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APPENDIX L - GROUNDWATER ASSESSMENT PEER REVIEW

Isaac Downs Extension Project - Technical Peer Review

Prepared for Stanmore Resources Ltd

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Section 1: Introduction

1.1 Overview

This report presents an independent technical peer review of the Isaac Downs Extension (IDE) Project (the Project) groundwater impact assessment (GIA) and the associated numerical groundwater modelling. The aim of the review is to ensure technical competency and adherence to regulations.

Stanmore ID Extension Pty Ltd (ID Extension, a wholly owned subsidiary of Stanmore Resources Limited (Stanmore) proposes to extend the current Isaac Downs Mine (IDM) within the Isaac Plains Complex (IPC) in the Bowen Basin, approximately 15 kilometres south-east of Moranbah. The IDM is an open-cut metallurgical coal mine that was approved for construction and operation in July 2021. Stanmore proposes that mining activities will transition from IDM to the Project as existing operations at the IDM wind down. The Project involves the development of an open-cut coal mine pit and associated infrastructure across approximately 2,707 hectares within Mining Lease Application (MLA) 700081, MLA 700082, MLA 700083 and MLA 700084, located within the Bowen Basin and the Isaac Regional Council local government area. The Project is expected to extend the operational life of the IPC through the extraction of approximately 46 million tonnes (Mt) of run-of-mine (ROM) coal over 15 years, at a production rate of approximately 2-4.5 million tonnes per annum (Mtpa). The Project is anticipated to produce approximately 30 Mt of primarily metallurgical coal product at a rate of around 1.5-3 Mtpa.

Stanmore has engaged SLR Consulting Australia (SLR) to develop the numerical groundwater model and GIA for the Project. The GIA and numerical modelling have been prepared in accordance with Queensland and Commonwealth Government requirements, specifically the terms of reference (ToR) for the Project's environmental impact statement (EIS). The objectives of the GIA are to provide a description of the existing hydrogeological environment, and assess the impacts of mining on that environment.

1.2 Documentation

Familiarisation of the Project was undertaken by reviewing numerous publicly available and client provided groundwater reporting covering the IDM complex.

This peer review is based on information presented in the following reports:

- Isaac Downs Extension – Groundwater Impact Assessment, SLR Project No.: 620.041537.00001, 28 May 2026, Revision 5.0 + 9 Appendices.
- Isaac Downs Extension – Groundwater Monitoring and Management Plan, SLR Project No.: 620.041537.00001, 28 May 2026, Revision 4.0 + 4 Appendices.

The technical review process was staged, involving numerous PowerPoint presentations, conversations and checkpoints at the model build, calibration, and prediction stages. The groundwater reporting process was iterative, undergoing numerous reviews by this reviewer to ensure technical competency. At report completion all remaining issues were adequately addressed and resolved (unless highlighted in this report).

Section 2: Numerical modelling review

2.1 Methodology

This review has been undertaken in accordance with the principles and guidelines outlined in the Australian Groundwater Modelling Guidelines (Barnett et al, 2012). The technical review incorporates the latest guidance on best practices for uncertainty analysis methods as presented in Uncertainty analysis - Guidance for groundwater modelling within a risk management framework (Middlemis and Peeters, 2023). The technical review is also based on a combination of professional expertise and modelling methodology, together with the model appraisal checklist provided in the Australian Groundwater Modelling guidelines and principles outlined by the Groundwater Modelling and Decision Support Initiative (Doherty and Moore, 2021).

The technical review consults the following federal regulatory guidelines to assess the sufficiency of the GIA and confirm compliance:

- Information guidelines for proponents preparing coal seam gas and large coal mining development proposals, issued by the Independent Expert Scientific Committee (IESC) of the Commonwealth of Australia (Peeters & Middlemis, 2023).
- Significant impact guidelines 1.3, issued by the Department of the Environment and Energy of the Commonwealth of Australia (DES, 2013).

2.2 Model level classification

Table 1 presents the three broad sectors for classification as listed in the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). These confidence indicators are somewhat outdated, although are familiar to regulators, hence their continued usefulness. The model generally meets the required Class 2-3 classification for reliable use with major approvals projects.

Table 1 Model confidence class indicators

Category	Description	Confidence level class
Data	Spatial and temporal distribution of groundwater head observations adequately define groundwater behaviour, especially in areas of greatest interest and where outcomes are to be reported.	3
	Spatial distribution of bore logs and associated stratigraphic interpretations clearly define aquifer geometry.	3
	Rainfall and evaporation data is available.	3
	Aquifer-testing data to define key parameter.	3
	Reliable land-use and soil-mapping data available.	3
	Good quality and adequate spatial coverage of digital elevation model to define ground surface elevation.	3
	Metered groundwater-extraction data may be available but spatial and temporal coverage may not be extensive.	2
	Streamflow data and baseflow estimates available at a few points.	2
	No available records of metered groundwater extraction or injection.	1
Calibration	Scaled RMS error or other calibration statistics are acceptable.	3
	Long-term trends are adequately replicated where these are important.	3
	Transient calibration is current, i.e. uses recent data.	3
	Observations of the key modelling outcome data set are not used in calibration.	2
	Validation is either not undertaken or is not demonstrated for the full model domain.	2
	Calibration statistics are generally reasonable but may suggest significant errors in parts of the model domain(s).	2
	Seasonal fluctuations not adequately replicated in all parts of the model domain.	2
	Observations of the key modelling outcome dataset are not used in calibration.	2
Prediction	Length of predictive model is not excessive compared to length of calibration period.	3

Category	Description	Confidence level class
	Level and type of stresses included in the predictive model are within the range of those used in the transient calibration.	3
	Temporal discretisation used in the predictive model is different from that used in transient calibration.	2
Key Indicator	Key calibration statistics are acceptable and meet agreed targets	3
	Model predictive time frame is less than 3 times the duration of transient calibration.	3
	Stresses are not more than 2 times greater than those included in calibration.	3
	Temporal discretisation in predictive model is the same as that used in calibration.	3
	Mass balance closure error is less than 0.5% of total.	3
	Model parameters consistent with conceptualisation.	3
	Appropriate computational methods used with appropriate spatial discretisation to model the problem.	3
	The model has been reviewed and deemed fit for purpose by an experienced, independent hydrogeologist with modelling experience.	3
Overall		**2-3**

This report also applies a newer concept for assessing model confidence. The 2023 IESC Explanatory Note for Uncertainty Analysis defines a model is fit for purpose when results are:

- Useable – relevant to the decision-making process, provide information on the uncertainty in conceptualisations and model simulations that allows decision-makers understand the effects of uncertainty on project objectives and potential bias.
- Reliable – demonstrate that the range of model outcomes is consistent with system knowledge. Uncertainties affecting decision-critical predictions are not underestimated.
- Feasible – trade-offs due to budget, time and technical constraints are reasonable and justifiable within the risk context of the project.

Table 2 presents this reviewer’s assessment of the four sources of uncertainty (structural, parameterisation, measurement error, predictions).

Overall, it is this reviewer’s opinion that the model is indeed useable and reliable in accordance with the IESC uncertainty note criteria. Given excessive runtimes (which was noted to impair the expedience of the calibration and uncertainty analysis) it is arguable that the model is feasible without significant computational and time expense. There is room for improvement in the next phase of modelling, which would aim to further reduce predictive uncertainty upon the onset of mine dewatering. This could be achieved by migrating to a more local model (that also represents relevant cumulative impacts), or alternatively using surrogate models to gather information on local processes.

Table 2 Model confidence assessment

Type	Part	Status	Comment
Structural/ Conceptual	Grid and Model Extent	Fit for purpose	The model extent and unstructured Voronoi grid are suitable for the assessment. Cell refinement is provided around the Project, neighbouring mines and drainage features.
	Layers and Geological Structure	Fit for purpose, future improvements possible	Model top and layer elevations are based on Digital Elevation Model (DEM) data (LiDAR would be better, and was available), mapped geology, regolith mapping, drilling, geophysical interpretation and site geological models. The vertical discretisation is suitable for the key hydrostratigraphic units.
	Faults and Structural Controls	Fit for purpose, future improvements possible	The main regional faulting has been incorporated into the model structure. The unstructured grid allows geological pinch-outs and displaced units to be represented. Some simplifications have been made to the east of the site regarding the Isaac Thrust fault disconnection (hydraulic zones used only). Future updates could simulate this with more accuracy; however, this refinement is unlikely to affect the reliability of key predictions, as they would further disconnect the system and compartmentalise drawdown.
	Conceptualisation – GDEs	Fit for purpose	Groundwater Dependent Ecosystem (GDE) conceptualisation is documented in the model reporting. No material issue was identified for the purposes of this assessment.
	Conceptualisation – Surface Water Groundwater Interactions	Fit for purpose, future improvements possible	Surface water-groundwater interaction is conceptualised as limited. Surface water features are ephemeral and long-term groundwater baseflow is not expected to be significant. Surrogate, simpler models could be used to better predict surface water leakage rates and frequency to heads and head changes (e.g. Pastas).
	Conceptualisation – Saturated Extent of Alluvium and Regolith	Fit for purpose	The saturated extent of the alluvium and regolith is informed by monitoring bore data and appears suitable for model calibration and prediction.
Parameterisation	Hydraulic Conductivity – Shallow Layers	Fit for purpose, future improvements possible	Spatial variability in shallow hydraulic conductivity is represented using pilot points in the alluvium and regolith. Additional hydraulic testing would improve confidence in parameter ranges and spatial connectivity.
	Hydraulic Conductivity – Hard rock / Depth Dependence	Fit for purpose	Available field testing indicates hydraulic conductivity generally declines with depth. The adopted depth-dependence relationship is a reasonable representation of this behaviour. Pilot points are applied on top of this depth dependence field to expose mild heterogeneity and potential avenues of enhanced drawdown/flow change.
	Storage	Fit for purpose, future improvements possible	The available information on storage parameters appears limited. Additional testing of specific yield and specific storage would improve confidence in the duration of drawdown and flow impacts.
	Vertical Hydraulic Conductivity	Fit for purpose, future improvements possible	Vertical hydraulic conductivity is constrained from available data, literature and calibration. Nested bores, VWPs or laboratory testing, and gradient specific observation targets during inversion would improve confidence in vertical connectivity assumptions.
	Spoil Properties	Fit for purpose, future improvements possible	It is noted that site-specific spoil hydraulic testing data was not available because mining has not commenced (although the client has obtained geochemistry and geophysics data from core holes in the pit area), however neighbouring sites owned by the proponent have emplaced spoil. Adopted spoil properties are reasonable for prediction, but future testing of emplaced saturated spoil would improve confidence.
	Rivers	Fit for purpose, future improvements possible	Major rivers and creeks are represented using the RIV package. The Isaac River is ephemeral and local stage data collection, refinement of leakage volumes and frequency through some unsaturated flow approximations/correction would improve future assessments.

Type	Part	Status	Comment
	Recharge	Fit for purpose, future improvements possible	Recharge is represented using mapped surface geology and calibrated recharge rates. This approach is suitable for the current assessment. The frequency of recharge events could be refined to help improve the calibration and consequently the uncertainty of shallow aquifer hydraulic properties.

2.3 GMDSI decision-support modelling guiding

In a similar vein to the IESC uncertainty, the Groundwater Modelling Decision Support Initiative (GMDSI) released 'Monograph: Decision-Support Modelling Viewed Through the Lens of Model Complexity' (Doherty & Moore, 2021). Manewell Groundwater has distilled the key guiding principles into checklist items to ensure the model is not overly complex, and the model is a useful tool that appropriately assesses the likelihood of the "bad thing" from occurring. Table 3 presents pertinent guiding principles as checklist items.

Table 3 Decision-support guiding principles checklist

Category	Guiding principle item	Yes/No	Comment
Client/Regulator Concerns	Have the impacts that the client/regulator fears been clearly identified before starting the modelling process?	Yes	Several iterations of this model have been presented to regulators and peer reviewers.
Model Purpose and Uncertainty	Is the model specifically designed to make a particular prediction and quantify the uncertainty associated with that prediction?	Partial	Model designed to predict drawdown, inflow and flow change for numerous stakeholders and includes 21 mines in the model area.
Simplicity Over Complexity	Has the model avoided unnecessary complexity, opting for simpler, effective approximations?	Partial	A 19 layer, 1.3 million node model used to history match and predict all aspects of the groundwater flow regime. However, other aspects of the flow regime have been simplified appropriately, perhaps too simplistically, resulting in mediocre climate replication.
Conceptual Model Collaboration	Is the conceptual model developed in collaboration with relevant experts, addressing where key information resides?	Yes	Model developed with team of hydrogeologists, groundwater modellers, and surface water/ecology specialists.
Exploration of Hydrogeological Representations	Are multiple representations of specific hydrogeological details explored, acknowledging system unknowns?	Yes	Pilot points used to represent heterogeneity in key aquifers and faults across 109 parameter realisations.
Historical Stress Response Simulation	Can the model simulate the system's response to historical stresses effectively?	Partial	Ensemble of models replicates absolute heads and transient trends appropriately. Short term responses to climate induced recharge are not well replicated around the Project.
Numerical Efficiency and Robustness	Does the model run reasonably fast and maintain numerical robustness for effective hypothesis testing?	Partial	Model runtimes would render effective hypothesis testing unfeasible, however, for typical GIA assessments, and the nature of the impacts, at this stage hypothesis testing is not typically required/useful.
Model-Partner Software Integration	Is there a non-intrusive interface with model-partner software, capable of running models in parallel?	Yes	History-matching and uncertainty analysis undertaken using in-house sequential Monte Carlo sampling software, employing PEST/USGS processing tools where required.
History Matching Approaches	Are appropriate numerical strategies, such as Tikhonov regularization and singular value decomposition, used in history matching?	Yes	Sequential Monte Carlo optimisation algorithm applied. The approach, in combination with long model run times, is very computationally demanding and relatively inefficient. However, a reasonable ensemble of parameters was achieved in spite of the avoidance of typical regularisation, singular value decomposition, Levenberg-Marquardt algorithm optimisation approaches.
Data-Driven Prediction Design	Is the primary model designed for calibration against historical field measurements?	Yes	Quarterly stress periods used to simulate climate response and historic dewatering.
Parameterization in Decision-Support Modelling	Are model parameters plentiful, adjustable, and capable of stochastic representation?	Yes	Major aquifers have an appropriate number of pilot points. Generally, all uncertain model input parameters were appropriately perturbed.
Accommodation of Uncertainty in Decision-Modelling	Does decision-modelling accommodate uncertainty, exploring the pessimistic end of the uncertainty bell curve?	Yes	The posterior parameter ranges are appropriately wide and informed by previous calibration exercises. Additional inversion did little to condition uncertainty of parameters,

Category	Guiding principle item	Yes/No	Comment
			so it is likely the pessimistic end of the bell curve is explored.
Reduction of Decision-Critical Uncertainty	Is decision support modelling tuned to reduce the uncertainty of one or a few critical predictions?	Yes	Drawdown, inflow, baseflow, flow change and particle movement predicted.
Avoiding Type 2 Statistical Error	Does the model avoid overstating the widths of decision-critical predictive uncertainty analysis?	Yes	Range of posterior parameter distribution enforced by expert knowledge, and remain appropriately wide through inversion, so worse case impacts are within reality.
Predictive Error Accounting	Is predictive error introduced by numerical methodologies accounted for and communicated effectively?	Yes	Posterior parameter distributions presented. Model parameter classification suitably discussed. Appropriate range of predictions present as likelihood bands.
System Component Representation	Are essential system components that impact predictions represented in the numerical model?	Yes	Key processes relevant to dewatering and the saturated groundwater phase represented.
Parameter Importance and Hosting of Information	Is the importance of parameters and their role in hosting information acknowledged?	Yes	Pilot points used to expose heterogeneity in response to groundwater level measurements.
Hypothesis Testing for Future Stresses	Is the hypothesis that future stresses will result in negative outcomes only rejected when demonstrably incompatible with known system measurements or behaviours?	Partial	Predictive uncertainty used historic groundwater level, drawdown and flow information to reject unrepresentative realisations. Hypothesis testing not undertaken.
Prediction Spectrum Awareness	Is there an understanding of the differences between data-driven, expert-knowledge-driven, and mixed predictions?	Yes	Not explicitly addressed, although mixed prediction approach used is appropriate.

Overall, it is this reviewer's opinion that the model serves as a blunt but suitable decision support tool. Generally, the model has the ability to harvest modest levels of information from the observation data, but only after months of intense computational inversion. If hypothesis testing were required for future studies (e.g., if early dewatering indicates more impacts than simulated), a simpler, highly parameterised version of the model should be developed that has the ability to expose avenues for drawdown/flow that were not previously represented in the complex approvals model.

2.4 Australian Groundwater Modelling Guidelines checklists

Table 4 is the Compliance Checklist from the Australian Groundwater Modelling Guidelines (Barnett, 2012). This checklist is used to judge whether a model is fit for purpose, and describes 10 questions which cover the essential aspects that any groundwater model needs to satisfy, independent of model objectives or confidence-level classification.

The results conclude that the groundwater model is "fit for purpose", where the primary purpose is to develop upon an existing model that is reasonably well calibrated to historical groundwater levels, drawdown, flow changes, and landholder impact. The model is a suitable tool for decision support where the purpose is to provide predictions on potential impacts due to mining caused by the Project.

Table 4 Compliance checklist

No.	Review Questions	Yes/No	Comment
1	Are the model objectives and model confidence level classification clearly stated?	Yes	Model objectives clearly stated, and model level confidence discussed in detail.
2	Are the objectives satisfied?	Yes	The objectives of the study of assessment of effects from the Project's mining activities have been satisfied through predictions of dewatering effects on receptors. Alluvial flow change and potential baseflow/leakage and landholder impacts are sufficiently calculated and discussed. The effects of the voids on the post mining groundwater system are presented and discussed.

No.	Review Questions	Yes/No	Comment
3	Is the conceptual model consistent with objectives and confidence level classification?	Yes	The conceptual model is consistent to the geological structure and mining included stresses. The interaction between surface and groundwater stresses is adequately simulated given the conceptualisation, field observations, and scale of the model. Although the model is high in cell count, it proves to be useable and reliable. The significant numerical overhead and computational burden come at the cost of fidelity, which in turn compromises its feasibility. The numerical model is history matched to best practice and uncertainty analysis assessed to industry standards.
4	Is the conceptual model based on all available data, present clearly and reviewed by and appropriate reviewer?	Yes	The model was based on a cumulation of previous modelling designs. Conceptual model is clearly described in the accompanying GIA report, developed by a team of hydrogeologists and modellers, and there are illustrations that include hydrogeological stresses and interactions.
5	Does the model design conform to best practice?	Yes	An adequate conceptual model has been generated and is reflected in the numerical model. The simplistic surface/groundwater interactions are aligned to the conceptual model. Pilot points are used to represent heterogeneity in the alluvium, regolith, Rewan, and coal seams. The model's ability to represent cumulative impacts at other model stakeholder's projects took priority over local model impact fidelity and information harvesting. This is a little at odds with contemporary guidance regarding reliability, reproducibility and information harvesting (i.e. Doherty & Moore, 2021), however it is fit for purpose.
6	Is the model calibration satisfactory?	Yes	The model correctly replicates absolute groundwater levels and changes to groundwater levels around the areas of importance proximal to the Project. There are some mismatches that remain at isolated bores. Drawdown trends are adequately replicated. Climate/river leakage responses are not well represented; however this is not expected to significantly change the uncertainty of predictive impacts. Remaining mismatches are exposed and discussed. The model ensemble has not been constrained to flow targets, meaning non-uniqueness is high, however, this is explored via non-linear uncertainty analysis.
7	Are the calibrated parameter values and estimated fluxes plausible?	Yes	History-matched parameter values are within plausible bounds and align to site information (although limited and reliant primarily on slug testing). Recharge rates and hydraulic parameters of the aquifer units are consistent with studies undertaken throughout the region. Fluxes into the mine workings appear plausible. Fluxes (and their absence) to surface water drains are aligned to site information.
8	Do the model predictions conform to best practice?	Yes	Model predictions include time variant pit seepage inflow, drawdown, and flow changes. Composite maximum drawdown maps are presented to show transient maxima, and post mining equilibrium. Impacts on leakage/baseflow and alluvial flow changes are presented. Predictive hydrographs are presented. Incremental and cumulative predictions are calculated using the difference between null, approved, and Project scenarios.
9	Is the uncertainty associated with the predictions reported?	Yes	A comprehensive calibration constrained Monte Carlo predictive parametric uncertainty analysis using 109 realisations spanning a wide range of parameters was completed. Structural uncertainty is discussed and attempts made to reduce error. Different scenarios are assessed. Variability in recharge across the uncertainty analysis arguably spans reduction in recharge implied by climate change. Post mining uncertainty analysis after 200 years presented and represents an adequate analysis of post mining impacts.
10	Is the model fit for purpose?	Yes	The model is built and assessed to industry standards. Given site information around the Project suggesting surface-groundwater interactions are minimal and predictive uncertainty presented is likely conservation, the model is considered fit for purpose.

Table 5 is the Review Checklist from the Australian Groundwater Modelling Guidelines (Barnett, 2012). This checklist is more comprehensive than the Compliance Checklist, and asks specific questions to ensure that the model meets the requirements outlined in the Guidelines.

Table 6 presents a distilled version of the IESC Information Requirements summary with brief comment on suitability.

Table 5 Review checklist

No.	Review Questions	Yes/No	Comment
1	**Planning**		
1.1	Are the project objectives stated?	Yes	Designed to support an EIS to inform the Projects approval process (section 1.1 of the *Groundwater Impact Assessment* report).
1.2	Are the model objectives stated?	Yes	Designed to support an EIS to inform the Projects approval process (section 1.1 of the *Groundwater Impact Assessment* report).
1.3	Is it clear how the model will contribute to meeting the project objectives?	Yes	The report states that the modelling results are to assess the likely impacts of the proposed mining activity on that environment (section 1.2 of the *Groundwater Impact Assessment* report).
1.4	Is a groundwater model the best option to address the project and model objectives?	Yes	Predicting the effects of mining on groundwater during the lifecycle of the Project is best tested through a 3D numerical groundwater model.
1.5	Is the target model confidence-level classification stated and justified?	Yes	Model performance discussed in Appendix H of the *Groundwater Impact Assessment* report.
1.6	Are the planned limitations and exclusions of the model stated?	Yes	Model limitations discussed in Appendix H of the *Groundwater Impact Assessment* report.
2	**Conceptualisation**		
2.1	Has the literature review been completed, including examination of prior investigations?	Yes	Information sources and investigations detailed in sections 1.3 and 1.4 respectively of the *Groundwater Impact Assessment* report.
2.2	Is the aquifer system adequately described?	Yes	The *Groundwater Impact Assessment* report describes in detail the aquifer/aquitard units, flow directions, recharge/discharges, likely parameter ranges.
2.2.1	Hydrostratigraphy including aquifer type (porous, fractured rock …)	Yes	The hydrostratigraphy describes the main components of the system related to the desired project objective - namely the unconfined alluvial aquifer and other Cenozoic sediments, Triassic Rewan group and Permian formations (section 4.0 of the *Groundwater Impact Assessment* report).
2.2.2	Lateral extent, boundaries and significant internal features such as faults and regional folds.	Yes	Appendix H of the *Groundwater Impact Assessment* report - fault displacement and potential lateral connectivity is represented using lateral connection groups. Along certain sections of the Isaac Thrust, model layers are laterally disconnecting though Lateral disconnection and layer absence. Hydraulic altering along the fault zones is also represented by the model and consistent with the hydrogeological conceptualisation (although drilling suggests narrower brecciated zone than literature and conceptualisation indicate). Appendix H of the *Groundwater Impact Assessment* report - rivers and creeks are represented but includes the Isaac River which is a disconnected surface water system. The model domain is exceptionally large, designed to represent cumulative interaction, and other mining projects operated by clients with investment in Central Bowen Basin groundwater model.

No.	Review Questions	Yes/No	Comment
2.2.3	Aquifer geometry including layer elevations and thicknesses.	Partial	Aquifer elevations and thickness discussed in multiple sections of all reports. The modelling appendix report presents a table with model wide average layer thicknesses. Appendix H of the *Groundwater Impact Assessment* report would be improved by the inclusion of layer elevations and thicknesses as maps, although given the coal resource, it is understandable that confidentiality issues may arise with such data.
2.2.4	Confined or unconfined flow and the variation of these conditions in space and time?	Yes	Nature of unconfined/confined conditions and saturation discussed in the *Groundwater Impact Assessment* report. Saturation mentioned in conceptualisation and throughout reports.
2.3	Have data on groundwater stresses been collected and analysed?	Yes	
2.3.1	Recharge from rainfall, irrigation, floods, lakes.	Yes	Recharge from rainfall calculated using Australian Landscape Water Balance model (AWRA-L) simulated deep drainage (compared against monthly rainfall data from SILO), and Chloride Mass Balance (CMB) analysis (section 5.4 of the *Groundwater Impact Assessment* report). There is sufficient discussion on the relationship between recharge events and groundwater level changes.
2.3.2	River or lake stage heights.	Yes	River stage setup described in Appendix I of the *Groundwater Impact Assessment* report. River stage representation is perhaps oversimplified, although as simulated should not significantly affect predictive results.
2.3.3	Groundwater usage (pumping, returns etc.)	No	Well package not used in the calibration or predictive scenarios.
2.3.4	Evapotranspiration.	Yes	Evapotranspiration (EVT) discussed in multiple sections of all reports. EVT package used, presenting calibrated extinction depth.
2.3.5	Other?	N/A	
2.4	Have groundwater level observations been collected and analysed?	Yes	Isaac Complex bores assessed as part of the Conceptual Site Model (CSM) and used in the model calibration.
2.4.1	Selection of representative bore hydrographs.	Yes	Selected monitoring bore hydrographs presented in section 5.5 of the *Groundwater Impact Assessment* report and are discussed adequately.
2.4.2	Comparison of hydrographs.	Yes	Multiple hydrographs with grouped bores presented and discussed. Vertical connectivity and hydraulic gradients between aquifers compared in section 5.5.4 of the *Groundwater Impact Assessment* report.
2.4.3	Effect of stresses on hydrographs.	Yes	The *Groundwater Impact Assessment* report discusses the relationship between recharge events and groundwater level changes. Effects of drawdown from existing projects is discussed.
2.4.4	Watertable maps/piezometric surfaces?	Yes	Observed potentiometric maps presented in *Groundwater Impact Assessment* report for Alluvium and Rangal Coal Measures. Simulated groundwater level surfaces presented post mining.
2.4.5	If relevant, are density and barometric effects taken in account in the interpretation of groundwater head and flow data?	N/A	Not relevant to the scale of this study.
2.5	Have flow observations been collected and analysed?	Yes	Detailed analysis regarding surface water flow presented in the *Groundwater Impact Assessment* in section 3.2.

No.	Review Questions	Yes/No	Comment
2.5.1	Baseflow in rivers.	Yes	Potential/absence of baseflow in rivers discussed in *Groundwater Impact Assessment*. The modelling appendix presents the change in flow due to water level drawdown, under the assumption of saturated connection when surface water is present (conservative).
2.5.2	Discharge in springs.	N/A	No springs mapped within the vicinity of the Project area.
2.5.3	Location of diffuse discharge areas?	N/A	Out of the scope of this study.
2.6	Is the measurement error or data uncertainty reported?	Partial	Discussed briefly in the model performance and limitations section of each report, although observation noise on head and drawdown targets assumed during inversion process not discussed.
2.6.1	Measurement error for directly measured quantities (e.g. piezometric level, concentration, flows).	No	Not reported. Modelling relies heavily on publicly available data, bore logs, etc. Timeseries water level data with varying resolution used for calibration.
2.6.2	Spatial variability/heterogeneity of parameters.	Yes	Local heterogeneity discussed in limitations section of all reports. Heterogeneity represented in the alluvium, regolith, Rewan Fm. and coal seams via pilot points (as per Appendix I of the *Groundwater Impact Assessment* report). Correlation distance of assumed spatial connectivity is presented and discussed in modelling appendix.
2.6.3	Interpolation algorithm(s) and uncertainty of gridded data?	No	Interpolation algorithm of gridded data not discussed.
2.7	Have consistent data units and geometric datum been used?	Yes	m3/day, ML/day and ML/year consistently used where appropriate.
2.8	Is there a clear description of the conceptual model?	Yes	Described in section 6.0 of the *Groundwater Impact Assessment* report.
2.8.1	Is there a graphical representation of the conceptual model?	Yes	Conceptual model clearly presented as several cross-sections representing both near surface and full profile conceptual models.
2.8.2	Is the conceptual model based on all available, relevant data?	Yes	Cross section based on geological information from drill-logs and geological models. Key processes are presented. Post mining conditions are represented.
2.9	Is the conceptual model consistent with the model objectives and target model confidence level classification?	Yes	The key system components have been integrated to target the project objectives, the objectives being effects of mine pit development on groundwater levels, groundwater users, alluvial aquifer levels and river and stream baseflows. Effects on GDE can be inferred from the report.
2.9.1	Are the relevant processes identified?	Yes	The main components of the hydrology, surface/groundwater interaction, hydrogeology, and transient stresses from the mine pit development have been included.
2.9.2	Is justification provided for omission or simplification of processes?	Yes	The report limitation section discusses these.
2.10	Have alternative conceptual models been investigated?	No	This is discussed somewhat in the limitations section of the *Groundwater Impact Assessment* report. It has been raised that there are future opportunities to adjust the modelling / calibration techniques used in order to improve the results.
3	**Design and construction**		
3.1	Is the design consistent with the conceptual model?	Yes	Generally, all major and relevant processes are consistent between the CSM and numerical model.

No.	Review Questions	Yes/No	Comment
3.2	Is the choice of numerical method and software appropriate (Table 4-2)?	Yes	Central Bowen Basin numerical groundwater model used. MODFLOW-USG Transport used and model grid refined around the Project area. Upstream weighting used to overcome dry cell issues. This 'mega model' serves as an appropriate tool for assessing major cumulative interactions, but the cost is the loss of fidelity and information extraction as a result of the very long runtimes, potential numerical instability, and the potential for many singular values that make hydrogeological truth difficult to resolve.
3.2.1	Are the numerical and discretisation methods appropriate?	Yes	Cell refinement for Project is sufficient to reduce structural error to a practical minimum. 100m cells used around IDE mining area, and 200 m cells along the drainage systems. Voronoi tessellation and node placement optimised around the location of key features.
3.2.2	Is the software reputable?	Yes	MODFLOW-USG is an accepted industry standard for this type of application.
3.2.3	Is the software included in the archive or are references to the software provided?	Yes	MODFLOW-USG is referenced across all reports.
3.3	Are the spatial domain and discretisation appropriate?	Yes	Spatial domain / discretisation briefly discussed in all reports.
3.3.1	1D/2D/3D.	Yes	3D
3.3.2	Lateral extent.	Yes	Lateral extent of alluvial sediments measured via ERI surveys. The lateral boundaries are located far enough from areas stressed during simulation and prediction.
3.3.3	Layer geometry?	Partial	Layer geometry briefly discussed and presented as model wide layer average thicknesses. Ideally structure and site-specific thickness presented, understanding there may be confidentiality issues.
3.3.4	Is the horizontal discretisation appropriate for the objectives, problem setting, conceptual model and target confidence level classification?	Yes	Horizonal discretisation is appropriate to meet the required model outputs, as discussed in points above.
3.3.5	Is the vertical discretisation appropriate? Are aquitards divided in multiple layers to model time lags of propagation of responses in the vertical direction?	Yes	Key aquitards relevant to IDE are represented appropriately. Coal seams simplified to aggregated seams (around 3-5m thick). Surficial layers discretised appropriately, given saturation extents.
3.4	Are the temporal domain and discretisation appropriate?	Yes	
3.4.1	Steady state or transient.	Yes	Steady state and transient calibration undertaken (Appendix H of the *Groundwater Impact Assessment* report), followed by transient predictive analysis.
3.4.2	Stress periods.	Yes	Stress period information appropriately simulated using quarterly periods during historic phase, then annual for predictions. Stress periods grow to 100 years during the recovery phase (Appendix H of the *Groundwater Impact Assessment* report).
3.4.3	Time steps?	Yes	Mentioned in predictive models timing table (Appendix H of the *Groundwater Impact Assessment* report).

No.	Review Questions	Yes/No	Comment
3.5	Are the boundary conditions plausible and sufficiently unrestrictive?	Yes	Drawdown extents from the Project do not interfere with general head boundaries. In post mining residual drawdown from the underground mine to the southwest is significant and appropriately represented. River cells used to represent surface water recharge do not leak unrealistic flows into the groundwater system.
3.5.1	Is the implementation of boundary conditions consistent with the conceptual model?	Yes	General Head Boundaries (GHBs) used to simulate regional throughflow. Drain (DRN) cells used to represent dewatering. RIV cells used to represent surface water leakage/discharge. EVT cells used to represented transpiration, and evaporation from pit lakes. Constant Head (CHD) cells used to represent post mining pit lake.
3.5.2	Are the boundary conditions chosen to have a minimal impact on key model outcomes? How is this ascertained?	Yes	Predictive impacts from the Project do not interact with the GHBs or no flow boundaries. River cells generally representing drains act as baseflow only. Sporadic river leakage represented is modelled as minimal and is unlikely to buffer near surface impacts.
3.5.3	Is the calculation of diffuse recharge consistent with model objectives and confidence level?	Yes	AWRA-L recharge signatures with a calibration factor used in the model and considered appropriate. River leakage is used to represent enhanced surface water recharge. AWRA-L recharge signatures are a little simplified and mis-timed (as discussed in the GIA), and river leakage volumes low, causing model to under-represent temporal recharge signatures.
3.5.4	Are lateral boundaries time-invariant?	Yes	General heads using fixed levels used for the entire simulation.
3.6	Are the initial conditions appropriate?	Yes	Steady state described in Appendix H and Appendix I of the *Groundwater Impact Assessment* report. Original calibrated model for Central Bowen Basin has a single stress period representing 40 years of mining (1988 to 2008), however, this has little relevance to Project history matching.
3.6.1	Are the initial heads based on interpolation or on groundwater modelling?	Yes	Steady state levels use a median model period from 1968-2024 (Appendix I of the *Groundwater Impact Assessment* report).
3.6.2	Is the effect of initial conditions on key model outcomes assessed?	Yes	Steady state heads reformulated for every parameter combination.
3.6.3	How is the initial concentration of solutes obtained (when relevant)?	N/A	
3.7	Is the numerical solution of the model adequate?	Yes	The numerical model solver settings produce percentage discrepancies of over the guidelines of <0.1%.
3.7.1	Solution method / solver.	Yes	Sparse Matrix Solver (SMS) package used as described in Appendix H of the *Groundwater Impact Assessment* report.
3.7.2	Convergence criteria.	Yes	Convergence methodology described in Appendix H of the *Groundwater Impact Assessment* report. Inner and outer convergence criteria of 0.005 and 0.05 m described and appropriate.
3.7.3	Numerical precision.	No	No discussion on numerical precision in the report.
4	**Calibration and sensitivity**		
4.1	Are all available types of observations used for calibration?		
4.1.1	Groundwater head data.	Yes	Model history matched using IDM / IPC specific head and drawdown measurements.

No.	Review Questions	Yes/No	Comment
4.1.2	Flux observations.	No	Available pit inflow rates from existing IPC operations likely unavailable/too uncertain to use as flow target. The absence of baseflow could have been used as a hard target, although the model validates the absence of significant baseflow through absolute heads under the Isaac River, proximal to the Project.
4.1.3	Other: environmental tracers, gradients, age, temperature, concentrations etc.	No	Not used, which is normal for these types of studies, together with the uncertainty associated with MODFLOW concentration predictions. Calibration to vertical head gradients would have likely been beneficial, although validation shows reasonable replication in areas of predictive importance.
4.2	Does the calibration methodology conform to best practice?	Yes	The calibration methodology adopted is novel. Previous attempts at standard calibration (IES) using this model proved ineffective, although this is normal using IES without appropriate safeguards like covariance reinflation, dynamic phi factor readjustment and representation of appropriate noise (although this reviewer was not privy to the detail of previous attempts – IES attempts in neighbouring projects have been successful). The approach avoids some of the artefacts that can arise from default IES application, particularly where ensemble collapse, parameter over-adjustment, or inappropriate prior/posterior conditioning are risks. However, the trade-off is a comparatively inefficient inversion workflow, which is consistent with rejection-based, sequential Monte Carlo, and related likelihood-free/history-matching approaches that often require many (tens of thousands of) model evaluations (Manewell and Shapoori, 2017; White, 2018). Because the base case is reasonably well calibrated, and the parameter uncertainty remains sufficiently wide, despite the significant computation burden and moderate information extraction, the methodology could be considered good practice.
4.2.1	Parameterisation.	Yes	Parameterisation is fit for purpose across the board - around the Project area there is adequate heterogeneity in the area of impacts. The parameter ranges and means are reasonable. Spoil properties based on historical data - to be updated once spoil emplacement occurs. Depth dependence has been incorporated into the model, with spatial variability added to those fields.
4.2.2	Objective function.	Yes	Calibration statistics and novel methodology described across the Numerical model and Central Bowen Basin reports (Appendix H and I respectively of the *Groundwater Impact Assessment* report). The evolution of the objective function(s) is not presented, which would have provided more clarity on the success of the calibration approach.
4.2.3	Identifiability of parameters.	Partial	The conditioning of the parameter uncertainty reduction is inferred through sensitivity analysis. Although not explicitly reported, the relative reduction of uncertainty through use of IDM specific observations (a suitable surrogate for identifiability) is moderate (5-25% max), as evidenced by histograms in Appendix H of the *Groundwater Impact Assessment* report. However, it is also noted that the prior is already constrained from other calibration exercises, which appears to have been around 50% of the prior on average - assuming the prior standard deviations were based on the reported upper and lower parameter bounds.
4.2.4	Which methodology is used for model calibration?	Yes	History matching was performed using the adequately described sequential Monte Carlo approach.

No.	Review Questions	Yes/No	Comment
4.3	Is a sensitivity of key model outcomes assessed against?	Yes	Sensitivity approximated from ensemble analysis calibration and predictive uncertainty. Suitable described, presented, and grouped into type I-IV parameters.
4.3.1	Parameters.	Yes	As above
4.3.2	Boundary conditions.	Yes	Sensitivity of boundary condition parameters discussed.
4.3.3	Initial conditions.	Yes	Not specifically discussed, although initial conditions are reformulated for every model realisation via steady state stress periods, so they are inherent in the results.
4.3.4	Stresses.	Yes	Recharge, EVT rate and River conductivity sensitivity discussed.
4.4	Have the calibration results been adequately reported?	Yes	Calibration statistics, scatterplots, histograms, hydrographs are adequately presented and described.
4.4.1	Are there graphs showing modelled and observed hydrographs at an appropriate scale?	Yes	Ensemble and best calibrated results presented in the Appendix A and Appendix H of the *Groundwater Impact Assessment* report.
4.4.2	Is it clear whether observed or assumed vertical head gradients have been replicated by the model?	Partial	Heads adequately presented and discussed, although simulated vertical gradients not specifically discussed. The absence of perfectly nested bores makes it difficult to clearly calculate vertical head gradients.
4.4.3	Are calibration statistics reported and illustrated in a reasonable manner?	Yes	Appropriate statistics, scatter, and histograms presented, although inclusion of the ensemble on the scatter plots would have been useful.
4.5	Are multiple methods of plotting calibration results used to highlight goodness or fit robustly? Is the model sufficiently calibrated?	Yes	Scatter, hydrographs and spatial residual maps presented to justify calibration methodology. The model is sufficiently calibrated given the methodology used and the model objectives. However, more targeted, local model calibration to more closely fit absolute heads, drawdown, and climate responses should be considered for future model iterations (to reduce parameter uncertainty (and consequent prediction uncertainty).
4.5.1	Spatially.	Yes	Spatial residuals maps of absolute heads and average head changes presented. Calibrated piezometric surfaces compared to observed not presented (although post mining simulated heads presented).
4.5.2	Temporally.	Yes	Transient calibration hydrographs presented.
4.6	Are the calibrated parameters plausible?	Yes	Within plausible bounds from available data using specified methodology.
4.7	Are the water volumes and fluxes in the water balance realistic?	Yes	Comparison was made to like hydrogeological examples in the regional area of the Project. Water fluxes to alluvial aquifers and streams/rivers are consistent with the broader Central Bowen Basin conceptual model.
4.8	Has the model been verified?	No	No verification section in any report.
5	**Prediction**		
5.1	Are the model predictions designed in a manner that meets the model objectives?	Yes	Progressive drain cells simulate open cut dewatering. Repeat of historic climate conditions assumed and appropriate. Predictions calculated as difference between the Null minus cumulative, and No project minus cumulative model scenarios.

No.	Review Questions	Yes/No	Comment
5.2	Is predictive uncertainty acknowledged and addressed?	Yes	Predictive uncertainty comprehensively addressed and graphically demonstrated in Appendix H of the *Groundwater Impact Assessment* report.
5.3	Are the assumed climatic stresses appropriate?	Yes	Climate detailed in section 3.1 of the *Groundwater Impact Assessment* report. Climate change addressed within the uncertainty analysis through varying recharge rates.
5.4	Is a null scenario defined?	Yes	All predictive runs are compared to a null scenario (where no mining occurs) and a no project scenario.
5.5	Are the scenarios defined in accordance with the model objectives and confidence level classification?	Yes	Predictive modelling undertaken throughout the entire mining operation to calculate specified quantities of interest. Includes a sufficient recovery period, and are assessed as a predictive model ensemble.
5.5.1	Are the pumping stresses similar in magnitude to those of the calibrated model? If not, is there reference to the associated reduction in model confidence?	Yes	Pit dewatering included in the predictions (Appendix H of the *Groundwater Impact Assessment* report). Dewatering (via drain cells) occurring at a similar magnitude cumulatively during historic phase compared to the predictive simulation.
5.5.2	Are well losses accounted for when estimating maximum pumping rates per well?	N/A	
5.5.3	Is the temporal scale of the predictions commensurate with the calibrated model? If not, is there reference to the associated reduction in model confidence?	Yes	The historic time period for mining is 18 years, the same as the predictive phase of mining (18 years). Post mining equilibration runs a further 476 years.
5.5.4	Are the assumed stresses and timescale appropriate for the stated objectives?	Yes	As above. Recovery stress periods are adequate for the environment, climate and simulated mining.
5.6	Do the prediction results meet the stated objectives?	Yes	The predictive results measure changes in groundwater level, flux to alluvial aquifers, changes to river baseflows and pit seepage - this meets the stated study objectives.
5.7	Are the components of the predicted mass balance realistic?	Yes	Inflows and discharge rates going into the model are realistic, and adequately reported and presented.
5.7.1	Are the pumping rates assigned in the input files equal to the modelled pumping rates?	N/A	
5.7.2	Does predicted seepage to or from a river exceed measured or expected river flow?	Yes	River leakage during recharge events is reasonable. Many bores do not show sufficient simulated recharge response, suggesting there is more leakage occurring temporarily than simulated by the model. This is a disconnected system, so there are minimal implications to additional induced leakage.
5.7.3	Are there any anomalous boundary fluxes due to superposition of head dependent sinks (e.g. evapotranspiration) on head-dependent boundary cells (Type 1 or 3 boundary conditions)?	No	EVT depths along the Isaac River are in line with the CSM, and the rate at which groundwater is removed declines linearly with depth. With the observed deep watertable this means deep transpiration operates at an expected fraction of the 600 mm/year value input. Whole of model EVT rates is reasonable and in line with expected inputs.
5.7.4	Is diffuse recharge from rainfall smaller than rainfall?	Yes	Recharge rates range from 0.003 to 4.7% of rainfall (Appendix H of the *Groundwater Impact Assessment* report).

No.	Review Questions	Yes/No	Comment
5.7.5	Are model storage changes dominated by anomalous head increases in isolated cells that receive recharge?	No	No obvious anomalous changes in storage from the averaged fluxes presented in the water balance charts and tables.
5.8	Has particle tracking been considered as an alternative to solute transport modelling?	Yes	Particle tracking used to simulate long-term movement of groundwater through the system post-mining using mod-PATH3DU code (Appendix H of the *Groundwater Impact Assessment* report).
6	**Uncertainty**		
6.1	Is some qualitative or quantitative measure of uncertainty associated with the prediction reported together with the prediction?	Yes	Type 3 Monte Carlo uncertainty analysis presented in Appendix H of the *Groundwater Impact Assessment* report.
6.2	Is the model with minimum prediction-error variance chosen for each prediction?	Partial	An ensemble of models is used in the predictive analysis that meet calibration statistical thresholds. Each model does not necessarily possess a combination of parameters that are statistically minimised through inversion.
6.3	Are the sources of uncertainty discussed?	Yes	Discussed in Table 7-2 of the *Groundwater Impact Assessment* report.
6.3.1	Measurement of uncertainty of observations and parameters.	No	Not specifically discussed.
6.3.2	Structural or model uncertainty.	Yes	Discussed in Table 7-2 of the *Groundwater Impact Assessment* report.
6.4	Is the approach to estimation of uncertainty described and appropriate?	Yes	Uncertainty is very well described. The likelihood of predictions is appropriately calculated, presented and discussed. Estimation of predicted sensitivity is novel and alternative, however, it adequately paints a picture of the key parameters and prediction that require future analysis and monitoring. There are adequate realisations to derive confident predictive likelihood. Parameter ranges remain sufficiently wide and only moderately conditioned by the calibration process. Prediction is undertaken for the null, approved, and project scenarios for the life and mine and recovery phases (long enough to confidently assess long-term impacts).
6.5	Are there useful depictions of uncertainty?	Yes	Predictions are presented as estimates of likelihood as per the IESC uncertainty guidelines, presented as flow percentile charts and exceedance maps.
7	**Solute transport**		
Not applicable for this Project			
8	**Surface water-groundwater interaction**		
8.1	Is the conceptualisation of surface water-groundwater interaction in accordance with the model objectives?	Yes	The conceptual model determined that surface water-groundwater interactions in the Project area were limited due to ephemeral surface water features (model performance and limitation table).
8.2	Is the implementation of surface water-groundwater interaction appropriate?	Yes	Given limited baseflow in the Project area and surrounds, the simplistic representation of surface water-groundwater interaction is appropriate.

No.	Review Questions	Yes/No	Comment
8.3	Is the groundwater model coupled with a surface water model?	Yes	Surface water model completed by HydroBalance (2026 – not reviewed) and results replicated in the IDE void (Appendix H of the *Groundwater Impact Assessment* report). There is no coupling with a surface water model for drainage simulation, which would be inappropriate, given the disconnection of the two flow regimes.
8.3.1	Is the adopted approach appropriate?	Yes	The simulation of rivers and streams through the application of boundary conditions is appropriate.
8.3.2	Have appropriate time steps and stress periods been adopted?	Yes	Model stress period length is appropriate given the lag of groundwater recharge pulses through the unsaturated system. This is a saturated groundwater flow simulator, not a surface water flow model, so the level of detail represented is appropriate at this stage in the approval process.
8.3.3	Are the interface fluxes consistent between the groundwater and surface water models?	Yes	See above. Pit lake recovery informed by iterative surface water/groundwater modelling.

Table 6 IESC Information Requirements Checklist Summary

Assessment item	Focus	Peer review status	Peer reviewer finding / comment
Context and Conceptualisation	Regional setting, project description, regulatory context and water-resource setting.	Adequate	The proposal and regional context are clearly described, including Project purpose, scale, duration, disturbance footprint, water resources, water-dependent assets and relevant surrounding developments.
Risk Assessment	Water-resource risks, impact pathways, mitigation and residual risk.	Adequate	Detail risk assessment undertaken appropriately. The assessment identifies the main water-related risks and links them to impact pathways, model predictions and proposed management responses.
Groundwater – Context and Conceptualisation	Geology, hydrostratigraphy, groundwater levels, hydrochemistry, recharge/discharge and connectivity.	Adequate	The groundwater conceptualisation is well developed, described, presented and supported by most available data.
Groundwater – Analytical and Numerical Modelling	Model design, calibration, sensitivity, uncertainty and prediction setup.	Adequate	The numerical groundwater model is appropriate for regional and cumulative impact assessment. The domain, discretisation, boundary conditions, calibration and uncertainty analysis are generally fit for purpose.
Groundwater – Impacts to Water Resources and Water-Dependent Assets	Predicted drawdown, dewatering, recovery, flux changes, groundwater users and residual impacts.	Adequate	Predicted groundwater impacts are assessed through drawdown, recovery, flux changes, river/baseflow interaction, groundwater-user impacts and cumulative scenarios. The assessment supports conclusions regarding impact magnitude and timing.
Groundwater – Data and Monitoring	Baseline groundwater data, monitoring program, triggers, reporting and model updates.	Adequate	Available monitoring data support baseline interpretation and model calibration. The network shows climatic/surface water responses, as well as long term drawdown responses from neighbouring dewatering operations. The proposed monitoring framework is suitable, provided trigger review, reporting, adaptive response and future model-update requirements are clearly implemented.
Water-dependent assets – Context and Conceptualisation	Identification of GDEs, ecological values, water-dependence and impact pathways.	Adequate/relies on supporting studies	Water-dependent assets and GDEs are identified and conceptualised through supporting ecological assessments. Groundwater dependence and impact pathways are described at a suitable level, with detailed ecological conclusions deferred to the specialist studies.
Water-dependent assets – Impacts, Risk Assessment and Management of Risks	Direct and indirect impacts, acceptable thresholds, mitigation and response actions.	Adequate	Potential impacts to water-dependent assets are considered through drawdown, flow change, risk assessment and management responses.
Water-dependent assets – Data and Monitoring	Baseline/reference monitoring, ecological response monitoring and review process.	Adequate/relies on supporting studies	Ecological and GDE monitoring are addressed in supporting assessment and management documents. The approach is suitable if baseline/reference monitoring, thresholds, reporting and revision processes are carried through to implementation.
Water and Salt Balance, and Water Quality	Site water balance, operational discharges, water management infrastructure and water quality risks.	Adequate/relies on supporting studies	The site water balance and operational water management are addressed by the HydroBalance assessment (2026 – not reviewed). Water quality and discharge-related risks are considered.
Cumulative Impacts – Context and Conceptualisation	Cumulative assessment extent, timeframe and inclusion of surrounding developments.	Adequate	The cumulative assessment benefits from the broad regional model domain and the representation of existing and reasonably foreseeable developments. This is a strength of the modelling approach.
Cumulative Impacts – Impacts	Spatial and temporal cumulative impacts to water resources and assets.	Adequate	Cumulative groundwater impacts are assessed spatially and temporally using scenario comparisons. The assessment is reasonable, noting that predictions should be updated if neighbouring projects significantly change.

Assessment item	Focus	Peer review status	Peer reviewer finding / comment
Cumulative Impacts – Mitigation, Monitoring and Management	Adaptive management, monitoring, reporting and mitigation of cumulative effects.	Adequate	Mitigation and monitoring well described and developed in the provided *Groundwater Monitoring and Management Plan*.
Acid-forming Materials and Other Contaminants of Concern	PAF material, rejects/tailings, leachate, contaminant pathways and controls.	Adequate /relies on supporting studies	Acid-forming materials and the potential for contaminant pathways (or lack thereof) are addressed through geochemical and management assessments (Terrenus, 2026 – not reviewed).

2.5 Model commentary

2.5.1 Model conceptualisation

Conceptualisation is presented in the *Isaac Downs Extension - Groundwater Impact Assessment* report. Sufficient rigor has been applied to the development of the conceptual model, which represents a culmination of previous regional studies, adjacent mine data, bore census work, drilling, hydraulic testing, ERI surveys, fault investigation drilling, GDE studies, groundwater level monitoring and water quality sampling.

The Conceptual Site Model (CSM) represents the key hydrostratigraphic units relevant to the Project, including the Isaac River/Cherwell Creek alluvium, regolith/Tertiary/weathered Permian, Triassic Rewan Group, Rangal Coal Measures, Fort Cooper Coal Measures and deeper Moranbah Coal Measures. This level of hydrostratigraphic segregation is appropriate given the model objectives. The CSM is presented diagrammatically across several figures and clearly illustrate existing and post mining conditions. Flow directions and gradients are presented, along with average piezometric groundwater levels surfaces for the shallower and Permian major aquifer units.

The Isaac Thrust Fault has been considered with more rigor than is often seen in these assessments. The Project area is located in a structurally complex part of the Bowen Basin, and the report describes the regional and local faulting, including the north-northwest trending reverse Isaac Thrust Fault, fault splays and throws of up to about 100 m. Project-specific drilling and downhole geophysics were undertaken to better characterise the fault zone east of the Project area. This provides a reasonable basis for representing fault-related hydraulic effects within the model. The model represents brecciation conservatively, given site specific data suggests only moderate, narrow brecciation than is supported by literature/regional investigations.

Appropriate presentation of data and analysis is applied to the groundwater level trends and responses to the climate stresses. Thought has been applied to potential recharge frequency and response, based on AWRA-L modelling, chloride mass balance estimations and experience from neighbouring projects.

The conceptualisation is generally consistent with the model objectives, which are focused on predicting Project-related and cumulative effects on groundwater levels, groundwater users, alluvial aquifers, river/baseflow systems, mine inflows and post-mining recovery. The disconnected nature of the Isaac River alluvium and deeper groundwater system is well described and presented. The 'perched' groundwater system (or the thin highly weathered strata at the surface that reaches 100% saturation temporally following rainfall events), disconnected from the saturated groundwater phase is correctly conceptualised. It is inappropriate to replicate perched behaviour explicitly above a thick unsaturated zone in regional models like these. The study has gone to substantial effort in the conceptual groundwater section of the GIA to characterise this behaviour and has made appropriate inferences pertaining to potential impacts, noting the disconnection to the saturated phase intercepted by mining.

The conceptualisation is fit for purpose. Future improvement is possible as additional monitoring data are collected, particularly in relation to recharge responses, hydraulic testing, and a better understanding of vertical gradients.

2.5.2 Model code / extent and mesh design

The model utilises the Central Bowen Basin regional numerical groundwater model. MODFLOW-USG Transport is used with an unstructured Voronoi grid. MODFLOW-USG is an industry standard code and is suitable for the stated model objectives. The unstructured grid allows local refinement around the Project, surrounding mines, pits, faults and drainage features while retaining a very large regional domain. This regional model originated as the Olive Downs Project model developed by HydroSimulations in 2018. Since that time, the model has been progressively expanded and updated to include additional mining areas, mesh refinements, revised model packages, expanded calibration datasets and updated calibration methods. As such, the current model is not a new model developed specifically for the Project, but rather the latest version of a regional cumulative impact model that has evolved over several project assessments. The model has 1.3 million active nodes and long runtimes, which results in significantly numerically demanding inversion and uncertainty analysis exercises.

The model is essentially a very large cumulative impact model with local refinement around several commissioned projects. This is appropriate for assessing interactions between the Project and nearby mining operations. The downside is that it is not a project specific impact model, and there is an expected loss of fidelity from simulating 21 other projects, many with specific grid refinement requirements that slow the model down and likely introduce potential numerical instability. As a result, local heads, recharge events and individual bore responses are unlikely to be perfectly replicated (i.e. less than ±2 m) compared to a local simulator.

However, given the eventual adequacy of the calibration and predictive impacts, this reviewer considers the model extent and mesh design fit for purpose.

2.5.3 Model layers

The model is vertically discretised into 19 layers. These represent the shallow alluvium/surface cover, regolith and Tertiary units, Triassic Rewan Group, Rangal Coal Measures including the Leichhardt and Vermont seams, Fort Cooper Coal Measures and deeper Moranbah Coal Measures. All layers are defined as convertible, allowing confined and unconfined conditions to develop in space and time. Suitable Layer Property Flow (LPF) options are applied.

This vertical discretisation is appropriate for the model objectives. The coal seams relevant to the Project are represented explicitly as aggregated volumes of coal (a common approach), and the overburden/interburden units are sufficiently represented for assessing mine dewatering, depressurisation and cumulative impacts. The representation of shallow units is also appropriate given the importance of alluvium, regolith and potential surface water-groundwater interaction. The regional water table is relatively deep, meaning there is limited potential for fine-scale interaction between the saturated groundwater system and perched groundwater system associated with the Isaac River Alluvium.

The modelling report presents model-wide average layer thicknesses. Spatial maps of layer geometry and thicknesses are not presented, and it is understood that commercial confidentiality around the coal resource may limit how much of this information can be presented.

2.5.4 Timing

The transient calibration period extends from 2008 to 2025 and is discretised into quarterly stress periods, which is appropriate given the available monitoring data, historical mining stresses, and lag in groundwater response through the deep unsaturated zone. The predictive model simulates mining from 2026 to 2043, followed by recovery to 2519. The post-mining stress periods increase in length through time, which is a common and appropriate approach for long-term recovery simulations.

The timing is fit for purpose. The use of annual predictive stress periods during mining is reasonable for an open-cut coal assessment at this scale. More frequent temporal discretisation would not necessarily improve the reliability of predictions, given the regional model scale and the relatively slow groundwater response in much of the system.

2.5.5 Boundary conditions and stresses

The boundary conditions (RIV, EVT, GHB, DRN, CHD) and stress representations are consistent with the conceptual model. Regional groundwater flow is represented through general head boundaries. These boundaries are far enough away to have zero implications to the reliability of the Project predictions. Surface water systems are represented using river boundaries. Recharge and river stage inputs are based on historical climate/deep drainage and surface water data. Evapotranspiration is represented, with calibrated extinction depths reported for major model zones.

The simplified representation of surface water-groundwater interaction is acceptable for this assessment. The Isaac River and associated drainage systems are ephemeral, and the assessment is concerned primarily with long-term groundwater impact rather than short-term surface water hydraulics. The model may under-represent short-duration recharge responses following flow events, but this is not expected to materially change the main conclusions regarding Project-related drawdown, alluvium take or long-term final void behaviour. It is expected that replicating these sporadic recharge signatures with more accuracy would have conditioned the uncertainty of recharge and near surface hydraulic properties, consequently reducing the uncertainty of predictions. Given the posterior range of parameters remains suitably high, this simplification ideally pushes the likelihood of predictions more to the pessimistic end of the bell curve, a recommended approach as described by the GMDSI to ensure the 'bad thing' from occurring is explored (Doherty and Moore, 2021).

Low volume groundwater extraction by private users is not represented using the Well package. This is unlikely to materially affect the predictions given the objective of assessing mining-induced impacts, although it should be acknowledged as a simplification.

2.5.6 Mining

Open-cut mining is represented through predictive mining stresses that simulate the progression of the Project and surrounding approved/foreseeable mines. Three predictive scenarios are used: Null Run, Approved and Proposed. This is the usual and correct framework for separating Project-specific incremental impacts from cumulative impacts.

Open-cut dewatering is represented using the Drains (DRN) package with nominally high conductance rates and drain elevations set to the base of the proposed target coal seam.

The final landform includes a residual void. Time Variant Materials (TVM), Recharge (RCH) and Evapotranspiration (EVT) packages are adjusted upon mine closure using reasonable values representative of expected post-mining properties. The final void is represented through an iterative process between the groundwater model and a surface water balance model. This is appropriate and accepted approach. Constant Head (CHD) nodes are used to present the recovery pit lake, and net flow volumes to the void are assessed. The predicted residual void behaves as a long-term groundwater sink, with groundwater inflows predominantly occurring through spoil rather than intact geological units. This is conceptually reasonable given the expected higher permeability of spoil compared with surrounding consolidated strata.

It should be noted that groundwater impacts are significantly sensitive to cumulative mining. For example, during mining, much of the potential impact to the Isaac Creek Alluvium is clouded by the presence of the Isaac Downs mine to the north of the Isaac Downs River and other nearby mines. Post mining, impacts are affected by the Cavil Ridge mine underground, and long-term evaporative sinks southwest of the Project. Details regarding the representation of these significant proximal stresses is not well documented. Changes to these stresses should be routinely refined as mine plans change and/or projects are approved or withdrawn.

The mining approach is acceptable and otherwise well documented.

2.5.7 History matching

Model calibration was undertaken using a Sequential Monte Carlo approach. This is a novel but acceptable method for this model, particularly given the model size, non-linearity, long runtimes and difficulty previously encountered with more traditional history matching approaches. History matching was performed using 646 target heads from 52 monitoring locations within or near the Project, separated into initial groundwater level targets and change-in-water-level targets. This is an acceptable approach and helps overcome model structural error by focusing on drawdown (the key objective of the model). Observation noise, assumed measurement uncertainty and how these may affect the SMC likelihood calculations is not discussed.

The calibration dataset is adequate for an approval-scale regional model. The available data include groundwater levels from the Project monitoring network and nearby monitoring networks, and the calibration period captures historical mining stresses from numerous surrounding mines. As previously discussed, this cumulative scale impact model is not expected to exactly reproduce every local groundwater response. It is more important that the model broadly reproduces groundwater levels, drawdown trends, saturated extent and flow directions in the areas of predictive importance. It is possible that a local, targeted model (which also simulates relevant cumulative projects), coupled with more traditional and efficient inversion approaches would have harvested more information residing in the observation data, consequently changing the mean and uncertainty of impact predictions.

Regardless, the model calibration is fit for purpose. Head and head change statistics are at acceptable levels and key impact trends are generally replicated. The main limitation is that some local head responses and recharge signatures are difficult to reproduce with a regional model and simplified recharge/surface water representation. This is expected and is appropriately carried through into uncertainty analysis.

2.5.8 Calibrated parameters, water balance, solution

Hydraulic properties are assigned using the Layer Property Flow (LPF) package and spatial variability is represented using pilot points within defined hydrogeological zones. Spatial covariance is applied to these pilot point fields suitably. This is appropriate for representing heterogeneity in the alluvium, regolith and relevant hard rock aquifer units. Boundary condition parameters do not apply the same heterogeneity; however, they are appropriately perturbed during inversion and uncertainty analysis.

Calibrated hydraulic parameters appear reasonable and are generally consistent with the available site testing, regional information and expected hydrogeological behaviour. Recharge rates, EVT extinction depths and riverbed conductance values are also within plausible ranges.

The model water balance appears numerically stable and within acceptable error thresholds (<0.1 %). Groundwater flow is solved using the Sparse Matrix Solver package in MODFLOW-USG with the PCGU solver. Reported inner and outer convergence criteria are 0.005 and 0.05 m respectively, which are appropriate for this type of model. Adaptive time stepping is also used to assist numerical stability.

2.5.9 Predictions

The predictive framework is appropriate. The use of Null, Approved and Proposed scenarios allows incremental Project impacts and cumulative impacts to be separated. This is consistent with current practice for mining groundwater impact assessments.

Predicted drawdown behaviour is generally as expected. The largest drawdowns are predicted in the mined coal seams and adjacent units, reducing with expected distance from the Project. Alluvial impacts are comparatively limited; partially a product of cumulative mining depressurising the alluvium before Project dewatering. The modelling report indicates no incremental drawdown exceeding 1 m is predicted in the alluvial aquifers, and predicted incremental alluvium take during mining is low relative to regional surface water flows.

The predicted Project mine inflows are reasonable. Incremental inflows rise during mining, peak at approximately 152 ML/year in 2038, then reduce as mining approaches completion. The predicted inflow pattern is consistent with progressive open-cut development and dewatering.

Particle tracking was undertaken using mod-PATH3DU for the recovery period. The particle tracking indicates that particles generally move toward the void lake, with many terminating in the void. Some particles move outside the Project’s MLAs toward adjacent mining areas at IDM, but these remain confined to the Rangal Coal Measures and terminate in the adjacent IDM void, with no loss to regional groundwater. This supports the interpretation that the final void and adjacent mine void act as long-term groundwater sinks. Upon analysis the risk for migration of contaminants to regional groundwater appears low given the strong sinks associated with the Project and IDM.

The likelihood of landholder bore groundwater level impacts, and duration they are affected are suitably presented. Details regarding their construction details is low, and therefore there is likely significant uncertainty in these predictions if groundwater is sourced from shallower formations than reported. As reported, groundwater levels at these locations should be monitored carefully and validated by the model regularly.

2.5.10 Sensitivity analysis and identifiability

The sensitivity analysis is novel and compares calibration sensitivity and predictive sensitivity, allowing parameters to be grouped according to whether they are conditioned by calibration and/or influential for predictions. The use of Spearman rank correlation and standardised regression coefficients is acceptable. These methods produce conditioning inference rather than parameter identifiability, but they are appropriate for illustrating influential parameters in a large, computationally expensive model. The distinction between Type I to Type IV parameters is useful and provides suitable information to steer future groundwater investigations.

Parameter identifiability is not explicitly presented, but inferred through appendix histograms, which indicate modest parameter conditioning. It is noted that prior standard deviations are somewhat “posterior”, having been informed through previous calibration exercises. However, it is this reviewer’s opinion that alternative approaches would have possibly harvested more information from the observation dataset, conditioned the parameters, and consequently reduced predictive uncertainty.

2.5.11 Predictive uncertainty analysis

A Type 3 Monte Carlo uncertainty analysis was undertaken using calibrated model realisations. The uncertainty analysis assessed key quantities of interest, including drawdown, mining inflows, alluvium take and changes to stream/river flow. Results are presented as weighted percentiles based on likelihood from the SMC calibration.

The use of 109 calibrated realisations is adequate given the long model runtimes and the convergence of the key prediction distributions. The base case prediction for alluvium take appears conservative, tracking near the upper end of the ensemble. Loss of stream flow has a relatively small uncertainty range, which suggests the prediction is not highly sensitive to the remaining parameter uncertainty. This is also due to the fact river conductance is low in the predictive ensemble. It should be noted that stream flow loss in such disconnected systems here is too uncertain for saturated phase numerical predictors to reliably estimate, given the "one way" nature of stream leakage through deep unsaturated profiles.

The uncertainty analysis appears fit for purpose. Based on the information reviewed, the assessed posterior parameter ensemble appears to be suitably wide and adequate for the current assessment.

2.5.12 Post-mining recovery

Post-mining recovery is simulated using a final void representation informed by iterative groundwater and surface water modelling. This is appropriate. A 200-year recovery period was included in the uncertainty analysis as recommended by Tomlin et al (2022). Although the final void level was not perturbed in this analysis (the lake remained a strong sink), importantly the parameters were perturbed, and potential drawdown impacts during the recovery phase and at approximate equilibrium were suitably assessed.

The final void is predicted to remain a long-term groundwater sink. This is reasonable. Predicted groundwater inflows are mainly through spoil rather than intact rock, which is also expected. Particle tracking supports the conclusion that groundwater flow is toward the void and remains contained over the long term.

This reviewer agrees with the general conclusion that the final void is unlikely to become a groundwater source for the migration of contaminants.

2.5.13 Model limitations

The reported limitations are not unusual for a regional mining groundwater model. These include simplified recharge timing, simplified surface water-groundwater interaction, uncertain fault hydraulic properties, uncertainty in spoil properties and difficulty matching local bore responses.

These limitations are adequately recognised. They do not prevent the model from being used for the stated objectives. They do, however, support the need for continued monitoring and future model updates.

Section 3: Report review

3.1 Groundwater Impact Assessment Report

The *Isaac Downs Extension – Groundwater Impact Assessment* report is a 237-page document including nine appendices. The GIA report presents detailed information regarding the environment, geology and hydrogeology, with references as appropriate to the *Groundwater Modelling Calibration and Prediction Report* and *Central Bowen Basin Regional Groundwater Model* report to justify decisions regarding the conceptual and numerical models as well as the predictive and uncertainty analysis.

The report is fit for purpose and written to a high standard. Figures, hydrographs, prediction plots and uncertainty outputs are clear and useful.

The guideline checklists included in the GIA demonstrate that the key assessment requirements have been considered and presented. The assessment addresses the key state and federal requirements, including project description, conceptualisation, groundwater systems, surface water-groundwater interaction, water-dependent assets, risk assessment, cumulative impacts, uncertainty and monitoring.

3.1.1 Groundwater Modelling Calibration and Prediction Report

The *Isaac Downs Extension Project – Groundwater Modelling Calibration and Prediction Report* is a 132-page document including five appendices. It is attached to the *Groundwater Impact* Assessment report as Appendix H. This report is focussed on the numerical modelling and provides in-depth detail regarding the model, predictions and analysis methodology. Missing detail in some areas of the report is deferred to the Central Bowen Basin numerical model report where appropriate, and this report is provided as Appendix I of the *Groundwater Impact Assessment* report.

An adequate executive summary is provided. Detail regarding the novel methodologies seems to have taken precedence over explanation of model outcomes in the report, however, the key outcomes and predictions are clearly presented across the two reports to an acceptable standard.

Section 4: Data review

The Project-specific dataset is adequate for an approval-scale assessment. The GIA draws on previous studies, regional datasets, adjacent mining data, data sharing agreements and new field investigations. Investigations include a bore census, drilling and bore installation, fault investigation drilling, downhole geophysics, slug testing, ERI surveys, GDE studies and routine groundwater monitoring.

The groundwater monitoring network from the IPC provides a reasonable basis for characterising baseline groundwater conditions and calibrating the model in the Project area. It should be noted that the model parameters are partially "pre-informed" by a very large monitoring dataset sourced from the 21 mines simulated within the domain.

Hydraulic testing is largely based on slug tests, supplemented by regional data and literature ranges. This is common for this type of assessment. Slug tests provide useful local-scale hydraulic property estimates, but they do not fully constrain larger-scale hydraulic behaviour. This limitation is appropriately dealt with by retaining parameter uncertainty in the modelling process.

Groundwater recharge has been assessed using AWRA-L deep drainage and chloride mass balance approaches. This is appropriate. Recharge remains inherently uncertain, particularly in an ephemeral, semi-arid system where recharge events can be episodic and delayed. The model application is suitable for the current objectives, but future monitoring/model refinement should continue to focus on recharge responses in shallow alluvium and regolith.

Groundwater quality and GDEs are adequately discussed in the GIA. The GDE assessment and GDE monitoring and management plan provide a reasonable basis for ongoing impact detection and management.

Section 5: Key findings & conclusion

In this reviewer's opinion, the documented groundwater modelling meets professional industry standards. The conceptual model is appropriate and supported by sufficient Project-specific and regional data. The use of the Central Bowen Basin regional model is appropriate due to the significant potential cumulative impacts. The conclusions from the review and checklists indicate that the model is fit for purpose, which is to produce a calibrated groundwater model and predict groundwater inflows, drawdown, and flow changes. The ensemble of predictive models is suitable for use as a decision support tool to predict future impacts due to the IDE Project.

The model is regional and complex, with local grid and parameter refinement around the Project area. As a result, it is possible that there is some loss of fidelity in information harvesting during the inversion process. This is common with regional cumulative models of this scale. The bonus is there are minimal compromises with the representation of cumulative interaction with neighbouring projects. Despite these compromises, the model and its associated predictions could be thought of as detailed and suitably reliable. The ensemble of models is moderately calibrated, with heads and drawdowns consistent with site observations.

Predicted impacts are generally reasonable. Project mine inflows are plausible, drawdown is concentrated around the Project and mined coal seams, alluvial impacts are limited, and the final void behaves as a long-term groundwater sink. Landholders are minimally impacted; however the uncertainty of screen information may play a role in the reliability of these predictions. The uncertainty analysis is well presented and provides a useful basis for interpreting prediction likelihood. Post mining impacts are suitably assessed using the parameter ensemble over a 200-year period.

This reviewer agrees that the model and GIA are suitable for supporting the Project's EIS, provided the identified limitations are acknowledged and addressed through ongoing monitoring and future model updates.

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Section 6: References

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