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Attention:	Christopher Knight		
Cc:			
From:	Damien Janssen; Jon Hall		
Date:	22/06/2018	**Job No:**	EWP72644.004
Subject:	Rix's Creek Pit Void Assessment		

Hi Christopher,

Further to our recent discussions, we present the following report on the benefits of, and justification for leaving a final void as part of the Continuation Project.

1 Background

Rix's Creek Mine of Rix's Creek Pty Ltd, is owned and operated by Bloomfield Collieries Pty Ltd (Bloomfield). The mine is an open cut coal mine approximately 5km northwest of Singleton in the Hunter Valley Coalfields of NSW. Bloomfield is seeking approval for the Rix's Creek Continuation of Mining Project which relates to the continued operation of the existing open cut coal mine – seeking to extend the life of the existing mining operation until approximately 2037. The continuation of mining operations will extend in a north-westerly direction. RPS have completed the Groundwater Impact Assessment (RPS, 2014)[1] for the Continuation of Mining Project, including the assessment of drawdown during operational dewatering, along with the predicted groundwater recovery and salinity trends for a remnant pit void with partial backfill placement in a post mine closure state.

To facilitate the ongoing public consultation during the approval phase, this report provides additional information and discussion on the dynamic hydrogeological conditions associated with an open pit void at the Project, and how the pit lake and resulting hydraulic sink environment will work to contain and mitigate potential regional impacts after mine closure.

The discussion includes two components:

- General Concepts - Key generic concepts underpinning pit lake development during recovery, and in equilibrium; and
- Specific Concepts - Application and discussion in the context of the Rix's Creek Continuation of Mining Project.

[1] RPS 2014, Rix's Creek Continuation of Mining Project Groundwater Impact Assessment, prepared for Bloomfield Collieries Pty Ltd, September 2014

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2 Pit Void Dynamics - General Concepts

Based on the conceptual hydrogeological model for this site, and extensive experience with long-term hydrological behaviour of pit voids in similar hydrogeological environments, it is expected that the pit void will remain a groundwater sink. That is, the equilibrium pit lake level will be lower than the surrounding groundwater table and groundwater will flow towards the pit from all sides.

The key factors that influence pit lake development and equilibrium level are:

- Rainfall recharge – direct precipitation and surface water runoff from the pit catchment;
- Evaporation; and
- Groundwater inflows.

Such groundwater sink conditions are typical in most mining areas in Australia and arise because evaporative losses from the pit lake are very high in relation to pit inflows. When mining (and pit dewatering) ceases, a pit lake will develop as a result of groundwater inflows and surface water runoff, and the pit lake water level will start to rise. However, as the pit lake rises and the pit lake surface area becomes larger, evaporative losses become higher. Also, as the pit lake rises, groundwater inflows diminish as the hydraulic gradients towards the pit declines. The pit lake will continue rising to a level at which evaporative losses balance all groundwater and surface water inflow. The actual pit lake level will fluctuate on a seasonal and annual basis depending on natural variability in rainfall, groundwater inflow and evaporation. However, these fluctuations tend to be minor and the equilibrium (long term average) pit lake level is driven by long term average parameters.

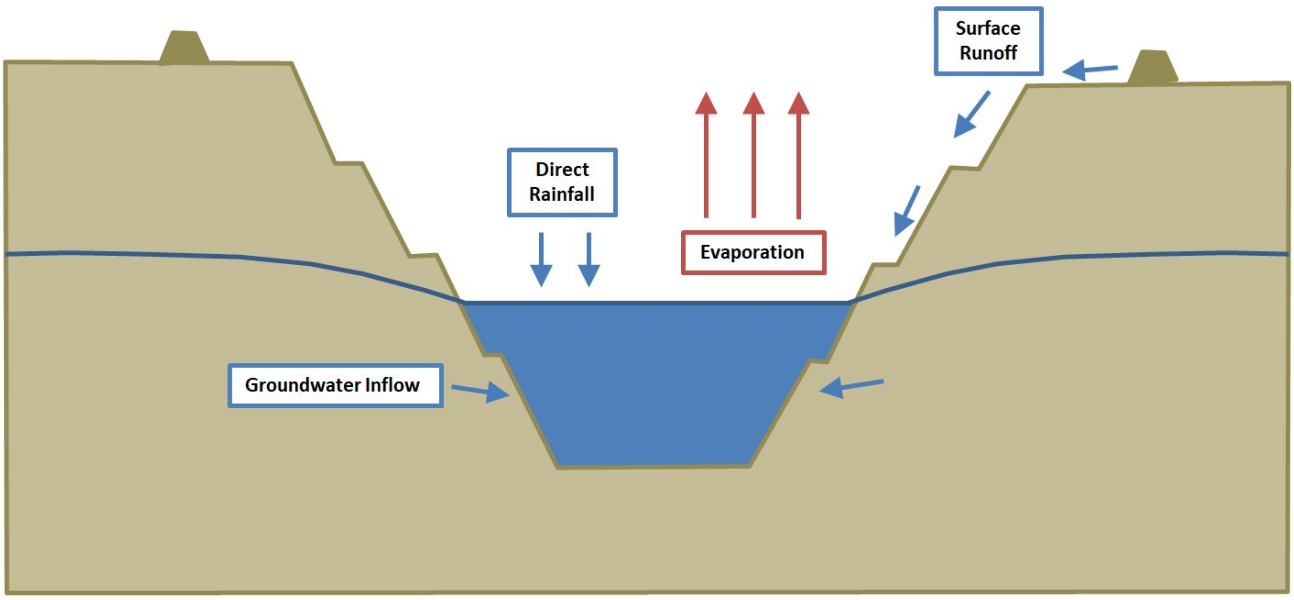

Figure 1 – Water Balance Drivers in Pit Lake Development (Note: schematic illustration only)

In terms of the salt balance of the pit lake, generally speaking – the direct rainfall and local surface runoff are fresh water, and therefore have virtually no associated salt load. The regional groundwater inflow to the pit

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void is typically the mechanism via which a salt load is introduced to the pit lake water (groundwater salinity concentrations can range from fresh (500 mg/L TDS) through to hypersaline (100,000+ mg/L TDS). The equilibrium salinity of a pit lake is therefore driven by a balance between:

- The groundwater inflows, which carry a salt load into the pit, and reduce over time as the pit lake level rises, and groundwater gradients decline;
- The direct recharge and surface runoff associated with rainfall events, which is effectively salt-free, therefore dilutes and lowers the salinity of the pit lake water; and
- The evaporation of the pit lake water, which leaves salt behind, drives an evapo-concentration process that leads to an increasing salinity trend in the pit lake.

It should be noted that in such an equilibrium state, the hydraulic gradient is toward the pit lake sink, and pit lake waters cannot flow into the surrounding groundwater resource. It is also worth noting that when pit lakes typically reach an equilibrium water level below the regional groundwater table, that there is significant freeboard storage above the pit level in which to contain additional rainfall recharge. This means that should climatic signatures change over time, and if an increase in average rainfall were to occur, that this would be unlikely to drive a change in the outcome of the pit being a hydraulic sink – although it may influence a small rise in equilibrium levels, and a slightly lower salinity concentration (based on the water and salt balance drivers outlined above).

Although there is no hydraulic gradient to induce flow from the pit lake, there is the potential (as the pit lake increases in salinity) for density-driven flow processes to occur. Saline water is slightly denser/heavier than fresh water, and can therefore move under gravity. The saline water would essentially “sink” from the pit through the underlying aquifer until it reached a hydraulic barrier (e.g. aquitard) and then move down slope along the base of the aquifer. Over time, there may be a localised zone beneath the base of the pit where a saline mixing zone would occur and stabilise over time.

3 Pit Void Dynamics – Rix’s Creek Specific

As part of the Groundwater Impact Assessment (RPS, 2014) for the Rix’s Creek Continuation Project, this used a detailed hydrogeological understanding of the site together with an updated groundwater model. That model was used to predict both the cumulative impacts of the Project with other proposed mining operations, as well as the incremental impacts that are directly attributable to the Project. This modelling included an assessment of a partially backfilled pit void in terms of pit lake development and associated salinity trends.

The Continuation Project plans to mine to the base of the Hebden Seam (and the contact with the Saltwater Creek Formation). Upon completion of mining the high-wall will be battered to 18 degrees, with a clean water diversion established half way up the slope. The partial backfill placement within the final pit void is also battered to 18 degrees.

The values predicted as part of that modelling work has been integrated here as part of the discussion of Rix’s Creek-specific pit void dynamics.

3.1 Pit Void Modelling Approach

The groundwater model (RPS, 2014) utilised for the impact assessment simulated the pit void hydraulic processes outlined in Section 2, including:

- No mine dewatering – therefore allowing available groundwater to flow back into the pit void

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- Representation of partial backfill with spoil material – adapting the shape of the pit void to match the intended final landform design, and assign suitable permeability and storage properties to the backfill material
- Assigning the areas where rainfall recharge and evaporation can occur – which adapts as the pit lake level recovers

For the purposes of predicting the long-term salinity within the final void, an analytical mass balance model was used based on flows predicted by the numerical model and adopted salinity values for various flow components and considered factors such as:

- Inflows to the void
  - Rainfall recharge to the surface of the lake (assumed 10 mg/L TDS in the rainwater, taking into account the surface water diversion that will be established on the high-wall)
  - Exchange of groundwater from backfill to the void (assuming 7,500 mg/L TDS in the inflowing groundwater)
- Outflows from the void
  - Evaporation from the lake surface (assumed 0 mg/L TDS – that is, no salt evaporates)
  - Exchange of groundwater to the backfill from the void[2] (assumes mixing/homogenised salinity concentrations)

3.2 Model Results

3.2.1 Groundwater Drawdown

The long-term impacts of mining following 100 years of recovery after the cessation of mining and dewatering activities are described below, and are presented in detail in the Groundwater Impact Assessment (RPS, 2014). The results are as follows:

- The final void will become a groundwater sink.
- The predicted water level in the backfilled portion of the void is approximately 55m AHD with a pit lake level of approximately 50m AHD;
- Predicted residual drawdown levels in excess of 50m are constrained to the backfill zones, the Pit 1 portal and the final void; and
- Predicted residual drawdown levels between 20 and 50m are constrained within the syncline formation and do not extend outside of the mine lease boundary.

3.2.2 Groundwater Quality

- As outlined above, the groundwater flow modelling predicts that the pit void will act as a groundwater sink;
- The salt mass balance modelling predict indicates that evapo-concentration processes will lead to an increase in pit lake salinity from approximately 7,500 mg/L at the end of mining, increasing to 9,000 mg/L after 200 years, up to 21,000 mg/L some 2,000 years after mining. This prediction is conservative with current pit water showing lower salinity levels; and

[2] For clarity, it should be noted that no groundwater outflows left the ultimate pit void – but did move between the pit lake and the backfill material.

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- Due to hydraulic sink conditions of the pit void, there is no mechanism for that void water to enter the surrounding groundwater system, and therefore the risk of adverse impacts to water quality is considered negligible.

3.3 Implications of a Pit Void at Rix's Creek

The key outcomes of this assessment, in relation to the implications of a pit void are as follows:

- Based on the modelling results from 2014, the long term pit void lake levels are predicted to be approximately 50m below the pre-mining water table – this is the equilibrium level reached based on the balance of groundwater inflows to the pit, rainfall recharge (directly to the pit lake and via surface runoff down the pit walls), and evaporation losses from the surface area of the pit lake;
- The ultimate drawdown footprint, particularly to the west and south of the Continuation Project, is highly influenced by the basement syncline structure, with the very low permeability of the siltstones isolating the pit lake and the local groundwater system from the regional groundwater system;
- The salt balance modelling predicts that pit lake water (currently around 7,500 mg/L TDS) will increase to 9,000 mg/L after 200 years, and up to 21,000 mg/L some 2,000 years after mining. Based on the hydraulic isolation observed in the constrained drawdown, and also the fact that density-driven flow dynamics will drive dense water flow towards the keel of the syncline, any saline water that "sinks" through the base of the pit would also be constrained by the geometry of the syncline basement structure;

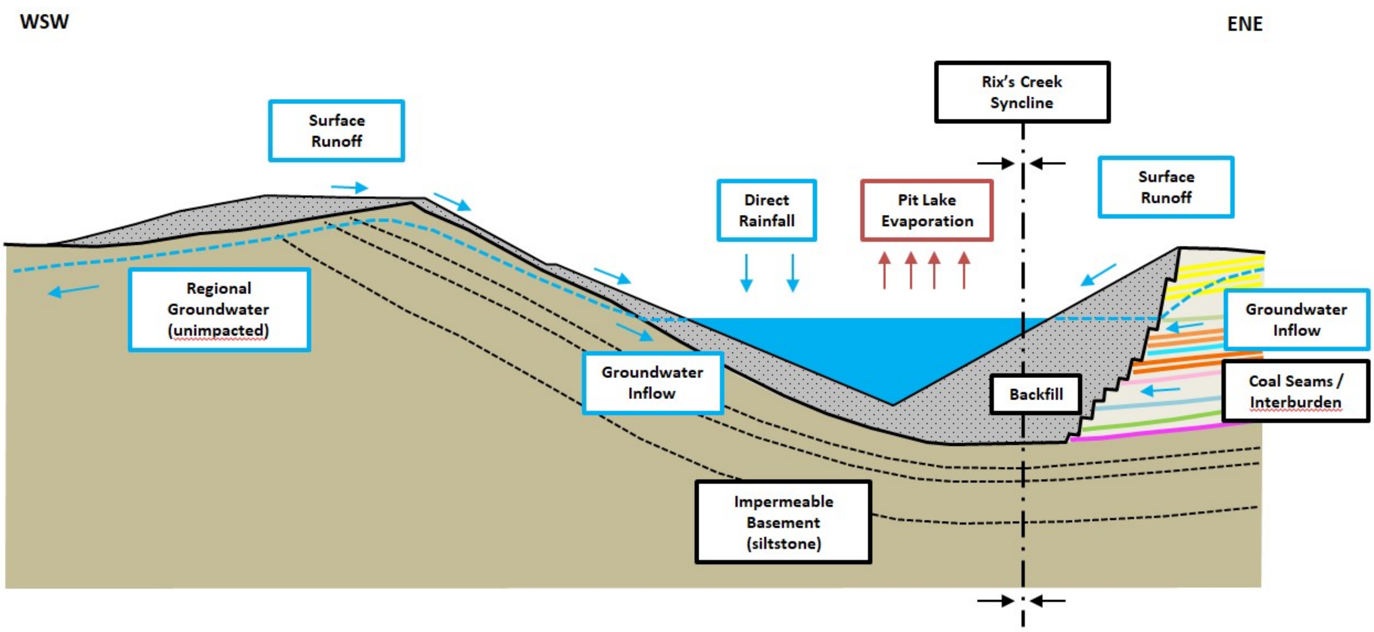

Figure 2 – Rix's Creek Continuation Project, Pit Void (Note: cross-section with vertical exaggeration)

- With the Pit void behaving as a hydraulic sink, and the local basement geometry also working to localise movement of groundwater, the saline groundwater contained is the pit lake will be isolated and contained, and unable to influence the water quality of the broader groundwater resource in the overall catchment; and

- Given that the equilibrium pit lake level is locally significantly lower than the regional groundwater system – it is not possible for even a massive surface water event, or a wetting climate trend over decades or centuries to influence the pit lake dynamics to a point where it might reverse the groundwater gradient away from the pit.

Based on the above key outcomes, it is concluded that a pit void at the Rix's Creek project, will contain any saline water within the pit void itself and will have negligible risk of influencing present or future water quality of the regional groundwater resource.

Yours Sincerely,
RPS Water

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