APPENDIX H2

GROUNDWATER ASSESSMENT PEER REVIEW 1

BIRD IN HAND GOLD PROJECT

MINING LEASE PROPOSAL MC 4473

TERRAMIN

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Unit 7 / 202-208 Glen Osmond Road | Fullarton SA 5063

Matt Daniel
Environment & Community Superintendent
Terramin Angas Zinc Mine
Unit 7, 202-208 Glen Osmond Road
Fullarton SA 5063

Via email: mdaniel@terramin.com.au

30 June 2017

Dear Matt

RE: Outcomes of Peer Review of Bird in Hand Gold Project Groundwater Assessment Report

Background

Innovative Groundwater Solutions (IGS) has been contracted by Terramin Exploration Pty Ltd to provide an independent peer review of the numerical groundwater flow model produced by Australian Groundwater Technologies Pty Ltd (AGT) to support the Mine Lease Proposal for the Bird in Hand Gold Project. The independent peer review is listed as a requirement by the *Determination for a Mining Proposal for the Bird in Hand Gold Project*, which states that the output of this peer review should be:

'*A final independent peer review report which must include; an assessment of whether the model is fit for purpose, verification of model inputs, the results of the review of the model against Tables 9-1 and 9-2 of the Australian groundwater modelling guidelines (National Water Commission Waterlines Report Series No. 82, June 2012), the scope of the review and details of any actions undertaken as a consequence of the findings of the review.*'

This letter forms our report on the findings of the peer review to date, and additional supporting documentation is provided as attachments herein.

Scope of the Review

The details of the background data, conceptual and numerical models were provided to IGS in various versions of a draft report, titled *Bird in Hand Gold Project Groundwater Assessment Report* prepared by Australian Groundwater Technologies (AGT). This was the main input for the review process.

The review focused on the following aspects of the modelling report:

1. Verification of data used to support the conceptual model of the study site, e.g. aquifer geometry and thicknesses, aquifer hydraulic properties, rainfall recharge, observations of groundwater and surface water levels, hydrochemistry and isotope data.
2. Implementation of the conceptual model in the numerical model, i.e. model design
3. Model calibration
4. Scenario modelling
5. Characterization / quantification of model sensitivity to key parameters and impacts of the related uncertainty on model outcomes.

The Review Process

The review was an iterative process, carried out in parallel with finalization of the modelling and reporting by AGT. It was clear to IGS throughout the review, through meetings with Terramin and AGT, and review of the draft report, that the numerical model is based upon a large quantity of data and system knowledge. However, the review sought to identify whether all aspects of the model and reporting are consistent with the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) and are scientifically defensible, and that the model is fit-for-purpose. IGS understands the primary purposes of the model are to: 1) predict aquifer water level drawdowns as a result of mine depressurization, and 2) predict mine water inflows for planning appropriate management strategies.

Various draft versions of the report were reviewed and the feedback provided resulted in updates to the report as well as additional modelling exercises. As such, the process was extremely rigorous, with IGS reviewing four versions of the report and subsequently assessing the work carried out to address issues raised in each review. Summaries of each stage the process and their outcomes are provided below:

Version 1 – AGT Report no. 1300-14-TAB, 23rd February 2017. Appendix F – Numerical Model Development version of 3rd May 2017. The documented preliminary feedback from that review is provided as Attachment A. The feedback from IGS on this preliminary draft was that issues with report structure and a lack of detail and explanation in many areas required amendment before the technical details of the model could be properly reviewed. However, preliminary questions were raised about various aspects of the model. These included the basis for an interpreted flow divide to the southeast of the mine, discrepancies between field-based estimates of aquifer parameters and model values, model calibration, conductance of drain cells implemented to represent the mine workings and the sensitivity / uncertainty analysis. IGS' primary requirement was further documentation to clarify these issues. This review was followed up with a meeting (5th May 2017) with AGT and Terramin to discuss the further work required to both enable the model to be reviewed and to provide Terramin and the Regulator with confidence that the model is fit for purpose.
Version 2 – AGT Report no: 1300-14-TAB, version 18 May 2017. Review comments are provided in Attachment B. Specific comments were provided to Terramin and

AGT in a Review Table, which was subsequently updated with the authors' responses and reviewed by IGS with an updated draft (Version 3). In Version 2, which was also a preliminary draft, the revised structure and some additional detail enabled a closer review of the technical aspects of the model. However, a lack of referencing to figures, data or literature in support of statements made in the report were highlighted as they made it difficult to assess the validity of some aspects of the modelling process. The same technical queries were raised as in the review of Version 1.

Version 3 – 1300-14-TAB, version 18 May 2017 (this was an update of Version 2, file name *Groundwater assessment_7-6-17_compiled_final_no_private.pdf*). Appendix F – Numerical Model Development version of 7th June 2017. This version of the draft was a vast improvement on the previous two drafts. The information that had been added to Version 3 provided much greater insight into the modelling process and greater confidence in the model outcomes. Author responses and updates provided in Version 3 as a result of review comments for Version 2 have been recorded in the Review Table described above to be submitted to the Regulator with the final report. Some issues from the review of Version 2 were still in the process of being addressed. The following four issues remained critical to the assessment of the model as being fit-for-purpose and were discussed with Terramin and the report authors (19th June 2017):

1. Consistency in presentation of aquifer property data obtained from pumping test analyses. Ensuring consistency between data presented in Appendix B, Tables 5, 8, F2 and F3. Ensuring that the basis for the selection of model aquifer properties is transparent and defensible. Ensuring that the sensitivity analysis for K covers the ranges observed in the field data.
2. Area of interpreted high rainfall recharge southeast of the proposed mine. The section describing the results of the chloride mass balance (CMB) method required presentation of additional information to enable an assessment of the validity of this high recharge area (and other model recharge zones).
3. Sensitivity analysis for high R area. This required further work to quantify the uncertainty associated with implementation of this high R area. IGS requested that K be adjusted to achieve equally valid steady-state calibration and a discussion of whether this is a plausible conceptual model. Sensitivity of model outcomes to this was to be identified through presentation and discussion of potentiometric surfaces, mine inflows and model water balances for both scenarios.
4. Conductance of drain cells used to represent mine workings. IGS requested that additional details of tests that supported the selection of the value of 1 m/d be presented, as well as the implications of uncertainty in this parameter for model outcomes.

Version 4 – 1300-14-TAB, version 19 June 2017 (file name *Groundwater assessment.pdf*, received 28 June 2017). Appendix F – Numerical Model Development (file name *Appendix_F_Numerical_Model_Development_7-6-17*, received 28 June 2017). This version aimed to address the four main issues listed above and IGS reviewed this final version of the draft report against these issues only. All other review comments provided in the Review Table described above were considered to be still applicable and were being addressed by AGT at the time of the review. The outcomes of the review against the issues listed above are as follows:

1. Aquifer property values: Tables 5, 8, F2 and F3 are now consistent and there is sufficient detail to allow the reader to follow the rationale behind the selection of the model aquifer property values, which are assessed as being valid.
2. Recharge (CMB results): The data behind the CMB analysis is now provided in Appendix C2 of the report, which adds transparency to this section. In the final version of the report, it is recommended that an identifier be used to relate the data in the CMB table to the points on the map. This will improve readability of the report but does not affect the assessment of the model.

3) Recharge sensitivity analysis: Additional modelling work has now been carried out to address this. A scenario without the high R zone to the southeast of the mine appears to be equally as plausible as the adopted model. IGS considers the adopted model to be fit-for-purpose as long as the uncertainty around this recharge feature is properly documented in the final report, i.e:
    a. Discussion of the plausibility of the reduced K values associated with this scenario, i.e. they are consistent with currently available field data.
    b. Provide model water balances for ***both*** scenarios and describe the implications of any differences.
    c. Report any difference in simulated impacts on existing users, particularly those to the east of the high R zone under this alternative conceptual model (comparison of drawdown maps would be sufficient).
4) Drain cell conductance: additional discussion along with Figure F27b now provide IGS with confidence that the selection of drain cell conductance values has been appropriate.

Outcome of the Review

After reviewing four iterations of the draft report and the additional work that has been carried out to quantify model sensitivity and uncertainty, IGS recommends that the model is fit-for-purpose regarding the objectives stated above, provided the uncertainty around the high recharge zone to the southeast of the mine is documented in the final report submitted to the Regulator, as described above. Terrmamin and AGT have also made a commitment to address any outstanding issues listed in the Review Table before submission of the final report to the Regulator. The review table, which tracks IGS' review comments and the authors' responses and/or actions taken, will also be submitted to the Regulator with the final report.

As mentioned earlier, the *Determination for a Mining Proposal for the Bird in Hand Gold Project* states that the independent peer review should assess the project against Tables 9-1 and 9-2 of the Australian Groundwater Modelling Guidelines

(Barnett et al., 2012). The assessment of the modelling project against these tables is provided as Attachment C.

Sincerely,

Dr Nikki Harrington
Principal Hydrogeologist

Dr Glenn Harrington
Director, Principal Hydrogeologist

Attachment A

Independent Peer Review – Preliminary Findings

Wednesday 10th May 2017

Bird-in-Hand Gold Project Groundwater Assessment
AGT Report no. 1300-14-TAB, 23rd February 2017.
(NB. ***Appendix F – Numerical Model Development*** version of 3rd May 2017)

Summary
This document describes the outcome of a preliminary review of Sections 1 to 6 and Appendix F of the above report to provide early feedback on the overall content of the report to facilitate timely delivery of the final product.

The preliminary review has found that this early draft, particularly in Appendix F on details of the numerical groundwater modelling, does not yet meet the standard set by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). It does not contain the level of detail required for the reader to become confident that the predicted magnitude and extent of mine-related drawdown are scientifically defensible. Accordingly, the following points need to be addressed to allow IGS to review the scientific merits of the modelling approach and predicted impacts.

Major Issues – Main Body of Report
The preliminary review of Sections 1 to 6 of the main report has considered the overall content of the report and how it supports the development of the numerical model described in Section 6 and Appendix F. It has *not* considered the validity of data collection methodologies, data analysis techniques or data interpretation. This will be included in the final review document.

In general, the report includes a wealth of data to support the development of conceptual and numerical models of the Bird in Hand Project site. It also contains a number of good quality figures that are helpful in understanding the outcomes of the project. However, the report structure is haphazard, which makes it difficult for a reader to follow how the work carried out relates to the overall objectives of the project and how it has informed the development of the conceptual and numerical models. Project objectives, site and background information, methodologies, results and interpretation are scattered throughout the report leading to large amounts of repetition and only a vague understanding of how the information presented has been used in the development of the numerical model. In particular, a stand-alone conceptual model section is not provided. This currently makes it difficult for a reader to assess the basis of the parameter values and boundary conditions implemented in the numerical model. A suggested report structure is included at the end of this report. Comments have been provided in the electronic version of the report to indicate information that should be moved to different sections.

Major Issues – Appendix F

1. Section F-2: there is no documentation of a robust conceptual model, and it is not clear how the conceptual hydrostratigraphic framework has been implemented in the numerical model. One or more detailed figures and supporting text are recommended, including an overlay of model grid/layers on different geologies, parameterisation and boundary conditions etc.
2. Section F-3.1: need to show evidence for groundwater flow divides, no-flow boundaries and justification for the GHB – that is, evidence for flow across the boundary including a map and details of representative up-gradient wells. Note this evidence is not provided in the main body of the report. There is simply a comment that a review of regional data has suggested that a groundwater divide exists.
3. Section F-3.1: again need to provide sound justification for both the groundwater flow divide (i.e., water table map from multiple wells) and forced region of higher recharge immediately east of the mine. These features of the model have major implications on the predicted impacts of dewatering.
4. Section F-3.1: streambed conductance needs to be documented (at least justification for the adopted range of hydraulic conductivity) and an argument for or against this parameter being included in the later sensitivity analysis.
5. Section F-3.1: need to refer to a representative network of wells from which the inferred water table surface clearly identifies a persistent groundwater flow divide southeast of the mine.
6. Section F-3.1: application of recharge to layer 6 (Tapley Hill Formation) east of the mine has no physical justification and makes no logical sense when overlying hydrostratigraphic units are saturated. This needs to be changed to layer 1 and the model calibrations and predictive simulations re-run. Doing so will also impact the sensitivity analysis for this aspect of the model (section 8.2). Furthermore, likening predicted mining-induced head changes with transient calibration to historical pumping-induced head changes is misleading due to (i) vasty different magnitudes of localised pumping for the two scenarios, and (ii) mine dewatering will be stressing deep, previously-undeveloped units with potentially vastly different storage properties to the shallow system currently bing used for licensed abstraction.
7. Section F-3.2: need to justify major differences between model–based and field-test values for T and S. For example, compare ranges in Table F3 for wells IB1, IB2 and 6628-20475. Also need commentary on why Kh for Layers 3 and 5 (Table F2) are so low given that they are likely to provide greatest inflows to mine workings.
8. Section F-3.2: Figure F3 provides the first evidence that some faults may have been included in the model. What is the basis for these? How were they implemented? And need to justify the hydraulic properties and explain why

numerous other faults weren't included in the model. Again the role of faults should be explicitly documented in developing the conceptual model.

9. Section F-3.2: further discussion and data is required to justify the distribution of Kv (Figure F4) – discuss vertical connectivity between layers, including that inferred from the CRD test.
10. Section 4: the documentation of different models, their different scales (spatial and temporal), revised calibration parameters and how they all fed into a suite of adopted models with consistent parameters is an important narrative that could benefit from an annotated flow chart.
11. Section F-4: how was predicted drawdown in model cells adjusted to enable comparison with measured drawdown in production wells?
12. Section F-4.3: the transient model "calibration" to only two years of historical water level data is arguably not meaningful, particularly when stresses from licensed abstraction are highly uncertain. Regardless, this section needs further explanation of the data sources and their reliability (e.g., pumping data). The hydrographs for all 27 monitoring bores contradict the statement (p15) that "the model adequately reproduces seasonal pumping induced fluctuations…" as numerous hydrographs show more than 10 metres difference in magnitude and don't reflect trends. It is stated that "these discrepancies are carried over from steady state calibration-based discrepancies", so why not recalibrate the SS model?
13. Section F-5.1: this plot suggests the creek is perennial – is there gauging data to support this? Units on the plot (ML/yr) also seem incorrect as the data is provided at a daily or monthly resolution.
14. Section F-5.2: this section needs to provide pumping rates and how they were estimated.
15. Section F-6.1: what values were used for drain cell conductance, and how were they determined – this has obvious implications for predicted mine water inflows, so requires substantial justification. Would also be helpful to show how well the coarse model drain cells represent the precise declines/drives mapped in the mine plan.
16. Section F-6.2: what were the drain cell conductances for grouting, and how was "ensuring numerical stability" relevant and overcome?
17. Section F-6.3: need to show and justify location of MAR injection wells, including target formations and injection rates etc.
18. Section F-6.4: this section requires further details around the delineation of the salinity zones and how they are expected to move under mine dewatering stress.
19. Sections F-7 and F-8: these sections are critical to the entire groundwater assessment, yet they are obviously far from complete; they needs thorough explanation and discussion of all results, with clear reference to all figures. Notwithstanding all of the documentation issues outlined above, there is inadequate text to give the reader any confidence in the modelling approach and results. The sensitivity analysis should provide a convincing argument for

where the model predictions are most sensitive and thus potentially most uncertain.

20. Prediction uncertainty analysis needs to reflect not only parameter ranges but also boundary conditions including very high recharge required to simulate the groundwater flow divide.

Minor comments and suggestions
Refer to edits and comments made electronically in the PDF documents.

Dr. Glenn Harrington
Director & Principal Hydrogeologist

Dr. Nikki Harrington
Principal Hydrogeologist

Suggested report structure:

Introduction

- Project Overview – high level overview of why the project is being carried out – the content of the current Project Overview section is good. However, add description of the modelling undertaken.
- Site Description – geography, geology, land use, *short* history of mining development, etc – some of this is included in Sections 4 and 5!!!
- Previous Investigations
- Scope and Objectives – bring together the objectives of the drilling, monitoring, modelling.
- Report Outline (if needed)

Methodology

Overall Approach
A description of the high-level approach could be provided here – i.e. drilling and testing wells to provide field data to fill knowledge gaps about x, y and z. Census of existing wells and groundwater dependent ecosystems. Monitoring of groundwater levels and quality to address z objective. Development of conceptual model based on this and a review of regional data. This informs the development of a mine water management plan and a numerical model which will be used to investigate scenarios….

Field and Analytical Methods
- Groundwater Census
- Drilling of Investigation Wells
- Geophysiscs
- Hydraulic Testing
- Groundwater Level Monitoring
- Groundwater Quality Monitoring

Results

- Census
- Drilling
- Pump Tests etc
- Groundwater chemistry…

Conceptual Model

This should be a clearly defined section. Here, the information drawn out of the results section and summarised into a conceptual model, which will form the basis for the numerical model. Most of the necessary text is included in Section 4 but it is interspersed with results. The numerical modelling appendix should then clearly refer to figures and tables from this section.

Mining Proposal

Describe how the outcomes of the field program have led to the development of the mining proposal (i.e. identification of the water-bearing fracture zone, water management options and MAR idea). Section 5 currently provides some background info on the mine plan that should really be included in the Introduction section.

Numerical Modelling

This should refer to specific figures and tables in the Conceptual Model section and clearly describe how parameter values or boundary conditions were selected based on the conceptual model. As it stands, for many input parameters the report only refers to a section number and the reader is expected to make the interpretation. This section should also describe how the various numerical modelling exercises have in-turn informed the conceptual model.

Attachment B

Report Title:	Bird in Hand Gold Project Groundwater Assessment AGT Report no: 1300-14-TAB, version 18 May 2017
Authors:	Jason van den Akker and Ty Watson, AGT
IGS Reviewer:	N. Harrington and G. Harrington
Format for editorial comments:	Comments in pdf document

GENERAL COMMENTS

Major Issues or Queries

This report requires a large amount of work before it can be released publicly or presented to the regulator. Some additional modelling work may be required if all of the concerns and queries raised here cannot be addressed through clarification in the reporting. Further review is recommended subsequent to the revisions being made. Despite the criticisms listed here, we would like to acknowledge the large body of work that has been carried out to characterize and simulate the groundwater system around the Bird-in-Hand mine. Building numerical models of groundwater flow systems in fractured rock aquifers is never a simple exercise, even with large amounts of data available. The authors have carried out a large amount of field and modelling work in attempt to do this. However, our task is to assess, based upon the information presented, whether the model and reporting are 'fit for purpose' and whether Terramin and the regulator can have confidence in the predictions provided.

Referencing and Justification of Statements

The purpose of a technical report is to describe the scientific method and thinking that has resulted in the conclusions and recommendations from the project. It should provide confidence that there is scientific justification for these conclusions and recommendations and that they are not the result of someone's imagination or misguided interpretation. The reader needs to be convinced that the statements are valid and not require them to trawl through the report in an attempt to find the data to draw the same conclusion. There are too many occasions in this version of the report where statements are made with no reference to figures – or sections where the data is presented – so the reader cannot easily view the data and be confident that the statement made is justified.

Justification of Implementation of Groundwater Flow Divide Using Zone of High Recharge
This was raised during our preliminary review and has not yet been adequately addressed. I.e. the presence of the flow divide – is there sufficient data to support this? There is inadequate justification for using a zone of higher recharge to force the occurrence of this flow divide.

Transient Calibration Results - CRDT
The results of the transient calibration to the CRDT indicate that the analytical model under-estimates drawdown in the Hanging Wall Fracture zone by several metres. This is attributed in the report to anisotropy that is not captured by the model and is rightly listed as a model limitation. However, this fracture zone is a major water-bearing zone adjacent the proposed mine workings and is an area of the model where accuracy is required. The sensitivity analysis presented in the report suggests that doubling K_H of the fracture zone can increase mine inflows by up to 10 L/s. This indicates that parameterization of the HW Zone is a major limitation of the model and this must be communicated throughout the report.

Transient Calibration – Regional
Most of the results for the transient calibration using regional abstraction show poor matches between observed and simulated hydraulic heads. We are unable to provide an opinion about this due to a lack of information provided on locations of pumping wells and the unit they are pumping from, or the locations of the observation wells and the units they are screened in.

Furthermore, as described in our review of the previous version of the report, likening predicted mining-induced head changes with transient calibration to historical pumping-induced head changes is misleading due to (i) vastly different magnitudes of localised pumping for the two scenarios, and (ii) mine dewatering will be stressing deep, previously-undeveloped units with potentially vastly different storage properties to the shallow system currently being used for licensed abstraction.

Whilst we are critical of the poor calibration results achieved for this model, we recognize that the authors have adopted a multi-stage calibration and validation approach to strengthen the model's predictive capability. Good calibration in fractured rock aquifers is notoriously difficult to achieve. However, a poor calibration is a sign that a model's predictive capability is limited. The report really needs some additional commentary around the calibration results that recognizes where there is a poor fit, discusses where this occurs (which unit and where relative to the mine) and the implications for model outcomes. For example, the model may produce reasonable results close to the area of influence of the mine but be poorly calibrated outside the area of interest or in the units that are of little interest. The reader currently has no feel for where the observation points used in the model are and hence cannot judge which of these are most important. Developing the discussion of the iterative calibration process may help to improve a reader's confidence in the model outcomes.

Conductance of Drain Cells
The method of selection of the conductance value for the drain cells representing the mine decline and drives requires additional discussion between IGS and the authors as we are not confident in this approach based on the information provided in the report. It is a key parameter that influences the estimation of mine inflows and drawdown. For this reason, it must also be included in the sensitivity analysis.

Model Sensitivity Analysis
The sensitivity analysis requires more work to be convincing that the model is 'fit for purpose'. Each sensitivity analysis simulation should report model water balances and potentiometric surfaces as well as maps of drawdown, predicted hydrographs at key locations, and graphs of mine inflows / stream baseflow. For example, the test of model sensitivity to high recharge over the interpreted groundwater flow divide must include comparisons of model water balances, simulated hydraulic heads relative to historical observations, mine inflows and baseflow. It currently compares drawdown contours only. However, groundwater flow towards the mine is controlled by the absolute head gradient. Whilst drawdown is not affected by the change in recharge, the absolute distribution of hydraulic heads will be and this must be assessed.

Cohesion Between Sections 6 and 7 and Appendix F:
In the current version of the report, it is clear that Appendix F, which provides the details of the numerical modelling, and Sections 6 and 7, which should be an overview of the numerical modelling and results, have evolved separately. There is some information provided in Section 6 that is not described at all in Appendix F, for example. These sections should be reviewed to ensure consistency. Also, Sections 6 and 7 are quite long and repeat (to a large degree) the information provided

in Appendix F. Appendix F should provide all of the detail and Sections 6 and 7 should provide only a broad summary of the modelling methodology with more discussion of the results. The authors should consider refining Sections 6 and 7 into a more concise summary of the modelling and determine the key information that really needs to be provided here (Table 10 is a good start). References can be made to Appendix F so that a reader who is interested can seek further details on any aspect of the model.

Appendix G:
Appendix G has not been provided so we are unable to assess the simulated depressurization maps that are discussed in Section 7.3.2.

Minor Comments
"Baseline" should not be used as a verb (i.e. "to baseline pre-mining groundwater conditions"). A more correct sentence is "to identify baseline groundwater conditions", or even "to characterize pre-mining groundwater conditions". We recognize this is a bit fussy, just something worth thinking about.

"Groundwater depend**a**nt" should be "Groundwater depend**e**nt" throughout.

All map figures – please show the location of the mine for reference.

There are numerous typos and grammatical errors throughout the document as indicated by comments in the pdf.

Most figure numbers are out by one. We stopped correcting this at page 108. Please check all figure numbers and all references to figures.

A number of figure captions are incorrect – they describe a different figure.

Some figure captions are placed above the figures.

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SPECIFIC COMMENTS			
Section	Page	Line / paragraph	Comment
Executive Summary	IX	Saline groundwater intrusion from the eastern Mt Lofty Ranges	A comment is required here that one reason that the results show negligible movement of the saltwater interface is that the simulation time is only 5.5 yrs.
			The Executive Summary requires a summary of the overall conclusions of the project and of the assessment of the project against the WAP (which is currently incomplete).
1.1 Project overview	17		This section is now an excellent overview of what the project involved and gives the reader an idea up front of what to expect in the rest of the report.
Section 1 in general			The structure of this section and the level of information provided is excellent and sets the scene for the rest of the report. There are numerous small grammatical errors to be addressed.
2. Groundwater Investigations			
2.1, 2.2	24-29	Fig 2, 3, 4	Figure 2 Conceptual hydrogeological cross-section - labels not consistent with figure caption and figure 4. Figures 2 & 4 do not represent the outcropping Brighton Limestone as represented in Figure 3. Which one has been adopted as the conceptual model?
2.1 Overview of the Bird-in-Hand Groundwater Investigation	25	Last two dot points	Recommend limiting this list to the groundwater investigation only (which is essentially the fieldwork). The last two dot points are not related to this chapter and they are already covered under Section 1.5 Project Objectives.
2.2, 3.1		Drilling/geophysics	Inclusion of water cut data and overlay of downhole geophysical logs on well composite logs would vastly improve

			the reader's ability to visualize the relationships between water bearing sections of the geological units. The downhole geophysical logs provided in Appendix A2 are poorly referenced within the report.
2.2.3 Downhole geophysical logging			This section does not describe a number of the pumping test analysis techniques used, e.g. Hantush Hvorslev Neuman-Witherspoon
2.4.2 Groundwater quality monitoring	42		Assume that samples collected for metals analyses were filtered and acidified. Sample preservation methods should be provided in this section.
	55		Units for EC and pH are incorrect (uS/cm instead of mS/cm, and mg/L for pH)
	56		Page missing
3.1.3 Groundwater level monitoring during drilling (airlifting)	57 - 59		Clearer descriptions of the activities would be beneficial. Airlifting during drilling – but was this at the completion of drilling or at the base of the Tarcowie Siltstone? All T values are for the Tarcowie Siltstone, but not all bores are completed in this formation. What was the duration of airlift? These details are provided in Table 5 in the subsequent section but not referred to in section 3.1.3. Also why does the T of the Tarcowie Siltstone vary considerably under the same airlift test? It is only when you read into the next section and Table 5 that details are provided that the same test was analysed using different methods, but there is no explanation for why this was the case.

3.2.5 IB-5 Tapley Hill Formation	72	para 2	Units for transmissivity.
3.2.6 Pumping test results of private wells	72	para 2	Spelling of AQTESOLV. Reference should also be provided in the reference list.
	78	Figure 25	Plot hydrograph as RSWL rather than mbgl to support previous text.
3.3 Baseline monitoring	79	Figure 27	This figure is missing and therefore the reader is unable to judge seasonal irrigation stresses on the aquifer system.
3.3.1 Groundwater levels	76	Para. 5	It has been inferred that all hydrostratigraphic units behave as one; however Figure 25 clearly indicates the Tapley Hill Formation (BH44) had a continual decline from spring(?) 2014 onwards in comparison to other wells which show seasonal fluctuation. No reasons are clearly provided for this. How does this impact on the development of the numerical model? There are some assumptions made about connectivity between aquifers.
3.2 Aquifer tests	61	Table 5, Appendix B	Interpretation of pumping test data is not consistent between results provided in Table 5 and Appendix B. This does not provide confidence that appropriate hydraulic parameters have been adopted in the numerical model design. Results provided in Table 5 should reference and match the analysis output provided in Appendix B. There is also some inconsistency with Table 8. Numerous analytical solutions have been presented for individual tests, each solution having varying assumptions. The adopted hydraulic parameters are not consistently the mean of either all results (airlift & pumping test) for an aquifer unit, or the mean of pumping test results only. Therefore, select interpretations have been used to infer the adopted hydraulic

			parameters, however no justification is provided as to which results, and hence which analytical solution has been selected. There also appears to be inconsistency or lack of clarity between the airlift rates presented in Table 5, the cumulative airlift rates in Figure 13 and supporting text e.g. IB-1: Table 5 = 15 L/s whereas Figure 13 = ~13 L/s and text on page 57 = 15 L/s. Furthermore, the statement regarding the results of the pumping test need to be prefaced with a statement that the drawdown induced by the pumping tests reflect the duration and rate at which those tests were undertaken. Without undertaking forward simulations, it is careless to infer for example that drawdown over the life of the mine cannot have impact on shallow bores.
3.3.2 Groundwater quality	54, 52	Figure 13, 12, Section 3.1	Figure 13 indicates pH during drilling of IB wells which at certain depth is >>8. Whereas background pH as recorded in regional chemistry sampling generally ranges between 7-8. Are these results influenced by mud drilling? Conventional air hammer is described to be the drilling method; however, Figure 12 appears to demonstrate mud drilling which is supported by dot point 1 under the key finding of investigation drilling that diamond drilling was used. Is the groundwater chemistry data for IB wells compromised by drilling fluids?
3.3.2	82		Are iron (and other metal) concentrations total or dissolved? At concentrations of 10 to 60 mg/L, dissolved Fe^{2+} has potential to

			precipitate out of solution on oxidation to Fe^{3+} and cause significant clogging issues (either inorganic or iron-bacteria related). Is this an issue in the area and has it been considered? The pH profiles in previous section showed quite alkaline water (pH > 8)?? Chemistry appendix also confirms that high Fe concentrations are associated with relatively high pH. This is unusual. A description of sampling and sample preservation protocols as well as whether the reported iron concentrations are dissolved Fe^{2+} or total iron may help to clarify what is going on here and whether there are any issues.
3.3.3 Groundwater salinity	84	Figure 28	An overlay of surface water salinity (April 2015), and post-summer depth to water table, would help to strengthen the discussion of surface water – groundwater interactions.
3.3.4 Surface water monitoring	87	Figure 30	What is the red outlined area?
4.2 Existing Users	91	Figure 32	It would be helpful if the geology layer was slightly more visible through the catchment layer. Add the location of the mine on this figure for reference.
4.2.2 Groundwater Use	93	First para	Zulfic et al. (2003) – is this the same reference as referred to in Section 1.4 (DWLBC, 2002)? If so, check consistency.
	94	Figure 33	As for Fig. 32
4.3 Groundwater Dependent Ecosystems	95	para 3	Comment that Inverbrackie Creek is of poor condition, has moderate species diversity and lacks any rare or sensitive species. Based on what? Who carried out the survey, what methods did they use and what are these determinations based upon? Reference?
		para 4	'The major ion chemistry shows that the water samples collected from pools in April are characteristic of local groundwaters of nearby wells. The surrounding summer

			groundwater elevations in some areas were higher than the base of the creek, and major ion chemistry of the groundwater and pools suggest that these sections of the creek receive some groundwater base flow.' There is no reference to a figure that supports this.
			This section refers to Section 4.7 Groundwater and surface water interactions (actually it refers to Sect 4.8 but should be 4.7). These sections should be put together to avoid repetition and a disjointed discussion. Perhaps move 4.3 to just before 4.7. The last two paragraphs in 4.3 can then be incorporated into 4.7.
Section 4.4 Geology	97-98		Please refer to useful figures (e.g. Fig 2, 11 or 36).
Section 4.4.1 The Supergene Layer	98	last para	'The supergene zone consists of silty clay which has a very high surface area to void space ratio. It has a firm toothpaste-like consistency which makes it both impervious and impermeable, and therefore virtually impossible to dewater. As such, it will retain water throughout the mining operation and preserve its present state of saturation with oxygen-poor water, maintaining the stability of the trace levels of pyrite within it.' Is some pyrite oxidation not possible if the area around this layer becomes oxic, e.g. via diffusion of oxygen into the low permeability sediments?
4.5 Aquifer Systems	99	Table 8	As described above, there are many inconsistencies between pump test curves shown in Appendix B and data presented in Table 5.

			Table 8 needs some commentary about how the values or ranges relate to the pump test data presented in Table 5, i.e. how were these selected? e.g. Tarcowie Siltstone – adopted value is 87 m2/day??? A clearer explanation of the origin of the values adopted for the conceptual model is required.
Section 4.5.1 Groundwater elevation and flow direction	103	para 2	'Groundwater monitoring undertaken to the east of Inverbrackie Creek sub-catchment, indicated a groundwater divide exists that is aligned with the topographical high (catchment boundary) between the Inverbrackie and Dawesley Creek subcatchments.' Figure 36 shows that the existence of this flow divide is based upon data from one well – is the water level measured here representative of the main aquifer and entire area? If there is more than one well, please discuss.
Section 4.5.3 Groundwater level trends	106	paras 2-4	When talking about responses to pumping observed in logger data this needs to refer to figures that demonstrate this.
Section 4.5.5 Aquifer yield	109	Figure 40	The caption should state that the data shown for the IB wells are cumulative yield – this is different from what is shown for all other wells. I.e. productive zones occur where there are large changes in yield, not where they are high but un-changing. For the IB wells, there is very little happening in the area described as the 'productive zone' on the figure. The large increases in yield occur near the bottom of this zone or below it – this needs to be discussed in relation to geology of the site. Also, for some of the IB wells, cumulative yield reduces to zero at depth – please explain or fix this.

	109		'The pumping test of IB's showed evidence of some connection created by smaller fractures between the zone of high permeability within the Tarcowie Siltstone and the underlying zone of low permeability rock (i.e. Marble and Tapley Hill Formation). Furthermore, the hydraulic head measured at site is uniform with depth, which might imply that fractures are connected.' Reference to a figure or section where this is demonstrated is required.
4.5.7	110		'Private monitoring bores which targeted the Kanmantoo Group to the east of the subcatchment revealed higher groundwater salinities (up to 4,000 mg/L), owing to low groundwater recharge and signifying older groundwater.' Refer to a figure that shows this groundwater salinity data. Is there evidence of lower recharge and older groundwater in this area? If not, leave this out as it may be incorrect.
	110	First dot point	'Shallow perched groundwater and some springs or seeps which plot closer to the centre of the diamond field and resemble waters that are close to rainfall recharge.' This statement requires a recharge composition to have been identified. Here, the authors are assuming that rainfall recharge is a Ca-HCO_3 type water, which may or may not be the case (reference or other data to support this is required). The typical evolution of groundwater along a regional flow-path is from Ca-HCO_3 type water towards a Na-Cl type water, but not always, particularly if soils / aquifer material is devoid of calcium

			carbonate. Further explanation is required. There are a few groupings on the piper plot that may indicate areas of connection in the system that are not discussed, particularly relating to the source of water to springs and the creek. The discussion that is included instead seems quite token and doesn't really say anything.
	112	Figure 41	It is not clear why there are two Piper plots?
	113		'Direct recharge tends to show relative enrichment in δ2H and δ18 O because of evaporation prior to recharge, whilst diffuse recharge shows less evaporative signature because once water infiltrates below 1 m into the soil it is not affected as much by direct evaporation. The isotopic compositions of the groundwater sampled from the shallow system sites (<80 m deep) show characteristics of direct recharge (i.e. many of these wells are located within drainage line/topographic lows), whilst diffuse mechanisms prevail for the deeper systems (i.e. IB-1 and -2 are more depleted).' This is poorly worded and (unless I misunderstand) doesn't really make sense. Also, all samples (there's only nine) seem to plot in a cluster on the MWL, just below mean rainfall.
	113		There is no reference to the 2H vs Cl plot in Figure 42.
Section 4.6 Recharge and Discharge	114		'In addition, due to the age of the geological units forming fractured rock aquifers weathering commonly occurs along the upper surface of the rock mass. This weathering commonly results in the alteration of the rock materials to form clay minerals which inhibit the vertical movement of water.'

			Poorly worded – how about: 'Surface weathering of fractured rock aquifers can result in the formation of clay minerals with low hydraulic permeability'? There should be a reference for the recharge characteristics of FRAs.
	114		'Recharge to the aquifer is thought to occur via diffuse rainfall recharge.' Based on what?
	115	first para	'Groundwater moves from the higher points in the landscape to the lowest, where discharge occurs to the Inverbrackie Creek.' Reference to an equipotential map is required here.
4.6.1 Groundwater recharge rates			'Groundwater recharge rates were estimated using the chloride mass balance (CMB) technique and adjusted during model calibration (see Appendix F for details).' We don't want to know about the adjustment of recharge rates during model calibration here – we only need to know about actual data on recharge. If recharge rates were adjusted from values derived from actual field data, justification for this will need to be provided in the numerical modelling section. Implications of this for the conceptual model can be discussed there.
			'When compared to the traditional broad brush water balance method for the calculation of recharge, the CMB technique was shown to underestimate recharge.'

			That doesn't mean it was wrong. It simply provided a lower estimate – re-word.
	116	Last para and Table 9	There is no information provided about the calculation of recharge using the CMB method, i.e. the chloride values used for rainfall or groundwater and the rainfall value used, the assumptions of the CMB technique (e.g. that there is negligible runoff) and whether these apply to the field site.
			'It is important to note that recharge values applied to the numerical model were adjusted during the transient calibration period, resulting in higher recharge values for some areas.' This does not belong here and good justification for changing recharge rates from those consistent with field data will need to be provided in the modelling section.
		Figure 42	Are there really values up to 470 mm/yr? Please change the legend or explain these high values.
4.7 Groundwater and surface water interactions	117	para 3	Reference made to data from a gauging station, which shows that Inverbrackie Ck is ephemeral at this location, however the figure reference is not provided (Figure 45). States that the creek flows after major rainfall events but these is no comparison of creek flow to rainfall.
		para 4	Reference to data from an observation well but no indication of where this data is provided.
		last para	Good statement about the chemical evidence that water in the pools is derived from baseflow.
		Figure 44	This figure is quite illustrative, but it does not really show the difference between creek elevation and groundwater elevation. A depth to water table map with the creek line shown would be

			more useful and, importantly, the data points (obs wells) used to create the depth to water table map should be shown on this so that the reader can gauge the level of confidence at any one point.
			It is not clear from the evidence provided that groundwater flows support baseflow to sections of the creek/GDEs. Regional or site specific maps highlighting regional groundwater level against creek stage/pool height and groundwater salinity against surface water salinity would be very informative.
5. Mine Proposal			
5.1, 5.2	120, 122	Para. 5, Para. 4	The mine plan and schedule refers to treatment and reinjection of any groundwater seeps into the mine, however there is no detail on the location and rates of MAR to support this concept.
6. Overview of the numerical model			Appendix F provides the full details of the numerical model and has been reviewed in detail regarding the technical details of the model. Sections 6 and 7 should provide an overview of the information provided in Appendix F and therefore have only been lightly reviewed. All technical comments made for Appendix F also apply to Sections 6 and 7.
6.3 Model inputs	124	Third dot point	This dot point states that aquifer hydraulic properties were assigned "according to observed changes in geology"… This is good to know but this is the first time it has been mentioned. Appendix F states that the properties were assigned based upon pump test results and model calibration. Needs better explanation.
	126	Table 10	This table is a very useful summary of the model inputs. I have not checked the references provided and recommend that these be checked prior to finalization of the report.

6.4.3 Simulation of Managed Aquifer Recharge	128		The two MAR options assessed through numerical modelling – the second one is not mentioned in Appendix F.
			Discussion of the selection of locations for MAR wells – a map of this is provided in Appendix F but the locations are not discussed there at all. This is also required in the Mine Proposal section. The detail should be provided in Appendix F with Section 6 providing a summary of this. Please review the contents of these sections.
7. Model Predictions and Impact Assessment			
7.1 Simulation of 'steady state' conditions	131	para 2	There is no discussion in Appendix F of the information presented in this paragraph. This belongs in Appendix F and this section should only include a brief summary.
7.2.1 Groundwater levels	132	last dot point	Please refer to figures – here you need to refer to the figure that shows drawdown and one that shows aquifer transmissivity. Also, I don't recall this being discussed in Appendix F.
7.3.1 Simulated groundwater inflows	138	last dot point	I don't understand what is being said here.
	140	Dot points discussing zone of depressurization.	Maps in Appendix G not provided. Figures 53, 54, 55 require some sort of scale. These are listed in text as Figures 51, 52 1nd 53 and the text indicates that results will be presented for Tapley Hill and Tarcowie but these are not provided in all figures. Captions also need to indicate which units we are looking at!
7.4.2 Groundwater level recovery	149		Why are results presented only for the 70% grouting scenario? At least a reference the figures showing drawdown at the end of mining is required, preferably overlay the two maps in Figure 60. It is not clear what the recovery has been.
7.5 Uncertainty analysis	153		All results do not need to be presented here. They should be

			presented in Appendix F. This section should just discuss the results of the uncertainty analysis and their implications for confidence in model results. The discussion of the results of the uncertainty / sensitivity analysis is insufficient.
7.5.4 Zone of weathering			What are the properties of this zone in the base case model?
7.5.5 Sensitivity based on aquifer properties	158	first dot point	Reducing and increasing KH and Kv by a factor of what? The figure shows a factor of two – is this consistent with the ranges observed in the results of pump tests?
		Figure 66	The legend in this figure is confusing and poorly explained in the text.
			The discussion of the results of this sensitivity test and their implications is completely inadequate (non-existent). This sensitivity test comes across as a token effort with very little thought put into it, which I am sure is not the case.
Uncertainty			The implications of the poor regional transient calibration on confidence in simulated drawdowns at private wells needs to be discussed. This also has implications for confidence in simulated baseflow to creek.
8. Assessment of the project against the WAP.			This section is incomplete.
9. References			I have not checked off the reference list. The authors should do this at finalization of the report. I note that there is at least one reference missing from the list.
Appendix F			
3. Model domain and layer structure		last para	It would be useful to show the catchment boundary on the model grid figure.
		Figure F3	Please indicate on cross sections the units each layer

			represents.
4.1 Boundary conditions and recharge		para 3	Conductances were assigned through calibration of the steady state model – are these reasonable based upon field data?
		River package parameters	Streambed K = 0 m/day to 1.5 m/day – justification? Adjusted during calibration – justification for the final values?
		Figure F4	Please add catchment boundary to the map and indicate actual recharge rates applied for each zone – the colour scale is not easy to interpret. A comparison between the values used and previously estimated recharge rates is required – i.e. the CMB recharge rates (although this method may be flawed due to the assumption of no runoff of rainfall), but perhaps also estimates from Zulfic et al. (2002)? Any other recharge rates available for nearby catchments??
		Recharge	The range of rates is given as a percentage of annual rainfall. Please also provide the actual range of values applied and discuss their validity in relation to the understanding of recharge for the study area. For example, from the CMB method, there appears to be only one well in the high recharge (R = 80 mm/yr) zone, which has a CMB value between 30 mm/yr and 50 mm/yr. The higher recharge needs to be justified.
4.2 Hydraulic properties		Table F1	Please add a column that identifies the hydrostratigraphic unit that each layer represents.
		Tables F2 and F3	Table 8 provides the hydraulic property data adopted for the conceptual model. Please refer to this for Tables F2 and F3. Need to discuss areas where the modelled values do not match the field values.
			Why is there so much variability in hydraulic properties within

			model layers? What are the zones based on? This is not explained.
			Further discussion and data is required to justify the distribution of Kv (Figure F7) – discuss vertical connectivity between layers, including that inferred from the CRD test.
			The maps of hydraulic conductivity seem to indicate that faults with low K have been implemented in Layers 2-4, but these are not discussed at all. Why implement these particular ones and not others? i.e. what is the conceptual model? I think it is due to the observations from the CRDT, that the cone of drawdown is smaller than predicted and this is attributed to compartmentalization of the flow system by faults, but if this is true, this is not discussed at all. Some commentary about the basis for the K zones is required – i.e. they are described as being related to pump tests and well yields, however there must be some knowledge of structure also built in here.
Section 5.1 Steady State Calibration		para 1	Justification for use of September 2014 pot surface for SS calibration. This is good.
Section 5.2 Transient Calibration - CRDT			Three wells exhibited no response – so presumably they also exhibited no response in the model? 'For three wells in particular, namely BH35, BH36 and BH42, the fit between simulated and observed drawdown for these wells is relatively poor. All three of these wells are located within the HW fracture zone (represented by model layer 3). Model hydraulic conductivities are presently represented as isotropic. The underestimation of drawdown at these three particular wells indicates potential local anisotropy in hydraulic conductivity in this hydrostratigraphic unit. This is common in

			fracture zones due to local-scale directional fracture connectivity.’ ‘Whether or not this local-scale anisotropy is represented in the model is not expected to significantly influence the simulation of key mining impacts such as mine inflows and drawdown in the Tapley Hill formation. Nonetheless, incorporation of this anisotropy should be a consideration for future model updates.’ This fracture zone is a critical component of the model and the sensitivity analysis demonstrates that mine inflows are sensitive to the properties of this zone. This requires further discussion.
			More information should be provided about how this simulation was set up – i.e. show location of pumping well, described which model layers it is screened in.
Section 5.3 Transient Calibration – Regional Extraction			Information about groundwater extraction data is not provided – or reference to a report section where this (including its reliability) is discussed. We have no idea how this was implemented in the model. Seasonal pumping data was used – applied over which months? Map of extraction wells? *Which layers are they pumping from?* All of this is important in understanding the simulated drawdowns at the observation wells.
			‘Model-based reproduction of temporal trends is generally considered to be more important than reproduction of absolute values (which were nonetheless reproduced to the greatest extent possible during the steady-state calibration process), as

			aquifer dynamics are critical to model forecasting ability (e.g., Peeters, 2011). Head gradients are also important in determining the magnitudes of groundwater inflows to the mine.
			At this stage, I would suggest that the transient calibration results indicate this model cannot accurately simulate inflows to the mine or impacts on existing users.
6. Model validation.			Simulated baseflow to Inverbrackie Ck – do the locations of this in summer co-incide with the locations of permanent pools? As the creek is ephemeral, this should be the case.
		Figure F15	Indicating the observations on the graph would be helpful.
7.1 Underground mine representation			There is now more discussion of the conductance values used for the drain cells than in the previous version. The discussion relates to cell sizes and numerical stability. However, further discussion of this between IGS and the authors is required before we can have confidence in this. See general comment below.
7.4 Solute Transport Modelling			How representative of water quality in the EMLR are the wells sampled as part of this study? It appears that the assumption of high groundwater salinity is based on only a few wells. It may be necessary to draw on salinity data from Water Connect.
8.2 Predicted Drawdowns			Not much confidence in these results based on the results of the two transient calibration exercises.
8.3 Drawdowns at private well locations			Where are these wells? I don't think they are identified on any map – if they are, there is no reference to the appropriate figure.
8.4 Baseflow impacts			Why does baseflow start at about 850 ML/yr? I thought the simulated pre-mining (steady state) simulated baseflow was 760 ML/yr.

8.6 Solute Transport		Figure F27	Take the locations of obswells off this figure (they are not informative) and add the location of the mine (the stress that is being applied) and the current observed and simulated equipotentials or flow lines. There has been very little movement of the saline interface due to the extremely short time of the simulation and groundwater flow velocities of ??? m/yr.
9. Sensitivity Analysis 9.1 Summary		Second dot point	This is more of a scenario than a part of a sensitivity analysis.
9.2 Recharge			Whilst drawdown is not sensitive to recharge, absolute heads will be and this needs to be quantified and discussed in the sensitivity analysis.
9.4 Significance of flow barriers		Figure F32	Graphs of mine inflows should have the same vertical scales to make comparison easier.
			The flow barriers appear to influence the results for the No Mitigation scenario only.

Attachment C – Assessment of the Bird in Hand modelling project against Tables 9-1 and 9-2 of the Australian Groundwater Modelling Guidelines (Barnett et al., 2012).

Table 9-1: Compliance checklist

Question	*Yes/No*
1. Are the model objectives and model confidence level classification clearly stated?	Objectives – yes Confidence level - no
2. Are the objectives satisfied?	Yes
3. Is the conceptual model consistent with objectives and confidence level classification?	Yes
4. Is the conceptual model based on all available data, presented clearly and reviewed by an appropriate reviewer?	Yes
5. Does the model design conform to best practice?	Yes
6. Is the model calibration satisfactory?	Yes
7. Are the calibrated parameter values and estimated fluxes plausible?	Yes*
8. Do the model predictions conform to best practice?	Yes
9. Is the uncertainty associated with the predictions reported?	Yes*
10. Is the model fit for purpose?	Yes

*The validity of a zone of high rainfall recharge (80 mm/yr) implemented in the adopted model to the southeast of the mine has been questioned. This is based upon minimal field data. However, an alternative conceptual model has been explored with the numerical model and the authors plan to document the differences in model outcomes between these two model scenarios and hence quantify the uncertainty associated with this.

Table 9-2: Review checklist

Review questions	*Yes/No*	*Comment*
1. Planning		
1.1 Are the project objectives stated?	Yes	
1.2 Are the model objectives stated?	Yes	
1.3 Is it clear how the model will contribute to meeting the project objectives?	Yes	
1.4 Is a groundwater model the best option to address the project and model objectives?	Yes	
1.5 Is the target model confidence-level classification stated and justified?	No	This is not explicitly stated in the report, however IGS is confident that the model confidence level is commensurate with the model objectives.
1.6 Are the planned limitations and exclusions of the model stated?	NA	
2. Conceptualisation		
2.1 Has a literature review been completed, including examination of prior investigations?	Yes	
2.2 Is the aquifer system adequately described?	-	
2.2.1 hydrostratigraphy including aquifer type (porous, fractured rock ...)	Yes	
2.2.2 lateral extent, boundaries and significant internal features such as faults and regional folds	Yes	
2.2.3 aquifer geometry including layer elevations and thicknesses	Yes	
2.2.4 confined or unconfined flow and the variation of these conditions in space and time?	Yes	
2.3 Have data on groundwater stresses been collected and analysed?	-	
2.3.1 recharge from rainfall, irrigation, floods, lakes	Yes	
2.3.2 river or lake stage heights	Yes	As appropriate.
2.3.3 groundwater usage (pumping, returns etc)	Yes	As far as possible.
2.3.4 evapotranspiration	No	NA – evapotranspiration is accounted for in chloride mass balance estimates of recharge.
2.3.5 other?	NA	
2.4 Have groundwater level observations been collected and analysed?	-	
2.4.1 selection of representative bore hydrographs	Yes	
2.4.2 comparison of hydrographs	Yes	
2.4.3 effect of stresses on hydrographs	Yes	
2.4.4 watertable maps/piezometric surfaces?	Yes	
2.4.5 If relevant, are density and barometric effects taken into account in the interpretation of groundwater head and flow data?	NA	
2.5 Have flow observations been collected and analysed?		

Review questions	*Yes/No*	*Comment*
2.5.1 baseflow in rivers	No	Not warranted based upon model objectives / uncertainty in other model parameters. Total value from previous study used.
2.5.2 discharge in springs	No	As above
2.5.3 location of diffuse discharge areas?	NA	
2.6 Is the measurement error or data uncertainty reported?	-	
2.6.1 measurement error for directly measured quantities (e.g. piezometric level, concentration, flows)	No	NA
2.6.2 spatial variability/heterogeneity of parameters	Yes	Quantified through multiple aquifer tests at various scales. Further work on this planned.
2.6.3 interpolation algorithm(s) and uncertainty of gridded data?	NA	
2.7 Have consistent data units and geometric datum been used?	No	Generally m AHD, occasionally m bgl. However, this is not considered to be a problem where this occurs in the report.
2.8 Is there a clear description of the conceptual model?	-	
2.8.1 Is there a graphical representation of the conceptual model?	Yes	
2.8.2 Is the conceptual model based on all available, relevant data?	Yes	
2.9 Is the conceptual model consistent with the model objectives and target model confidence level classification?	Yes	
2.9.1 Are the relevant processes identified?	Yes	
2.9.2 Is justification provided for omission or simplification of processes?	Yes	
2.10 Have alternative conceptual models been investigated?	Yes	
3. Design and construction		
3.1 Is the design consistent with the conceptual model?	Yes	Further documentation of alternative recharge model planned.
3.2 Is the choice of numerical method and software appropriate?	Yes	
3.2.1 Are the numerical and discretisation methods appropriate?	Yes	
3.2.2 Is the software reputable?	Yes	
3.2.3 Is the software included in the archive or are references to the software provided?	Yes	
3.3 Are the spatial domain and discretisation appropriate?	-	
3.3.1 1D/2D/3D	Yes	3D
3.3.2 lateral extent	Yes	
3.3.3 layer geometry?	Yes	
3.3.4 Is the horizontal discretisation appropriate for the objectives, problem setting, conceptual model and target	Yes	

Review questions	*Yes/No*	*Comment*
confidence level classification?		
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	
3.4 Are the temporal domain and discretisation appropriate?	-	
3.4.1 steady state or transient	Yes	
3.4.2 stress periods	Yes	
3.4.3 time steps?	Yes	
3.5 Are the boundary conditions plausible and sufficiently unrestrictive?	Yes	
3.5.1 Is the implementation of boundary conditions consistent with the conceptual model?	Yes	
3.5.2 Are the boundary conditions chosen to have a minimal impact on key model outcomes? How is this ascertained?	Yes	Boundary was moved further out when simulated cone of depression extended to previous boundary. No sensitivity test to boundary but confident that it is appropriate for the model objectives. Recharge zones are loosely based upon chloride mass balance data but we are confident in these and two equally plausible recharge scenarios have been tested.
3.5.3 Is the calculation of diffuse recharge consistent with model objectives and confidence level?	Yes	
3.5.4 Are lateral boundaries time-invariant?	Yes	
3.6 Are the initial conditions appropriate?	Yes	Steady state simulation used as initial conditions.
3.6.1 Are the initial heads based on interpolation or on groundwater modelling?	Groundwater modelling	
3.6.2 Is the effect of initial conditions on key model outcomes assessed?	NA	Steady state model re-calibrated each time model updated.
3.6.3 How is the initial concentration of solutes obtained (when relevant)?		Loosely based on measured salinities obtained from the Well Census.
3.7 Is the numerical solution of the model adequate?	-	
3.7.1 Solution method/solver		Not provided in report.
3.7.2 Convergence criteria		Not provided in report.
3.7.3 Numerical precision		Not provided in report.
4. Calibration and sensitivity		
4.1 Are all available types of observations used for calibration?	-	
4.1.1 Groundwater head data	Yes	
4.1.2 Flux observations	Yes	

Review questions	*Yes/No*	*Comment*
4.1.3 Other: environmental tracers, gradients, age, temperature, concentrations etc.	Yes	
4.2 Does the calibration methodology conform to best practice?		We consider the calibration methodology to be adequate, using a combination of field data and soft system knowledge.
4.2.1 Parameterisation	NA	
4.2.2 Objective function	NA	
4.2.3 Identifiability of parameters	NA	
4.2.4 Which methodology is used for model calibration?		Combination of trial and error and automated calibration using PEST.
4.3 Is a sensitivity of key model outcomes assessed against?		
4.3.1 parameters	Yes	
4.3.2 boundary conditions	Yes	
4.3.3 initial conditions	NA	
4.3.4 stresses	Yes	
4.4 Have the calibration results been adequately reported?	Yes	
4.4.1 Are there graphs showing modelled and observed hydrographs at an appropriate scale?	Yes	
4.4.2 Is it clear whether observed or assumed vertical head gradients have been replicated by the model?	NA	None observed nor assumed.
4.4.3 Are calibration statistics reported and illustrated in a reasonable manner?	Yes	
4.5 Are multiple methods of plotting calibration results used to highlight goodness of fit robustly? Is the model sufficiently calibrated?		
4.5.1 spatially	Yes	
4.5.2 temporally	Yes	
4.6 Are the calibrated parameters plausible?	Yes*	
4.7 Are the water volumes and fluxes in the water balance realistic?		Baseflow has been provided and this is realistic. Other elements of the water balance to be provided in final report for all modelling scenarios.
4.8 has the model been verified?	No	Some validation against previous mine inflow data, total estimated baseflow volume and spring locations.
5. Prediction		
5.1 Are the model predictions designed in a manner that meets the model objectives?	Yes	
5.2 Is predictive uncertainty acknowledged and addressed?	Yes*	
5.3 Are the assumed climatic stresses appropriate?	NA	
5.4 Is a null scenario defined?	No	

Review questions	*Yes/No*	*Comment*
5.5 Are the scenarios defined in accordance with the model objectives and confidence level classification?	Yes	
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?	No	This has been acknowledged - further pump tests are planned and model will be updated using results of these pump tests.
5.5.2 Are well losses accounted for when estimating maximum pumping rates per well?	NA	
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?	TBA as for 5.5.1	
5.5.4 Are the assumed stresses and timescale appropriate for the stated objectives?	Yes.	
5.6 Do the prediction results meet the stated objectives?	Yes	
5.7 Are the components of the predicted mass balance realistic?	TBA.	See 4.7
5.7.1 Are the pumping rates assigned in the input files equal to the modelled pumping rates?	Yes	
5.7.2 Does predicted seepage to or from a river exceed measured or expected river flow?	No	
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	
5.7.4 Is diffuse recharge from rainfall smaller than rainfall?	Yes	
5.7.5 Are model storage changes dominated by anomalous head increases in isolated cells that receive recharge?	Unknown	
5.8 Has particle tracking been considered as an alternative to solute transport modelling?	No	
6. Uncertainty		
6.1 Is some qualitative or quantitative measure of uncertainty associated with the prediction reported together with the prediction?	Yes	
6.2 Is the model with minimum prediction-error variance chosen for each prediction?	Yes	
6.3 Are the sources of uncertainty discussed?		
6.3.1 measurement of uncertainty of observations and parameters	No	
6.3.2 structural or model uncertainty	Yes	
6.4 Is the approach to estimation of uncertainty described and appropriate?	Yes	
6.5 Are there useful depictions of uncertainty?	Yes*	Further work on this has been recommended.
7. Solute transport		
7.1 Has all available data on the solute distributions, sources and transport processes been collected and analysed?	NA	Solute transport exercise was demonstrative only, not requiring this level of detail.
7.2 Has the appropriate extent of the model domain been delineated and are the adopted solute concentration	Yes	

Review questions	*Yes/No*	*Comment*
boundaries defensible?		
7.3 Is the choice of numerical method and software appropriate?	Yes	
7.4 Is the grid design and resolution adequate, and has the effect of the discretisation on the model outcomes been systematically evaluated?	Yes No	
7.5 Is there sufficient basis for the description and parameterisation of the solute transport processes?	Yes	
7.6 Are the solver and its parameters appropriate for the problem under consideration?	Yes	
7.7 Has the relative importance of advection, dispersion and diffusion been assessed?	NA	
7.8 Has an assessment been made of the need to consider variable density conditions?	NA	
7.9 Is the initial solute concentration distribution sufficiently well-known for transient problems and consistent with the initial conditions for head/pressure?	Yes	
7.10 Is the initial solute concentration distribution stable and in equilibrium with the solute boundary conditions and stresses?	Not assessed.	
7.11 Is the calibration based on meaningful metrics?	NA	Not calibrated for solute transport.
7.12 Has the effect of spatial and temporal discretisation and solution method taken into account in the sensitivity analysis?	NA	No sensitivity analysis for solute transport.
7.13 Has the effect of flow parameters on solute concentration predictions been evaluated, or have solute concentrations been used to constrain flow parameters?	No	
7.14 Does the uncertainty analysis consider the effect of solute transport parameter uncertainty, grid design and solver selection/settings?	No	
7.15 Does the report address the role of geologic heterogeneity on solute concentration distributions?	No	Not necessary for this solute transport modelling exercise.
8. Surface water–groundwater interaction		
8.1 Is the conceptualisation of surface water–groundwater interaction in accordance with the model objectives?	Yes	
8.2 Is the implementation of surface water–groundwater interaction appropriate?	Yes	
8.3 Is the groundwater model coupled with a surface water model?	No	
8.3.1 Is the adopted approach appropriate?	Yes	
8.3.2 Have appropriate time steps and stress periods been adopted?	Yes	
8.3.3 Are the interface fluxes consistent between the groundwater and surface water models?	NA	

*The validity of a zone of high rainfall recharge (80 mm/yr) implemented in the adopted model to the southeast of the mine is based upon minimal field data. However, an alternative conceptual model has been explored with the numerical model and the authors plan to document the differences in model outcomes between these two model scenarios and hence quantify the associated uncertainty.