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Dear Paul

Comments from peer review – Christmas Creek LOM

HydroConcept has completed a peer review of the FMG (Fortescue Metal Group) hydrogeological assessment relating to the Christmas Creek life of mine management scheme. The review was undertaken by Mr Seth Johnson (Principal Hydrogeologist) with a focus on ensuring the conceptualisation is a realistic representation of the water regime; the numerical modelling provides reliable predictive outputs; and the water resource management strategy integrates and considers the findings.

The document presents a technical discussion on the water management approach associated with the life of the Christmas Creek operation, as well as the relationship with the nearby Cloudbreak operation. It has been completed to a high standard and is acceptable for submission to the different Government agencies for their review and consideration.

There has been nearly ten years of field investigations and data collection along the Chichester Range associated with Christmas Creek and Cloudbreak. The progressive improvement in understanding of the water resources has resolved the connectivity between surface water hydrology, flooding/drying cycles of the Fortescue Marsh, and water levels within the groundwater system. The methodologies employed in the field activities are appropriate and align with industry standards.

The interpreted conceptual hydrogeology is valid and forms the basis of the numerical groundwater flow model. The hydrostratigraphy is well defined with descriptions and some appreciation of variability within each unit. There is recognition of the significance of hydraulic connectivity between the Oakover Formation and ore body, as this is important for understanding potential inflows of hypersaline water from beneath the Marsh resulting in higher volumes of dewatering, injection and recirculation.

There is a proven understanding of salinity distribution across Christmas Creek, based on interpretation of an airborne electromagnetic survey, density flow modelling, and actual data from monitoring bores. The spatial appreciation and ongoing monitoring of the transitional saltwater interface is critical for long-term maintenance of water quality in the mining operations.

Mine dewatering and reinjection at Christmas Creek and Cloudbreak has provided opportunities to gain understanding of hydraulic response, as well as operational learning about dewatering rates and design. Each dewatering exercise can be considered a longer-term aquifer test for determining more accurate hydraulic parameters.

The water management approach employed by FMG is considered best practice for the mining industry. The system is extensive with a comprehensive network of dewatering and injection bores linked via pipeline conveyance. Connection with the Cloudbreak operation provides additional contingency and an improved ability to manage impacts at Christmas Creek.

Despite the lack of groundwater monitoring beneath the Fortescue Marsh, FMG have been able to develop a conceptualisation for recharge and discharge processes associated with the Marsh. The conceptual approach seems appropriate, logical and representative of hydraulic functioning and interactions between flooding and drying stages.

The numerical groundwater model is based on the conceptualisation. It was developed to the requirements of the Australian Groundwater Modelling Guidelines, and the use of finite element (FeFlow) enables consideration of density-driven flow. The model has been progressively reviewed, refined and calibrated for reliable predictions of abstraction and injection volumes, assessment of potential impacts, and sizing of the water management system.

The model area is sufficiently large for no boundary effects and to not compromise model outputs in the vicinity of the Marsh. There is a high level of confidence in the numerical model simulations in terms of accuracy, usefulness for water management planning, and regulatory approval. Ongoing monitoring and progressive upgrading of the model will be required, as part of operational water management at the mine site scale, for improved calibration and verification.

A range of water management scenarios have been undertaken. Given the variability in climate and lack of actual rainfall data in the project area, FMG has developed a synthetic rainfall data set using a stochastic approach. This approach is considered appropriate in representing the variability in rainfall between years and over a long timeframe, and provides the basis for scenario evaluation between wet and dry seasons.

Below are a number of the key observations from the modelling process and generated model outputs that are of importance and significance for life of mine water management at Christmas Creek.

- Water levels at the edge of the Marsh are naturally variable. In places, the water level may range from near surface to 5 m below ground level, and change by 2 to 5 m in response to differing recharge scenarios.
- As the project develops, there will be increased recirculation and double-handling of injection water. In the years 2020 to 2023, there will be substantial recirculation of water. The recirculation will need to be progressively assessed and closely monitored over time to determine whether there are opportunities for different injection approaches to reduce double handling.
- Modelling of water levels, as well as operational data, has demonstrated that aquifer injection has minimised drawdown and is an effective mitigation tool for protection of the Marsh.
- Demand projections suggest that brackish water will need to be managed carefully. There is potential that mine planning and dewatering schedules will need to be aligned to ensure that brackish water availability is maintained. In light of this scenario, a range of contingency measures have been suggested for consideration.

- The overall water balance is largely driven by recharge and discharge processes at the Marsh, which is in keeping with the regional understanding. The mining activities will have a minimal impact at the regional scale; however, the management of impacts through mitigation will be an ongoing requirement and obligation.
- Model sensitivity analysis was undertaken on the five most likely parameters with an upper and lower evaluation approach. The hydraulic conductivity of the Oakover and mineralised Marra Mamba Formations, as well as recharge, are the most sensitive parameters and have the greatest influence on model predictions.
- Post-closure recovery of water levels will take many decades to reach a new equilibrium. The rate of recovery will be largely dependent on recharge, as well as the hydraulic response to backfilled materials.
- An understanding of heterogeneity is a major challenge for representation with the numerical model; however, this will improve as mining proceeds and the variability is better appreciated. Other model limitations include a lack of monitoring beneath the Marsh preventing accurate calibration and a full understanding of the hydraulic conductivity of the backfill material – this will improve as backfilled areas recover and effectively provide a pseudo-recovery test.

The lack of monitoring beneath the Marsh is problematic and should be a focus of ongoing investigation and monitoring. It is recommended that FMG continue with ongoing development and calibration of the model to improve confidence in dewatering and injection volumes, as well as ensuring alignment with actual responses.

Conclusion

The Christmas Creek life of mine water management strategy builds on operational experiences, as well as nearly ten years of investigations and data collection. It shows a commitment by FMG to continually improve its understanding of the water resources and progressively integrate any new knowledge into its predictive modelling. This approach has been demonstrated through the integration of modelling predictions into operational water management decision making, and ongoing calibration of model output with actual responses.

The numerical groundwater model is considered representative and is based on a robust conceptual understanding. There will be a need for ongoing model calibration against actual responses and progressive improvement in understanding, so that water management is as optimal as possible.

The predictions for the life of mine are within bounds and of sufficient accuracy for water management and mine planning. The volumes of dewatering and injection are significant and highlight that ongoing monitoring and management will be critical for project success. There will be challenges with recirculation between 2020 and 2023 to ensure that the system has sufficient capacity to handle the necessary volumes of injection and prevent the need for discharge.

There has been careful consideration of the Fortescue Marsh throughout the whole life of mine planning stage and in FMG's water management strategy. It is considered that impacts to the Marsh will be minimal and that injection is a valid mitigation approach. The peer reviewer would again reiterate the lack of monitoring beneath the Marsh is problematic and should be a focus of ongoing investigation and monitoring.

The success of the injection process will be limited by the capacity of the Oakover Formation; as such the ongoing monitoring of aquifer response will be necessary. In addition, the connectivity of the Oakover and mineralised Marra Mamba Formations is important for understanding dewatering and injection volumes, as well as the extent of recirculation.

FMG have demonstrated a whole of system approach, with consideration for interaction between the Cloudbreak and Christmas Creek operations. There are no immediate issues with cumulative impacts as Marillana is too distant and there are mutual benefits in aquifer drawdown for the Roy Hill operations. The development of the approved Stakeholder Consultation ReInjection Management Plan with Roy Hill will ensure that potential water management interactions can be readily addressed between companies.

The peer reviewer is satisfied that the 'Hydrogeological assessment of the Christmas Creek life of mine management scheme' report provides an accurate and representative appreciation of the water resources, and potential impacts associated with the future mining operations.

Yours sincerely



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The peer review has been completed by Mr Seth Johnson, a Registered Practising Geoscientist (Number 10106), who is bound by the Australian Institute of Geoscientists' Code of Ethics. It has been produced independently being based on information provided by Fortescue Metals Group Ltd. All comments are considered accurate and provided in good faith.