19 December 2018

Director - Resources Assessments
Department of Planning and Environment
GPO BOX 39
SYDNEY NSW 2001

Attention: Mr Mike Young

Dear Mike,

Bylong Coal Project (SSD 6367)
Response to IPC Request for Additional Information

1 INTRODUCTION

We refer to the correspondence from David Way, Senior Planning Officer of the Independent Planning Commission (IPC) NSW Secretariat dated 23 November 2018 requesting additional information from the Department of Planning and Environment (DPE).

On 26 November 2018, DPE subsequently provided the above letter correspondence to KEPCO and sought further advice / information to the Department on the IPC's questions as soon as practicable.

This document provides the requested advice / information in relation to the five issues raised within the IPC's correspondence for review and consideration by DPE. This document also provides an appropriate response to the submission (and presentation) from Mr Doug Anderson of the University of New South Wales Water Research Laboratory (UNSW) (commissioned by the Environmental Defenders Office (EDO), on behalf of the Bylong Valley Protection Alliance (BVPA)) which make invalid assertions in relation to the modelling and assessment which warrant a response.

2 RESPONSE TO MR ANDERSON'S SUBMISSION

2.1 BACKGROUND

KEPCO has commissioned Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to review and provide an appropriate response to Mr Anderson's submission to the IPC. A copy of this response is provided within **Appendix A**, with a summary of the key findings provided below.

It should be noted that the presentation which is appended to Mr Anderson's submission (and referred to in the IPC letter) is dated 12 November 2018. The public meetings held by the IPC for the Project occurred in Mudgee on 7 November 2018 and Douglas Anderson was not on the speaker list and did not present. Until recently (with the recent upload of the transcript for the meeting with the BVPA on the IPC website), it was unclear as to whether this presentation was provided by way of the submission only or whether this was presented to the IPC in a separate meeting.

Mr Anderson's submission raises the following matters of concern:

- Characterisation of the groundwater regime;
- Approach to numerical modelling;
- Water Management Plan; and
- NSW Government groundwater legislation and policies.

A response to each of these matters is summarised in the following sections.

2.2 CHARACTERISATION OF GROUNDWATER

Mr Anderson's submission commented that the level of field investigation and monitoring does not appear to match the extensive numerical modelling which has been undertaken for the Project. This comment appears to have been reached simply by reviewing a summary timeline for groundwater investigations provided within the Response to PAC Review Report (Hansen Bailey, 2018). These comments are ill informed and demonstrate a clear lack of understanding in relation to the detailed process of developing a numerical model for a particular development site.

Groundwater monitoring and field investigations in relation to the Project have been exhaustive in order to characterise the groundwater regime within and surrounding the Project Boundary. This has entailed five separate field investigation campaigns which have been undertaken in consultation with Department of Industry – Crown Lands and Water Division (DoI-Water) between 2011 and 2016. Details of the extensive groundwater monitoring regime currently in place for the Project have been provided in various approvals documents.

The numerical modelling conducted for the Project is founded on high quality field data collected by KEPCO (and its consultants), with the exhaustive amount of numerical modelling being a reflection of thorough internal validation and continuous requests from stakeholders for additional analyses.

Mr Anderson makes several references to environmental impacts associated with underground coal mining operations within the Southern Coalfields and relates this to the predicted impacts of the Project. This approach is unsubstantiated as there are fundamental differences between the groundwater regime in the Southern Coalfield compared to the Project. For example the Southern Coalfield example referred to has shallow groundwater close to the surface (i.e. relied upon by vegetation and streams), whereby much of the underground area for the Project comprises deeper groundwater levels which do not directly interact with surface vegetation and streams.

Mr Anderson refers to a perched aquifer occurring above the underground mining areas. The Supplementary Response to Submissions (RTS) (Hansen Bailey, 2016) report provided further detail of the field investigations undertaken within the underground area which confirmed that the basalt capping was essentially dry. The conceptual hydrological model for the basalt is that it remains unsaturated, although it may support some short-term perching of water as rainfall drains to the deeper units.

Mr Anderson appears to flag that geological structures have not been appropriately represented within the model and refers to impacts experienced within the Southern Coalfields (which as noted earlier is not a similar comparison to the Project). AGE has developed the regional model using detailed geological information gained by extensive exploration activities within the Authorisations. Appendix C of the EIS comprehensively outlines all types of exploration undertaken within Authorisations (A)287 and A342 and, in addition, summarises the geological model derived from these exploration programs. All relevant geological features, or structures, identified as part of the geological model evolution are reported. No significant fault structures have been identified within the longwall mining domain by any drilling completed for the Project. Therefore, the potential for faults to be intersected by mining is considered low.

2.3 NUMERICAL MODELLING APPROACH

2.3.1 Specific Storage Parameter

As a major theme throughout Mr Anderson's submission, the specific storage values adopted within the numerical modelling was questioned and asserts that, as a result, the drawdown impacts from the Project have been under predicted. **Appendix A** provides a thorough technical response to this assertion, with a brief summary provided below.

Mr Anderson has questioned the specific storage values adopted within the model for layers 1 to 3 (alluvium, tertiary basalt and weathered zone), 7 (Permian rock) and 8 (Coggan seam) of the numerical model. He has referred to a paper by Rau et al (2018) which indicates that specific storage is limited to a range which is based on poroelastic theory.

Mr Anderson appears to have mistakenly concluded that the alluvium, tertiary basalt and the weathered zone layers within the model comprise of significant "*confining*" units. Based on the comprehensive field testing and monitoring program, these units have been characterised as "*unconfined*" units within the conceptual hydrological model. Therefore the range of specific storage suggested by Rau et al (2018) which has been relied upon by Mr Anderson does not apply to these layers within the numerical model.

Further to the above, AGE has indicated that the borefield pump testing program which was reported on within the Supplementary RTS further validated and confirmed site specific values for water storage within the alluvium. These have subsequently been used within the numerical model for the Project. These verified values for specific yield (and specific storage) are orders of magnitude higher than those suggested by Mr Anderson for the alluvium.

AGE completed a model sensitivity analysis of alluvial drawdown to the specific storage parameter (using range from Rau et al (2018) which demonstrated that there is very little influence to maximum drawdown within the alluvial aquifer. This was expected as the model employs unconfined storage (i.e. specific yield) properties across these surface layers.

AGE has acknowledged that the specific storage for layers 7 and 8 are higher than the upper bounds provided by Rau et al (2018). These values were reached through the model calibration process to match water fluctuations measured within the groundwater monitoring network. AGE's uncertainty analysis completed for the Project has included lower values for layers 7 and 8 which occur within the range described by Rau et al (2018). This was not acknowledged within Me Mr Anderson's submission.

2.3.2 Model Code & Groundwater - Surface Water Interaction

Mr Anderson's submission comments that the MODFLOW model used for the Project could not appropriately represent the near surface subsidence on surface water and groundwater interactions in the State Forest, Bylong River and underlying alluvium. He states that MODFLOW models are normally focussed towards predicting deep depressurisation impacts rather than the shallow groundwater-surface water interaction processes. This appears to be the primary reason that he does not consider MODFLOW to be appropriate for the Project. This assumption again appears to be derived from his personal experience within the Southern Coalfields (in relation to underground mining below shallow surface aquifers), which as mentioned previously is not consistent with the hydrological regime associated with the Project.

MODFLOW is the most commonly used software for the modelling of impacts for resource development projects. At the direction of Peer Review and stakeholder comments, two versions of MODFLOW have been used throughout the approvals process.

The Project's underground mining footprint has been specifically designed to remain outside of the alluvial aquifers (where shallow water table is present). In this regard, the surface water-groundwater interaction is not considered to be a critical matter to determine the likely impacts of the Project to water users in the area. Therefore, the model code is considered appropriate.

2.3.3 Drought

Mr Anderson commented a number of times during his submission that when drought coincides with maximum takes from the Project, that drawdown impacts will increase. The groundwater modelling for the Project has addressed the effects of drought in a number of ways.

Firstly, at the request of Kalf & Associates, a model run was completed with no recharge through the river bed to maximise the extent of drawdown within the alluvial aquifer. Secondly, as part of the RTS and Supplementary RTS, the groundwater recharge within the model was estimated based on rainfall conditions which occurred over the “Millennium Drought”. Further to this, the uncertainty analysis completed for the Supplementary RTS modelled scenarios with recharge up to 14 times lower than the base case modelling. This further exacerbated the impacts of the Project during the “Millennium Drought” conditions modelled.

2.3.4 Post Mining Water Takes

Mr Anderson commented that the modelling for the revised mine plan within the Supplementary Information report did not include updated predictions of the post mining water take. AGE has consequently provided the results of the post mining conditions for the revised mine plan in **Appendix A**.

When mining is completed, pumping from the mine and borefield ceases and water take would gradually reduce over time. These post-mining water takes are less than those predicted to be taken throughout the life of the Project and would therefore be able to be accounted for with licences to be held by KEPCO.

2.4 WATER MANAGEMENT PLAN

Mr Anderson in his presentation requests that further information be provided throughout the life of the Project, including model updates, water management measures (including triggers) and make good agreements.

All of these matters are fully addressed in the draft Water Management Plan (draft WMP). KEPCO is significantly advanced in this area and has prepared a draft WMP (as part of the Response to PAC Review Report) to provide further information around the proposed management of water resources associated with the Project.

2.5 NSW GOVERNMENT LEGISLATION & POLICIES

Mr Anderson also makes a number of suggestions in relation to the application of the NSW Government legislation and policies. These comments are matters for the NSW Government to consider.

2.6 CONCLUSION

Mr Anderson discusses topics which have previously been raised by other submissions earlier within the approvals process. The simplistic approach by applying Southern Coalfield experiences and behaviours is technically flawed as it infers that the environmental conditions within the Southern Coalfield are similar to the environment at the Project site. AGE has generally drawn on this previous work to respond to the matters raised in his submission. The submission does not raise any valid matter which could result in any changes to the magnitude of environmental impacts predicted as such the proposed management and mitigation measures to be implemented remain appropriate.

3 GROUNDWATER IMPACTS

3.1 IMPACTS TO WATER AVAILABILITY

3.1.1 Issue 1

"The potential for significant impacts to groundwater availability to neighbouring properties, specifically what is the probability that the Project will have an adverse impact on the availability of groundwater to neighbouring properties and what the "worst-case" scenario would be, taking into account climate change factors?"

3.1.2 Response

Since the acquisition of the Project in 2010, KEPCO has acknowledged the importance of the water resources to agriculture within the Bylong Valley. As such, the Project has been carefully designed so as not to adversely impact the water resources of the Bylong Valley. A primary focus of the water assessments has been to ensure that there will be no adverse impacts to neighbouring private landholder water bores.

Comprehensive modelling and assessment has been undertaken throughout the approvals process to determine whether the various proposed elements of Project will result in adverse impacts to neighbouring landholder water bores. This work has demonstrated that neighbouring landholder water bores will not be adversely impacted as a result of the Project.

Landholders of the neighbouring private properties generally extract water from bores within alluvial sediments of the Bylong River and its tributaries. The properties from which the majority of landholder concerns over the potential impacts of the Project are being raised are located within the Growee River subcatchment, upstream of the Growee Rivers' confluence with the Bylong River. The Growee River subcatchment is located on the western side of the Growee Ranges, to the west of and in a separate subcatchment to the Project.

It is also important to note that as previously explained within Section 5.9.5 of the RTS and Section 4.2 of Appendix K of the Response to PAC Review Report, historical weathering of the coal seams in the vicinity of the alignment of the Bylong River, Lee Creek and the Growee River has removed sections of the primary coal seams proposed for mining.

This results in there being no direct connectivity for water to travel through the coal seam between the proposed mining areas and the properties to the west of the Growee Ranges. Therefore, the only possible (but improbable) influence from the Project could be indirectly through the alluvium.

Given the proposed mining operations are located within the upper Bylong River subcatchment (and not in the Growee River subcatchment), adverse impacts to these sections of the Growee River alluvium by the Project are improbable. The Growee River alluvium will continue to receive groundwater recharge from rainfall, river bed leakage, upstream flow through the alluvium and upflow from the underlying bedrock. This is consistent with the results of the modelling and uncertainty analysis which has been completed for the Project.

Appendix J of the Supplementary RTS, Appendix K of the Response to PAC Review Report and Appendix G of the Supplementary Information Report have presented the most recent impact assessments for the Project. Each of these approvals documents demonstrate that the Project will not result in adverse impacts on neighbouring landholder bores. This is also the case for the extreme uncertainty analyses scenarios, when considering the maximum drawdown by combining the extremes of drought and low permeability/storages within the aquifers.

Figure 2-5 of Appendix K of the Response to PAC Review Report shows the likelihood of the maximum drawdown within the alluvium exceeding the 2 m limit nominated in the NSW Aquifer Interference Policy The drawdown shown is a composite of statistics from the 140 calibrated model runs (completed for the uncertainty analysis) shown spatially over the Project area. The results in this figure do not represent any single model run, but rather the likelihood of drawdown exceeding 2 m at any time throughout the Project life.

This figure and supporting text in Section 2.3.1 of Appendix K of the Response to PAC Review Report illustrates that even on the basis of the most extreme model runs completed for the uncertainty analysis, that it is highly improbable that the Project will result in adverse impacts to neighbouring private landholder bores.

As described within Section 2.2.2 of Appendix K of the Response to PAC Review Report (and **Section 2.3.3** above), the numerical modelling undertaken for the Project as part of the Supplementary RTS incorporated groundwater recharge using rainfall from a period which encompasses the “Millennium Drought”. Further to this, the uncertainty analysis completed for the Supplementary RTS modelled scenarios with recharge up to 14 times lower than the base case modelling which further exacerbated the drawdown impacts of the Project. These uncertainty modelling scenarios were considered within the analysis described above which concludes that it is highly improbable that the Project will result in adverse impacts to neighbouring private landholder bores.

As outlined in the draft WMP and discussed in **Section 3.1.4**, KEPCO has committed to implementing a groundwater monitoring program to proactively monitor the impacts of the Project to the surrounding hydrological regime, including private landholder bores (subject to the necessary agreements).

3.1.3 Issue 2

"In the event of significant adverse groundwater availability impacts to neighbouring properties, do the current and proposed monitoring regimes have adequate sensitivity and demonstrate suitable design to provide pre-emptive notice or warning that groundwater supplies may be impacted? Are the compensatory mechanisms proposed in the draft conditions of consent and the applicant's proposed compensatory scheme suitable to address any significant adverse impacts within a realistic timeframe to prevent financial losses to neighbouring properties as a result groundwater impacts, including the duration of compensatory water supply?"

3.1.4 Response

Appendix F of the Response to PAC Review Report provides a draft WMP which has previously been prepared for the Project for review and consideration as part of the approvals process. Section 7.3 of the draft WMP includes details of the groundwater monitoring program to be implemented to monitor impacts from the Project on the surrounding hydrological regime.

This groundwater monitoring program comprises existing monitoring bores (developed in consultation with DoI-Water as part of conditions under A287 and A342), some of which have been in place since 2011. In this regard, KEPCO has several years of reliable baseline monitoring information for the Bylong River catchment and as such has a good understanding of the impacts of climate variability on the alluvial aquifer.

As illustrated within Figure 2.5 of Appendix K of the Response to PAC Review Report, it is considered "*very unlikely*" (i.e. between 1 and 10% on the likelihood scale) that the 2 m drawdown as a result of the Project will extend downstream from the proposed borefield beyond the Bylong River's intersection with Bylong Valley Way. As described within the report prepared by AGE dated 10 August 2018 which was included as Appendix E3 of DPE's Final Assessment Report and summarised in Section 2.4 of the Final Assessment Report, the main drawdown impacts predicted for the Project are the result of the borefield. Incidental takes from mining alone are very minor in comparison to borefield takes.

The controlled drawdown impacts on the alluvial aquifer will be monitored by KEPCO's monitoring bores within and downstream of the borefield. This will enable the drawdown extents to be carefully monitored and managed before these impacts extend to neighbouring landholders bores. That is, KEPCO will have the ability to reduce or cease its borefield pumping activities at any time to minimise its drawdown impacts on the alluvial aquifer.

KEPCO also proposes (subject to agreements with the landholders) to monitor neighbouring private landholders bores remote from its mining and licenced borefield. In this regard, KEPCO has commenced monitoring on three landholdings to the west of the Project within the upper Growee River catchment.

As illustrated on Figure 2.5 and described within Section 2.3.1 of Appendix K of the Response to PAC Review Report, there was a single model run from the 140 runs (i.e. represented by the "*exceptionally unlikely*" or between 0 and 1% on the likelihood scale) that predicted a drawdown exceeding 2 m on the Eagle Hill and Cherrydale Park properties at some time throughout the life of the Project. However, it is noted that this predicted drawdown did not occur in areas where private water bores on these properties are registered on the Government database. Dissimilar to other drawdown shown on Figure 2.5, this "*exceptionally unlikely*" drawdown on the Eagle Hill and Cherrydale Park properties is not directly connected to other areas of drawdown around the mining areas. This is because the coal seams sub-crop under the alluvium in this area, and the single model run (out of 140) that resulted in this outcome had a combination of properties that heightened the connectivity (through the coal seams) between the mining areas and these landholders in the downstream section of Growee River. This model run required highly permeable coal and alluvium to achieve this result; a combination that is exceptionally unlikely based on the available field measurements.

The groundwater monitoring program described within the draft WMP also includes monitoring of depressurisation within the Permian aquifers. This includes monitoring bores within the Permian between the underground mining area and the predicted drawdown as well as nested bores (i.e. bores installed into the alluvium, weathered materials and Permian aquifers at the same location) in the vicinity of the predicted drawdown. This program will assist in monitoring the depressurisation of the Permian as mining progresses and to assist in confirming the extent of drawdown resulting to the alluvium as a result of underground mining operations.

The numerical model reviews and updates (as required by Schedule 4, Condition 28(c)(iv) of the Recommended Development Consent conditions) will ensure the validation of parameters used within the numerical model.

The draft WMP contains a plan to respond to any exceedances of trigger levels and/or performance criteria, and includes measures to provide compensatory water supplies to any affected water user. Trigger levels are designed to identify any unforeseen circumstances on KEPCO owned land, well before there would be any potential for off site impacts. Of course ceasing pumping from the borefield would result in the recovery of water levels within the alluvial aquifer.

Schedule 4, Condition 25 of the Recommended Development Consent conditions states:

> "*The Applicant must provide a compensatory water supply to the landowner of privately-owned land whose water supply is adversely and directly impacted (other than a negligible impact) as a result of the development, in consultation with DoI Water and to the satisfaction of the Planning Secretary.*
>
> *The compensatory water supply measures must provide an alternative supply of water that is equivalent in quality and volume, to the loss attributable to the development. Equivalent water supply should be provided (at least on an interim basis) as soon as practicable after the loss is identified, unless otherwise agreed by the landowner.*
>
> *If the Applicant and the landowner cannot agree on whether the loss of water is to be attributed to the development or the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Planning Secretary for resolution.*
>
> *If the Applicant is unable to provide an alternative long-term supply of water, then the Applicant must provide compensation, to the satisfaction of the Planning Secretary.*
>
> *However, this condition does not apply if the Applicant has a compensatory water agreement with the owner/s of the land and the Applicant has advised the Department in writing of the terms of this agreement.*
>
> ***Notes:***
>
> - *The Water Management Plan (see condition 28) is required to include trigger levels for investigating potentially adverse impacts on water supplies.*
> - *The burden of proof that any loss of water supply is not due to mining impacts rests with the Applicant.*"

In this regard, the Recommended Development Consent conditions require the Water Management Plan to include trigger levels for investigating potentially adverse impacts on water supplies. The groundwater monitoring program described above will then be used to monitor the impacts of the Project and be compared against the relevant trigger levels. In the unforeseen event that impacts were identified to neighbouring landholders bores, under this condition, KEPCO is required to provide an alternate supply of water to the landholder (as soon as practicable after the loss is identified), unless otherwise agreed by the landholder.

If KEPCO is unable to provide the alternate water supply, KEPCO must provide compensation to the landholder to the satisfaction of the Secretary of DPE. This provides an appropriate mechanism in the unforeseen event that adverse long-term impacts were to occur and it is impractical to provide an alternate water supply. This compensation would assist in making good any legitimate financial losses which may occur to neighbouring landholders in the unforeseen event that the Project adversely impacts water supplies.

In addition to the Recommended Development Consent condition, KEPCO has prepared a draft Compensatory Water Supply Agreement (CWSA) (and associated guideline documents) for review and consideration by neighbouring landholders. The draft CWSA allows for the establishment of an agreed approach (in regard to landholder and KEPCO's responsibilities, baseline assessments, land access, setting triggers for compensatory measures, provisions for compensation, timing and dispute resolution processes) in the unforeseen and improbable event that their water supplies are directly affected by the Project.

3.2 PREDICTED DRAWDOWN

3.2.1 Issue 3

"The geographical relationship and extent of the predicted drawdown, specifically in relation to the potential drawdown impacts on the nearby Greater Blue Mountains World Heritage Area, and any cumulative impacts or interactions between the Project and existing mining projects in the regions, including the Wilpinjong Coal Mine and Moolarben Coal Mine?"

3.2.2 Response

KEPCO presented the most recent groundwater impact assessment within Appendix J of the Supplementary RTS and a comparison of impacts for the revised mine plan imposed by DPE in Appendix G of the Supplementary Information Report (Appendix C of the DPE Final Assessment Report).

The Permian coal seam aquifer which is predicted to be depressurised as a result of the Project's mining operations are located more than 400 m below the surface topography within the Wollemi National Park and with groundwater levels in excess of 50 m to 100 m below the land surface. The significant depth of groundwater below the land surface means the minimal predicted depressurisation within the Permian will not have any consequence for the surface hydrology within the neighbouring Wollemi National Park (which forms part of the Greater Blue Mountains World Heritage Area (GBMWHA)).

Further to this, the maximum predicted drawdown within the alluvium (including the results for the exhaustive uncertainty analysis undertaken) does not extend into or adjacent to the GBMWHA. As a result, it is not possible that the proposed mining operations will lead to significant impacts to any surface hydrological systems within the GBMWHA as suggested within some submissions received by the IPC.

The Wilpinjong Coal Mine and Moolarben Coal Mine are located more than 20 km from the Project. As explained within Section 7.6.3 of the EIS, these operations are located well beyond the predicted zone of influence generated by mining (refer to Figure 6-18 of Appendix J of the Supplementary RTS). As a consequence, there will be no cumulative impacts or interactions in relation to groundwater resources between the Project and these operations.

3.3 MODELLING CONSIDERATIONS

3.3.1 Issue 4

*"**Clarification on modelling considerations and outcomes for the Moolarben Coal Project, as raised through public submissions and the public meeting**, including any identified factors which may have contributed to the identified disparity between the modelled level of groundwater take and the realised level of groundwater take? Are there any implications for the assessment of groundwater impacts for the Project?"*

3.3.2 Response

It is not reasonable nor would it be appropriate for KEPCO to comment on matters which have been questioned in relation to the Moolarben Coal Project.

However, KEPCO can confirm that it has completed a comprehensive groundwater impact assessment for the Project which has included detailed numerical modelling (and exhaustive uncertainty analyses) to identify the range of potential outcomes for the Project.

This modelling has utilised site specific data which has been collected from KEPCO's exploration and baseline environmental monitoring programs (undertaken since 2011) which have been extensive. The use of site specific data provides valuable information to ensure that the potential groundwater impacts of the Project can be identified with the greatest level of certainty possible. KEPCO has also completed exhaustive uncertainty analyses in response to stakeholder concerns regarding the uncertainty of water modelling. This has subsequently resulted in a range of worst case groundwater inflows to the mining areas (as presented within Figure 6-19 of Appendix J of the Supplementary RTS).

Section 2.3.3 of Appendix K of the Response to PAC Review Report completed an analysis of predicted versus actual groundwater inflows at nearby mining operations. This analysis confirmed that the modelling predictions within each respective EIS achieved its intended purpose of identifying the likely impacts of the development on the surrounding groundwater regime and to determine measures to monitor manage and mitigate the actual impacts on the ground. It is considered that the assessments completed by KEPCO have also achieved the same intended purpose.

3.4 WATER STORAGE

3.4.1 Issue 5

*“**Clarification on the potential safety risks of water storage in the mine underground mine goaf,** and the relationship and importance of this water storage option on the overall function of the Project’s site water balance.”*

3.4.2 Response

In Sections 4.2.1.8 and 4.2.1.9 of the Response to PAC Review Report, KEPCO presented the outcomes of the water balance sensitivity analysis completed to assess the risk of mine water discharge from the Project. This analysis confirmed that there was a high level of confidence that the mine water management system could be managed to contain worst case mine water makes on site. Figure 3 of the Response to PAC Review Report identifies the modelled mine water supplies over the life of the mine against the available capacity for water storage within the open cut mining areas and within the underground mine goaf for the 100 series panels. Figures 4 and 5 of the Response to PAC Review Report provide the results for various sensitivity cases completed.

Under the base case scenario (representing the most likely conditions), the goaf storage would not be required for the Project. However, in the most extreme and highly unlikely scenarios modelled, the underground mine goaf has been identified to be available for the storage of mine water.

In the unlikely event that this storage is required (the most extreme and highly unlikely scenarios modelled indicate this would occur from Project Year 19), the underground mine goaf storage within the 100 series panels (which are scheduled for longwall mining between Project Year 9 to Project Year 18) would be available to store excess water. Depending on the amount of water to be stored, this may involve the sealing of the gate roads between the 100 series and 200 series longwall panels. This sealing would involve the construction of bulkheads designed to withstand the pressure of water behind them. These bulkheads would be designed, installed and maintained in accordance with the relevant regulatory guidelines and standards. Sealing of mine goaf areas using bulkheads is standard practise within the underground coal mining industry, with the design risk mitigations well understood. The bulkheads are subjected to a routine monitoring regime that would be implemented to ensure their ongoing structural adequacy throughout the life of the Project.

The Water Management Plan is required to include a program to review and validate the site water balance, and review mine water storage capacities and forecasts on a regular basis. Based on the results of the water balance modelling, KEPCO will have at least 18 years to identify the need for the underground water storage option (and/or other contingency measures). In this regard, in the circumstances where indeed there is any surplus water at the mine site beyond year 18 of mining there may be other opportunities available to manage or best utilise this water.

There remains a high level of confidence that the mine water management system will be able to be managed over the life of the Project to prevent the discharge of mine water from the site.

4 CONCLUSION

We trust this letter assists DPE in responding to the IPC's request for additional information.

Please do not hesitate to contact us should you like to discuss any queries that you may have in relation to this letter or any matter relating to the Bylong Coal Project.

Yours faithfully

HANSEN BAILEY

Nathan Cooper
Principal

James Bailey
Director

APPENDIX A

AGE RESPONSE TO MR ANDERSON’S SUBMISSION

Australasian Groundwater and
Environmental Consultants Pty Ltd

Report on

Bylong Coal Project
Response to UNSW Submission on Bylong Groundwater Assessment

Prepared for
KEPCO Bylong Australia Pty Ltd

Project No. G1606S December 2018
www.ageconsultants.com.au ABN 64 080 238 642

Document details and history

Project	G1606S
Document title	Bylong Coal Project - Response to UNSW Submission on Bylong Groundwater Assessment
Site address	Bylong NSW
File name	G1606S.Report_Response_to_UNSW_v01.01.docx

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Report on

Bylong Coal Project – Response to UNSW Submission on Bylong Groundwater Assessment

1 Introduction

KEPCO Bylong Australia Pty Ltd (KEPCO) proposes to develop an open cut and underground coal mine in the Bylong Valley (the Project), which is located in the Mid-Western Region of New South Wales (NSW).

The Project has been subject to two levels of environmental assessment which has been coordinated by Hansen Bailey Pty Ltd (Hansen Bailey) on behalf of KEPCO. The first stage was an initial groundwater assessment addressing the requirements of the NSW Gateway Certificate Assessment process. The second stage of work was a groundwater impact assessment prepared for the Environmental Impact Statement (EIS), which described the field investigations and impact assessment using numerical modelling. The EIS has included a number of supplementary reports including additional field investigations and modelling to address comments from government and non-government stakeholders.

In November 2018, the Environmental Defenders Office of NSW (EDO) engaged the University of New South Wales Water Research Laboratory (Anderson 2018) to review the groundwater assessment and modelling undertaken for the Project. This review was presented to the Independent Planning Commission (IPC) who subsequently requested NSW Department of Planning and Environment's (DPEs) clarification over a number of queries. DPE has subsequently sought KEPCO's response to the matters raised in relation to the impacts of the Project on water sources, including items raised by Anderson (2018). Hansen Bailey engaged Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to respond to the Anderson (2018) submission on behalf of KEPCO.

The matters raised by Anderson (2018) have been categorised as follows:

- characterisation of the groundwater regime;
- approach to numerical modelling;
- Water Management Plan; and
- NSW government groundwater legislation and policies.

The sections below discuss these matters in detail.

2 Characterisation of the groundwater regime

2.1 Field investigation program

The Anderson (2018) submission concluded the *"amount of field investigation and hydrological and hydrogeological data analyses from first principles described in Figure 4.5 appears minimal in comparison to the complex numerical modelling work that has been undertaken."*

This conclusion appears to have been reached simply by reviewing the timeline for the groundwater investigations (Figure 2.1) provided by AGE (2017). KEPCO has taken an exhaustive proactive approach to the field investigations required to characterise the groundwater regime. There have been five separate campaigns undertaken in consultation with DPI-Water to install an extensive monitoring and testing network between 2011 and 2016.

The groundwater investigations were manged by Douglas Partners (DP) and integrated with the coal resource drilling. During the first campaign DP supervised the installation of 31 monitoring sites between August 2011 to July 2012 comprising 25 sites within the alluvium and 6 within the Coggan Seam, being the predominate target coal seam. A second phase of drilling was undertaken between July and December 2012. The drilling program included installing six multilevel groundwater monitoring bores, two multilevel Vibrating Wire Piezometers (VWP's), within the alluvium and the Coggan Seam. A further four vibrating wire piezometers and 11 groundwater monitoring bores were installed throughout 2013.

During the preparation of the response to submissions in 2016, KEPCO engaged DP to drill an additional five bores along the alignment of Dry Creek to characterise the nature of any alluvial sediments along the creek line, and the potential for this material to form an aquifer that could support deep rooted vegetation.

Finally in 2016, KEPCO installed trial pumping bores at four sites to test the yield from the alluvium and to measure the hydraulic properties of the sediments. At each of the four trial sites, a pumping bore and adjacent monitoring bores were installed.

In summary, the monitoring bore network now comprises:

- 4 test pumping bores within the alluvium;
- 8 monitoring bores adjacent to the test pumping bores to monitor drawdown;
- 35 bores screened with alluvium;
- 5 bores within Dry Creek alluvium;
- 10 bores screened within the weathered zone;
- 1 bore screened within basalt;
- 3 bores screened within sandstone strata;
- 13 bores screened within the Coggan and Ulan coal seams; and
- 13 arrays of multilevel vibrating wire piezometers measuring pressure in overburden strata.

In addition to the above, KEPCO has continued to monitor water levels and water quality within the monitoring network (including monitoring locations on neighbouring privately owned land) to gather baseline data during the approvals process. Up to seven years of baseline data has now been gathered which has captured the systems response to periods of drought and above average rainfall. This data has been used to assess recharge rates, aquifer storage and bore yields from first principles (AGE 2016a, AGE 2016b). Clearly, it is both illogical and speculative to describe the field investigation and data analyses as minimal in comparison to numerical modelling. The numerical modelling is founded on high quality field data collected by KEPCO and its consultants, with the exhaustive amount of numerical modelling is simply a reflection of thorough internal validation and continuous requests from stakeholders for additional analyses.

2.2 Southern Coal Fields

Anderson (2018) make several references to environmental impacts associated with underground coal mining operations in the Southern Coalfields, including the Metropolitan underground mine north of Wollongong NSW. There are fundamental differences between the groundwater regime at the Metropolitan Mine compared to the Project. The most significant of these is the depth to the water table in the underground mining area. At Metropolitan Mine, a shallow water table close to the surface is present. This shallow water feeds permanent baseflow to the streams. This is not the case in the majority of the area where underground mining is proposed at Bylong. The water table is deep and well below the land surface. The depth of the water table at Bylong means there is no interaction between the water table and overlying streams and vegetation. This key difference is not recognised by Anderson (2018) as it is an important consideration where comparing actual impacts at Metropolitan Mine with predicted impacts for the Project. As such, it identifies Anderson's (2018) approach as unsubstantiated.

2.3 Perched aquifers

Slide 10 of Anderson's (2018) presentation to the IPC suggests an unquantified potential for perched aquifers to occur above the proposed underground mining areas. The uncertainty in the occurrence of the perched aquifers is indicated by questions marked on the slide. Anderson (2018) also considers there is potential for subsidence movements to lower the water table resulting in mortality for vegetation during drought. Again the review refers to experiences in the Southern Coalfields, incorrectly inferring this experience is directly applicable to the Bylong Project, and essentially concludes the state forest is a groundwater dependent ecosystem. The potential for a perched aquifer to occur above the proposed longwall mining area within the Tertiary basalt capping was initially identified by AGE (2016a). Further investigation using water levels measured in exploration holes described in AGE (2016b) confirmed that the water table is well below the base of the basalt, indicating it is dry. The conceptual hydrogeological model for the basalt is that it remains unsaturated, although it may support short-term perching as part of normal recharge mechanisms as rainfall drains to deeper units.

2.4 Geological structures

Slide 10 of the Anderson (2018) submission highlights geological structures (faults, folds, dykes) and appears to question if these have been investigated and included within the numerical model. The Bylong Coal Project EIS (Volume C, Geology Report) comprehensively outlines all types of exploration undertaken within Authorisations (A)287 and A342 and, in addition, summarises the geological model derived from these exploration programs. All relevant geological features, or structures, identified as part of the geological model evolution are reported.

The groundwater assessment prepared for the EIS (AGE 2015) was based upon the geological model developed for the Project area. The EIS discusses the presence of geological structures (Section 5.6.3) and their investigation in the Project area, and notes KEPCO identified gentle folding through the Project area which is represented in the numerical model through the model layers. Drill hole testing and seismic data identified only minor faulting with a displacement being less than 5 m being less than the seam thickness. Faults were not represented in the groundwater model as their presence within the Project area is uncommon and they were not considered to have a regionally significant influence of the groundwater regime.

The Anderson's (2018) submission asks *"have all structures been mapped?"*. Such a general question does not account for the fact that geological structures vary in scale/type/continuity and, as a result, have varied potential influences on groundwater. It is assumed that in this case, "*all structures"* refers to significant geological structures such a large-scale faulting, seam rolls or igneous intrusions, as opposed to smaller-scale structures such as joints, micro-faults etc. As such, based on the comprehensive exploration programs undertaken to date, any such significant structures are identified and documented as part of the Bylong Coal Project EIS (Volume C, Geology Report). Ultimately, detailed *"mapping"* of all structures is only possible during underground mining when such structures are exposed in underground workings.

The submission from Anderson (2018) states in paragraph 35 c) that "*In my opinion, this is a reasonable consideration as geological structural features if unmapped could potentially cause some localised water impacts in National Park or World Heritage Area; I am not a subject expert in mapping of geological structures or non-conventional subsidence prediction and could not comment further in the context of SSD 6367, although I have observed in public environmental management plan annual reporting the environmental water quantity and quality outcomes of unpredicted subsidence from failure to consider such factors in the Southern Coal Fields."*

KEPCO has undertaken 2D and 3D seismic surveys followed by detailed drilling to identify structures focussing on the proposed underground mining area, not the adjacent National Park. Exploration is only legislated within designated Authorisations, following relevant approval. The proponent is not within its rights to undertake exploration outside its Authorisations, especially within adjoining National Parks etc. Obviously drilling investigations in the National Park are physically not possible, desirable or warranted.

Geological interpretations for areas adjoining the Authorisations are made from publicly available information (i.e. regional geology maps, or regional airborne type studies) in combination with extrapolations made from detailed exploration with the Authorisation boundaries. Again, based on the comprehensive exploration programs undertaken to date, any such significant structures are identified and documented as part of the Bylong Coal Project EIS (Volume C, Geology Report).

Slide 10 of the Anderson (2018) submission again refers to the Southern Coalfields, inferring they are similar to the environment at the Project site. This is another unsupported and speculative comment by the Anderson (2018). As stated previously, there are fundamental differences in the groundwater regime at Bylong when compared with the Southern Coalfields, the key one being there is not a permanent shallow water table feeding baseflow to creeks and rivers in the area overlying the proposed underground mining area at Bylong. The groundwater modelling for the Project has represented the enhancement of permeability that occurs following subsidence, and was undertaken in collaboration with the subsidence specialists. Geological characterisation conducted for underground mining projects aims to identify faults within the mining area as they pose a major constraint to the longwall mining method and cannot be intersected. The geological characterisation work conducted to date by KEPCO has not identified the presence of significant fault structures in the Longwall Mining Domain. Therefore, the potential for faults to be intersected during mining is considered low.

2.5 State Forest and National Park

Paragraph 35b i) in the Anderson (2018) submission suggests there is potential for the Project to impact upon the groundwater regime within the NSW Bylong State Forest with the submission stating *"the magnitude of the development and the magnitude of the longwall mining subsidence (about 3m) which will result in:*

> *i) Shallow groundwater, streamflow and forestry impacts in the overlying NSW State Forest – NSW DPI Water has stated an integrated model could have been developed (Document 11, p. 57). This is a sensible suggestion for prediction near surface impacts – such impacts have been observed from one metre of subsidence in the Southern Coalfield (Document 53, Section 2, p2); in MODFLOW modelling software this process is not represented for various reasons such as some of those described in Section 4.2.8."*

Again, the Anderson (2018) submission refers to experience in the Southern Coalfields and applies the same assumptions to the Project, despite the fundamentally different groundwater regimes. Mines in the Southern Coalfields underlie areas with shallow water tables, which is not the case where underground mining is proposed at Bylong. Figure 7.3 within AGE (2015) provides an indication of the depth to the groundwater within the area of the proposed underground mine at Bylong. It also indicates that the water table is commonly in-excess of 50- 100 m below the land surface. This significant depth to water means the water table will not have any significant interaction with the streams or vegetation in the area where underground mining is proposed. It is correct that groundwater within the Triassic and Permian rock strata will be depressurised in this area around the underground mine, but the significant depth of groundwater below the land surface means the predicted drawdown will not have any consequence for the state forest or national parks.

3 Numerical modelling

3.1 Specific storage values

Much of the Anderson (2018) submission discusses the specific storage values adopted in the numerical modelling for the Project. The submission concludes the values of specific storage adopted in the groundwater model were unrealistically high in a number of the model layers, and this will result in the drawdown due to the Project being underestimated. The submission by Anderson (2018) refers to a paper by Rau et al (2018) which indicates that specific storage is limited to the range of 2.3×10^{-7} m^{-1} and 1.3×10^{-5} m^{-1} based on poroelastic theory. The Anderson (2018) submission then concludes that the values adopted in the numerical modelling for the Project for model layers 1, 2 ,3, 7 and 8 are higher than the upper limit identified by Rau et al (2018) and that this would subsequently reduce the drawdown predicted for the Project. The geological units questioned by Anderson (2018) are:

- layer 1 –Quaternary alluvium;
- layer 2 - Quaternary alluvium and basalt cap;
- layer 3 – Zone of weathering within Triassic/Permian bedrock;
- layer 7 – Permian non-coal interburden rocks; and
- layer 8 – Coggan coal seam.

When reviewing the specific storage adopted for the groundwater modelling for the Project, it is important to understand the conceptual model which the numerical model represents. Model layers 1, 2 and 3 represent unconfined groundwater systems. These geological units occur at the surface and allow recharge to directly enter the water table from seepage of rainfall at the land surface. In layers 1, 2 and 3 there are no extensive continuous layers of low permeability material that form continuous confining units that would result in water being released by elastic storage in response to declining water levels. In unconfined aquifers, the specific yield controls the volume of water that drains under the forces of gravity and is higher than specific storage because it represents drainage to an unsaturated state. Therefore, the values of specific storage identified by Rau et al (2018) do not apply to the model layers that represent the unconfined alluvium, basalt and weathered zone.

3.1.1 Quaternary alluvium

The Anderson (2018) submission appears to have mistakenly concluded that significant confining units occur within the alluvium. This conclusion appears to have been reached through review of cross sections presented within AGE (2016a) which are reproduced in the Anderson (2018) presentation. The sections within AGE (2016a) were presented in response to requests from government stakeholders to specifically illustrate lithological layers from borehole logs. The lithological layers in the sections are shown in a simplified manner as extending across the flood plain as they occur where single boreholes are situated. The sections are not intended to infer the presence of regionally continuous low permeability confining layers across the alluvial flood plain. The finer grained lithological units that are intersected in boreholes form discontinuous lenses rather than continuous regional confining layers. This is clear as there is no relation between the layers shown in the various sections presented in AGE (2016a).

The borehole logs from test pumping and monitoring bores within the alluvium provided within AGE (2016b) show clays are variable in occurrence and do not form extensive confining units across the flood plain. The unconfined nature of the alluvium was demonstrated by the pumping tests described in AGE (2016b). Trial pumping bores and surrounding monitoring bores were installed at four sites in response to a request from government submissions. Each test site comprised a pumping bore and two or three adjacent monitoring bores located between 6 m and 60 m from the pumping bore to measure drawdown response during pumping. Bores were pumped at rates between 5 L/sec and 14 L/sec for up to 100 hours, with between 1.8 m and 11.5 m drawdown recorded in the pumping bores. The drawdown measured at adjacent monitoring bores at three sites was very limited between about 0.2 m to 0.4 m or less at three of the pumping sites, and 0.8 m to 1.2 m at the fourth site. A simple groundwater model representing unconfined conditions within the alluvium was developed to analyse the pumping tests. The model predicted the measured drawdown and recovery well, and indicated a specific yield from 0.02 m to 0.19 m. These site specific values indicate the water storage and release potential within the alluvium is orders of magnitude higher than suggested by Anderson (2018) because the system is unconfined.

Anderson (2018) conducted simplistic modelling to show the influence of specific storage on predicted drawdown in a sand aquifer. The modelling represents a confined sand aquifer system. This is not an appropriate assumption as the alluvial aquifers at the Project are not confined. The results of this modelling therefore should not be applied to the alluvial aquifer occurring adjacent to the Project. This model predicts drawdown extending over 12 km from the pumping bore over time. These predictions from a hypothetical confined aquifer are completely inconsistent with actual observations from pumping test bores at the Project site which recorded very limited drawdown and results consistent with unconfined aquifer conditions where specific storage does not apply.

3.1.2 Tertiary basalt

Layer 2 within the numerical model also represents the Tertiary basalt cap where this occurs. Investigations described by AGE (2016b) have concluded this layer is largely unsaturated. However, this layer may support short-term perching as part of normal recharge mechanisms as rainfall drains to deeper units. Under these conditions, the basalt would also be unconfined and the applied specific storage values therefore have no influence on the model predictions.

3.1.3 Weathered zone

Layer 3 within the numerical model represents the zone of weathering within Triassic/Permian bedrock. This layer also occurs at the surface as the highest active layer within the MODFLOW model, without any significant low permeability confining layer. It is again conceptualised within the numerical model as an unconfined groundwater system that releases groundwater according to the specific yield, not specific storage. Consistent with layers 1 and 2, the ranges described by Rau et al (2018) do not apply to this layer due to its unconfined nature.

3.1.4 Permian layers

Layer 7 within the groundwater model represents low permeability non-coal rocks that occur within the Permian sequence which forms a confining unit above the Coggan coal seam (layer 8 within the numerical model). The numerical model applied a specific storage of 7.6×10^{-5} m^{-1} to model layer 7 and 2×10^{-5} m^{-1} for model layer 8. It is acknowledged that the value of specific storage in layer 7 is higher than the upper bound approximated by Rau et al (2018). The value adopted for layer 8 is close to, but also marginally above the upper bound reported by Rau et al (2018) of 1.3×10^{-5} m^{-1}. These values were reached through calibration of the model to water level fluctuations measured in the monitoring bore and VWP network.

The groundwater studies for the Project have always recognised the inherent uncertainty in hydraulic parameters applied to the numerical model. The early work conducted for the Gateway process and EIS addressed this uncertainty by assessing the sensitivity associated with single model parameters. Subsequent work for the RTS and Supplementary RTS reports used first linear, and then non-linear methods to assess how parameter uncertainty could affect the impact predictions. The most recent non-linear uncertainty analysis within the Supplementary RTS report varied specific storage range within the confined model layers by one order of magnitude either side of the base case value. For layer 7, this means values as low 7.6×10^{-6} m^{-1} could occur within the uncertainty analysis. For layer 8 values as low as 2×10^{-6} m^{-1} were able to occur. These lower values for layers 7 and 8 are within the ranges described by Rau et al (2018).

The subject of specific storage has been raised previously in a review of the EIS groundwater modelling by Pells Consulting (2015) which also noted theoretical limits on this parameter. The comments provided within Pells Consulting (2015) were responded to by conducting additional modelling with lower values of specific storage, particularly in layer 8 (refer AGE 2016a and AGE 2016b). In the submission to the Planning Assessment Commission (PAC) public hearing, as well as the latest letter prepared by Pells Consulting (2018) (commissioned by the EDO), the issues of specific storage are not raised again and the hydrogeological studies are noted in general to have been undertaken to an acceptable standard.

Anderson (2018) notes the uncertainty in the specific storage parameter by concluding that the issue of appropriate values of specific storage can only be resolved by *"further data collection and recalibration of the predictive model to determine more appropriate choices of hydraulic conductivity and recharge using realistic, measured values of specific storage".* Specific storage is best measured directly via field tests that induce drawdown in surrounding strata and can be used to calculate the volume of water released from storage. Whilst this type of testing has been successfully undertaken in the alluvium for the Project, it is very difficult to implement in low permeability rock strata which occur at Bylong, as the rocks do not yield large volumes of groundwater amenable to pumping. The best data set for estimating specific storage remains bores adjacent to mines that have recorded drawdown due to mining and can be used to estimate specific storage through model calibration. Again, as the Project is a greenfield site, this information is not available.

3.1.5 Sensitivity of alluvial drawdown to specific storage

Given the concerns raised over using appropriate values of specific storage, the numerical model was used to further investigate the influence of the specific storage range identified by Rau et al (2018) on model predictions. Two additional model runs were conducted, firstly where the specific storage in all model layers was not allowed to exceed an upper limit of 1.3×10^{-5} m^{-1}, and secondly where the specific storage was set at the lower bound in all model layers of 2.3×10^{-7} m^{-1}.

The MODFLOW model allows setting of a specific storage value for all layers, but rightly only utilises this value if the layer is confined by an overlying layer, or the water level is above the top of the layer. Therefore, whilst the value was set in the unconfined layers, it is not used by the model to calculate drawdown within the alluvial aquifer.

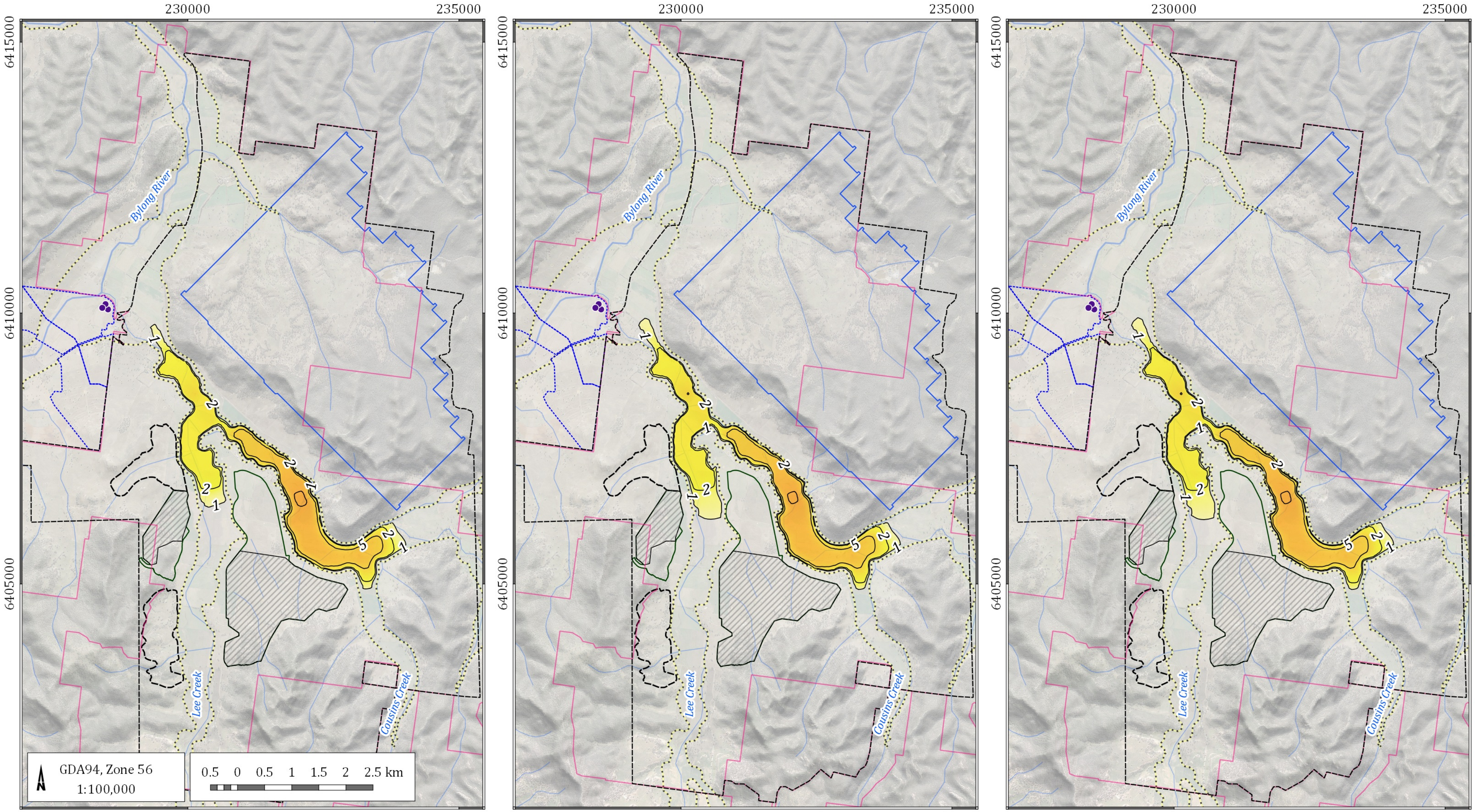
The maximum drawdown predicted by the model to occur within the alluvial aquifer for these cases is shown in Figure 1 below along with the base case results. The figure shows how changing specific storage to remain within the ranges identified by Rau et al (2018) has very limited influence to the maximum drawdown occurring within the Quaternary alluvium. This is because the model employs unconfined storage (specific yield) properties across the majority of layer 2 and layer 3. More depressurisation is predicted within the Permian bedrock when storage values are reduced, however this is of no consequence as it is not a significant water source within the region, and there are no flow on effects to the alluvium.

This sensitivity analysis of specific storage highlights that uncertainty in this parameter does not have significant flow on effects for the main receptors being bores within the alluvial aquifers. Therefore, the conclusions of the EIS and the associated measures to manage groundwater impacts from the Project are appropriate.

Maximum drawdown - Basecase

Maximum drawdown - Specific storage < 1.3×10^{-5} m-1

Maximum drawdown - Specific storage > 2.3×10^{-7} m-1



LEGEND

- Original Open Cut mining area
- Overburden Emplacement Area
- Underground Extraction Area
- Revised Open Cut Mining Area
- Quaternary alluvium
- Drainage
- Project Boundary
- KEPCO owned land
- Eagle Hill property
- Drawdown contour (m)
- Private bores on Eagle Hill property

Drawdown (m)

- 1
- 2
- 5
- 10
- Drawdown contour (m)

AGE

Bylong Coal Project (G1606S)

Influence of specific storage on maximum drawdown within Quaternary alluvium

DATE
03/12/2018

FIGURE No:
1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1606.Bylong Coal Project\3_GIS\Workspaces_QGIS\G1606T_new_mine_plan_20180508\01.00_G1606T_Influence of specific storage on maximum drawdown within Quaternary alluvium.qgs

3.2 Model code and simulation of groundwater-surface water interaction

In paragraph 36e, the Anderson (2018) submission comments that that MODFLOW model used to assess the impact of the Project could not appropriately represent the impact of near surface subsidence on surface water-groundwater interactions and water availability in NSW State Forest, Bylong River and underlying alluvium. It was commented MODFLOW models are normally focused and/or biased towards predicting deep depressurisation impacts rather than shallow surface water-groundwater interaction processes and leakage impacts.

The MODFLOW code used for the groundwater assessment for the Project is the most commonly used software for modelling the impact of resource development projects. Two versions of the MODFLOW code have been used over the course of the approvals process, firstly MODFLOW SUFACT then MODFLOW USG. In 2016 the MODFLOW SUFACT and MODFLOW USG versions of the model were audited by Hydrosimulations at the request by Dr F. Kalf of Kalf & Associates Pty Ltd who acted on behalf of DPE as the Peer Reviewer. Hydrosimulations (2016) did not report any significant issues of concern from the model audit and concluded the choice of model code remains with the modeller.

The Anderson (2018) submission appears to consider shallow fracturing from subsidence and interaction with shallow water tables and streams to be the reason the model code is considered inappropriate. Again, and as stated previously, this assumption appears based on Anderson's (2018) previous experience in an entirely different circumstance in the Southern Coalfields where shallow water tables that interact with surface water systems can occur above longwall mining areas. This is not the case at the Project site where the underground mine is proposed to be located in an area where groundwater is commonly in the range of 50 m to 100 m below the land surface as noted previously.

It is important to note that the underground mining has been deliberately planned not to occur under the alluvial aquifer, where there is a shallow water table. The underground mining is proposed outside alluvial areas with a buffer zone to prevent subsidence induced fracturing interacting with the alluvial groundwater systems and the Bylong River. In addition, the majority of the water licenses held within the Bylong River water source are for groundwater. There are only very limited licenses for surface water because of the intermittent and unreliable nature of surface flows within the catchment. This means the water resources are largely flowing underground and the reason why water users in the area have historically largely used wells to access water. Therefore, whilst surface water-groundwater interaction is considered important for recharge to the alluvial aquifer, it is not a critical matter to determine the likely impacts to water users in the area as suggested by Anderson (2018).

3.3 Drought

The Anderson (2018) submission mentions drought a number of times (paragraph 35b ii, 36a, 56a vii), indicating that when mining impacts coincide with drought, the drawdown impacts from the Project will increase and there is potential for landholder bores to be affected. It is important to note that concerns about the combined effects of drought and mining on landholder bores have been raised since the early stages of the Project and addressed comprehensively in a number of ways.

During the approvals process, Kalf & Associates recognised the potential for leakage through the river bed in the model to recharge the alluvial aquifers. To investigate the impact of drought, Kalf and Associates requested the model be run assuming no recharge occurred through the river bed over the life of the Project. The results of this modelling is presented in AGE (2016a). In response to further submissions on drought further modelling undertaken by AGE (2016a) and AGE (2016b) utilised groundwater recharge rates calculated over the 'Millennium drought'. The groundwater recharge used for the basecase numerical model used rainfall records from 2000 to 2013, which represented a period of drought, followed by a number of years where the drought was broken by above average rainfall. This cycle of recharge was then repeated for the Project life meaning effectively that two Millennium droughts are represented within the basecase numerical model. This cycle of drought within the basecase model was also retained within the model used for uncertainty analysis. The uncertainty analysis results described by AGE (2016b) indicate drawdown impacts do not extend to neighbouring private landholders' bores, even when low rainfall from drought periods combine with hydraulic parameters within the model that promote the expansion of drawdown within the alluvial aquifer. Therefore, it is concluded that all impacts presented in AGE (2016a), AGE (2016b) and AGE (2017) have considered the cumulative impact of mining and drought on the groundwater regime.

It is also important to note that the NSW government has the ability under the *Water Management Act 2000* to reduce the volume of water taken by each water access license holder during drought to manage the cumulative impacts of pumping from rivers and bores. The available water determination for the last 10 years has not required any reduction in water access with 1 unit equalling 1 ML. However, the NSW government does have this option in times of drought to sustainably manage the impacts of extraction. KEPCO has previously indicated that the management of their agricultural and mining operations will be adjusted if this circumstance ever arises to ensure the Project's water extraction remained within the allocated limits.

3.4 Post mining water take and entitlements

Anderson (2018) commented that the further modelling conducted for the revised mine plan summarised in the DPE Assessment report (from AGE 2018) did not include updated predictions of post mining water take. Post mining model predictions from the EIS (AGE 2015) indicated that when pumping from the mine and borefield ceases, the water take would gradually reduce and could adequately be accounted for by water licenses held by KEPCO. Therefore, subsequent interactions to the numerical model focussed on impacts during the operational stages. However, for completeness, the table within Attachment A provides predictions of water take during mining and post mining based on modelling described for the reduced mine footprint by AGE (2018). As noted, when mining is completed, pumping from the underground mine and the borefield will cease. Groundwater will flood the mining areas and a new equilibrium condition will gradually be established. The table within Attachment A shows that the post mining water take will gradually reduce over a period of 100 years with a net increase possible after this time due to enhanced recharge through the mining areas. The water take post mining is significantly less than the peaks predicted during the operational period and less than the entitlements currently held (or will be held) by KEPCO throughout the operations to offset its water takes from the various water sources. Therefore, the measures to manage post mining impacts remain appropriate as KEPCO will have obtained sufficient entitlements during operations to surrender post mining and permanently offset the residual impact occurring as the groundwater systems recovers to a new equilibrium.

4 Water Management Plan

The presentation from Anderson (2018) to the IPC requests further information including model updates, water management measures including triggers and make good agreements. KEPCO is significantly advanced in this area and has prepared a draft Water Management Plan (WMP) (as part of the Response to PAC Review Report) to provide further information around the proposed management of water resources associated with the Project. The draft WMP provides information on the proposed groundwater monitoring, management and mitigation measures that will be implemented throughout the life of the Project. The Groundwater Management Plan within the draft WMP outlines the continuing monitoring during the life of the Project, and additional monitoring sites that will be installed to improve the ability to detect impacts early. The monitoring program is designed to supply information that will be analysed every quarter and if predetermined limits are exceeded, an investigation will be triggered. Trigger Action Response Plans (TARPs) have been developed which utilise trigger thresholds to provide an early warning of potential impacts, and higher level triggers to mitigate, manage and remediate any impacts. Regular updates to the groundwater model also described.

KEPCO is also in the process of negotiating Compensatory Water Supply Agreements (Make Good Agreements) with neighbouring landholders (13 landholders), the intention of which is to provide further certainty for neighbouring landholders including short term water supply provisions to protect landholders should unforeseen impacts occur. These agreements would require the installation, reading and maintenance of meters to record hours of operation of pumps and volumes of water taken at the expense of KEPCO (if the Compensatory Water Supply Agreements are taken up). Installation of ‘cheap’ water meters on landholder bores is suggested by Anderson (2018). Australian Standard water meters will be installed where Compensatory Water Supply Agreements are entered into.

5 NSW groundwater policies

Anderson (2018) provide a range of comments and suggestions to improve groundwater policies and management in NSW. Comments are also provided on the draft conditions of approval. These comments are matters for NSW government consideration.

6 Project team qualifications and experience

All groundwater modelling for the Project has been conducted by AGE. AGEs mission is to provide robust advice about the impact of major projects to enable decision makers and industry proponents to make informed decisions about groundwater management. The groundwater impacts have been assessed by a consistent team at AGE since the Project's environmental studies commenced in 2011/12. The groundwater investigations have been managed by Principal consultant James Tomlin, with numerical modelling conducted by Senior consultant Neil Manewell.

James Tomlin has a BSc undergraduate degree from Griffith University 1992 and a MSc in Hydrogeology and Groundwater Management from the University of Technology Sydney 1999. James has investigated the impacts of numerous major projects on groundwater though the last 19 years with AGE and 24 years as a consultant. This has included assessing impacts for coal mines in NSW adjacent to alluvial aquifers in the Hunter Valley including the Bengalla, Dartbrook, Mount Thorley Warkworth, Hunter Valley Operations, Integra Underground and Mount Owen Operations. James has also managed groundwater investigations for major projects and mines in the Gunnedah Basin of NSW that are located adjacent to alluvial groundwater systems including Boggabri Mine, Maules Creek Mine and the Watermark Project. Finally, James has broader experience assessing groundwater impacts from mines and quarries in QLD and NSW across a broad range of environmental and geological settings including the Great Artesian Basin.

Neil Manewell has BSc (Geology) 2005, and a MSc (Hydrogeology/Engineering Geology) 2008 from the University of Canterbury New Zealand. Neil has 11 years' experience working as a groundwater modeller assessing the impacts of major projects in Australia and overseas focusing on coal, iron ore, metalliferous mining and coal seam gas projects. Neil has significant experience in the Hunter Valley having conducted numerical modelling for the following mines: Mangoola mine, Mount Owen Operations, Integra Underground and Hunter Valley Operations. Outside the Hunter Valley, Neil has also prepared numerical models for the Watermark Project, Caroona Project, Surat Basin coal seam gas projects and Galilee Basin mining projects.

Peer review of the numerical modelling was conducted by Dr Noel Merrick from Hydrosimulations. Dr Merrick is a groundwater modeller, hydrogeologist and geophysicist with over 40 years' experience in groundwater management issues and policies. He retired in 2009 as an Associate Professor at the University of Technology, Sydney, where he was Director of the National Centre for Groundwater Management and ran courses in Groundwater Modelling, Groundwater Geophysics and Groundwater Policy and Management. Since then he has specialised in providing groundwater modelling and peer review services, particularly for the mining industry.

Dr Merrick was a member of the NSW working group that drafted the State Groundwater Policy documents and recently has been instrumental in the final form of the NSW Aquifer Interference Policy. He has participated on several expert panels for the NSW government, is a salinity auditor for the Murray-Darling Basin Authority, and has been a modelling adviser to the Commonwealth government and to five State governments.

7 Summary and conclusions

We have reviewed the submission from Anderson (2018) and responded to the subject themes raised within this document. The Anderson (2018) review discussed topics that have previously been raised by other submissions and we have drawn from previous work by AGE to respond. It is concluded the matters raised do not result in any changes to the magnitude of environmental impacts and the committed management and mitigation measures for the Project (as encompassed by the Recommended Development Consent conditions) remain appropriate.

8 References

Australasian Groundwater and Environmental Consultants Pty Ltd (2015). *"Bylong Coal Project Groundwater Impact Assessment"*, Prepared for Hansen Bailey Pty Ltd, June 2015, G1606.

Australasian Groundwater and Environmental Consultants Pty Ltd (2016a). *"Bylong Coal Project Response to Submissions on Groundwater"*, Prepared for Hansen Bailey Pty Ltd, March 2016, G1606E.

Australasian Groundwater and Environmental Consultants Pty Ltd (2016b). *"Bylong Coal Project Response to Submissions on Groundwater"*, Prepared for Hansen Bailey Pty Ltd, September 2016, G1606.

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Appendix A Tabulation of water licencing requirements – during and post mining

Table A.1 Model water budgets and water licensing for the Revised Project mine plan

Year	Numerical model water budget item (ML/year)					Water licensing (ML/year)					
						Hunter Unregulated WSP			North Coast WSP		
	(a) Permian to alluvium flow change	(b) borefield pumping	(c) agricultural pumping (capped)	(d) stream flow change	(e) mine inflow	(f) Surface water take (=d)	(g) Ground water take (=a+b+c-d)	Total water take (=f+g)	Ground water take (=e)	Surface water take (=0)	Total water take (=e+0)
1	0	0	714	0	0	0	714	714	0	0	0
2	0	0	714	0	6	0	714	714	6	0	6
3	-73	1,000	714	372	44	372	1,269	1,641	44	0	44
4	-76	1,150	714	529	54	529	1,259	1,788	54	0	54
5	-65	1,100	714	641	53	641	1,108	1,749	53	0	53
6	-88	1,189	714	502	49	502	1,313	1,815	49	0	49
7	-78	1,071	714	565	76	565	1,142	1,707	76	0	76
8	-68	901	714	474	70	474	1,073	1,547	70	0	70
9	-17	960	714	920	702	920	737	1,657	702	0	702
10	3	960	714	662	1,675	662	1,015	1,677	1,675	0	1,675
11	41	800	714	729	2,065	729	826	1,555	2,065	0	2,065
12	55	720	714	630	1,812	630	859	1,489	1,812	0	1,812
13	13	710	714	383	1,498	383	1,054	1,437	1,498	0	1,498
14	9	710	714	421	1,148	421	1,012	1,433	1,148	0	1,148
15	10	710	714	489	1,006	489	945	1,434	1,006	0	1,006
16	0	710	714	417	725	417	1,007	1,424	725	0	725

Year	Numerical model water budget item (ML/year)					Water licensing (ML/year)					
						Hunter Unregulated WSP			North Coast WSP		
	(a) Permian to alluvium flow change	(b) borefield pumping	(c) agricultural pumping (capped)	(d) stream flow change	(e) mine inflow	(f) Surface water take (=d)	(g) Ground water take (=a+b+c-d)	Total water take (=f+g)	Ground water take (=e)	Surface water take (=0)	Total water take (=e+0)
17	-6	710	714	491	751	491	927	1,418	751	0	751
18	0	710	714	432	1,471	432	992	1,424	1,471	0	1,471
19	19	710	714	691	2,492	691	752	1,443	2,492	0	2,492
20	18	710	714	496	2,776	496	946	1,442	2,776	0	2,776
21	40	710	714	588	3,387	588	876	1,464	3,387	0	3,387
22	54	710	714	559	2,999	559	919	1,478	2,999	0	2,999
23	17	710	714	372	4,099	372	1,069	1,441	4,099	0	4,099
24	33	710	714	417	3,202	417	1,040	1,457	3,202	0	3,202
25	36	710	714	487	3,952	487	973	1,460	3,952	0	3,952
End of mining											
26	91	0	0	259	0	259	91	350	0	0	0
27	85	0	0	141	0	141	85	227	0	0	0
28	88	0	0	113	0	113	88	202	0	0	0
30	76	0	0	107	0	107	76	182	0	0	0
31	82	0	0	124	0	124	82	206	0	0	0
33	76	0	0	116	0	116	76	192	0	0	0
36	70	0	0	63	0	63	70	133	0	0	0

Year	Numerical model water budget item (ML/year)					Water licensing (ML/year)					
						Hunter Unregulated WSP			North Coast WSP		
	(a) Permian to alluvium flow change	(b) borefield pumping	(c) agricultural pumping (capped)	(d) stream flow change	(e) mine inflow	(f) Surface water take (=d)	(g) Ground water take (=a+b+c-d)	Total water take (=f+g)	Ground water take (=e)	Surface water take (=0)	Total water take (=e+0)
39	66	0	0	49	0	49	66	116	0	0	0
42	64	0	0	50	0	50	64	114	0	0	0
47	60	0	0	46	0	46	60	106	0	0	0
52	55	0	0	45	0	45	55	100	0	0	0
58	49	0	0	42	0	42	49	91	0	0	0
66	41	0	0	36	0	36	41	77	0	0	0
74	30	0	0	31	0	31	30	61	0	0	0
85	17	0	0	24	0	24	17	41	0	0	0
98	2	0	0	16	0	16	2	18	0	0	0
113	-14	0	0	8	0	8	-14	-7	0	0	0
132	-29	0	0	-2	0	-2	-29	-32	0	0	0
154	-40	0	0	-10	0	-10	-40	-50	0	0	0
181	-48	0	0	-15	0	-15	-48	-63	0	0	0
213	-53	0	0	-18	0	-18	-53	-71	0	0	0
251	-58	0	0	-24	0	-24	-58	-82	0	0	0
297	-63	0	0	-29	0	-29	-63	-92	0	0	0
343	-66	0	0	-31	0	-31	-66	-98	0	0	0

Year	Numerical model water budget item (ML/year)					Water licensing (ML/year)					
						Hunter Unregulated WSP			North Coast WSP		
	(a) Permian to alluvium flow change	(b) borefield pumping	(c) agricultural pumping (capped)	(d) stream flow change	(e) mine inflow	(f) Surface water take (=d)	(g) Ground water take (=a+b+c-d)	Total water take (=f+g)	Ground water take (=e)	Surface water take (=0)	Total water take (=e+0)
382	-69	0	0	-33	0	-33	-69	-102	0	0	0
430	-71	0	0	-35	0	-35	-71	-105	0	0	0
487	-71	0	0	-36	0	-36	-71	-107	0	0	0
525	-71	0	0	-36	0	-36	-71	-107	0	0	0