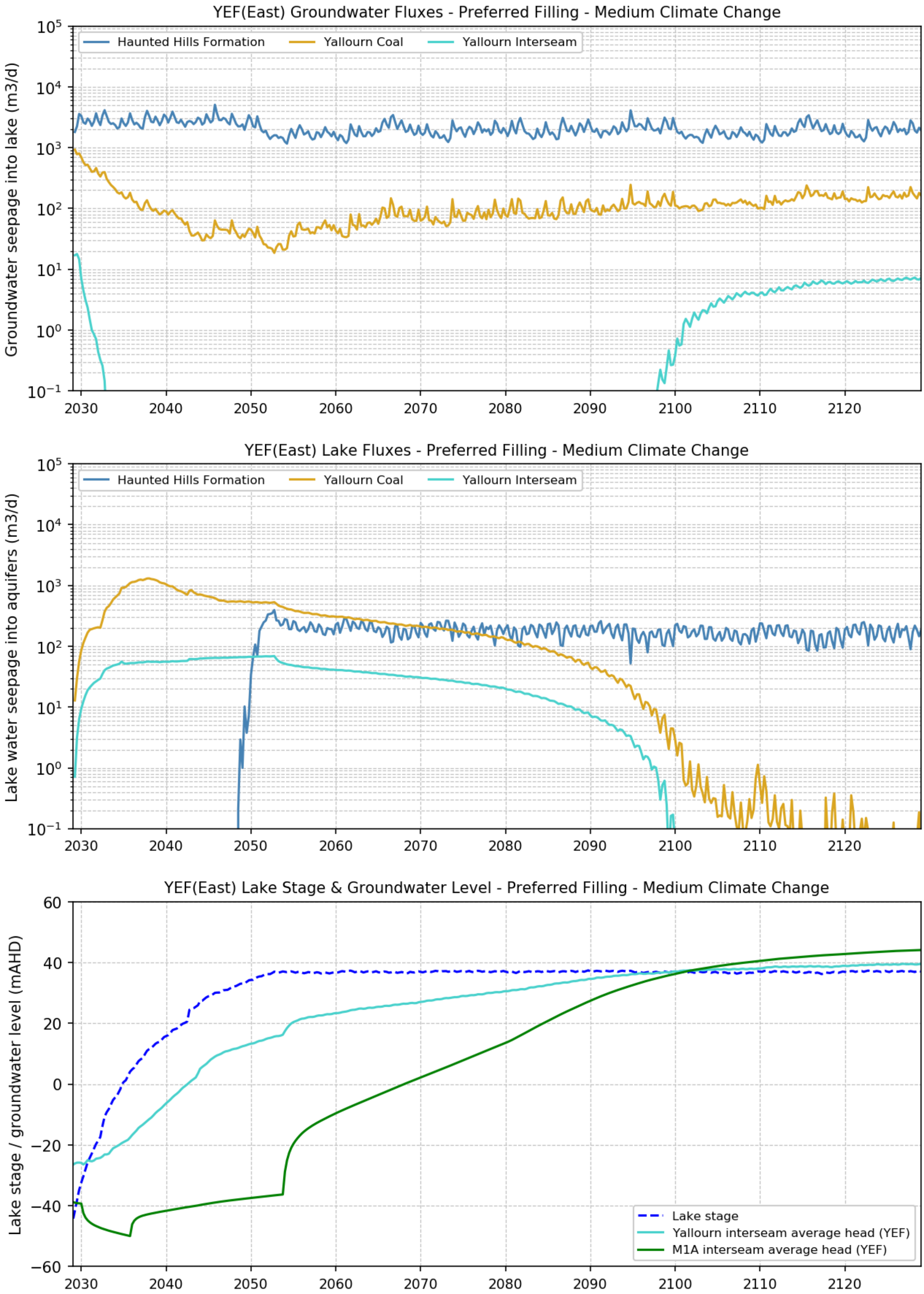


Figure 38 ***Preferred Filling scenario lake – groundwater fluxes for YEF***

4.3.4 Lake-aquifer flux maps

The LAK-aquifer flux maps for the Preferred Filling scenario are included in Figure 39 and Figure 40. The main difference compared to the flux maps of the Base Case can be seen in the larger extent and magnitude of positive fluxes (as shown in Figure 39) resulting from the higher lake stage and faster rate of filling (indicating a net increase in the area and magnitude of lake water leakage). Once the full pit lake is formed and groundwater pumping is ceased, the recovery of groundwater levels results in the lake leakage reducing over time until the pit lake ultimately becomes a net groundwater sink. This is demonstrated in Figure 40 (for 2090 to 2110 average), showing a larger area of small negative fluxes as the pit lake tends towards a predominantly gaining condition when the groundwater levels begin to exceed the lake stage. The change in fluxes computed along the perimeter of the pit lake (from the Haunted Hills Formation) can also be seen in these maps, along the YEF northern batters where the direction of fluxes changes from predominantly gaining (negative fluxes, as shown in Figure 39) to losing (positive fluxes, as shown in Figure 40) as the lake stage reaches RL 37 mAHD and the Haunted Hills Formation becomes re-saturated.

The LAK-aquifer flux maps are generated from the fluxes computed by the LAK package. The additional component of fluxes arising from the over-topping of the lake is derived using RIV cells. Figure 41 is an example of a flux map that combines the fluxes calculated from the LAK and RIV cells, focusing on the area north of the YEF northern batters. The flooding of the Haunted Hills Formation is simulated to result in larger fluxes than those occurring along the floor of the lake due to the higher hydraulic conductivity of this aquifer (compared to the Yallourn Coal) and the proximity to the Latrobe River that acts as a local point of discharge (maintaining the hydraulic gradient towards the river, facilitating more flow out from the RIV cells).

4.3.5 Inter-aquifer fluxes

Charts of inter-aquifer fluxes for the Preferred Filling scenario are included in Appendix A. As per the Base Case most of the vertical flux entering the top of the Yallourn Interseam passes through this unit and enters the M1A Coal below, due to the downward vertical hydraulic gradient created by the rising lake stage and pumping in the M1A Interseam. The vertical flux leaving from the bottom of the Yallourn Interseam is very slightly less than the vertical flux entering from the top due to a small component flow captured by the aquifer storage or lost via horizontal flow. Similar to the Base Case, most of the vertical flux entering the M1A Interseam is captured by pumping during filling, resulting in very little vertical flux leaving from the bottom of this unit.

After the filling is completed and pumping is ceased in 2052, the groundwater levels begin to recover and the downward vertical fluxes become progressively smaller due to the reduced rate of leakage from the pit lake. By year 2100, there is a net upward vertical flux as the groundwater levels begin rise above the final lake stage, consistent with the pit lake becoming a long term groundwater sink. The rate of upward vertical flux is small compared to the rate of fluxes during the filling stage, due to the small hydraulic gradient developed between the pit lake and the aquifer units.

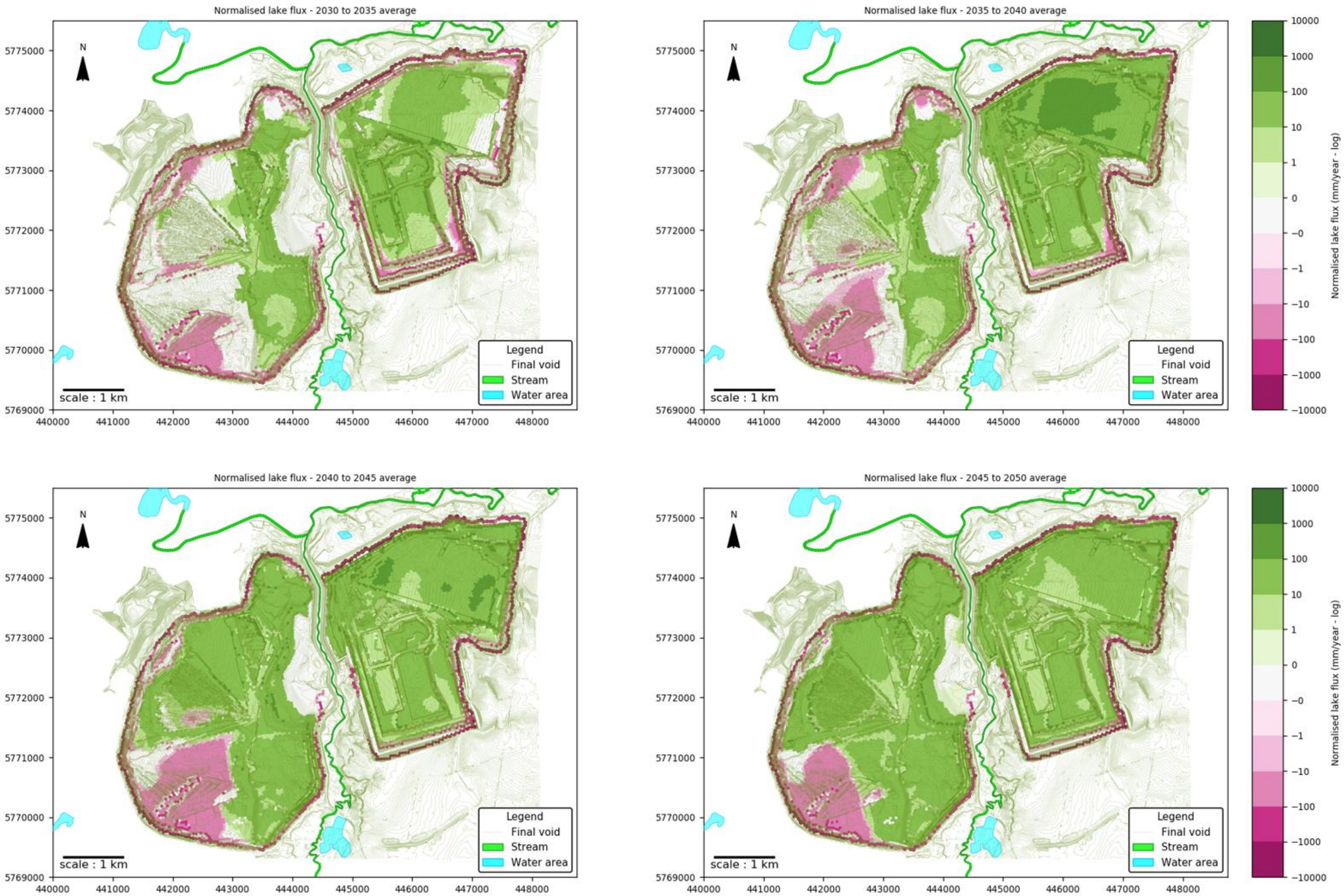


Figure 39 ***Preferred Filling lake-aquifer flux map – 2030 to 2050***

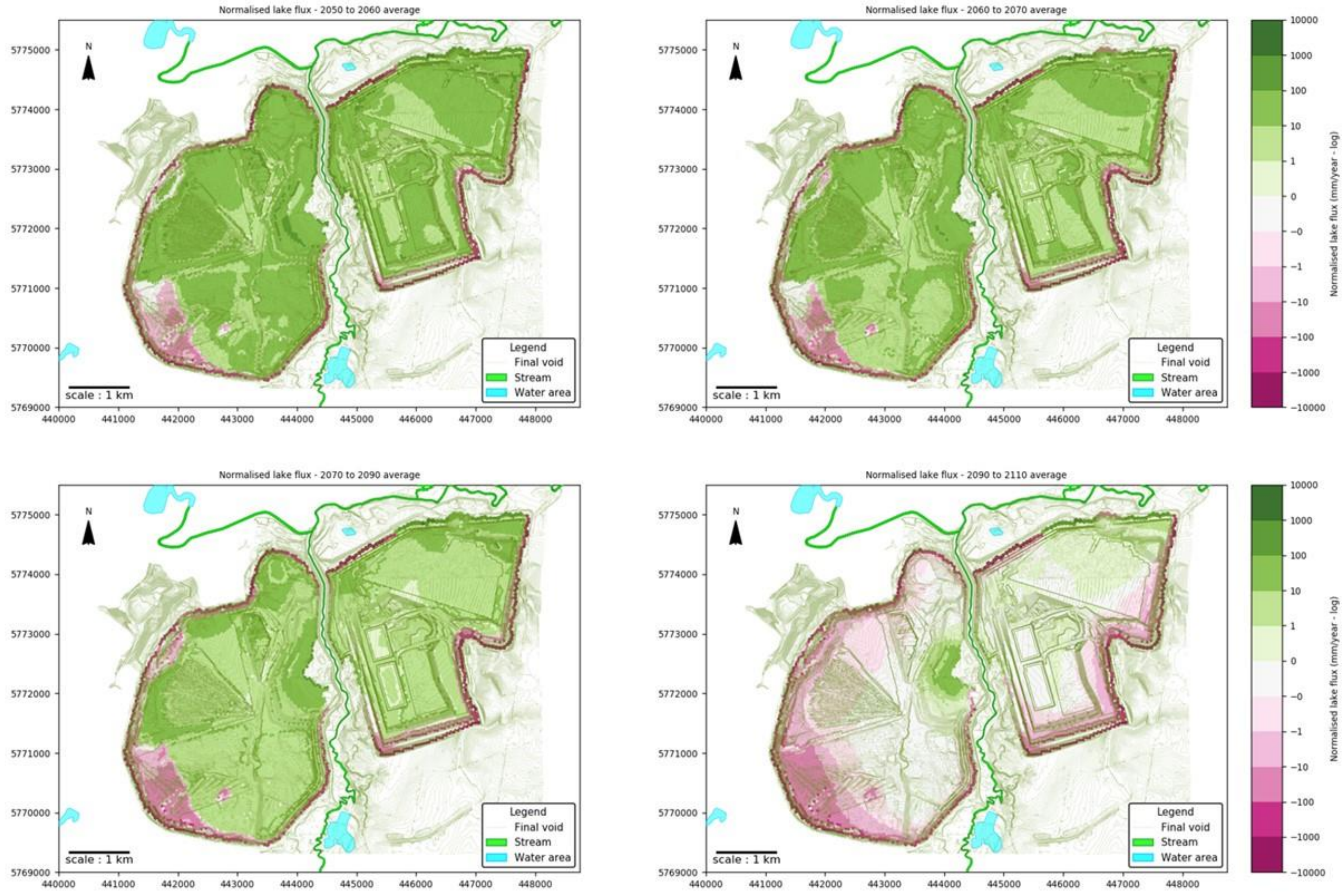


Figure 40 *Preferred Filling lake-aquifer flux map – 2050 to 2110*

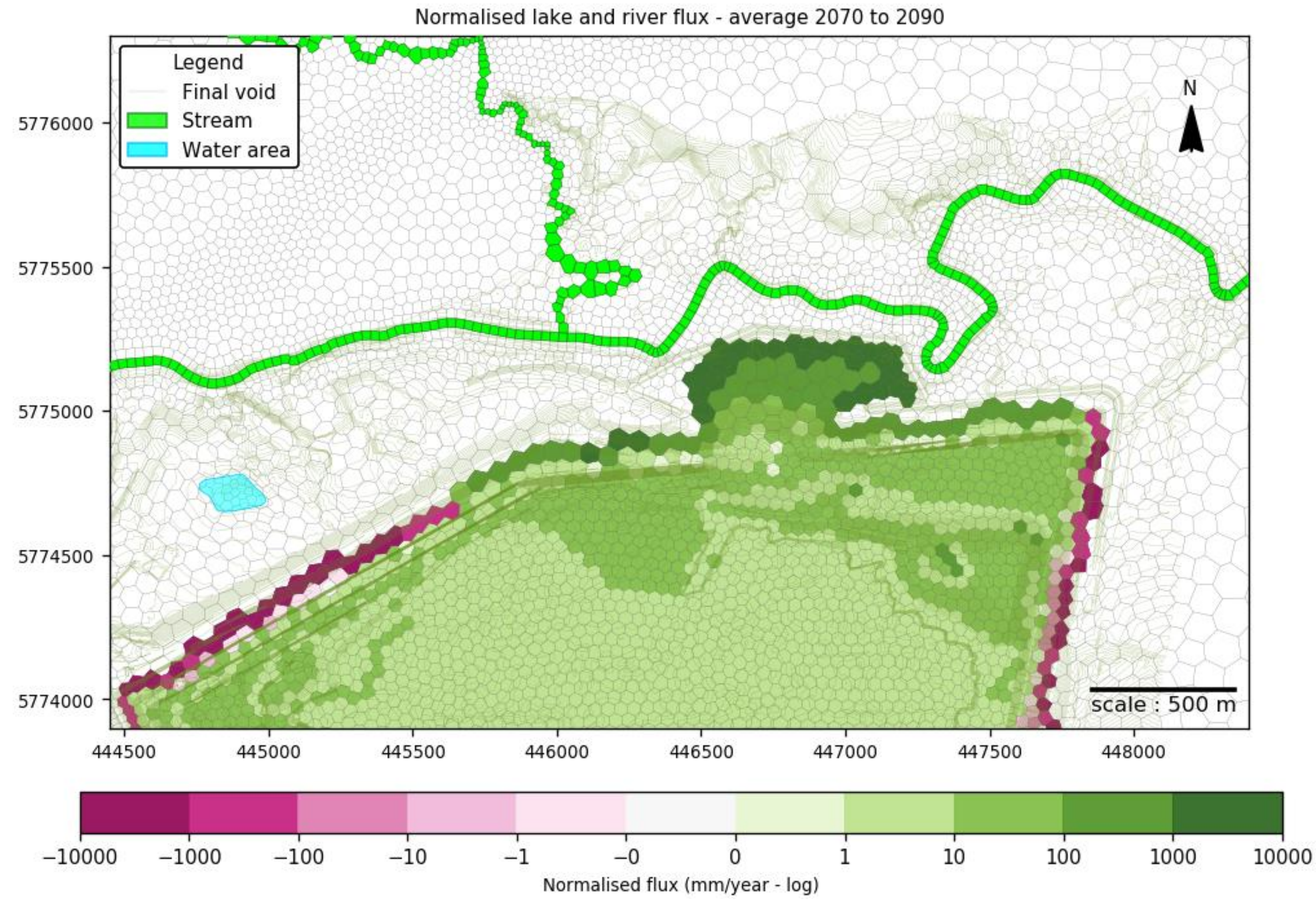


Figure 41 Combined RIV and LAK flux plot

4.3.6 Water balance

Table 5 below summarises the cumulative water balance and average volumetric fluxes for the Preferred Filling scenario. Compared to the Base Case, the inflow from the lake boundary condition is more than double while the outflow has been slightly reduced (due to the higher lake stage). Small differences in flows also occur in other boundary conditions due to the changes in groundwater levels e.g. stream leakage (inflow) is slightly reduced and baseflow (outflow) is slightly increased due to the higher shallow groundwater levels caused by the presence of the full pit lake. Inflow from recharge is slightly lower due to the larger area of lake surface (leading to less direct recharge to the exposed mine floor) and outflow from evapotranspiration is slightly higher due to the shallower water table.

Table 5 Preferred Filling scenario modelled water balance

Component	Transient cumulative (ML)		Transient average rate (ML/d)	
	In	Out	In	Out
Recharge	4,531,850	0	121	0
Evapotranspiration	0	4,269,857	0	123
Drain	0	382,250	0	11
Well	0	75,889	0	2.1
River	855,844	388,722	23	11
Stream	82,810	1,117,405	2.3	31
Lake	24,976	150,916	0.7	4.1
GHB	2,109,030	781,295	58	22
Storage	3,709,692	4,147,828	111	114
Total	**11,314,203**	**11,314,163**	**317**	**317**

As per the Base Case, the cumulative mass balance error as well as the maximum mass balance error for any given time step for the entire rehabilitation simulation period is less than 0.001 %, well below the 1 % threshold recommended by the Australian Groundwater Modelling Guidelines.

5. Conclusions

5.1 Summary of key findings

Numerical groundwater flow modelling has been undertaken to quantify the effects of the proposed Yallourn Mine rehabilitation on groundwater, specifically on groundwater levels, quantity and interactions with features such as the pit lake. Two rehabilitation scenarios have been modelled, which include the Base Case, representing the continuation (maintenance) of the final void, and the Preferred Filling scenario that utilises an external water source and flood flows to form a full pit lake (lake stage of RL 37 mAHD). A deterministic sequence of future climate has been generated from the historical (post-1975) climate data, with scaling applied to incorporate climate change effects (based on the medium climate change projection). The rehabilitation scenarios are assumed to commence in 2029, with a 100-year simulation period used to quantify the long term effects on groundwater during and after rehabilitation.

Lake stage and filling

The modelling indicates the retention of water derived from rainfall, runoff and groundwater (included pumped groundwater to maintain ground stability) would lead to water levels in the two mine voids increasing over time. Without the external water source, however, the full pit lake does not form within the 100-year simulation period and the lake stage stabilises at around RL 11 mAHD in the Yallourn Township Field (YTF) lake (corresponding to the elevation of the conveyor tunnels) and around RL 0 mAHD in the Yallourn East Field (YEF) lake. When the external source of water is used for filling, supplemented by flood volumes from the Morwell River, the lake stage is predicted to rise more rapidly, reaching the final lake stage of RL 37 mAHD in 2052. This difference is primarily due to the volume of the external water source used for filling (25 GL/year), which is much larger than the volume of water available from rainfall, runoff and groundwater.

Groundwater levels and inter-aquifer fluxes in confined aquifers

The groundwater levels in the Yallourn Interseam are predicted to rise with the lake stage due to the proximity of this aquifer to the mine floor (locally exposed in the mine floor, leading to hydraulic connections with the pit lake). However, the groundwater levels remain below the lake stage due to the downward vertical hydraulic gradient created by the effects of groundwater pumping from the deeper M1A Interseam. This means there would be a net downward vertical flux during filling, from the pit lake to the Yallourn Interseam and into the M1A Interseam below where most of the flux is ultimately captured by the pumping bores (resulting in very little vertical flux leaving the bottom of the M1A Interseam). This effect can also be seen in the groundwater level contours simulated in the M1A Interseam, which shows a cone of depression in the piezometric surface centred on the pumping bores, representing a large capture zone for any vertical flux that ultimately enters this deep aquifer. As the groundwater levels in the M1A Interseam are maintained low by pumping, the vertical hydraulic gradient between the Yallourn Interseam and M1A Interseam increases with the rising lake stage, leading to greater downward vertical fluxes over time.

The groundwater level changes in the Yallourn Interseam are predicted to vary spatially, depending on the connectivity with the pit lake. The largest increase is predicted to occur in the deepest parts of the mine, where the top of the Yallourn Interseam is close to or exposed in the mine floor (and where there is little intervening coal to create resistance to flow from the pit lake). Away from the mine void, the groundwater level is predicted to decline where the downward leakage from groundwater pumping in the M1A Interseam is greater than the fluxes gained from the pit lake. This effect is most pronounced for the Base Case, due to the lower lake stage and the slower rate of rise compared to the Preferred Filling scenario (resulting in less leakage of lake water).

The recovery of groundwater levels in the M1A Interseam occurs when the pumping is reduced or ceased. For the Base Case, the reduction in the pumping rate is assumed when the lake stage in the YEF lake reaches RL 0 mAHD in 2087 and one of the two pumping bores is decommissioned, resulting in a small recovery. For the Preferred Filling scenario, the same reduction occurs earlier in 2034 followed by a complete shutdown of pumping in 2052 when the pit lake reaches RL 37 mAHD. This leads to the recovery of groundwater levels in all confined aquifers, including the deep M2 Interseam which is assumed to recover earlier following the rehabilitation of the neighbouring Hazelwood Mine. The groundwater levels in the Yallourn Interseam and the M1A Interseam are predicted to exceed the lake stage by year 2100, around 48 years after the pit lake becomes full. The rate of recovery becomes progressively slower as the hydraulic gradient reduces over time, ultimately resulting in a small net upward vertical hydraulic gradient from the M2 Interseam to the pit lake. This means the full pit lake, formed in the Preferred Filling scenario, becomes a long term groundwater sink to the confined aquifers, with minor seepage of groundwater into the lake predicted due to the very small upward vertical hydraulic gradient.

Shallow groundwater levels in unconfined aquifer

For the Preferred Filling scenario, the final lake stage of RL 37 mAHD results in local re-saturation of the Haunted Hills Formation where the base of this aquifer is below the lake stage and has been previously drained by the presence of the mine void. This includes an area to the north and northeast of the YEF northern batters, where the lake overtops and extends towards the Latrobe River. The modelling indicates the existing areas of shallow water table within the Latrobe River floodplains could become slightly larger after the pit lake is formed, potentially reaching ground surface along parts of Latrobe Road and locally adjacent to the river. It is possible that engineering controls such as drainage structures may become necessary in the future to maintain the water table below the road surface, subject to further monitoring and investigations to ascertain the potential for surface expressions of groundwater to form in these areas.

Lake water balance and groundwater interactions

The predicted fluxes exchanged between the pit lake and aquifers indicate the volume of lake water lost to the groundwater system is much smaller than the volume of groundwater gained by the lake. For the Base Case, the average net leakage rate of lake water is predicted to be around 300 m^3/d compared to around 5,000 m^3/d of groundwater seepage (most of which is originating from the Haunted Hills Formation). For the Preferred Filling scenario, the rate of lake leakage is much larger, averaging around 1,800 m^3/d, with the average groundwater seepage rate reducing to around 4,100 m^3/d. This difference is due to the higher lake stage and the re-saturation of the Haunted Hills Formation once the full pit lake is formed, including overtopping of the lake adjacent to the YEF northern batters that results in flooding and full saturation of the Haunted Hills Formation. The difference between the components of flow into and out of the pit lake indicates a net gaining condition, with an average net inflow of around 4,700 m^3/d (1.72 GL/year) for the Base Case and 2,300 m^3/d (0.8 GL/year) for the Preferred Filling scenario (including leakage from the overtopping of the lake and excluding pumped groundwater, which ranges from 1 to 1.5 GL/year during filling). To put into context, the volume of external water source assumed during filling is 25 GL/year, which is far greater than the contribution from groundwater and represents the most dominant component of the pit lake water balance during filling.

5.2 Recommendations for future work

The rehabilitation scenario modelling has relied on the outputs generated from a model that has been rigorously calibrated (and validated) to data collected up to the end of 2023. As additional data become available, a periodic review and update of the model is recommended to improve model confidence and incorporate necessary changes where gaps/deficiencies have been previously identified in the model. In some cases, localised and high resolution models may become necessary to address specific questions that may arise during the course of rehabilitation planning and implementation, if these cannot be adequately addressed at the scale of the current model.

The modelling results detailed in this report are based on the medium climate change projection and the sensitivity of model outputs to different climate change projections have not been assessed. The PRMS model runs show large differences in the simulated recharge and evapotranspiration rates when the climate inputs are scaled for different climate change conditions, which could influence the model results (particularly in relation to model fluxes and timing such as the rate of recovery of groundwater levels that would be sensitive to long term recharge). The effects of climate change can be quantified by rerunning the two rehabilitation scenarios using the climate inputs for the low and high medium climate change projections (and comparing these results to those of the medium climate change presented in this report).

The IESC uncertainty analysis guideline suggests the confidence level classification of the AGMG should be replaced by more effective uncertainty analysis techniques. These range in complexity from simple deterministic analysis to more sophisticated ensemble (non-linear) analysis. The automated PEST based calibration workflow developed as part of the calibration stage of the modelling (as documented in GHD, 2025) can be readily extended to accommodate predictive uncertainty analysis of rehabilitation scenarios, using a suite of PEST utilities that facilitate rigorous quantification of model uncertainty. The uncertainty analysis is recommended as part of future studies, subject to the findings from ongoing data collection, monitoring and model verification/updates.

6. References

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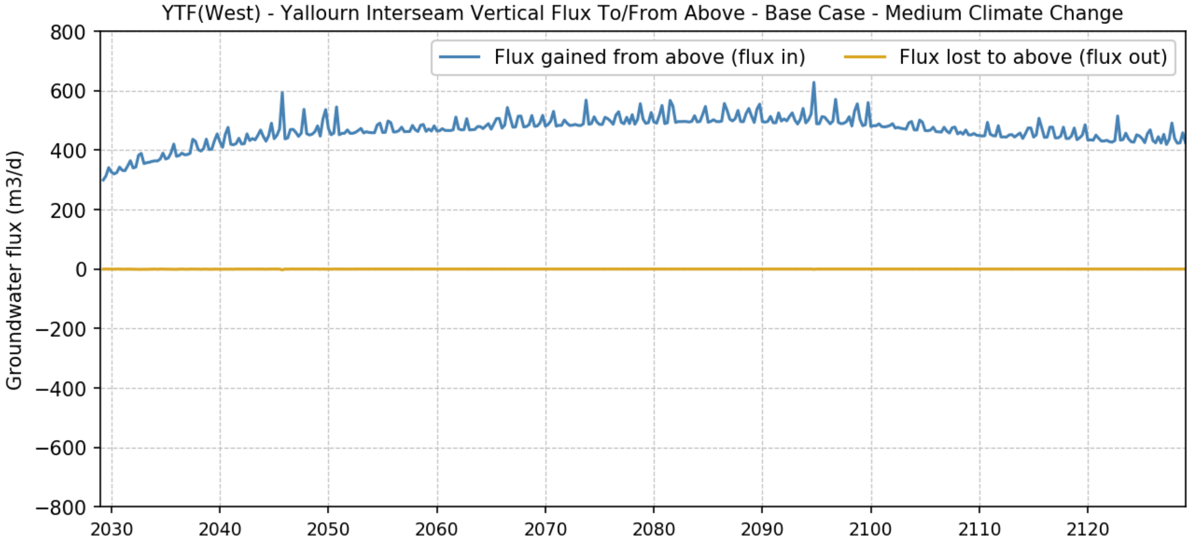
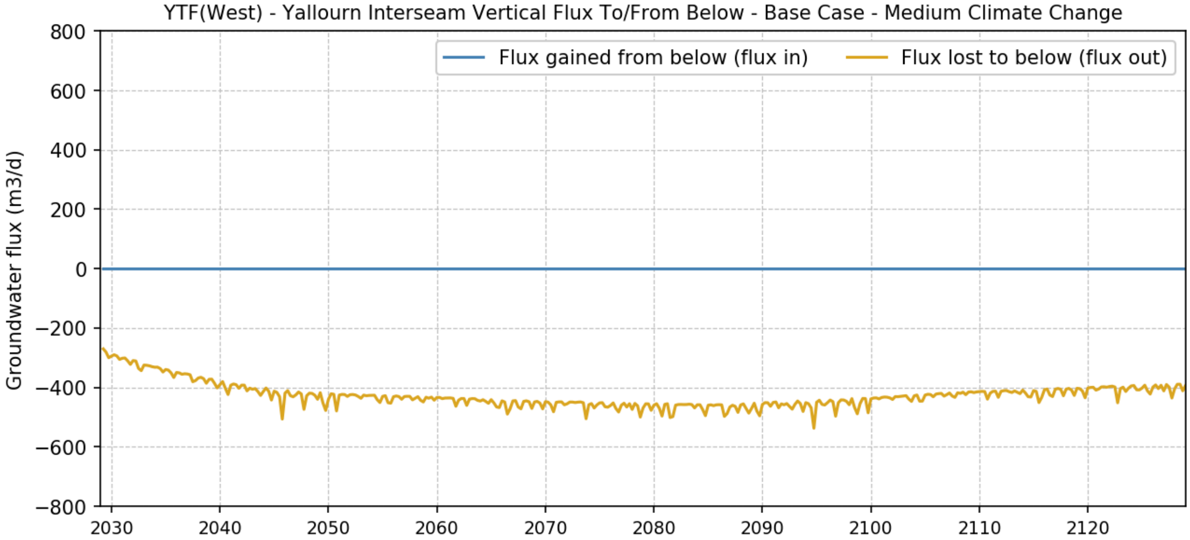
Appendices

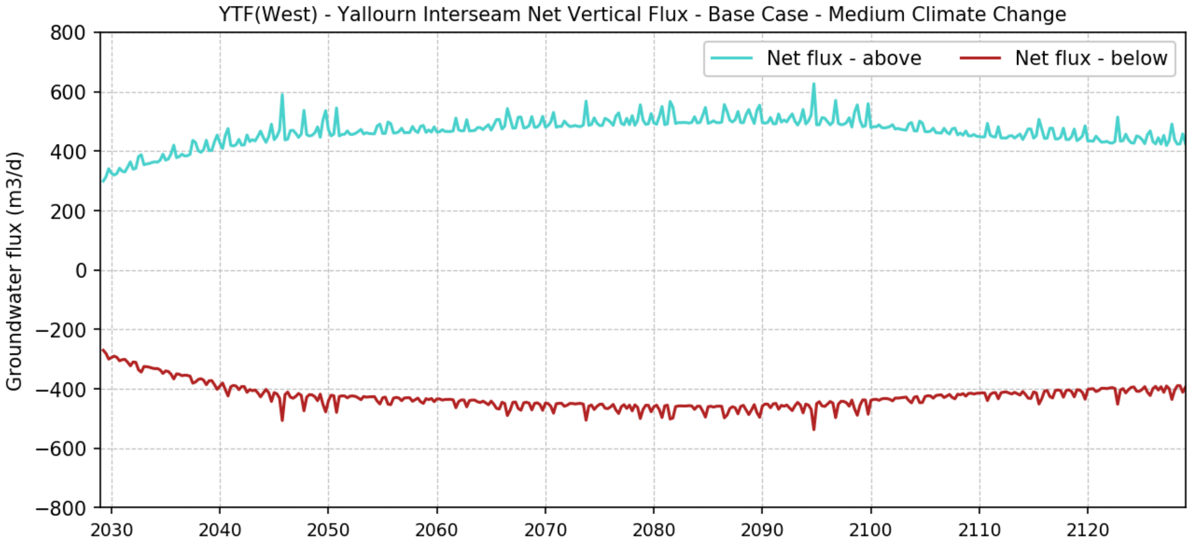
Appendix A

Inter-aquifer Flux Plots

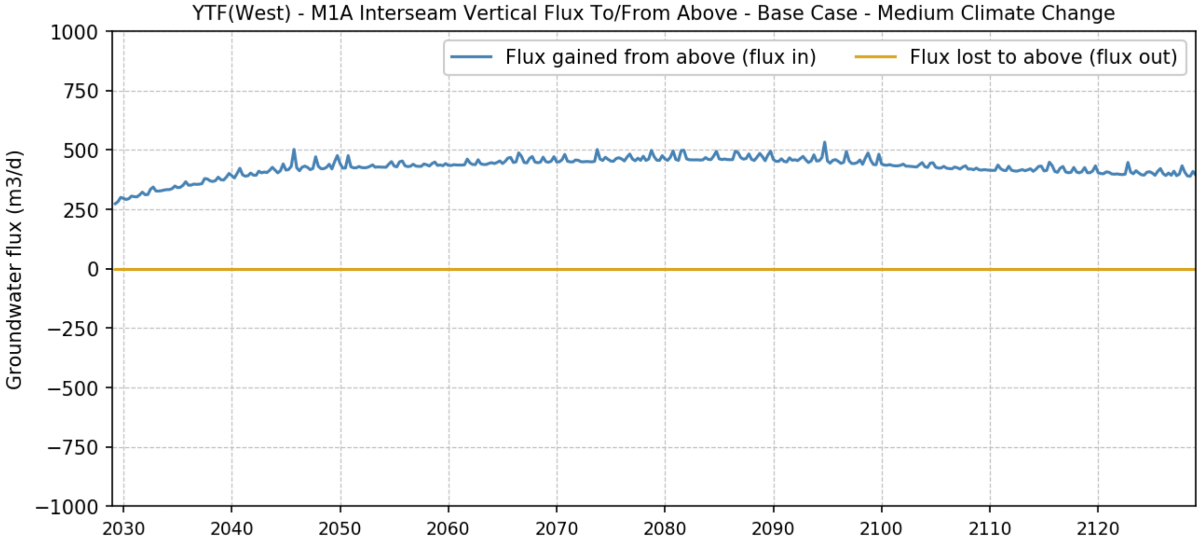
Base Case Yallourn Interseam vertical fluxes – YTF (West)

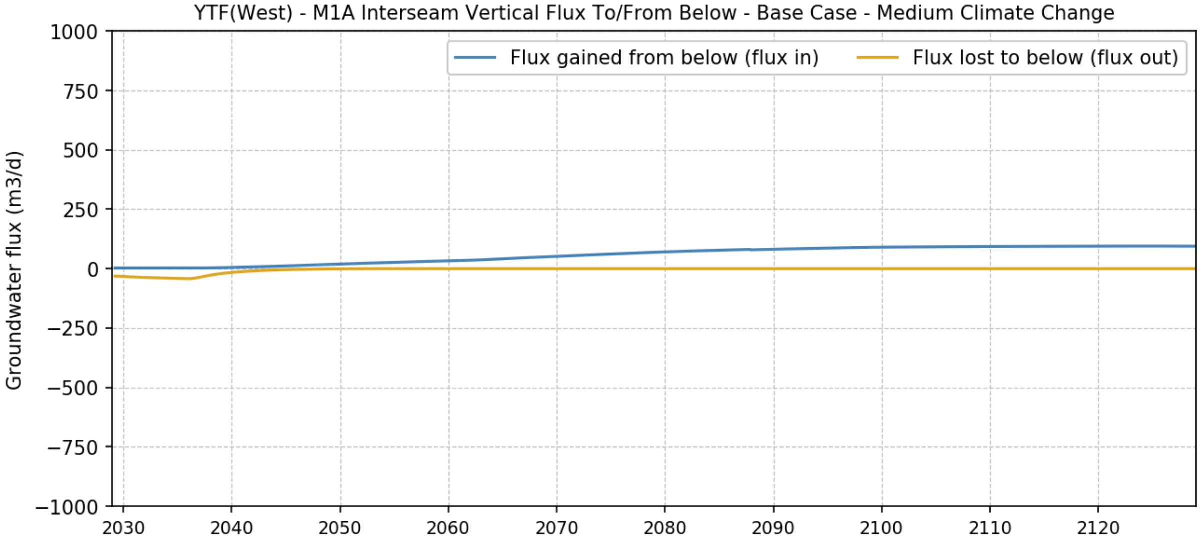


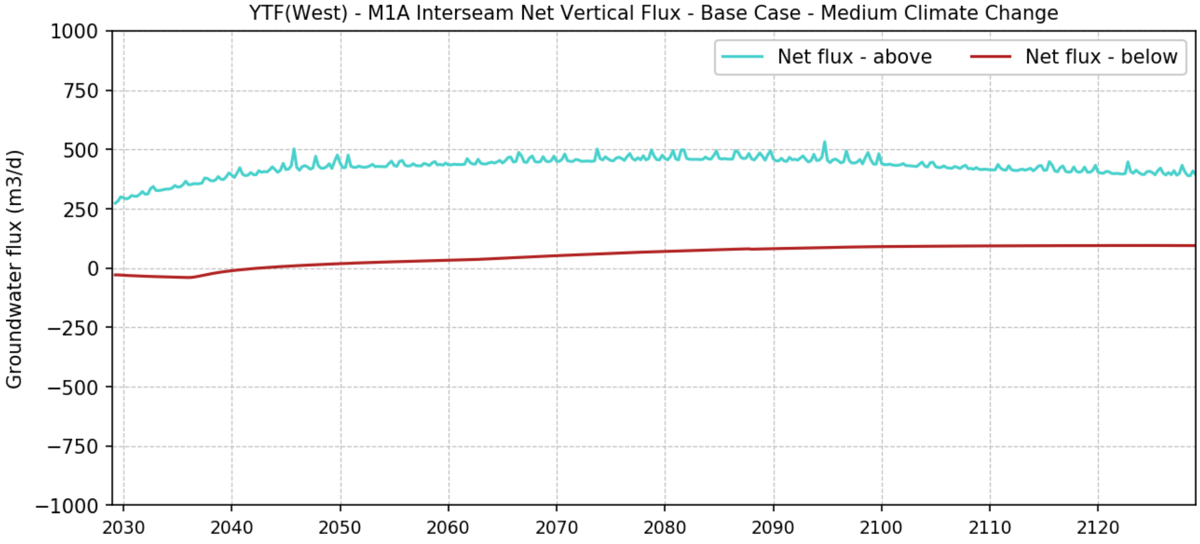




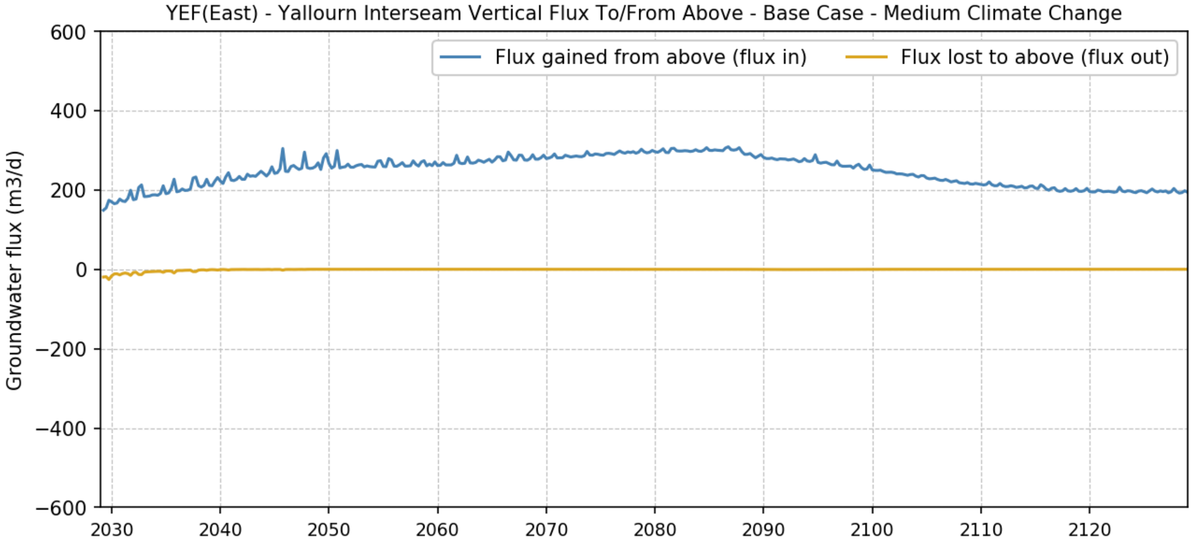
Base Case M1A Interseam vertical fluxes – YTF (West)

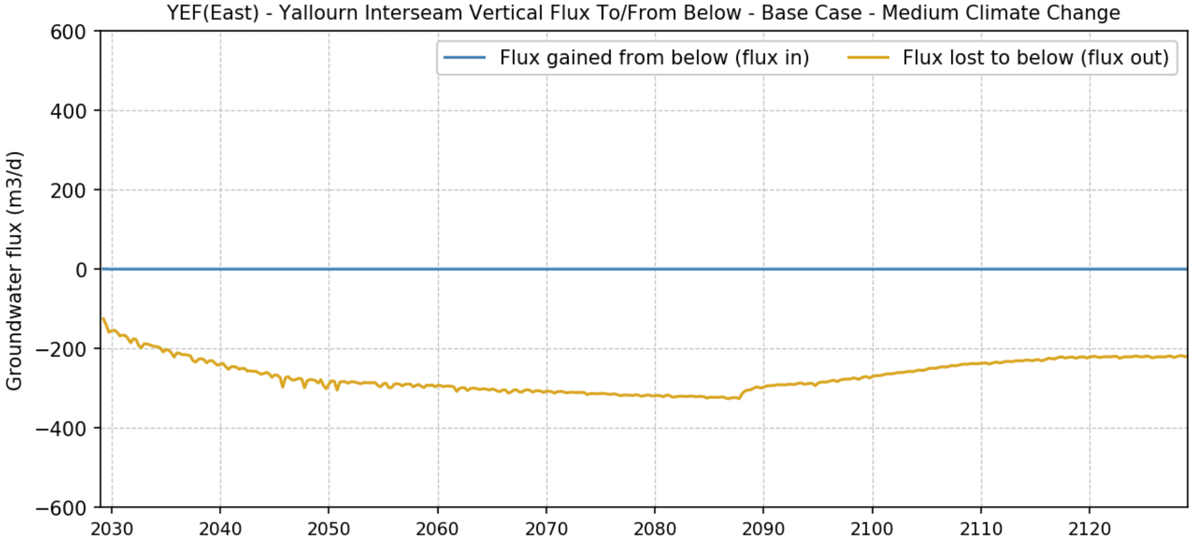


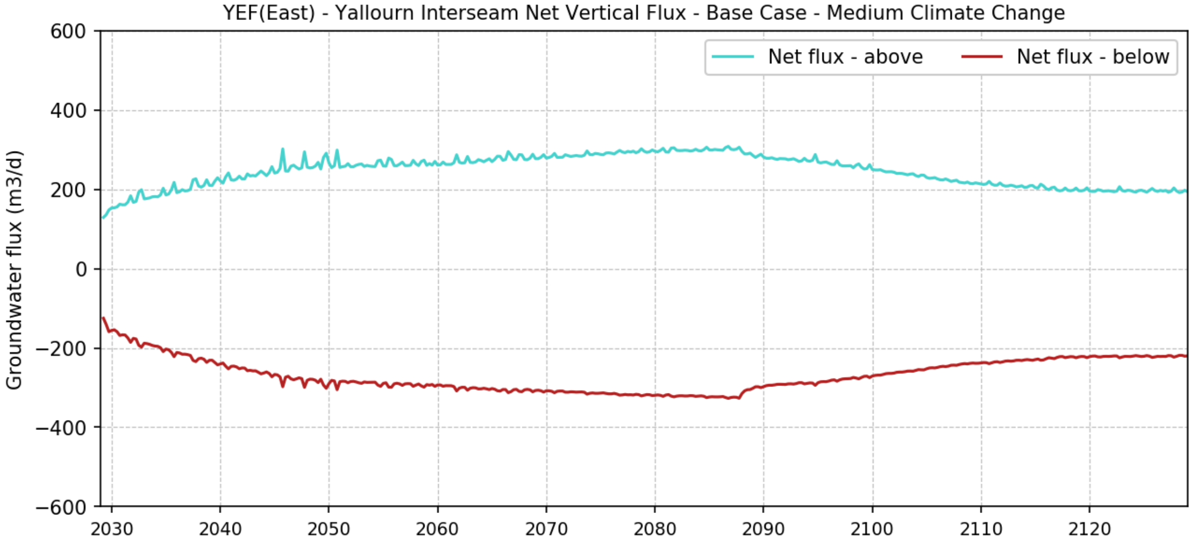




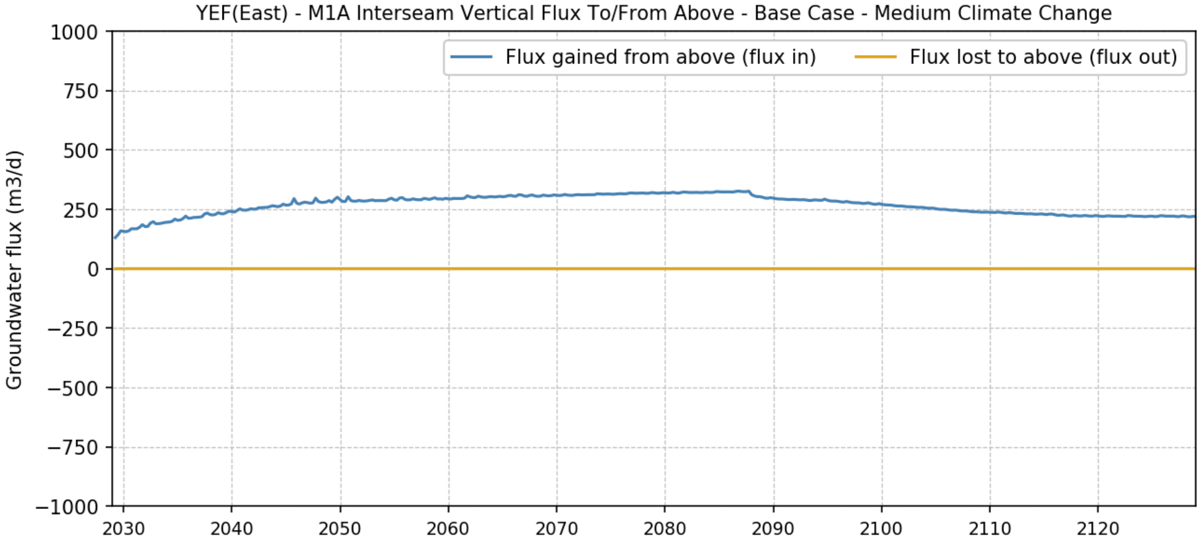
Base Case Yallourn Interseam vertical fluxes – YEF (East)

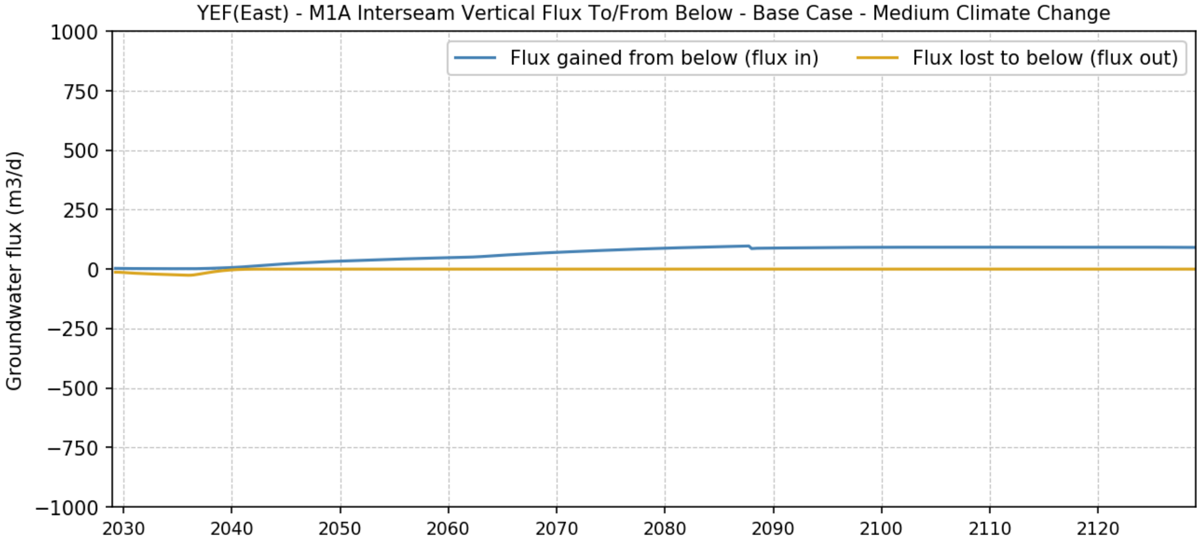


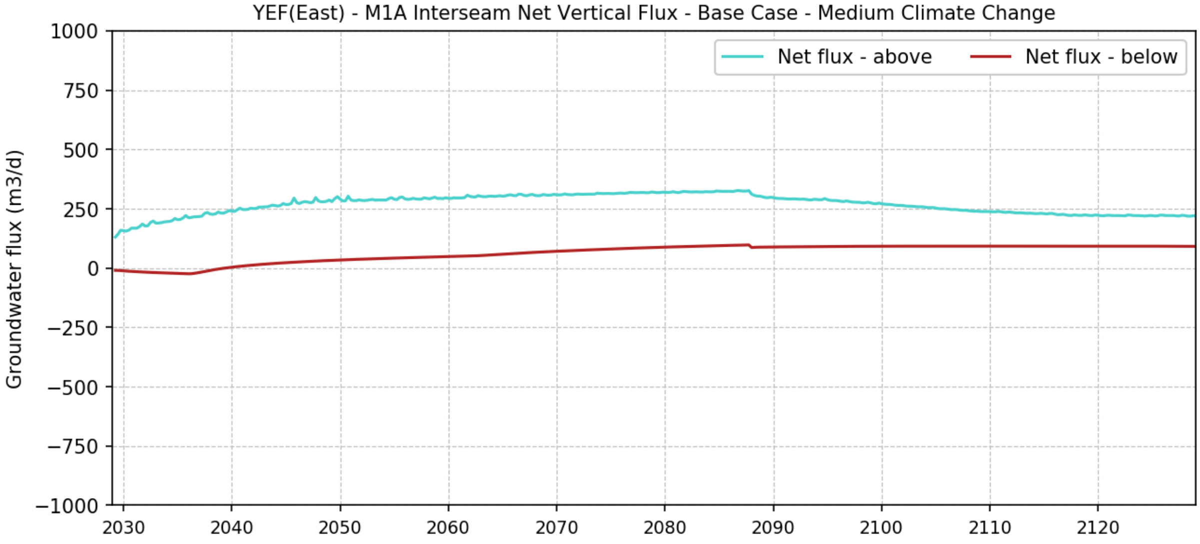




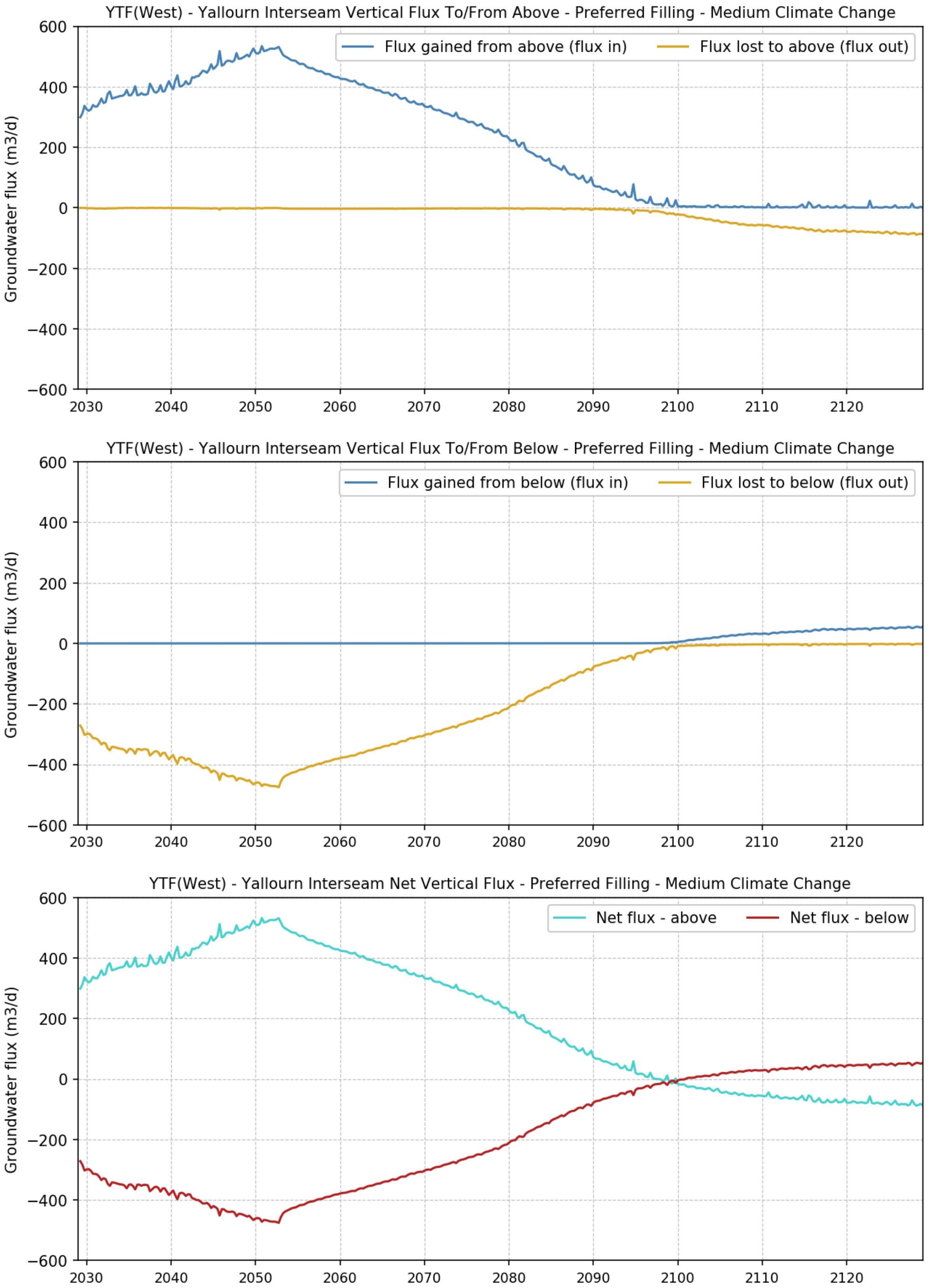
Base Case M1A Interseam vertical fluxes – YEF (East)







Preferred Filling scenario Yallourn Interseam vertical fluxes – YTF (West)



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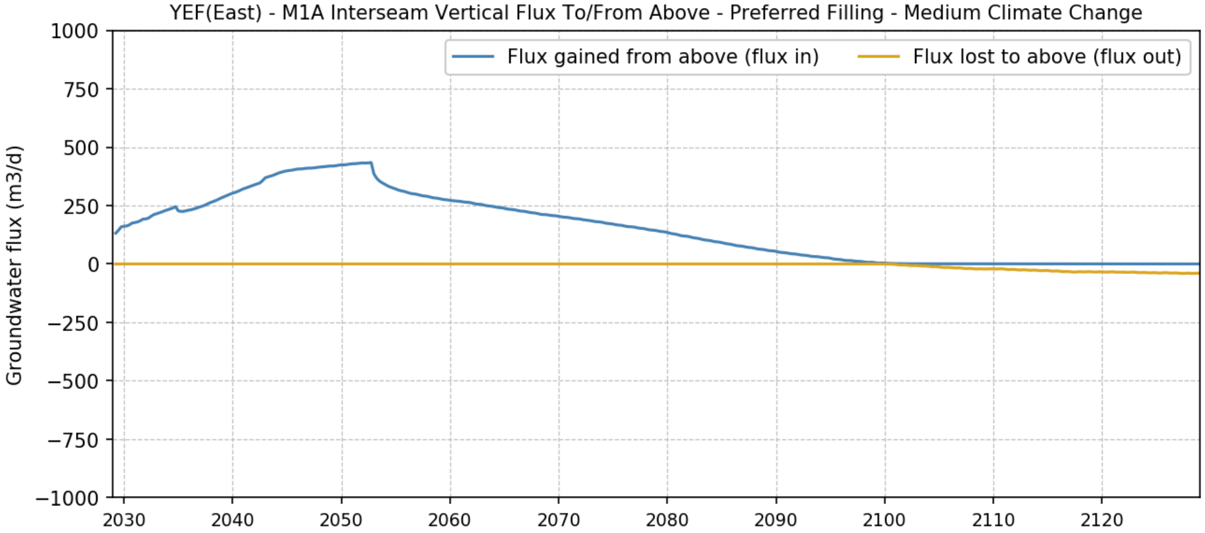
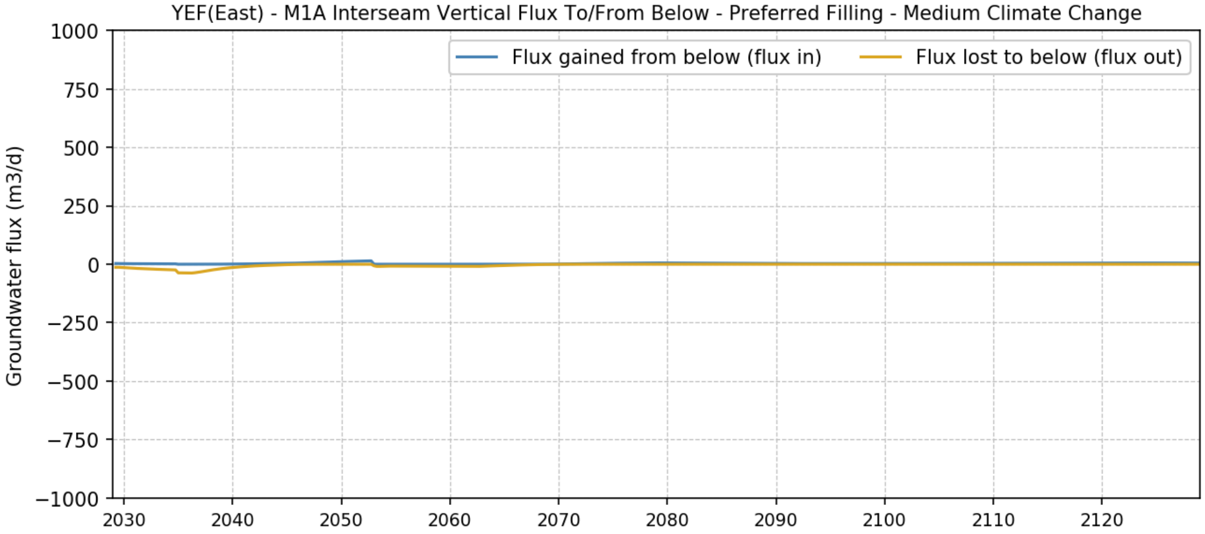
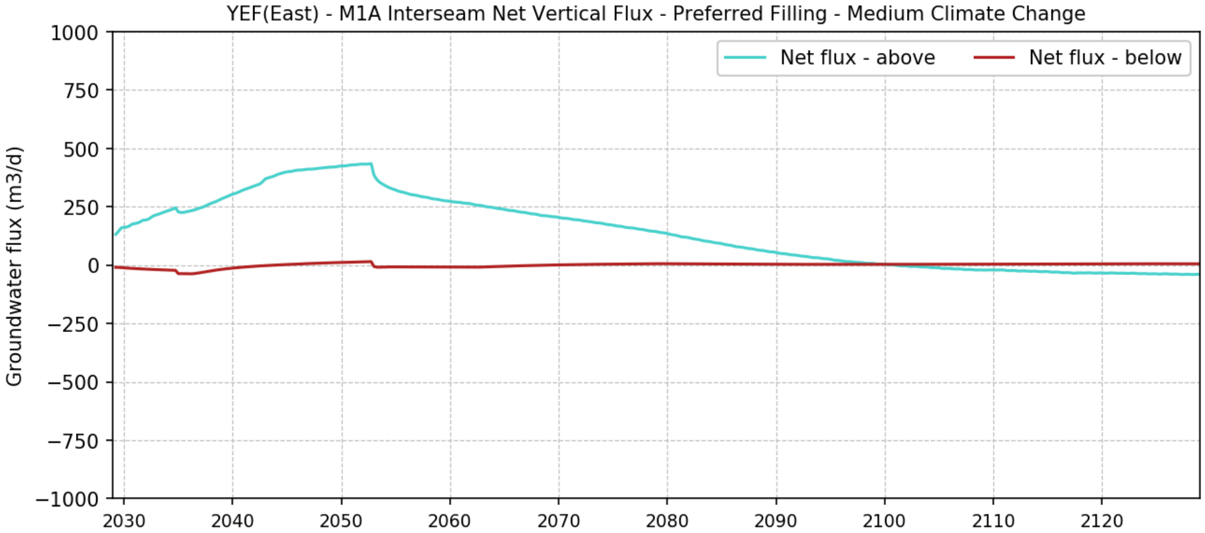
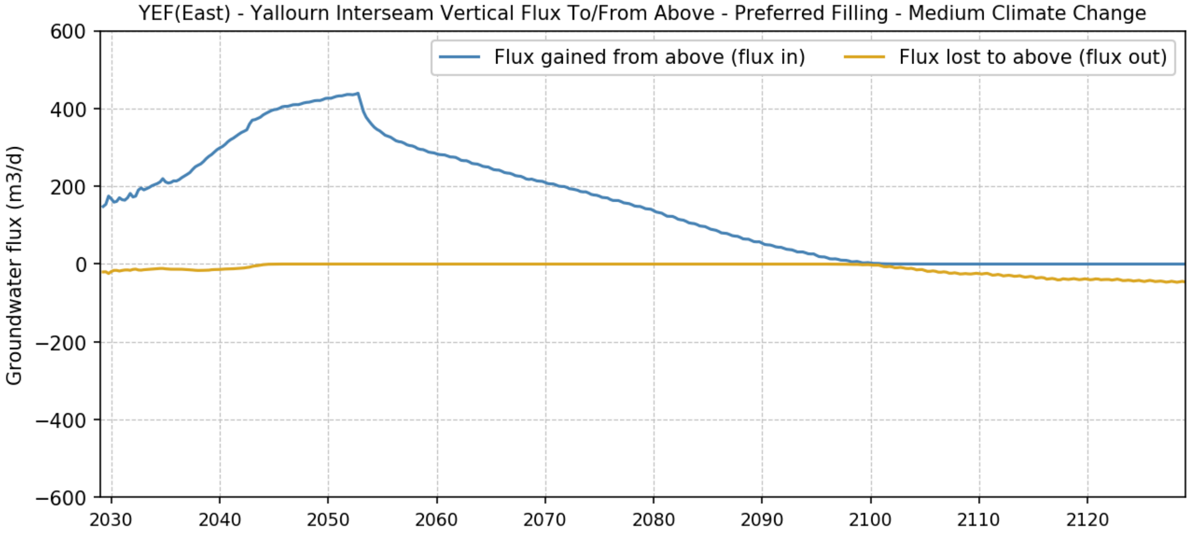
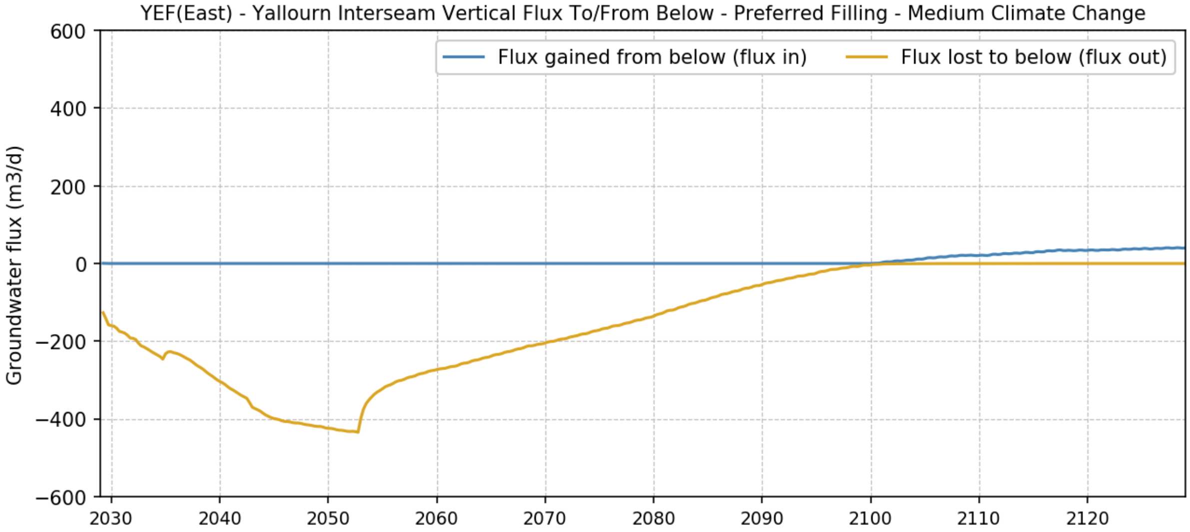


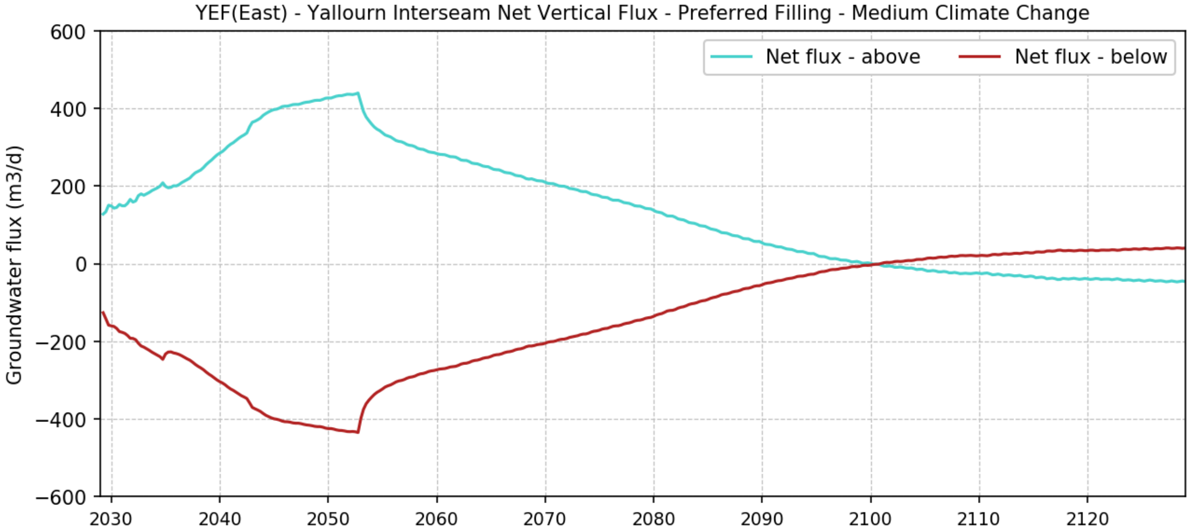




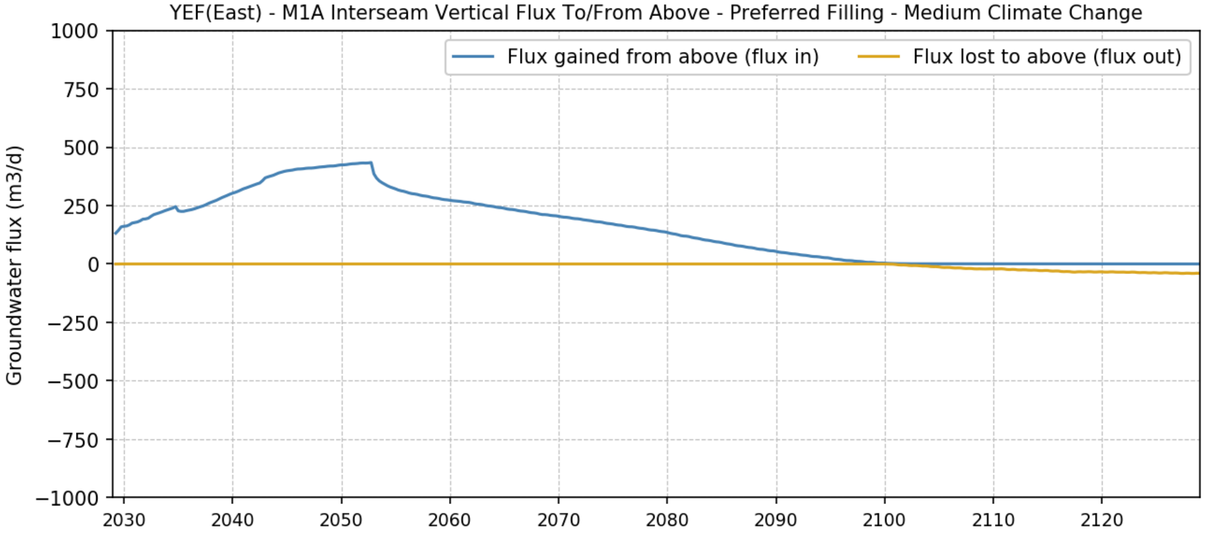
Preferred Filling scenario Yallourn Interseam vertical fluxes – YEF (East)

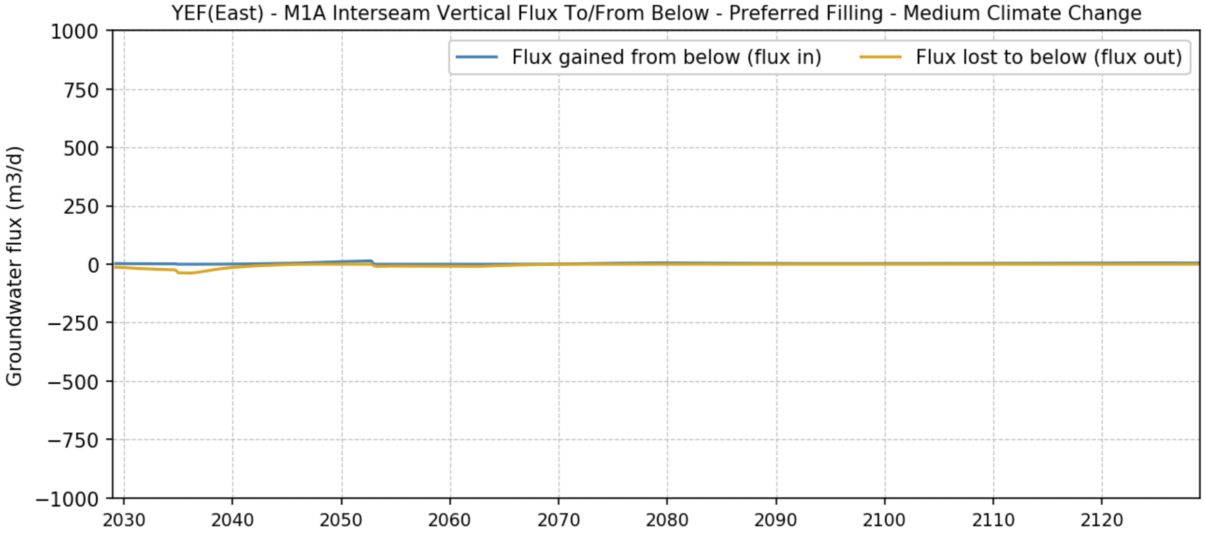


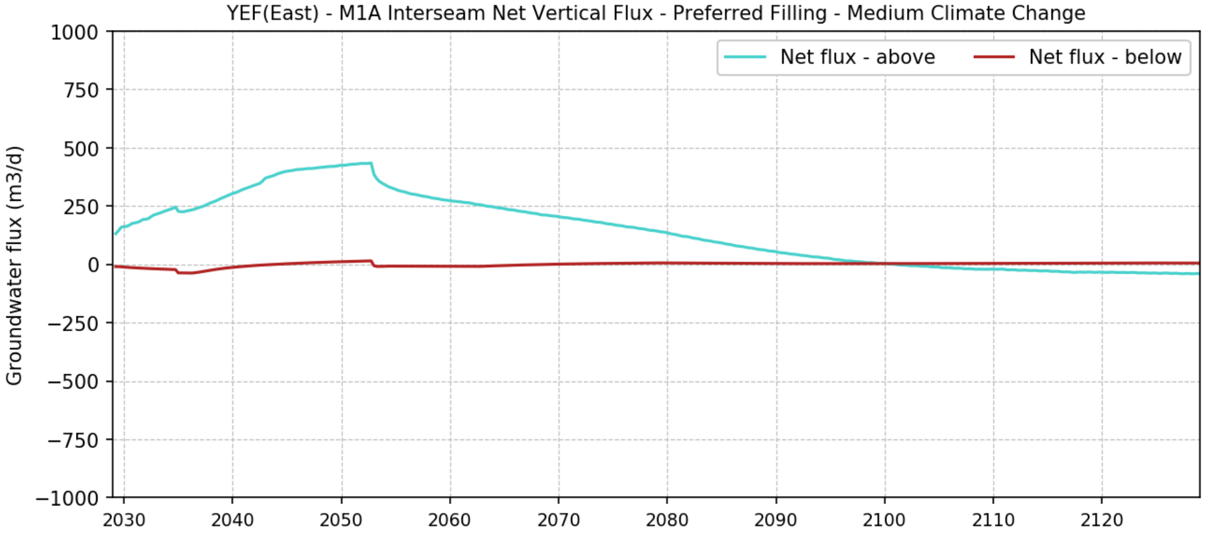




Preferred Filling scenario M1A Interseam vertical fluxes – YEF (East)







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