Appendix

I

Peer Review

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19 September 2012

Ms Trish McDonald
Environment and Approvals Manager
Cobbora Holding Company
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Re: Cobbora Coal Project - Independent Groundwater Modelling Review

Dear Ms McDonald,

The impacts of the Cobbora Project on groundwater behaviour have been modelled by specialist hydro-geologists from Parsons Brinkerhoff. As this technical area is complex, an independent peer review was commissioned from Dr Noel Merrick. Dr Merrick is a former lecturer in groundwater and groundwater modelling at the University of Technology Sydney and is a recognised expert in these fields.

Dr Merrick's review was carried out in a number of stages, culminating in an assessment report dated 28th February 2012. A copy of that review is included in Appendix I. This was provided to Parsons Brinkerhoff, the model authors, and they responded to the points made in a letter dated 28th June 2012.

As the mine plan evolved, changes were made to pit layouts and it was felt desirable to have Dr Merrick carry out another assessment to determine if those changes affected any of his original conclusions. The result of his further review is also included in Appendix I, together with a tabulated response from Parsons Brinkerhoff.

We anticipate that groundwater issues will attract particular attention during the assessment process. Accordingly, the purpose of these reviews was to ensure that the Project was subject to a robust and fully contemporary assessment based on best practice modelling and monitoring.

Yours sincerely,

EMGA Mitchell McLennan Pty Limited

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HERITAGE COMPUTING REPORT

PEER REVIEW OF THE COBBORA COAL PROJECT GROUNDWATER ASSESSMENT

FOR

PARSONS BRINCKERHOFF

GPO Box 5394, SYDNEY NSW 2001

By

Dr N. P. Merrick

Report Number: HC2012/5
Date: February 2012

DOCUMENT REGISTER

REVISION	DESCRIPTION	DATE	COMMENTS
A	DRAFT	26 FEBRUARY 2012	Original
B	DRAFT FINAL	28 FEBRUARY 2012	Updated references

TABLE OF CONTENTS

1.0 INTRODUCTION

This report provides a peer review of the groundwater assessment for the Cobbora Coal Project conducted by Parsons Brinckerhoff for Cobbora Holding Company Pty Ltd.

The Cobbora coal resource is a large unallocated deposit in the Western Coalfield to the west of existing Ulan, Moolarben and Wilpinjong coal mines. It lies to the east of Dubbo and 15 km to the west of Dunedoo. An open-cut operation is being investigated as a source of coal for Hunter Valley power stations operated by Macquarie Generation, Delta Electricity and Eraring Energy.

As part of the Environmental Assessment (EA) for the mine, a numerical groundwater model has been developed to inform the groundwater assessment for the project. The groundwater model is to assess possible environmental impacts of the mine and provide indicative mine inflow estimates.

2.0 SCOPE OF WORK

This reviewer was requested to conduct a peer review of the groundwater assessment and the groundwater model. There are firm guidelines for reviewing groundwater models but not for associated groundwater assessments. For that reason, the checklists in the Australian groundwater flow modelling guidelines have been used for both assessments.

3.0 MODELLING GUIDELINES

The review has been structured according to the checklists in the Australian Flow Modelling Guideline (MDBC, 2001). This guide, sponsored by the Murray-Darling Basin Commission, has become a *de facto* Australian standard but is currently under review. This reviewer was one of the three authors of the guide, and is the person responsible for creating the peer review checklists. The checklists have been well received nationally, and have been adopted for use in the United Kingdom, California and Germany.

The modelling has been assessed according to the 2-page Model Appraisal checklist in MDBC (2001). This checklist has questions on (1) The Report; (2) Data Analysis; (3) Conceptualisation; (4) Model Design; (5) Calibration; (6) Verification; (7) Prediction; (8) Sensitivity Analysis; and (9) Uncertainty Analysis. For the groundwater assessment component, only the first three sections are relevant.

It should be recognised that the effort put into a modelling study is very dependent on timing and budgetary constraints that are generally not known to a reviewer.

4.0 EVIDENTIARY BASIS

The primary documents on which this review is based are:

1. *Parsons Brinckerhoff (2012) Groundwater Assessment. Draft Report for Cobbora Holding Company Pty Ltd. 72p (plus Figures and 6 Appendices).February 2012.*

2. *Parsons Brinckerhoff (2012) Cobbora Coal Project Groundwater Model - Technical Report. Draft Report for Cobbora Holding Company Pty Ltd. 32p (plus Figures and 2Appendices).25 January 2012.*

No other documentation was considered.

The reviewer attended one progress meeting at the Sydney premises of Parsons Brinckerhoff on 15 November 2011.

There have been numerous emails in the style of progress reports received by the reviewer during the course of the review, with comments supplied in return.

An interim review on 10 February 2012 (by email) would have initiated changes to both reports that are subsequent to the review presented here. Many of the comments made here could have been addressed in the final reports issued by Parsons Brinckerhoff.

Electronic copies of the model files have not been examined.

5.0 PEER REVIEW

In terms of the modelling guidelines, the Cobbora Coal numerical groundwater model developed by Parsons Brinckerhoff is best categorised as an *Impact Assessment Model* of medium complexity, as distinct from an *Aquifer Simulator* of high complexity. This classification is derived from the MDBC guideline. Document #2 acknowledges the role of the MDBC guideline and nominates the intended model as being of *moderate* complexity.

The Australian best practice guide (MDBC, 2001) describes the connection between model application and model complexity as follows:

- Impact Assessment model - a moderate complexity model, requiring more data and a better understanding of the groundwater system dynamics, and suitable for predicting the impacts of proposed developments or management policies.

This contrasts with a more demanding level of complexity:

- Aquifer Simulator - a high complexity model, suitable for predicting responses to arbitrary changes in hydrological conditions, and for developing sustainable resource management policies for aquifer systems under stress.

The completed model appraisal checklist is presented in Table A1 (at the back of this report) for the Groundwater Assessment Report [Document #1] and in Table A2 for the Model Technical Report [Document #2]. The main findings are discussed in Section 6.

6.0 DISCUSSION

6.1 THE GROUNDWATER ASSESSMENT REPORT

Document #1 is a high quality document of about 70 pages length, plus figures and appendices. It is well structured, well written and the graphics are of high quality. Some figures had faulty symbols and legends when converted to PDF format. At the time of the review, the report was missing the Executive Summary.

The report serves well as a standalone document, with no undue dependence on earlier work.

The report includes sections on legislation, licensing and the existing environment which the reviewer understands to be outside the terms of reference for this review. The intent of the review is to examine the groundwater investigation program for sufficiency with primary emphasis on the credibility of the modelling.

It is the reviewer's opinion that the field investigation program has been sufficient for the purpose of an environmental assessment. The investigations have included: new drilling and extra piezometers and test production bores; geophysical logging; hydraulic testing by several methods; groundwater level monitoring; water quality sampling; environmental isotope sampling; investigation of groundwater-surface water interactions; groundwater dependent ecosystem surveys; a land-based geophysical survey; and a bore census.

The objectives of the groundwater assessment are summarised clearly in the Scope of Works in Section 1.2. It is the reviewer's opinion that the study has satisfied the stated objective.

The report provides a summary of modelling results and addresses in more detail the potential environmental impacts suggested by the modelling. There is a statement in Section 7.3 ("Baseflow to rivers/creeks") that "Reduced flow of groundwater to surface water bodies is expected to make up a much smaller component of the 280 ML/yr indicated by the model" because "surface water bodies are a net source of water to the groundwater system". It should have been possible for the model to separately account for reductions in baseflow and increases in stream leakage due to mining.

The comments on groundwater quality impacts in Section 7.5 seem more concerned with the change in mine water quality than regional effects on aquifers and receptors.

The report concludes with plans for monitoring and mitigation. Section 9 mentions one of the risks being "final void groundwater inflows", but this has not been assessed with the model.

One point of difference between the groundwater assessment report and the model report is that the former states that "Rapid recharge during flood events is therefore an important recharge mechanism...". However, the model does not simulate flood recharge explicitly, but allows some implicit recharge by keeping active continuously watercourses that are ephemeral.

Extra comments on *The Report* can be found in Table A1.

6.2 THE MODEL REPORT

Document #2 is a well structured and well written document of about 30 pages length. The graphics are of good quality but not all figures were available at the time of the review.

Although the report is associated with its companion report [Document #1], not much prior knowledge is assumed. As a result, this report comes close to being a standalone document. The field and conceptualisation aspects of the groundwater assessment are summarised succinctly, rather than merely referenced. However, the conceptual model graphic should be repeated in this report. It is listed in the List of Figures but it was not included in the report as reviewed.

The objective of the groundwater assessment is stated to be:

> *"...to identify and quantify the potential impacts of the proposed mining operation on the groundwater regime, and to propose mitigation and contingency measures, where applicable, for those impacts that are likely to be unacceptable."*

By inference, the objective of the modelling study is the same. The mitigation and contingency measures, however, appear only in Document #1.

Water balance reporting is more comprehensive for steady-state modelling than for transient calibration. For the latter, only the last time step is considered. This is of little use, except for final pit inflows, and an average water balance over the 18 months of calibration would have been more informative. For scenario predictions over the life of the mine, there is no overall water balance summary. Only pit inflow rates are presented year by year. An average water balance should indicate which of the natural processes might change significantly in providing the water discharges to the pit. For example, is the water coming primarily from storage, or from reduced evapotranspiration (ET), or reduced baseflow?

Extra comments on *The Report* can be found in Table A2.

6.3 DATA ANALYSIS

This study is based on two stages of field investigations, culminating in the drilling of 53 piezometers and five test production bores. Aquifer testing has been done by means of pumping tests, slug tests, and packer tests. No core measurements were taken. Extensive water quality and environmental isotope sampling has been undertaken. Conceptualisation and model calibration have been able to draw on about 18 months of baseline groundwater level data. There is still a lack of knowledge of groundwater levels at the edges of the model area, and assumptions have had to be made there in the setting of boundary condition water levels.

In addition, a transient electromagnetic (TEM) survey was commissioned to aid the interpretation of alluvial boundaries and thicknesses.

The aquifer system appears to be under no significant stress, but fluctuations in the water table have reached about 3 m at some locations due to strong rainfall events and/or stream flow. It is not easy to comment on whether deep formations show any response to climate stresses, as the field hydrographs in Appendix E are not classified according to depth or lithology. Some hydrographs reveal artesian pressures; the typical magnitide of the head difference between Permian units and alluvium should be stated.

Groundwater head contours and flow directions are established for the water table and the Dapper Formation, showing clearly the potential for artesian conditions along Sandy Creek and the Talbragar River. This diagram of field contours is misrepresented in Document #2 as a map of simulated contours.

A map of posted field depths to water would have been useful to assess the likely importance of ET.

The baseline monitoring period includes a fortunate high rainfall event in December 2010. Document #1 compares groundwater responses at all 46 hydrographs with rainfall residual mass. Document #2 examines 11 hydrographs and compares them with rainfall residual mass, rain events and stream stage.

The natural fluctuation in water levels from rain should be stated in support of the adopted threshold level for predicted drawdown impacts.

Extra detailed comments on *Data Analysis* can be found in Table A1 and Table A2.

6.4 CONCEPTUALISATION

There is a very good description and justification for the conceptual model of the area in Document #1.

Illustrative pre-mining conceptual model graphics are shown in Figure 5.15 for sections across Talbragar River, Sandy Creek and Laheys Creek. Inclusion of a modified section for post-mining conditions would be informative to the reader to indicate how groundwater flow directions will change. The same or similar diagram should appear in Document #2; although referenced, it was not included in the report at the time of review. There are conceptual cross-sections in Section 2 of Document #2, but they are meant to show geological complexity rather than recharge-discharge processes.

A conceptual model diagram can serve a dual purpose for displaying the magnitudes of the water budget components derived from data sources or from simulation. This has not been done in this case.

The hydrostratigraphy adopted for modelling (7 layers) seems appropriate.

Extra detailed comments on *Conceptualisation* can be found in Table A1 and Table A2.

6.5 MODEL DESIGN

The model is based on a highly respected advanced version of MODFLOW simulation software called MODFLOW-SURFACT (version 3) within the Groundwater Vistas graphic user interface (GUI). This choice minimises dry cell issues encountered with Standard-MODFLOW, and allows more robust solution. The time-varying TMP facility of SURFACT has been used rather than the alternative method of time-slices to allow incorporation of dynamic backfilling in the model.

The option for fully-unsaturated flow has been invoked, more for numerical stability than for serious modelling of unsaturated conditions.

The model grid discretisation is sufficiently fine (uniform 100 m x 100 m cells). The model grid consists of 502 rows and 290 columns across a rotated grid, covering 29 km east-west and 50 km north-south. The total number of model cells is just over 1 million. Normally, modellers regard 1 million cells as a practical upper limit.

The boundary conditions are not well controlled. While there is a reasonable assumption of inactive cells in the more elevated areas where older formations outcrop, there is poor control at model edges in the northern half of the model where some cross-boundary flow can be expected. A general-head boundary is reasonable, but there is no firm knowledge of the magnitude of those heads as there is no water level data in those areas.

Internal boundary creeks and the Talbragar River are represented reasonably as continuously active model "river" (RIV) cells. Normally, time-varying river stages would be placed in a model during transient calibration, but in this case that has not been done, presumably because of the substantial distance from the nearest active stream gauge and the lack of firm data on local river and creek levels. On the one hand, continuously active river cells would over-estimate potential rechage along ephemeral streams. On the other hand, maintenance of steady water levels would under-estimate flood recharge events. Document #1 considers flood recharge an important component of the water balance. Document #2 has not simulated floods explicitly but offers a compromise mechanism by deliberately sustaining recharge from creeks at times when they are dry.

As MODFLOW represents ET by a linear decay function (with depth), use of a maximum ET value close to potential evapotranspiration (PET) is likely to be too high in the model. A value closer to half the PET rate would give a better linear approximation to what in reality would be an exponential decay curve. The sensitivity analysis following transient calibration shows that the maximum ET rate could be reduced without affecting calibration performance.

A weekly stress period has been used for transient calibration, and an annual step for prediction over the life of the mine.

Extra detailed comments on *Model Design* can be found in Table A2.

6.6 CALIBRATION

Several lines of evidence are provided in Document #2 in support of steady-state calibration in the form of a scatter plot and RMS performance statistics. The steady-state performance is measured at 2.7 %RMS and 4.4mRMS, which is satisfactory. To demonstrate good spatial calibration, a simulated groundwater level map should have been offered for comparison with the observed/interpolated contour map.

Transient calibration evidence is provided also by a scatter plot and RMS performance statistics, with examples of a few hydrographic matches. The transient performance is measured at 2.4 %RMS and 4.1mRMS, which is quite good. However, not all hydrographic matches are presented. Of the eight comparisons that are presented, only two are particularly good (in alluvium at Bore GW5A) and in the Digby Formation (at Bore GW5B). The others generally suffer from offsets in absolute value, although trends are generally good. Without seeing the full set of hydrographic matches, or a residuals map, it is not possible to say which areas of the model are well calibrated or which natural processes are well replicated.

The modelling report has not given specific attention to replication of vertical hydraulic gradients or artesian pressures. It is not clear if the model performs well in this regard.

Extra detailed comments on *Calibration* can be found in Table A2.

6.7 VERIFICATION

There is insufficient transient data for a verification dataset.

6.8 PREDICTION

Prediction is run for one scenario consisting of a single mine plan with average steady climatic conditions. This is normal practice. Missing is a simulation of equilibrium groundwater conditions when the final void reaches a stable water level.

Annual stress periods and progressive updating of backfill extent and permeability are acceptable ways of representing mining progression with spoil emplacement (time-varying material properties). Reasonable spoil properties are applied, although they are uncertain.

In representing the mine void by "drain" cells in the basal coal seam, it is not clear whether drain cells were applied also to overlying layers which would in reality be excavated. In a model, they are likely to be given perched water tables unless deliberately dewatered.

A recovery run has been done for 50 years with drawdown results presented after 20 years. It is not clear how the final void was handled in this case. Was it left with host parameters, or filled with spoil and allowed to develop a water table? What storage properties were assumed? The timeframe for full or partial recovery is not clear, but it can be determined from recovery hydrographs in Figure 5-9.

Modelling suggests that the current mine plan will cause less than 1 m drawdown in the alluvium at the Talbragar River, for both the base case scenario and a high-inflow scenario. The drawdown extent is expected to remain localised close to the mine footprint with about 5 km maximum propagation to the south.

From four to 10 private bores are expected to experience more than 2.5 m drawdown during the life of the mine. However, some of these bores appear close to the 1 m drawdown contour on the maximum predicted drawdown contour map (Figure 5.3). The drawdown map does not seem to be consistent with the hydrographs displayed in Figure 5-9. Is it that the drawdown map is for the water table only, and the hydrographs apply to deeper formations?

Extra detailed comments on *Prediction* can be found in Table A2.

6.9 SENSITIVITY ANALYSIS

Sensitivity analysis is done thoroughly on both steady-state and transient models using the traditional perturbation method. The tested parameters are: horizontal and vertical hydraulic conductivity (all layers); rainfall recharge; ET rate and extinction depth. Storage coefficient and specific yield (all layers) have also been assessed by perturbing the transient model.

The steady-state analysis found the most sensitive parameters to be the horizontal permeability of the Digby and Dapper Formations and the Ulan Seam; rain recharge rate; and ET extinction depth. The transient analysis surprisingly showed no sensitivity to anything.

One criticism is that the vertical permeability was not perturbed far enough. This should be altered by an order of magnitude either way, rather than a factor of two. The base case model has 0.1 m/d for the vertical permeability of alluvium, but a local area model found a value of 0.001 m/d. Sensitivity analysis should explore these extremes.

Extra comments on *Sensitivity Analysis* can be found in Table A2.

6.10 UNCERTAINTY ANALYSIS

Uncertainty in Ulan Coal permeability (horizontal and vertical) has been explored by a factor of 2.7 increase in both. The model outputs have been examined for incremental effects on pit inflow, drawdown extent, baseflow and storage.

Pit inflow was found to increase by 44% for a 170% change in inputs. Other environmental incremental effects were found to be minor except for a doubling in maximum reduction in river flows. However, the effect remains less than 1% of annual Talbragar River flow.

7.0 CONCLUSION

The focus of this peer review has been on the sufficiency of the groundwater investigation program and the credibility of the conceptualisation of the groundwater system and subsequent regional modelling.

It is the reviewer's opinion that the field investigation program has been sufficiently comprehensive for the purpose of an environmental assessment. The investigations have included: piezometer installations (53); drilling of test production bores (5); hydraulic testing by several methods; groundwater level monitoring; water quality sampling; environmental isotope sampling; investigation of groundwater-surface water interactions; groundwater dependent ecosystem surveys; land-based and downhole geophysical surveying; and a bore census. The baseline groundwater level dataset has a length of about 18 months.

The objectives of the groundwater assessment are summarised clearly in the Scope of Works in Section 1.2. It is the reviewer's opinion that the study has satisfied the stated objectives.

The conceptual model and the numerical model have been developed competently. The stated modelling objective, to identify and quantify the potential impacts of the proposed mining operation on the groundwater regime, has been achieved satisfactorily.

The performance statistics suggest that the Cobbora groundwater model is well calibrated. However, there are offsets in absolute level of several metres on average. Without more information being supplied, it is not clear if there are some areas of the model that are better calibrated than others.

One aspect of modelling that has not been done is the final void analysis. This would examine the final equilibrium water levels and flow directions after the final void fills with water to a stable level. However, a 50-year recovery simulation has been done but it is not clear what assumptions were made for the pit void.

Modelling suggests that the current mine plan will cause less than 1 m drawdown in the alluvium at the Talbragar River, for both the base case scenario and a high-inflow scenario. The drawdown extent is expected to remain localised close to the mine footprint with about 5 km maximum propagation to the south.

From four to 10 private bores are expected to experience more than 2.5 m drawdown during the life of the mine.

8.0 REFERENCES

MDBC (2001). Groundwater flow modelling guideline. Murray-Darling Basin Commission. URL: www.mdbc.gov.au/nrm/water_management/groundwater/groundwater_guides

Parsons Brinckerhoff (2012) Groundwater Assessment. Draft Report for Cobbora Holding Company Pty Ltd. 72p (plus Figures and 6 Appendices).February 2012.

Parsons Brinckerhoff (2012) Cobbora Coal Project Groundwater Model - Technical Report. Draft Report for Cobbora Holding Company Pty Ltd. 32p (plus Figures and 2Appendices).25 January 2012.

Table A1. MODEL APPRAISAL: Groundwater Assessment Report

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
1.0	THE REPORT								
1.1	Is there a clear statement of project objectives in the modelling report?		Missing	Deficient	Adequate	Very Good			Page 1: Scope of works.
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes				Impact Assessment Model, medium complexity. Reference to MDBC guide.
1.3	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very Good			Only pit inflows. Full water balance in companion report.
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very Good			
1.5	Are the model results of any practical use?			No	Maybe	Yes			Based on comprehensive investigation program, valid conceptualisation and subsequent modelling.
2.0	DATA ANALYSIS								
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very Good			Comprehensive groundwater investigation and drilling program.
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very Good			There is a field contour map (Fig.5.7) for water table & Dapper Fm. Field values of depth to water would be useful to assess ET.
2.3	Have all potential recharge data been collected and analysed? (rainfall, streamflow, irrigation, floods, etc.)		Missing	Deficient	Adequate	Very Good			Rainfall residual mass is presented. Floods mentioned as important but hard to quantify.
2.4	Have all potential discharge data been collected and analysed? (abstraction, evapotranspiration, drainage, springflow, etc.)		Missing	Deficient	Adequate	Very Good			ETmax could be high, as BoM has average annual actual ET about 600 mm/a. This study has 1400mm/a max declining to 5m depth.
2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very Good			Groundwater hydrographs are compared with rainfall residual mass for 46 bores. Better comparison in companion report is extended to rain events and stream stage. State natural fluctuation from rain.

2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes			All bores used (46); 2800 measurements for transient calibration.
2.7	Have consistent data units and standard geometrical datums been used?			No	Yes				In summary, ML/d could be shown in addition to GL/a.
3.0	CONCEPTUALISATION								
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes			
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very Good			Section 5.7
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very Good			Good pre-mining diagrams (Figure 5.15). A post-mining diagram could be included to show changed interactions.
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No				Reasonable aggregation of stratigraphic layers.

Table A2. MODEL APPRAISAL: Groundwater Model Report

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
1.0	THE REPORT								
1.1	Is there a clear statement of project objectives in the modelling report?		Missing	Deficient	Adequate	Very Good			Page 1: potential impacts.
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes				Impact Assessment Model, medium complexity. Reference to MDBC guide.
1.3	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very Good			Reported for steady-state and transient, showing % breakdown for calibrated models. Transient is final time step, not averaged over 1.5 years. Only pit inflow provided for life-of-mine simulations.
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very Good			A good model, sensible predictions.
1.5	Are the model results of any practical use?			No	Maybe	Yes			Some uncertainty due to greenfield project.
2.0	DATA ANALYSIS								
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very Good			Parallel groundwater investigation and drilling program. Covered in companion report.
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very Good			There is a field contour map (Fig.5.7) in the companion report for water table & Dapper Fm. The same figure appears in the model report as "simulated"(Fig.4.2) - this is not correct. Field values of depth to water would be useful to assess ET.
2.3	Have all potential recharge data been collected and analysed? (rainfall, streamflow, irrigation, floods, etc.)		Missing	Deficient	Adequate	Very Good			Rainfall residual mass is presented. Floods mentioned as important in companion report but not explicitly modelled.
2.4	Have all potential discharge data been collected and analysed? (abstraction, evapotranspiration, drainage, springflow, etc.)		Missing	Deficient	Adequate	Very Good			ETmax could be high, as BoM has average annual actual ET about 600 mm/a. This study has 1400mm/a max declining to 5m depth.

2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very Good			11 Groundwater hydrographs are compared with rain events, residual mass and stream stage. State natural fluctuation from rain. 18 months baseline data.
2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes			All bores used (unstated number); 2800 measurements for transient calibration; 38 points for steady state.
2.7	Have consistent data units and standard geometrical datums been used?			No	Yes				In summary, ML/d could be shown in addition to GL/a.
3.0	CONCEPTUALISATION								
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes			
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very Good			Section 3.
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very Good			Figure 3.1 in list of figures but not included. Good diagrams in companion report. There are conceptualisation cross-sections in Section 2.
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No				Reasonable aggregation of stratigraphic layers.
4.0	MODEL DESIGN								
4.1	Is the spatial extent of the model appropriate?			No	Maybe	Yes			1.02million cells; 100mx100m cells. 7 layers. 29kmx50km, 502rows x 290 columns. Weekly time scale for transient calibration; yearly for scenarios.
4.2	Are the applied boundary conditions plausible and unrestrictive?		Missing	Deficient	Adequate	Very Good			Poor control on boundaries due to absence of data. Far enough away to be not impacting on the solution. GHB in each layer for top half of model.
4.3	Is the software appropriate for the objectives of the study?			No	Maybe	Yes			MODFLOW-SURFACT & TMP with Gw Vistas GUI. Minimises dry cell issues.

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
5.0	CALIBRATION								
5.1	Is there sufficient evidence provided for model calibration?		Missing	Deficient	Adequate	Very Good			*Steady-state*: %RMS; scatterplot; no contour map. *Transient*: %RMS; scatterplot; some hydrograph comparison but not enough. Mostly manual calibration.
5.2	Is the model sufficiently calibrated against spatial observations?		Missing	Deficient	Adequate	Very Good			Field contours are not compared with simulated contours. Good statistics. Are vertical head differences replicated?
5.3	Is the model sufficiently calibrated against temporal observations?		Missing	Deficient	Adequate	Very Good			Good statistics. Not enough hydrographs are compared - not grouped to illustrate response in alluvium or rock; rain or stream stresses. Some large offsets in water levels. Good amplitude and timing response to rain events.
5.4	Are calibrated parameter distributions and ranges plausible?		Missing	No	Maybe	Yes			Consistent with field studies. ET rate is high - no allowance for linear MODFLOW algorithm.
5.5	Does the calibration statistic satisfy agreed performance criteria?		Missing	Deficient	Adequate	Very Good			Steady-state: 2.7%RMS, 4.4mRMS. Transient: 2.4%RMS, 4.1m RMS.
5.6	Are there good reasons for not meeting agreed performance criteria?		Missing	Deficient	Adequate	Very Good			Stream stage not varied with time. Offsets probably due to K distribution.
6.0	VERIFICATION								
6.1	Is there sufficient evidence provided for model verification?		Missing	Deficient	Adequate	Very Good			Not enough transient data for any to be reserved.
6.2	Does the reserved dataset include stresses consistent with the prediction scenarios?	N/A	Unknown	No	Maybe	Yes			
6.3	Are there good reasons for an unsatisfactory verification?	N/A	Missing	Deficient	Adequate	Very Good			
7.0	PREDICTION								

7.1	Have multiple scenarios been run for climate variability?		Missing	Deficient	Adequate	Very Good			Only long-term average rain and river stage.
7.2	Have multiple scenarios been run for operational /management alternatives?		Missing	Deficient	Adequate	Very Good			Just base case scenario – one mine plan. No final void simulation.
7.3	Is the time horizon for prediction comparable with the length of the calibration / verification period?		Missing	No	Maybe	Yes			18 months calibration; 21 years prediction.
7.4	Are the model predictions plausible?			No	Maybe	Yes			Intuitively reasonable results. The 2.5m drawdown threshold (on hydrographs) should be related to natural fluctuation magnitude. Apparent inconsistency with drawdown at private bores on contour map and time-series hydrographs.
8.0	SENSITIVITY ANALYSIS								
8.1	Is the sensitivity analysis sufficiently intensive for key parameters?		Missing	Deficient	Adequate	Very Good			Thorough conventional sensitivity analysis on steady-state and transient models: Kx, Kz, recharge, both ET parameters; S & Sy. Kz not perturbed enough.
8.2	Are sensitivity results used to qualify the reliability of model calibration?		Missing	Deficient	Adequate	Very Good			List of RMS statistics. Steady-state sensitive to Kx of Digby, Ulan, Dapper; recharge rate; ET depth. Transient surprisingly insensitive to everything.
8.3	Are sensitivity results used to qualify the accuracy of model prediction?		Missing	Deficient	Adequate	Very Good			Done for high-inflow scenario: Ulan seam Kx and Kz increased 2.7 times. Assessment of changes in pit inflow, drawdown extent, baseflow, storage.
9.0	UNCERTAINTY ANALYSIS								
9.1	If required by the project brief, is uncertainty quantified in any way?		Missing	No	Maybe	Yes			Quantitative for coal seam permeability: 44% increase in inflow for 170% increase in permeability; minor addition to environmental effects.
	TOTAL SCORE								PERFORMANCE:

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28 June 2012

Our ref: 2162570C LT_1079

Phil Towler
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EMGA Mitchell McLennan
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Dear Phil

External peer review of the groundwater assessment and modelling reports for the Cobbora Coal Project

In accordance with the scope of works presented to Cobbora Holding Company Pty Limited, an independent external peer review of the draft Groundwater Assessment Report and Groundwater Model Technical Report was carried out by Dr Noel Merrick (Heritage Computing).

Dr Merrick is a former lecturer in groundwater and groundwater modelling at the University of Technology Sydney and is a recognised industry expert in groundwater modelling and impact assessment in NSW. Dr Merrick undertook the peer review of the draft reports and provided his comments in a report entitled Peer Review of the Cobbora Coal Project Groundwater Assessment, dated February 2012.

The reviewer concluded that in his opinion the field investigation program was *sufficiently comprehensive for the purpose of an environmental assessment*, and that *the conceptual and numerical models were developed competently*. The reviewers report offered a number of comments and suggestions for improvement of the final report. Parsons Brinckerhoff addressed these comments in the final versions of the Groundwater Assessment and Groundwater Modelling reports. The following table provide the list of review comments provided by Dr Merrick and how they have been addressed in the final reports.

Table 1 Reviewer comments on the draft Groundwater Assessment report and Parsons Brinckerhoff responses

Item	Reviewer comment	Report ref.	Parsons Brinckerhoff response
1	"It should have been possible for the model to separately account for reductions in baseflow and increases in stream leakage due to mining."	P4, Para 1	Noted. Text revised and made more explicit regarding partitioning of stream losses.
2	"final void groundwater flows…have not been assessed with the model"	P4, Para 3	The groundwater model was revised and re-run to include residual voids and equilibrium lake levels during post-mining recovery phase. Results were incorporated into the final report. Pit void filling and water quality has been assessed in the surface water report.

Item	Reviewer comment	Report ref.	Parsons Brinckerhoff response
3	"The model does not simulate flood recharge explicitly, but allows some implicit recharge by keeping active continuously watercourses that are ephemeral."	P4, Para 4	Acknowledged. Text in modelling report updated to describe the RIV cells and assumptions. RIV boundaries are steady state on the assumption that the model is used to assess average conditions and long term impacts and recovery.
4	"The conceptual model graphic…was not included in the report as reviewed."	P4, Para 7; see also item 3.3 in Table A2	Conceptual model cross section included in final report.
5	"There is no overall water balance summary. Only pit inflow rates are presented year by year."	P5, Para 1	Water balance summaries are provided for the steady state and transient model simulations.
6	"There is still a lack of knowledge of groundwater levels at the edges of the model area, and assumptions have had to be made there in the setting of boundary condition water levels."	P5, Para 3	Acknowledged. There is little regional data at the model margins. Reasonable estimates of groundwater levels have been used in those locations based on available regional bore information. This is unlikely to affect the magnitude of simulated drawdown.
7	"A map of posted field depths to water would have been useful to assess the likely importance of ET."	P5, Para 7	Noted. This information is included in tables provided.
8	"The natural fluctuation in water levels from rain should be stated in support of the adopted threshold level for predicted drawdown impacts."	P5, Para 9	Text revised; 2.5 m cut-off justified by observed natural groundwater level variation
9	"A conceptual model diagram … has not been done in this case."	P6, Para 4	See Item 4, above
10	Time-varying river stages [have not been implemented in this model], presumably because of the substantial distance from the nearest active stream gauge and the lack of firm data on local river and creek levels."	P7, Para 2	See item 3, above.
11	"Potential evapotranspiration (PET) is likely to be too high in the model. A value closer to half the PET rate would give a better linear approximation to what in reality would be an exponential decay curve."	P7, Para 3	Noted. The model was re-run with the appropriate PET value (600 mm/a)
12	"To demonstrate good spatial calibration, a simulated groundwater level map should have been offered for comparison with the observed/interpolated contour map."	P7, Para 6; see also Item 2.2 in Table A2	Contours of water table elevation and the piezometric surface in the Ulan Coal Seam are shown in Figure 4.2 of the Modelling Report.
13	Regarding the transient calibration: "not all hydrographic matches are presented…[many simulated hydrographs] generally suffer from offsets in absolute value, although trends are generally good".	P7, Para 7	All hydrographs are now included in Figure 4.5 of the Model Report. Some absolute offsets are acknowledged; however in the transient calibration, trends are considered more important.

Item	Reviewer comment	Report ref.	Parsons Brinckerhoff response
14	"The modelling report has not given specific attention to replication of vertical hydraulic gradients or artesian pressures. It is not clear if the model performs well in this regard."	P8, Para 2	Contours of water table elevation and the piezometric surface in the Ulan Coal Seam are shown in Figure 4.2 of the Modelling Report. The implied vertical head differences are consistent with field observations.
15	"It is not clear whether drain cells were applied also to overlying layers which would in reality be excavated."	P8, Para 7	Text revised to clarify - DRN cells are applied to all layers above the base of the pit during excavations, with invert levels at the base of the excavation
16	"It is not clear how the final void was handled in this case. Was it left with host parameters, or filled with spoil and allowed to develop a water table? What storage properties were assumed?"	P8, Para 8	Text updated to clarify; backfilled spoil was assigned appropriate parameters that are different to the host rock.
17	"The drawdown map does not seem to be consistent with the hydrographs displayed in Figure 5-9."	P9, Para 1	Amended; drawdown in the hydrographs relate to corresponding model layers. Drawdown contours now included for both water table aquifer and Ulan Coal Seams
18	In the sensitivity analysis, "the vertical permeability was not perturbed far enough."	P9, Para 5	Acknowledged. The model was re-run with Kz = 0.001 and sensitivity analysis extended. Final results are from the revised model.
19	"One aspect of modelling that has not been done is the final void analysis."	P10, Para 6	See item 2, above.
20	Model verification is not included.	Item 6.1 in Table A2; see also P8, Para 4.	Insufficient historical data are available to carry out model verification as described in the MDBC guidelines. This is typical in areas that do not have a long irrigation history and associated groundwater monitoring records.

Yours sincerely

Stuart Brown
Principal Hydrogeologist
Parsons Brinckerhoff

REVIEW

Our Ref:
HC2012/16

Date: 29 July 2012

To:

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From: Dr Noel Merrick

Re: Peer eview - Cobbora Coal Project Groundwater Assessment

This note is provided in response to your email dated 12 July 2012 which requested an update of my previous peer review report for the Cobbora Coal Project Groundwater Assessment. A comprehensive peer review report was issued on 28 February 2012 according to the MDBC Groundwater Flow Model Guideline and its associated checklists. The review was made on the Technical Report draft dated 25 January 2012, and on components of the Groundwater Assessment draft dated February 2012.

You have made available final reports dated 4 May 2012 for both reports. As changes in the reports are of an incremental nature, this review letter is also offered as incremental to the original peer review report (Heritage Computing Report HC2012/5).

Groundwater Assessment Report

The final report now includes an Executive Summary and several expanded sections, especially those related to water sharing plans and water licensing matters. In the original peer review, an opinion was expressed that the field investigation program had been sufficient for the purpose of an environmental assessment. That is still the case.

The peer review report made comments on the need for more consideration of water quality impacts, final void inflows and flood recharge. These aspects have all been addressed in the final report.

Other comments in the peer review report checklists referred to summary statements regarding the groundwater modelling exercise. They are examined below.

Groundwater Model Technical Report

The original peer review report included a number of criticisms, the most substantial being:

1. Not all groundwater hydrographs were analysed for cause-and-effect, or exhibited for calibration performance;
2. A water level contour map (for the water table and the Dapper Formation) was presented as if it were a simulated steady state map, but the same figure was presented in the Groundwater Assessment Report as a field contour map;
3. No depth to water spot values or averages were presented to assist in conceptualising the importance of the evapotranspiration process;
4. The adopted evapotranspiration rate was considered (by the reviewer) to be too high;
5. There was inadequate consideration of the significance of flooding as a source of recharge;
6. The calibration period water balance was presented for the last time step rather than averaged over the 74 weeks of calibration;
7. For the prediction scenario, no complete water balance was offered;
8. The sensitivity analysis considered only a narrow range for vertical hydraulic conductivity; and
9. No final void equilibrium analysis was done, although a 50-year recovery simulation was reported.

These matters have now been addressed in the following ways:

1. More hydrographs are now shown and they are examined in five different groupings;
2. The water level map inconsistency has not been resolved;
3. No additional depth to water information has been provided;
4. The evapotranspiration rate has been reduced substantially in accordance with BoM estimates of actual evapotranspiration for the project area;
5. There is now discussion of the contribution of flooding at several places in the report;
6. A water balance averaged across the calibration period is presented. However, there is an unexplained inconsistency in the relative rainfall recharge volumes for steady state and calibration models;
7. There is still no overall water balance for the prediction scenario. There is discussion and quantification of mine inflow, net baseflow loss and losses from storage in each layer of the model, but no consideration of changes in evapotranspiration volumes or the additional recharge that enters the groundwater system through the spoil footprint;
8. The sensitivity analysis has been repeated for an order of magnitude variation (higher and lower) in vertical hydraulic conductivity. This prompted a revision of the findings on sensitivity: *"The model was most sensitive to vertical hydraulic conductivity in the Whaka Formation, and to vertical*

hydraulic conductivity, specific yield and recharge in the Digby Formation"; and

9. A steady state final void equilibrium analysis has been done by setting void water level at a constant (undisclosed) elevation. There is no reporting on the results of this analysis, but it is understood that this matter is addressed in the surface water hydrology assessment report (not seen by this reviewer). It would be normal practice to include in the groundwater assessment report a statement on final groundwater fluxes and a final watertable contour map to illustrate groundwater flow directions and to show clearly whether the void would act as a groundwater sink. There is comment that the lake would be a flow-through system, which implies a water quality risk to the alluvial water source (as foreshadowed in the Groundwater Assessment Report). The likelihood of that risk deserves consideration.

There remain a couple of editorial matters:

- Section 3.2.5.4 has an incomplete sentence: "*This allowed for groundwater to recover to levels that approach in all other excavated areas, backfill material has been simulated.*"
- Section 7 notes there are only two private bores with excessive predicted drawdown, but Section 5.2.1 and the Groundwater Assessment Report recognise six bores.
- Table 3.3 has specific yield "2-12" for the Dapper Formation (should be 0.02-0.12).

The assessments were completed prior to the release of a second draft of the Aquifer Interference Policy, and new National Groundwater Modelling Guidelines. In light of the revised Aquifer Interference Policy, a drawdown threshold of 2.0 m would have been better than the adopted 2.5 m drawdown. The introduction of new modelling guidelines has no material effect on the assessment or the review.

Apart from the few issues identified above, the revised assessment has considered and addressed comments in the original peer review report. Fundamentally, the conceptual hydrogeological model and the numerical groundwater model have been developed competently. The stated modelling objective, to identify and quantify the potential impacts of the proposed mining operation on the groundwater regime, has been achieved satisfactorily.

Yours sincerely,

Dr Noel Merrick

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6 August 2012

Our ref: 2162570A-EW-LTR-001 RevB

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Dear Phil

Re: Peer review of Cobbora Groundwater Assessment by Noel Merrick - Response

At the request of EMGA Mitchel McLennan (EMM), Dr Noel Merrick provided an updated review of the Cobbora Coal Project Groundwater Assessment Report and Technical Modelling Report. This letter provides our responses and additional information to address specific comments raised by the updated review.

Dr Merrick provided a detailed review of the draft reports in February 2012. The reports were then revised on the basis of Dr Merrick's and other's comments and included with the Environmental Assessment Report that was submitted for adequacy review in July 2012. Dr Merrick's latest review (dated 29 July 2012) relates to the revised Groundwater Assessment and Technical Modelling Reports.

It is noted that Dr Merrick's review finds that the groundwater assessment and numerical model were developed in a competent manner and that the modelling objective, *to identify and quantify the potential impacts of the proposed mining operation on the groundwater regime*, was achieved satisfactorily.

The review identified several items that require clarification. These are summarised in Table 1 below, together with responses from the groundwater assessment team.

Table 1 Responses to reviewer comments

Item*	Reviewer comment	Response by Parsons Brinckerhoff
2	Water level map inconsistency.	A contour map showing observed groundwater elevation contours is included in the revised report.
3	Depth to water information not provided.	A depth to water map is provided in relation to the potential groundwater availability to ecosystems in the revised Groundwater Assessment Report.
6	Water balance for calibration period and apparent inconsistency of recharge.	The transient calibration period included a period of unusually high rainfall (March 2010 – August 2011) compared with the long term average. In order to simulate the observed increases in groundwater levels and aquifer storage over the calibration period, it was necessary to increase recharge during the transient calibration.

Item*	Reviewer comment	Response by Parsons Brinckerhoff
7	Overall water balance for the prediction scenario not provided.	Simulated mine inflow rates were derived by processing model groundwater flows from multiple geological layers and zones surrounding each pit. The raw data sets are too large and complex to present in the report and therefore only the relevant components of the water balance are presented in the revised Groundwater Assessment Report).
9	Comments relating to final void	The section relating to the final landform and groundwater recovery has been significantly revised in the final Groundwater Assessment Report. Comments by Dr Merrick have now been addressed. Specifically, maps showing the simulated water table elevation 20 years and 50 years after the end of mining are included in the revised report.

* Item numbers relate to those listed in Dr Merricks updated review (29 July 2012; pages 2 and 3).

Dr Merrick noted that the assessment adopted a drawdown threshold of 2.5 m, whereas the Draft Aquifer Interference Policy refers to a threshold of 2 m. The Aquifer Interference Policy has not been formally adopted by Government and this assessment was carried out prior to the release of the second draft of the Policy. The drawdown threshold adopted in the Groundwater Assessment Report was based on the average annual water table fluctuation in monitoring bores across the site. In the absence of specific Policy guidance, the 2.5 m threshold is considered appropriate for assessment at this location.

It is noted that the editorial issues referred to in Dr Merrick's review (page 3) were resolved and corrected prior to submission of the final Groundwater Assessment and Technical Modelling Reports.

Yours sincerely

Stuart Brown
Principal Hydrogeologist
Parsons Brinckerhoff

Reference

Parsons Brinckerhoff, 2012. Cobbora Coal Project – Water balance and surface water management system. Unpublished report for Cobbora Holding Company, June 2012.

Appendix

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Groundwater management plan framework

Groundwater Management Plan Framework

This document sets out a framework for the management of groundwater prior to and during the life of the Cobbora Coal Mine. The framework is intended as a first step in the management of groundwater for the operational mine, and draws upon the groundwater investigations carried out to date. Specifically the framework draws upon information set out in the *Groundwater Assessment* (PB, 2012) report, prepared as part of the Environmental Assessment process.

The framework below sets out the sections that may be included in a groundwater management plan for the mine, and the information that will constitute each section.

1 Introduction

1.1 Background

- Project details
- Site location details including summary of climate/topography/land use.

1.2 Purpose and scope

- Details of the groundwater management plan
- Date of commencement and details of the life of the groundwater management plan
- Areas the groundwater management plan applies

2 Objectives and legislative requirements

2.1 Objectives

- Details of the aim of the groundwater management plan.

2.2 Legislative requirements

- Details of the relevant legislation and development consent conditions (discussed in Section 2 of the Groundwater Assessment, PB 2012).

2.3 Environmental protection licence

- Licence conditions for the project and the relevant licence details.

2.4 Guidelines

- Introduction of key guidelines relevant to the preparation and implementation of the groundwater management plan.

3 Characteristics of groundwater resources

- Hydrogeological descriptions of aquifers present in the area (described in Section 5 of the Groundwater Assessment, PB 2012);
    - the alluvium aquifer associated with unconsolidated sediments of the Talbragar River, and also minor alluvium associated with the tributaries to the Talbragar River (Sandy Creek and Laheys Creek)
    - the porous rock aquifer within the Permo-Triassic sediments of the Gunnedah-Oxley Basin
    - porous rock aquifers of Jurassic age

- fractured rock aquifers within the metamorphic basement rocks of the Lachlan Fold Belt.

4 Groundwater monitoring program

4.1 Focus of monitoring program

The groundwater monitoring network and program will focus primarily on the identified impacts as predicted by the Groundwater Assessment (PB, 2012). Based on the predicted impacts the monitoring network will be refined to focus on;

- Drawdown of groundwater levels and pressures within the alluvium and porous rock aquifers in the assessment area (Section 7.1 of Groundwater Assessment):
  - The alluvium aquifer of the Talbragar River to the north east of the project Area. Specifically the monitoring of alluvium between the upstream alluvial irrigators (Collaburragundry-Talbragar Valley Alluvium Water Source) and the area of the alluvium aquifer predicted to be impacted by mining (new monitoring bores).
  - The Talbragar River alluvium aquifer adjacent to the mine site (existing bores GW5A, GW4, GW10).
  - The Talbragar alluvium aquifer downstream of the proposed mine location (new monitoring bore adjacent to one of the existing porous rock bores GW19, 20 or 21).
  - Several additional monitoring bores to the west and south of the mining areas constructed into the Permo-Triassic units between existing private groundwater users and the mining areas (existing GW2, and new monitoring bores).
  - New nested monitoring bores to the west of current Site 6 between Pit B and Sandy Creek to monitor long-term groundwater level and quality changes. This site would provide valuable data during mining and also be critical to monitor the recovery of groundwater levels between Pit lake B and Sandy Creek.
- Reduced groundwater discharge to creeks and loss of potential groundwater availability to ecosystems (Sections 7.3 and 7.4 of Groundwater Assessment):
  - Semi-permanent pools along Sandy Creek, Laheys Creek and the Talbragar River which are likely sustained by seepage from the alluvial aquifers, and potentially also the Permo-Triassic aquifer where they outcrop in the stream beds (six new monitoring sites).
  - Naran Springs (one new monitoring bore screened into the base of the Jurassic rock, and one into the underlying Permian Ulan Seam).
  - Additional porous rock and alluvium aquifer monitoring bores between the mining area A and the Talbragar River to monitor groundwater levels and quality between the former pits and River.

- Reduction in available groundwater for identified existing groundwater users within the assessment area (Section 7.2 of Groundwater Assessment):

  - The groundwater assessment indicates six registered groundwater bores may be potentially impacted by the Project, of which five are owned by CHC. To ensure the Project does not result in undue impact on the availability and quality of groundwater supplies to neighbouring landholders, all potentially impacted bores will be fully assessed prior to the commencement of mine operations, and where required, each bore will have trigger levels set for groundwater quality (electrical conductivity) and groundwater availability (water level). These bores will be monitored as part of the overall mine monitoring network.

- Monitoring of mine water dams and general groundwater quality (Section 7.5 of Groundwater Assessment):

  - To ensure early detection of any groundwater contamination, new shallow monitoring bores should be installed adjacent to mine water dams and overburden stockpiles that contain potentially contaminated water or waste rock materials.

  - New monitoring bores (and/or existing where present) should be installed upstream and downstream, and adjacent to the Pit B in the alluvium to monitor groundwater level and quality changes.

4.2 Monitoring plan procedures

4.2.1 Groundwater levels

- Procedures for measurement of groundwater levels.

Where monitoring of groundwater level drawdown impacts are the priority, permanent groundwater level data loggers will be installed. At all other monitoring sites groundwater levels will be monitored manually on a regular basis. The monitoring plan will take into account mitigation measures outlined in Section 9.1 of the Groundwater Assessment (PB, 2012) for groundwater level management.

4.2.2 Groundwater quality

- Listed analytical parameters for groundwater monitoring and details of sampling and QA/QC procedures. Details of acid mine drainage potential.

The groundwater quality monitoring program will be designed based on the requirements of each monitoring site, e.g. shallow monitoring bores around waste rock stockpiles will be monitored for analytes which indicate acid mine drainage potential, while the more regional monitoring bores will be monitored for changes to baseline quality results. The monitoring plan will take into account mitigation measures outlined in Section 9.2 of the Groundwater Assessment (PB, 2012) for groundwater quality management.

4.1 Frequency of monitoring and procedures

- Details of monitoring point locations and frequency of monitoring events.

Detailed table listing all monitoring bores, respective locations (GPS), monitoring bore purpose, construction details and monitoring frequency. The list of monitoring bores that constitute the current monitoring network and their construction details are provided in Table 4.1 of the Groundwater Assessment (PB, 2012).

4.2 Data management

- Details of data co-ordination, review and quality control procedures.

4.3 Assessment criteria

- Details of the relevant guidelines and trigger values for groundwater level drawdown and groundwater quality.

It is proposed that soft trigger levels for groundwater levels and quality be developed immediately prior to mining commencing. Trigger levels should not necessarily be fixed for the life of the mine operation, but should be developed in collaboration with nearby groundwater users, the NSW Office of Water and other professionals including ecologists.

5 Mitigation measures and response plans

- Details of the mitigation measures and response plans prepared for: exceedance of trigger values, emergency spills and clean-up, acid potential of the waste rock, leaching of minerals to the groundwater system and groundwater seepage to the mine pits.

6 Plan implementation

6.1 Key responsibilities and procedures

- Responsibilities and procedures will be outlined for the implementation of the groundwater management plan. An action plan with timeline will be included.

6.2 Reporting and review

- Groundwater monitoring report details will be provided including: contents, time frames and review procedures.
- Details of the review and revision procedures for the groundwater management plan.

7 References

Parsons Brinckerhoff, 2012, Groundwater Assessment, prepared for Cobbora Holding Company Pty Ltd.