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Calga Sand Quarry Project

KA Review Comments related to Groundwater

Background

The Department of Planning and Infrastructure (DoPI) on the 27 February 2013 requested that Dr F. Kalf of KA review specific documents related to the proposed extension of the Calga Sand Quarry. The relevant documents downloaded from the DoPI Web site for this assessment are listed in the References section at the end of this document.

The tasks as set out by DoPI were specifically to review:

1. The groundwater assessment in the EA
2. Rocla's response to submissions including additional groundwater analyses
3. Rocla's preferred project report
4. NOW public submissions including those of Calga Peats Ridge Community Group and Australian Walkabout Wildlife Park (AWWP)

The Calga sand quarry is situated 1.7km northwest of the Calga Interchange of the F3 Freeway north of Sydney.

Rocla, the mine owners, are proposing to extend extraction of the Hawkesbury Sandstone formation for sand product. The extent of the current mine including the proposed Stage 4 and 5 zones are provided in Figure E (Corkery & Co - Executive Summary). Mining is to be extended into these stages progressively with mining depths proposed of up to 30m or more.

GeoTerra Hydrogeological and Golders Modelling Report

A hydrogeological investigation of the area has been conducted by GeoTerra (GeoTerra 2009) and a subsequent modelling study was completed to determine the impact of the extension and final mine dimensions on the groundwater system by Golders (Golders 2009).

Overall the hydrogeological description is reasonable given the available data. However, there are a number of omissions in the modelling report in both the descriptions, simulations conducted and presentation of results that make it difficult to be precise about the veracity of the those results presented and their interpretation. The modelling work is often somewhat vague about the background in the setup process and assumptions made. Without having

access to discuss these aspects with the modelling consultant this review therefore becomes somewhat less rigorous.

Some of the KA questions and comments for modelling consultant would be as follows:

1. Does the model include the surface topography and how was that achieved.
2. Based on an assessment of the bore water level hydrographs and rainfall as set out in GeoTerra (2009) it may have been possible to simulate these hydrographs using transient simulation thereby reinforcing the model parameters adopted and determining the long-term storativity for the system. KA suggests that the hydrographs for the CQ bores from the period 2001 to 2008 (Aquaterra 2008) could have been used for this purpose, and it may also have been possible to separate out any pumping periods and mine influence in such an analysis.
3. It is assumed that recharge applied was net recharge and evapotranspiration was not included.
4. For the sensitivity case it is stated that the Sandstone permeability was increased to 5×10^{-7} m/sec. KA assumes this is for the fresh sandstone layer (Layer 2) and that the vertical permeability was retained at 10^{-8} m/sec. So was the weathered sandstone (Layer 1) permeability of 10^{-6} m/sec retained or was it also modified?
5. What is the basis for the 30% recharge applied just north of the mine site in the 'base case'. Ditto for 6% recharge in zone 3. What bores and records were used since there is no supporting evidence or information for this assignment.
6. How was the mining progress simulated over time and during recovery?
7. A Rainfall Residual Mass Curve for the region should have been presented which would have assisted in separating out the drought effects on the regional watertable in certain hydrographs.
8. It may have been possible to examine construction details of landholders bores in the local region for standing water level data pre-mine. This would have assisted in a steady state simulation of the pre-mine potentiometric surface and allowed the drawdown of the existing mine to be simulated thereby allowing the cumulative drawdown due to all Stages to be determined.
9. It is not clear whether the drawdowns simulated include the drawdowns for Stages 1,2 and 3 in the Golders report¹. If so it would have been useful if the existing mine drawdowns also had been shown rather than just the existing potentiometric surface.
10. It would have been useful for two model sections north-south and east-west across the existing and proposed mining stages to include any drainage lines. These sections would have been either pressure head contours or total head and watertable position at the pre-mine, end of mining and after 50 years recovery (or less if equilibrium is attained before 50 years). This would have presented a clearer diagram of the potentiometric surface at the end of mining in relation to the topographic features and drainage channels.

¹ It would seem they were not since only the existing potentiometric surface is shown in the Golders report (Figure 8) that would include existing drawdown due to Stages 1,2 and 3. Presumably this was the set of starting heads used to calculate the drawdowns for Stages 4 and 5.

Steady State Model Calibration and Sensitivity Case

Golders model study and predictions of regional drawdown effects are based on a Steady State modelling approach. Use of Steady State condition for predicting drawdown is severe, but in one sense is a conservative approach where effectively the storage of the groundwater system is set to zero. However, under these conditions, rainfall recharge can often then become the proxy forcing parameter for obtaining a satisfactory calibration due to the lack of buffering by formation storage. This is evident in the 'sensitivity analysis' in the Golders report on page 7 where higher sandstone permeability was applied which necessitated the application of very much higher recharge values to achieve what was described as an "acceptable" calibration based purely on achieving a small error of fit². Hence the three zonal percentage rainfall recharge values for the case of higher permeability adopted (Zone 1 =55%; Zone 2 = 66%; Zone 3 = 13% compared to Zone 1 = 15%; Zone 2 = 30%; Zone 3 = 6% used initially)³ are certainly not "in the order of several percent" higher as suggested in the report but very much higher. Compared to these higher recharge values page 3 of the GeoTerra (2009) report (page 1-97 in Appendix A Groundwater Assessment) states that empirical recharge estimates for the region⁴ are in the range 10% to 20%. The Executive Summary (Corkery 2009) on the other hand states that "Based on rainfall and groundwater monitoring records a recharge proportion of 5% to 15% has been estimated".

Whilst recharge for a weathered sandstone could be somewhat higher than 15% the recharge values (Zone 1 = 55%; Zone 2 = 66%; Zone 3 = 13%) used for the higher permeability 'sensitivity' case are considered to be too high and therefore the predictions as shown in Figure 13 and 14 (Golders 2009 - Appendix A) are questionable.

The problem that has arisen is that the calibration result for the 'sensitivity case' was based on the false premise that a forced fit for an accepted calibration was taken as being valid when clearly the recharge values appear to this reviewer to be unrealistic. A number of possibilities emerge from this result. The exclusion of storativity in the model could have required increased recharge to achieve a fit not only for the initial (base) case but also for the sensitivity case. The higher permeability values based on the pumping test may also have been localised values for permeability and not representative of the regional bulk value. This is evident from the range of bore yields obtained from landholders' bores that point to generally low permeability of the Sandstone over the region with isolated higher yields.

The above issue has also been recognised by GeoTerra and in their report when in summarising the modelling report they state (GeoTerra 2009 page 1-56):

"Based on the excessive recharge values required to calibrate the Sensitivity Case scenario, which applied higher hydraulic conductivities than the Base Case scenario and generated unreasonable inflow rates into the existing Stage 3 operations, it is considered that the Sensitivity Case scenario is considered to be conservative, and that the Base Case scenario more likely represents the groundwater system in the vicinity of the approved and proposed extraction stages. This conclusion is supported by observation of groundwater level response to the current extraction, observed stream flows, observed extraction area pit wall seepages."

² It is stated that the use of higher permeability values than used in the initial (base) case prediction was because of the transmissivity derived from a pumping tests conducted on the CQ series of bores.

³ Recharge has been divided into three separate zones in the modelled region. The three zones include: Zone 1 that covers the vast majority of the region; Zone 2 that covers a very much smaller localised area north of the current mining area and Zone 3 that extends across the eastern edge of the proposed Stage 4 (see Figure A4 GeoTerra 2009)

⁴ Relevant to regional Zone 1.

The reasoning given above has merit and seems more likely. The comment that this conclusion is "*supported by observation of groundwater level response to the current extraction*" seems to be based on the annual groundwater review conducted by Aquaterra (2008). This concluded that mine drawdown was not evident in water level data from surrounding bores although the hydrographs had at that time been confounded by rising water levels due to a resumption of rainfall recharge during 2007 following the drought. No monitoring data has however been assessed up to 2013 since that time.

Model Predictions

The modelling report makes predictions for the long-term drawdown and over some unspecified recovery period. However, it is not clear from the figures presented whether the predictions only include those for the proposed Stage 4 and 5 at the end of mining or total drawdown for all mining including Stages 1,2 and 3. Therefore although the so called "*conservative*" drawdown estimate has been presented the full extent of the drawdown created may not have been shown. As a result the total (cumulative) drawdown impact on bores and other features of the landscape surrounding the mine may not have been fully assessed. Nevertheless, based purely on the 'base case' simulation presented it is clear that a number of bores in the near vicinity to the mining stages would be ultimately affected in excess of the stipulated maximum permitted drawdown ($\leq 2\text{m}$) as described in the Aquifer Interference (AI) policy.

With regard to the GDE's in the area this reviewer is not qualified to judge what vegetation species [as set out in NOW (2010)] would rely on an accessible watertable or which such GDE's rely entirely or predominately on soil moisture provided by natural rainfall percolation irrespective of the water table elevation affected by mine drawdown. Such a distinction is also not made in the NOW document and would require a relevant expert to provide advice.

Community Concerns

The comments provided by the community that relate specifically to the mining influence on groundwater levels and hence groundwater yields in bores have been assessed and the key issues can be briefly summarised⁵ as follows:

- a) Bore yields [surrounding the mine] have been "*seriously depleted*" as a result of the existing mine influence and such influence has "*disrupted*" the flow of groundwater in the Australian Walkabout Wildlife Park bore for example. AWWP (2013) claim that their bore has been affected and that it can only be pumped for 3 hours before it needs to recover. They state they do not want the bore tested.
- b) The owner of the Kashouli bore in 2004 indicated that the quarry had caused the bore to "*dry up*".
- c) Monitoring bores (DWE) within 10km of the mine showed falling water levels during the period 2002 to 2006. These falling water levels need to be taken into account in any impact created by the mine.
- d) Difficulty of establishing practical available drawdown in landholders bores "*because they do not take into consideration the position of pumps or aquifers*"
- e) The consultant groundwater assessment that the drawdown effect from the quarry would be limited to 100 metres from the edge of the quarry is false and misleading.
- f) "*In 2008 a sudden SWL [standing water level] drop (approx 5m) occurred in one of NOW's*

⁵ The KA review herein cannot explore every notated issue concerning bore water levels changes because of scope limitations and time available for this assessment.

monitoring bores 2 km N of the current [mining] operations" (CPRCG -Water submission Part B).

g) CPRCG (Water submission Part A) refers to *"State of the Art Modelling"* and that there was deliberate selection of the *"best case"* of the final [ground]water inflow that was 161ML per year (referred to in GeoTerra (2009) page 1-76) rather than in the other 'sensitivity case' at 616ML⁶ per year based on the model results.

The following are the KA responses:

a) There are no diagrams in the model report that show the model drawdown created by the existing mining conditions. Only total head is presented that makes it difficult to determine such drawdown influence. Because there has been no transient analysis of the CQ bore hydrographs it therefore becomes difficult to present results that indicate the mine influence compared to a declining watertable during the and no doubt increased pumping in individual bores under those conditions. Whilst the Aquaterra (2008) performance review indicated no evident impact by the mine this observation needs to be validated by more rigorous and specific model simulation of the existing mine drawdown influence. Therefore no complete or definite answer can be provided for allegations made by the community for bores in the close proximity to the mine.

With regard to the AWWP bore, given the distance of this bore of about 1 km from the existing quarry it is very unlikely that drawdown from the mine has affected the bore and is the cause of the claimed decrease in yield. The effects of declining water levels during the period 1999 to 2007 is more likely a factor. Without proper monitoring and testing of this bore the claim of a decreased production cannot be verified. Nevertheless if Stage 4 and 5 proceed then it is likely that there would be some drawdown interference at this bore site. The exact magnitude of such drawdown cannot be determined with confidence from the current model results in my opinion.

b) There has to be a recognition that the 1999 to 2007 drought period in the region and state-wide was a severe dry period. This was therefore a time of severe deficits of rainfall recharge to the groundwater system, falling groundwater levels, increased or longer periods of pumping by landholders and depending on bore location, some influence by mine drawdown. Therefore a number of factors would have contributed to the *"dry up"* condition observed in the bore quoted. A similar conclusion regarding drought cause and local pumping drawdown influence can be found in the Jewell and Associates pumping test report (Corkery and Co 2012). At present the model analysis and data interpretation does not provide sufficient information to separate out these influences or their magnitude.

c) The DWE bores referred to have perhaps water level hydrographs records available that could provide additional evidence of the magnitude of the water level decline during the drought period that could be used in a more rigorous model analysis. A hydrograph analysis by Williams (2010) has shown that water level decline during the 1999 to 2007 drought was up to 7m in the region and hence this also needs to taken into account in how this would have influenced landholders bore water levels during pumping particularly during the dry period.

d) The EA consultant response to this landholder comment does assume that the water bearing zone in the Hawkesbury Sandstone extends from the standing water level to the bottom of the bore.

" The available drawdown is calculated by subtracting the NOW reported or measured water level in bore from the total bore depth. Pumps can be raised or lowered within the water

⁶ Actually 1,700 m³/day or 621.3 ML/year. (Golders report page 8)

column....". This a simplified response and not necessarily correct. Water bearing zones can occur sporadically throughout the formation profile and depending on their depth, water levels can fall below these zones and cause groundwater cascading from those exposed zones. Lowering a pump intake does not always necessarily increase the yield under those conditions. Each bore would need to be inspected and/or hydraulically tested whether such lowering is practicable and whether it could achieve an improved yield.

e) It is presumed that this drawdown refers to the existing mine. However, there is no drawdown figure presented in the report that shows the difference between the simulated pre-mine potentiometric surface (groundwater level or head) and that created by the existing mine for checking. The "100m" limit to drawdown suggested however would clearly not apply to the total drawdown created by the existing and proposed stages as demonstrated by the model output. However, for the existing mine it is recorded that that the Gazzana bores were relocated by the previous quarry owners during the Stage 1 and 2 operations because of insufficient yield (CPRCG⁷ 2013). It would seem then that possibly drier conditions and consequent watertable decline, pumping rate increase or longer pumping periods⁸ but also mine influence may have led to this response. The hydrogeological or modelling reports have not addressed this issue as pointed out by CPRCG (2013) and without model validation the mine component of this effect on the Gazzana bore water levels (and elsewhere for bores in close proximity to the mine) remains open to conjecture.

f) This is presumed to be Bore GW080167. That a sudden 5m drop in standing water level could have been caused by drawdown from the mine at a distance of 2 kilometres is not probable or possible. Williams (2010) has noted logger malfunction or logger interference as a possible cause which is consistent with the very sudden rapid water level response.

g) As noted above in this review, the 'sensitivity case' modelled by Golders is considered to be unrealistic because of the excessive recharge applied to the model. That simulation yielded a total mine inflow of 1,700 m³/day (621 ML/year). Hence the choice made by the GeoTerra consultant of 161 ML/year inflow was deliberate not because it was the "*best case*" (i.e. lowest value) but because it was more realistic.

Conclusions and Considerations

1. The modelling work available at present for the existing and proposed extensions to the Calga Quarry is considered to be incomplete and therefore inadequate to fully assess the cumulative drawdown impact for the existing and proposed Stage 4 and 5 mine extensions.
2. It is considered that either the current modelling consultants be asked to attempt a more complete analysis suggested in this review or preferably one conducted by an experienced modelling consultant such as Heritage Computing (HC) for example. Dr Merrick from HC has experience in the region having developed a regional model some years ago to determine sustainable yields of the groundwater system. The consultant to be commissioned should develop a more rigorous model and study that takes into consideration and includes the various omissions and suggestions indicated herein.

⁷ CPRCG - Calga Peats Ridge Community Group

⁸ Aquaterra (2008) have noted that the local hydrographs did show the influence of drawdown interference by local pumping.

References

(All documents are available at the DoPI Calga Web site):

http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=42

Australian Walkabout Wildlife Park (AWWP) 2013. *Submission - Section 4.0 Groundwater. Feb.*

Aquaterra 2008 *Calga Sand Quarry 2008 Annual Groundwater performance Review. Report ref: S4B/B4/600/006b. Sept. Report prepared for Rocla Pty Ltd.* [Report is contained in the GeoTerra 2009 document referenced below.]

Corkery & Co 2012. *Final response to Government Agency submissions and non-confidential public submissions.*

Corkery & Co 2009 *Calga Quarry Environmental Assessment - Executive Summary. Report No 664/01*

Corkery & Co 2009 *Calga Quarry Environmental Assessment. Section 2 Project Description. report No 664/01*

Corkery & Co 2009 *Calga Quarry Environmental Assessment. Environmental Setting.*

Corkery & Co 2012. *response to Government Agency submissions and non-confidential public submissions. Report No 664/04. Attachment 1 Results of Kashouli Pumping Test December 2005*

Community submissions from Sharp, Carlier & Sawkins, Wilby, Hellyer, Orban

Calga Peats Ridge Community Group Inc (CPRCG) 2013 *Submission 1 . Water- Part A 14 February.*

Calga Peats Ridge Community Group Inc (CPRCG) 2013 *Water Submission Part B. NOW Monitoring bores. 14 February.*

GeoTerra 2009. *Calga Sand Quarry Southern Extension - groundwater Assessment. Special Consultant Compendium part 1. Oct. This report contains the Golder Modelling report and an Appendix B that deals with an Annual performance review by Aquaterra in December 2007 that contains bore hydrographs compared to absolute rainfall.*

NSW Office of Water (NOW) 2010. *Memorandum Meeting Notes F. Hancock. 12 February* [Document is attached to the CPRCG Submission 1 - Water Part A referenced above]

Williams 2010. *Kulnura - Mangrove Mt Groundwater Sources. Groundwater Management Area 605 Hydrograph Summary. Oct.* [Document contained with CPRCG Water Submission Part B. referenced above]



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