REVIEW

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From: Dr Noel Merrick

Re: **Peer Review - Groundwater Impact Assessment, NorthParkes Mine Step Change Project**

Introduction

In the *Response to Exhibition of Environmental Assessment* by the Department of Primary Industries, dated 21 August 2013, for the *NorthParkes Extension Project (MP 11_0060)*, one of the comments offered by the NSW Office of Water was that the Groundwater Impact Assessment Report "does not specify if the site model has been independently reviewed by a hydrogeologist". Accordingly, the "suitability of the model for the intended purpose is therefore uncertain".

This letter report confirms that an independent review was undertaken by Dr Noel Merrick from March to August 2012 on the groundwater assessment for a significantly larger project (a number of block cave extensions). Since the initial review, the scale of the project has been reduced and recommended changes to the groundwater model and reporting have been made, as documented in the Golder Associates *Groundwater Impact Assessment Report* dated July 2013. This report has been checked by the reviewer for implementation of recommended changes.

The more recent review is based on the following impact assessment report and its Appendix C, a standalone report on the Project Area Model:

1. Golder Associates, 2013, NorthParkes Mine Step Change Project: Groundwater Impact Assessment Report. Appendix 10 of the Environmental Assessment. Report Number 117626007-007-Rev1 submitted to Umwelt (Australia) Pty Ltd. July 2013. 124p + 6 Appendices.

Also provided for information were the following reports:

2. Mackie Environmental Research, 1999, NorthParkes Mines Groundwater Management Studies: E27 and E22 Pits. Report prepared for NorthParkes Mines. April 1999. 12p + 13 Figures + 3 Appendices.
3. Parsons Brinckerhoff, 2003, NorthParkes Mine In-Pit Tailings Disposal Hydrogeology Investigation and Groundwater Impact Assessment. Report A356 2120123A pr_2676 Rev D for NorthParkes Mines. March 2003. 48p + 20 Figures + 1 Appendix.
4. Mackie Environmental Research, 2006, NorthParkes MinesE48 Project: Groundwater Studies. Report prepared for R.W.Corkery & Associates and NorthParkes Mines. April 2006. 25p + 16 Figures + 4 Appendices.
5. Department of Primary Industries, 2013, Northparkes Extension Project (MP 11_0060): Response to Exhibition of Environmental Assessment. Letter from P. Anquetil to E. Donnelley, NSW Department of Planning and Infrastructure. 21 August 2013, 8p.
6. Umwelt (Australia) Pty Ltd, 2013, NorthParkes Mine Step Change Project: Response to Submissions, Part 3A Environmental Assessment. 70p + 4 Appendices.

Document #1 comprises the groundwater impact assessment for the Environmental Assessment (EA). It has the following sections:

1. Introduction
2. Legislative Framework
3. Data Review
4. Site Characterisation
5. Hydrogeological Modelling
6. Discussion on Groundwater Impact Assessment - Mining Phase
7. Groundwater Monitoring.

Review Methodology

While there are no standard procedures for peer reviews of entire groundwater assessments, there are two accepted guides to the review of groundwater models: the Murray-Darling Basin Commission (MDBC) Groundwater Flow Modelling Guideline[1], issued in 2001,and the new guidelines issued by the National Water Commission at the end of June 2012 (Barnett *et al.*, 2012[2]). The latter guide was introduced after the initial review was completed.

Both guides also offer techniques for reviewing the non-modelling components of a groundwater impact assessment. The 2012 national guidelines build on the 2001 MDBC guide, with substantial consistency in the model conceptualisation, design, construction and calibration principles, and the performance and review criteria, although there are differences in details. The new guide is almost silent on mine modelling and offers no direction on best practice methodology for such applications.

The earlier groundwater impact assessment was reviewed according to the 2-page Model Appraisal checklist[3] in MDBC (2001). This checklist has questions on (1) The Report; (2)

[1] MDBC (2001). Groundwater flow modelling guideline. Murray-Darling Basin Commission. URL: www.mdbc.gov.au/nrm/water_management/groundwater/groundwater_guides
[2] Barnett, B, Townley, L.R., Post, V., Evans, R.E., Hunt, R.J., Peeters, L., Richardson, S., Werner, A.D., Knapton, A. and Boronkay, A. (2012). *Australian Groundwater Modelling Guidelines*. Waterlines report 82, National Water Commission, Canberra.
[3] The new guidelines include a more detailed checklist with yes/no answers but without the graded assessments of the 2001 checklist, which this reviewer regards as more informative for readers.

Data Analysis; (3) Conceptualisation; (4) Model Design; (5) Calibration; (6) Verification; (7) Prediction; (8) Sensitivity Analysis; and (9) Uncertainty Analysis. Non-modelling components of the groundwater impact assessment are addressed by the first three sections of the checklist.

The more recent review has been less intensive, with restriction to checking the implementation of earlier recommendations and the minimal harm considerations of the NSW *Aquifer Interference Policy* (NSW Government, 2012[4]), introduced in September 2012.

It should be recognised that the effort put into the modelling component of a groundwater impact assessment is very dependent on possible timing and budgetary constraints that are generally not known to a reviewer.

Impact Assessment Report [Document #1]

Issues Raised in Initial Review

Most matters raised in the initial review have been addressed adequately in the revised report. As the earlier report was found to be verbose and repetitive, the structure and the content of the revised report are markedly improved.

Important issues that have been addressed adequately are:

- Reporting;
- Proper citations of prior studies;
- Conceptual model graphic;
- Tailings Storage Facilities (TSF) history;
- More reasonable TSF recharge rates;
- Improved model calibration;
- Inclusion of comparative hydrographs (observed and simulated); and
- More investigative sensitivity analysis.

Other issues considered by the reviewer *not* to have been addressed adequately are:

- Comparison of observed groundwater hydrographs with rainfall residual mass to reveal any climatic signature in groundwater responses;
- Model calibration is still poor;
- Only one-third of available hydrographs have been used for transient calibration;
- No calibration performance statistics;
- No map of current or recent mining-affected groundwater level contours;
- No steady-state water balance;
- No predicted water table contour map at the end of mining (or during mining);
- Insufficient attribution of model complexity (according to the MDBC guidelines of 2001) or model confidence classification (according to the NWC guidelines of 2012); and
- Missing units for specific storage.

[4] NSW Government, 2012, NSW Aquifer Interference Policy – NSW Government policy for the licensing and assessment of aquifer interference activities. Office of Water, NSW Department of Primary Industries, September 2012.

Remaining Issues

The site model has benefitted from a long data baseline (from 1995), a long history of hydrogeological investigation (from 1984), and the existence of previous models (in Documents #3 and #4). It should be noted that the earlier "calibrated" models were limited to calibration against pit inflows (MER) and steady-state pre-mining water levels (PB) rather than hydrographic calibration. The Golder model has calibrated also against hydrographs, and calibration to recorded mine inflows is good and is consistent with previous predictions. However, the reported steady-state calibration in Figure 25 of Document #1 remains poor. The transient calibration illustrated in Figure C8 of Appendix C [Document #1] also is generally weak. The rising trends in observed hydrographs near TSFs are not replicated, and simulated hydrographs show excessive drawdown at sites that have clear mining effects. It appears that calibration was based on 15 or 16 hydrographs, whereas up to 46 sites would have been available.

The water balance in Table C9 of Appendix C [Document #1] seems to report mine inflows ("Drain outflow") that are not consistent with the rates shown in Figure C10. The Table has 0.45 ML/day during the calibration period and 0.22 ML/day averaged across the prediction period. The rates should be closer to 0.8 ML/day, as stated in the Executive Summary.

The hydrographic plots (Figures 11-13 in Document #1) have not been updated since about March 2012.

In the analysis of water chemistry, there should be a statement on the lack of apparent mining effects in the data.

Table 22 [Document #1] is not specific as to which model layer hosts the TSFs.

Issues Raised by NSW Office of Water (NOW)

Material issues raised by NOW in Document #5 are summarised in Table 1, with comments by the reviewer and an indication of the proponent's response [Document #6]. Issues of a minor or editorial nature are excluded.

Table 1. NSW Office of Water Issues

	ISSUE	REVIEWER'S RESPONSE (based on Document #1)	PROPONENT'S RESPONSE
1	AIP minimal impact considerations not addressed	❖ True. There is consideration of "takes", but not of water table, water pressure, or water quality minimal impact considerations ❖ Figure 34 missing	❖ RTS S2.6.2.2 ❖ App1 S2.3: Statements on 2m effect. ❖ Figure 34 included.
2	Model classification not stated or defended	❖ True. There is a hint of Class 3 in the report (based erroneously on water balance discrepancy), but a statement of Class 2 in an email from Golder. ❖ Assignation of Class 2 should be defended.	❖ RTS S2.6.2.2 ❖ Class 2 stated.

		❖ Class 2 is an appropriate level ("impact assessment" model under MDBC guidelines)	
3	Final void modelling not done thoroughly	❖ Agreed	❖ RTS S2.6.2.2
4	Water quality impacts of final void - sink or source	❖ Not done quantitatively, as tailings infill and evaporation have not been included. ❖ Stated qualitative expectations are reasonable (for a sink).	❖ RTS S2.6.2.2 ❖ App1 S2.4 ❖ Tailings infill removed from consideration.
5	2.1 ML/day should be licensed (maximum in 2026; ignoring preceding value of 5 ML/day)	❖ Figure 29 shows that predicted inflows are spiky. This is a numerical artefact due to sudden activation of pits in the model. ❖ It is not valid to insist on spike values as a maximum for licensing. A value from a smoothed curve would be more realistic. ❖ The peak occurs much earlier than the stated 2026 (likely topographical error)	❖ RTS S2.6.2.2 ❖ App1 S2.1: revised Table C8 (lower maximum earlier in time)
6	"A breakdown of groundwater inflows based on each mining area is requested to further define the water take requirements."	❖ This is provided graphically in Figure 29. ❖ Tabulation is superfluous as the licensed water take pertains to a single water source, not pit by pit. ❖ It would be wrong to aggregate the separate pit maxima, if that is the intention.	❖ App1 S2.1: Breakdown provided for pits.
7	Model has not assessed groundwater take after mine closure.	❖ Agreed. ❖ Not easy to do with software as Drain accounting is no longer available (have to get polygon budgets)	❖ RTS S2.6.2.2 ❖ Water level results for 2032 and 2079 suggest reduced take (Figure C6b) ❖ Takes not quantified (due to software difficulty) ❖ Hydrographs to 2079 show recovery (Figure C8a-q)
8	Changes in water quality have not been quantified.	❖ This is too difficult to do quantitatively, and cannot be done with a conventional groundwater flow model. ❖ Qualitative assessment is sufficient.	❖

9	Graphical presentations of historical analytes are required.	❖ Agreed	❖ RTS S2.6.2.2 ❖ Graphs of TDS, As, Pb, Zn ❖ App1 S2.6: Figures 16d-g
10	Model has not been reviewed independently.	❖ It has.	❖ RTS S2.6.2.2 ❖ Noel Merrick
11	In Figure C8, "computed drawdowns underestimate the measured drawdowns". Impacts will be underestimated.	❖ Not true. ❖ The model overestimates drawdowns at the affected monitoring sites. ❖ Predictive runs are likely to be conservative in terms of drawdown impact.	❖ RTS S2.6.2.2 ❖ App1 S2.7, S5.1 ❖ NOW's opinion is wrong. ❖ Mining affected drawdowns are predicted conservatively. ❖
12	Some monitoring bores are not used calibration.	❖ True. ❖ This should be justified in more detail.	❖ RTS S2.6.2.2 ❖ App1 S2.8, S5.9 ❖ Some bores had no screen details at time of modelling. ❖ P149 hydrograph provided - reasonable match of mining effect
13	Arsenic and lead not included in chemical analyses.	❖ True - not reported.	❖ RTS S2.6.2.2 ❖ App1 S3.6 ❖ Now included.
14	Bore W12 is calibrated poorly.	❖ Agreed	❖ RTS S2.6.2.2 ❖ App1 S5.6: due to continuous mining in the model without allowing for an intervening period of recovery near pit E22.
15	Deletion of claim that simulated groundwater pressure rise is evident in Figure C8.	❖ Agreed ❖ Model appears to be not capturing water level rises near the TSFs.	❖ App1 S5.7, Figure C8l ❖ *[TSF effects are not captured - reviewer].*

Notes:
RTS : Response to Submissions by Umwelt
App1: Golder response (Appendix 1) in the RTS

Model Classification

According to the MDBC guidelines of 2001, the site model is clearly an impact assessment model of medium complexity. The guide 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.*

The NWC guidelines of 2012 offer more advice on determination of model complexity, now expressed in terms of model *confidence*. It should be noted that this reviewer regards the term "confidence" as misleading, as added complexity does not necessarily add confidence to a simulation. At times it can do the opposite. Nevertheless, the guidelines provide a useful list of attributes for different model classes. There is a mistaken impression amongst the community of model users that ALL attributes must be satisfied for a particular class for a model to be given the corresponding classification. If that were the case, nearly all mining models would default to Class 1 and that is intuitively wrong and unhelpful.

The attributes for each class are summarised in Table 2 for Data, Calibration, Prediction and Indicators. Note that this summary has been prepared by the reviewer, and is not necessarily endorsed by the NWC. When each attribute is examined, there are elements of Class 1, 2 and 3. On balance, the reviewer's assessment of the dominant class attribution for the different characteristics of the site model is:

- Data: Class 2
- Calibration: Class 2
- Prediction: Class 2
- Indicators: Class 3

Accordingly, the site model is mostly Class 2 as stated in the Response to Submissions [Document #6]. There is a mistaken interpretation in Document #1, which hints at Class 3 because the water balance discrepancy is close to the 0.5% criterion for a Class 3 model. This is an erroneous use of the guidelines, especially as the water balance discrepancy is a very minor feature of model performance.

Table 2. Summary of Model Classification Criteria

CLASS	DATA	CALIBRATION	PREDICTION	INDICATORS
1	Not much. Sparse. No metered usage. Remote climate data.	Not possible. Large error statistic. Inadequate data spread. Targets incompatible with model purpose.	Timeframe >> calibration Long stress periods. Transient prediction but steady-state calibration. Bad verification.	Timeframe > 10x Stresses > 5x Mass balance > 1% (or single 5%) Properties <> field. Bad discretisation. No review.
2	Some. Poor coverage. Some usage info. Baseflow estimates.	Partial performance. Long-term trends wrong. Short time record. Weak seasonal replication. No use of targets compatible with model purpose.	Timeframe > calibration. Long stress periods. New stresses not in calibration. Poor verification.	Timeframe = 3-10x Stresses = 2-5x Mass balance < 1% Some properties <> field measurements. Some key coarse discretisation. Review by hydrogeo.
3	Lots. Good aquifer geometry. Good usage info. Local climate info. K measurements. Hi-res DEM.	Good performance stats. Long-term trends replicated. Seasonal fluctuations OK. Present day data targets. Head and flux targets.	Timeframe ~ calibration. Similar stress periods. Similar stresses to those in calibration. Steady-state prediction consistent with steady-state calibration. Good verification.	Timeframe < 3x Stresses < 2x Mass balance < 0.5% Properties ~ field measurements. Some key coarse discretisation. Review by modeller.

Conclusion

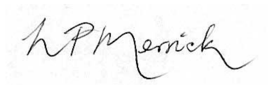
This reviewer is of the opinion that the site model is *fit for purpose*, where the purpose is to estimate environmental (especially drawdown) impacts and mine inflow rates.

It is admitted that the model is not particularly well calibrated to absolute groundwater levels for steady-state or transient conditions, and that drawdowns are overestimated. Fortunately, the prediction of drawdown magnitudes will always be more reliable than prediction of absolute water levels. In this case, the over-prediction of drawdowns means that predictions would be conservative from an environmental point of view. Even then, it is clear that there are no impacts of concern.

The model appears to be quite good at estimating historical pit inflows, is consistent with previous model predictions, and should be capable of predicting reasonable future values.

The sensitivity analysis has shown that the model predictions for pit inflow are not sensitive to any property other than horizontal hydraulic conductivity. The report is not specific as to the size of the increase in hydraulic conductivity that has caused roughly a doubling of total pit inflow. This should be stated. More importantly, there appears to be no significant shift in the predicted drawdown extent when this sensitive property is perturbed.

Yours sincerely,



Dr Noel Merrick