campbelltown
city council

16 January 2013

Mr H Reed
Manager Mining Projects
Major Projects Assessment
Department of Planning and Infrastructure
GPO Box 39
SYDNEY NSW 2001

Dear Mr Read

Camden Gas Stage 3 Project Application Response to Submissions Report

Council has previously provided a submission on the Environmental Assessment (EA) associated with the Camden Gas Stage 3 Project Application which outlined its objection to the project's determination on a number of grounds.

A submission on the 'Response to Submission Report' (RtS) associated with this project application, which was endorsed by Council at its meeting on 18 December 2012, and the following accompanying attachments is enclosed:

- A report produced by the Water Research Laboratory, who were engaged by Council to review the adequacy of the RtS in providing a comprehensive understanding of groundwater behaviour and impacts associated with the project.
- Summary of how the 'Response to Submissions Report' addressed Council's submission on the Environmental Assessment that accompanied the Camden Gas Stage 3 Project Application

Please be advised that following its consideration of a report regarding the 'Response to Submissions Report', Council resolved to:

> *Continue to object to the determination of the project application based on inadequate assessment of the risks to groundwaters and fugitive greenhouse gas emissions as well as inadequate response to previously raised issues regarding deficiencies in the assessment of impacts associated with the proposed development particularly in regard to cumulative impacts on water resources and impacts on biodiversity.*

Council further resolved at this meeting to request the NSW Department of Planning and Infrastructure to require the inclusion of a number of matters in the Terms of Reference for investigation by the Planning Assessment Commission (PAC) that are referred to in the attached submission.

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I need to advise the Department that notwithstanding the information raised in the Response to Submissions Report, Council is still of the view that the Camden Gas Stage 3 Project must not proceed given the potential risks to the environment and the community.

Insufficient information has been made available that can assure Council that the environment and the community will not suffer any deleterious impacts.

Council has received an invitation from the PAC to discuss issues raised in its submission at a meeting on 24 January 2012. It would therefore be appreciated if the attached submission and accompanying attachments could be forwarded to the PAC for their review prior to this meeting.

If you require any further information please contact Council's Director Planning and Environment, Jeff Lawrence, on (02) 4645 4576.

Yours sincerely

Michael Sewell
Acting General Manager

Submission on the Camden Gas Stage 3 Project Application Response to Submissions Report

Council has previously provided a submission on the Environmental Assessment (EA) associated with the Camden Gas Stage 3 Project Application which outlined its objection to the project's determination on a number of grounds. Council has since raised concern over shortcomings in scientific knowledge on the risks to groundwaters presented by coal seam gas extraction in representations to the NSW Government and resolved to:

> *Make further representations to the Minister for Resources and Energy requesting that no new licences for Coal Seam Gas mining or exploration be approved or renewed until such time as scientific evidence guarantees that such activities do not compromise the environment or health and safety of the community.*

Following a detailed review of the Response to Submissions Report, Council wishes to advise the NSW Department of Planning and Infrastructure of its continuing objection to the project application. This submission outlines the requested action by the NSW Department of Planning and Infrastructure (DP&I) to address deficiencies in the Response to Submissions Report which has failed to respond to Council's previous concerns. An assessment of the response by the proponent to each issue raised in Council's previous submission by the proponent is presented in Table 1 (Attachment 1). This submission was endorsed by Council at its meeting on 18 December 2012

a) Issues associated with the project application

Issue 1: Provision of additional detail regarding operational aspects of the Rosalind Park Gas Processing Plant

Council requests that the DP&I seek further amendment of the application to include the nomination of wells where 'in-field processing' is likely to be required, as well as potential impacts associated with the construction and operation of 'in-field infrastructure'. Council further requests that the Planning and Assessment Commission (PAC) be asked to investigate this matter as part of its merit assessment of the amended application.

Issue 2: Permissibility of the project at State and local level

Council strongly opposes coal seam gas extraction activities in environmental sensitive areas such as the Scenic Hills given the inconsistency that exists between such activities and the values and planning objectives for such areas. In this regard, Council is of the view that the proposed development is inconsistent with a number of relevant objectives in the current local planning instrument that applies to this district (LEP D8 Central Lands).

Issue 3: Inadequate description of the groundwater environment and potential impacts of the development on this environment

A specialist and independent consultancy, 'The Water Research Laboratory' (WRL) was engaged by Council to review the adequacy of the Response to Submissions Report in providing a comprehensive understanding of groundwater behaviour and the assessment of impacts associated with the application. The report produced by the WRL is presented in Attachment 2.

Council requests that the DP&I seek further amendment to the project application to address all items raised in the attached WRL report. Council also requests that the DP&I seek further amendment to the project application to include details of its compliance with the requirements of the Government's Aquifer Interference Policy and Codes of Practice for Hydraulic Fracturing (Fraccing) and Well Integrity and the Gateway Process associated with the NSW Government's Strategic Rural Land Use Policy. In addition, Council further

requests that the PAC be asked to investigate the accuracy of the predicted dewatering volumes and resolve the risks to the groundwater environment posed by the Project. This request is in response to the advice in the WRL report that the lack of certainty of the conceptual modelling in determining the extent of interconnectivity between groundwater aquifers can only be adequately addressed by further computerised modelling that is supplemented by extensive groundwater drilling and sampling.

Issue 4: Inadequate assessment of potential impacts on surface waters during the installation and operation of gas extraction wells and gas gathering lines

Council requests that the DP&I seek further amendment of the project application to include the specification of those watercourses (with both permanent and non-permanent flow) intended to be crossed by gas gathering pipelines as well as intended procedures and mitigation measures. In addition, Council strongly requests that the DP&I require the proponent to place a full list of the volumes and types of chemicals to be used as drilling additives and any hydraulic fracturing (fraccing) operations on its website as soon as practically possible and in any distributed information regarding the project.

Issue 5: Inadequate assessment of potential impacts on biodiversity and precise identification of the extent of vegetation clearance as a consequence of the project

Council requests that the DP&I seek further amendment of the project application to include an enhanced description of intended assessment of surveys, assessments and commitments for site rehabilitation to more adequately apply to both gas wells and gas gathering pipelines. In addition, the DP&I is requested to obtain clarification from the proponent over the apparent inconsistencies between the main body of the Response to Submissions Report and the supporting Specialist Report regarding the actual extent of remnant Endangered Ecological Communities to be cleared.

Issue 6: Inadequate assessment of fugitive methane emissions associated with the project and shortcomings in scientific knowledge regarding this matter

Council requests that the DP&I seek further amendment of the application to include a detailed quantitative assessment of fugitive emissions associated with the project application that is not restricted to gas extraction well sites. Council further requests that the PAC be asked to investigate this matter in detail in relation to both the project application and the Coal Seam Gas Industry.

Issue 7: Inadequate assessment of potential impacts associated with individual gas extraction sites and sections of gas gathering pipelines

Council requests that the DP&I require the further amendment of the project application to include an assessment of all direct and indirect impacts associated with the installation and operation of gas extraction wells and sections of gas gathering lines that includes potential impacts on the local community.

b) Other issues raised in Council's submission

The requested action by the DP&I to address deficiencies in the Response to Submissions Report in addressing other issues is provided in Table 2

Table 2: Requested action by the DP& in relation to other issues raised in Council's submission

Issue raised in Council's submission	Requested DP&I Action
Impacts of the proposed access wells by the initial application on local roads	Require the proponent to prepare Traffic Management Plans for each well site that is consistent with Council's requirements.
Deficiencies in the assessment of potential impacts on items of Aboriginal Heritage	Seek further amendment of the project application to include an updated Aboriginal Cultural Heritage Management Plan for the Camden Gas Project that specifically applies to the Stage 3 Project Area.
Deficiencies in the assessment of issues associated with land sterilisation	Request the Planning Assessment Commission to investigate this matter as part of its investigation into land use conflicts associated with the project application within the Scenic Hills.
Potential health and environmental impacts associated with lateral drilling in the subsurface project area	Request the Planning and Assessment Commission to investigate potential health, environment and safety impacts associated with lateral drilling within the subsurface project area given that this area underlies most of the urbanised portion of the Campbelltown Local Government Area.

c) Conclusion

This submission has outlined a range of deficiencies in the Response to Submission Report in responding to issues previously raised by Council. These include an inadequate assessment of the risks presented to groundwater sources by the Project confirmed by specialist advice commissioned by Council which further justifies Council's continuing objection to the project's determination. In addition, the submission has requested that a number of items be investigated by the Planning Assessment Commission as part of its merit assessment. In this regard, Council requests being provided with an opportunity to present its position on the amended project application at any Public Hearing conducted as part of the assessment.

SUBMISSION ON THE CAMDEN GAS STAGE 3 PROJECT APPLICATION 'RESPONSE TO SUBMISSIONS REPORT' - ATTACHMENT 1: TABLE 1

Assessment of the response to each issue raised in Council's submission on the Environmental Assessment

Issue	Requested amendments in Council's submission on the draft amended EA	Adequacy of addressing comment			Comment on response
		Nil	Partial	Full	
1. Operational aspects of the project					
1.1 Finalisation of the layout of the project	AGL be required to undertake site design studies that at a minimum would enable the intended location of wells and pipeline within each envelope to be identified.	√			The RtS confirms the comment in the EA in relation to this matter.
1.2 Inclusion of subsidiary sub plans	AGL be required to prepare sub-plans, and in particular, a detailed Soil and Water Management Plan that are specifically related to Stage 3 of the CGP prior to project approval.	√			The RtS confirms the comment in the EA that existing generic Plans applying to Stages 1 and 2 of the Camden Gas Project will be utilised.
2. Issues associated with the processing of extracted gas					
2.1 In-field processing	The EA be amended to include the following prior to public exhibition: • The nomination of the well sites within the project area where 'in-field processing' will be required; • The description of construction and operational details associated with the 'in field' process; and • The assessment of potential impacts associated with the 'in field' process on a site specific basis for each relevant well site and appropriate site specific environmental safeguards. .	√			The RtS confirms the comment in the EA by stating that the need for in-field processing cannot be determined for operational reasons and will be subject to a separate application if required.
2.2 Air emissions	The EA be amended to provide further clarification in regard to any increase in emitted pollution levels from the facility as a consequence of the deletion of the Gas Processing Plant in the Scenic Hills.			√	The RtS contains a description that adequately addresses Councils submission.

Issue	Requested amendments in Council's submission on the draft amended EA	Adequacy of addressing comment			Comment on response
		Nil	Partial	Full	
3. Surface water related impacts					
3.1 Potential impacts associated with the construction and operation of well sites	The EA be amended to include a site specific description and assessment of impacts associated with the construction and operation of well sites prior to its public exhibition.	✓			The RtS states that Site Layout Plans will be prepared for approved wells prior to commencement of operations.
	The EA be amended to include an assessment of the potential for evaporation from the settling ponds at gas extraction well sites.			✓	The RtS has largely addressed Council's comment by stating that lined pits will not be used for evaporation purposes and that retrieved water will be stored in enclosed tanks.
	The EA be amended to include a comprehensive description of the intended volumes and types of chemicals, storage procedures and intended safeguards to prevent impacts on nearby surface waters at gas extraction well sites.	✓			The RtS provides additional information in relation to the holding of Material Safety Data Sheets. However, the RtS has not provided a definitive list as requested by Council the NoW, and the DP&I.
3.2 Salinity related impacts	AGL be required to prepare a site specific salinity assessment for any activity involving potential disturbance to groundwater as a component of the Soil and Water Management Plan to be submitted prior to project approval.	✓			The RtS has not provided any response to this comment raised in Council's submission.
3.3 Impacts on surface waters associated with the installation of gas gathering pipelines	The EA be amended to specify the precise location of pipelines intended to be located within waters.		✓		The RtS includes a map at a smaller scale however precise locations have not been specified.
	The EA be amended to include a more definitive assessment of potential impacts on surface waters and environmental safeguards specifically related to Stage 3 of the Camden Gas Project.	✓			The RtS does not include site specific assessments for individual sections of gas gathering pipelines.

Issue	Requested amendments in Council's submission on the draft amended EA	Adequacy of addressing comment			Comment on response
		Nil	Partial	Full	
4. Groundwater related impacts					
4.1 Compliance with applicable Director General's Requirements.	The EA be amended to include additional information that would demonstrate compliance with applicable Director General's Requirements regarding baseline data and assessment of impacts associated with the application.		✓		The RtS states that Government Agencies were satisfied with the compliance with the project DG Requirements.
4.2 Description of the groundwater environment	The EA be amended to include a description of the key aspects of the existing groundwater environment and clarification of the baseline data used to inform the hydrogeological conceptual model in the existing description.		✓		The RtS contains a significantly enhanced description to the EA. However, the WRL report identified deficiencies in the monitoring program and conceptual model.
4.3. Adequacy of detail and level of assessment of groundwater related impacts	The EA be further amended to provide a more comprehensive description of the proposed fraccing process, and in particular, the chemical additives intended for injection.		✓		The RtS has included a more detailed description of the Fraccing process. However this is based on the conclusions of the conceptual mode. The RtS has not listed chemicals to be used in drilling or fraccing operations.
	The EA be amended to provide a comprehensive description of the specific measures intended to minimise potential wellbore pathways during the drilling and construction program.		✓		The RtS states that aquifers are isolated but the possibility exists that they may be interconnected. The WRL report recommends assuming interconnectedness exists due to deficiencies in baseline data.
	The EA be amended to include a detailed assessment of impacts associated with the use of chemicals to comply with a DG Requirement.	✓			The RtS has confirmed statements in the EA regarding this matter.
	The EA be amended to assess the potential for gas migration through either wellbores or geological formations.		✓		The RtS has considered this matter and concludes the risk is minimal. However this conclusion is based on the hydrogeological conceptual model.
4.4 Impacts on the volumes of groundwater aquifers.	The EA be amended to include additional information regarding the current drawdown levels of groundwater aquifers and a detailed description of the geological formations and aquifers in the vicinity of the project area.		✓		The WRL report advised that the RtS had adequately identified the regional geological and hydrogeological setting. However, the WRL also identified a number of deficiencies in relation to the matter of dewatering aquifers.
	The EA be amended to provide a (cumulative) impact assessment to neighbouring aquifers, groundwater users and environmental receptors from the dewatering of the coal measures, and any proposed environmental safeguards (including any current and proposed groundwater monitoring program, trigger levels and investigation and response process)".	✓			The RtS has included significantly more information regarding this matter compared to the EA. However, the WRL report identified a range of deficiencies in regard to each of the items listed in Council's comment.

Issue	Requested amendments in Council's submission on the draft amended EA	Adequacy of addressing comment			Comment on response
		Nil	Partial	Full	
5 Biodiversity related issues					
5.1 Adequacy of the targeted surveys and assessment of impacts.	Council requests that AGL be required to consult with OEH to address previously identified deficiencies in the adopted 'envelope' approach prior to consideration of project approval.		✓		The application has been amended to reflect OEH comments to the satisfaction of the DP&I. However some outstanding deficiencies in this approach have been identified by the review.
	Council supports the request made in the DP&I submission that additional targeted flora and fauna surveys be undertaken for threatened flora and fauna species and populations potentially occurring within the Surface Project Area		✓		The RtS includes an updated specialist report that includes additional surveys. However, this specialist report is noted to advise that further surveys may be required in a number of defined envelopes.
	The DP&I require that site specific surveys and assessment of impacts be required prior to any drilling activity commencing	✓			The Biodiversity specialist report stated that additional assessment may be required. In this regard, clarification is needed over the circumstances in which additional assessment will occur.
5.2 Issues associated with clearance of vegetation.	The RtS is not considered to have provided an accurate description of vegetation to be removed associated with the installation of gas extraction well sites and gas gathering lines.		✓		The review identified discrepancies between the updated specialist report and main body of the document regarding this matter. In addition, the extent of clearance specifically associated with gas gathering pipelines has not been adequately considered.
	The RtS is not considered to have included the intended removal of 12.43 ha of grassland in the total area of Cumberland Plain Woodland to be cleared as a consequence of the project.		✓		The RtS states that no CPW will be cleared but that 4.88 ha of native shrubland will be cleared. In this regard, there is an absence of description over the composition of this shrubland.
6. Impacts on the landscape values of the Scenic Hills					
	It is requested that impacts on the distinct values of the Scenic Hills be considered as part of the site specific assessments (requested by Council) associated with individual gas wells as well as gas gathering pipelines. Impacts associated with the application have the potential to adversely impact on the implementation of strategic planning documents that apply to the district.		✓		The impacts on the district have been considered in a broad sense but not on a site specific basis. In this regard, the RtS states that the 'envelope' approach has essentially precluded the need for additional site specific assessments.

Issue	Requested amendments in Council's submission on the draft amended EA	Adequacy of addressing comment			Comment on response
		Nil	Partial	Full	
7. Aboriginal heritage related issues					
	There is an absence of measures for the protection of Potential Archaeological Deposits that specifically relate to the Stage 3 application.			✓	The RtS includes measures that would appear adequate subject to approval from OEH and Aboriginal groups.
	The Aboriginal Cultural Heritage Management Plan (applying to Stages 1 and 2 of the Camden Gas Project) be updated to specifically relate to Stage 3 of the Project prior to consideration of project approval.	✓			The RtS confirms statements in the EA that the existing Plan will be applied.
8 European heritage related issues.					
Protection of items of significance	Council would appreciate being notified of the details and timing of work that potentially impacts on State or local listed heritage items.			✓	The RtS has adequately responded to Council's request regarding this matter.
9. Issues associated with land sterilization					
	The EA be amended to discuss the potential implications of the project application on the layout and construction of new urban release areas and possible reduction in land values and associated reduction in revenue to Council in the form of rates.		✓		The amended location of wells has addressed Council's concerns regarding implications to the layout of new urban release areas in the Campbelltown LGA and associated possible reduction in land values. However, Council requests that the PAC investigate this matter as part of its investigation into land use conflicts associated with the project application.
	The EA consider the implications of the application to land that has been classified in the recently approved Campbelltown-Macarthur Structure Plan as future residential areas	✓			The RtS has not provided any response to this comment in Council's submission

Issue	Requested amendments in Council's submission on the draft amended EA	Adequacy of addressing comment			Comment on response
		Nil	Partial	Full	
10. Impacts associated with lateral drilling in the subsurface project area					
	The EA be amended to accurately quantify the short and long-term extent of surface subsidence that could occur within urban areas of the Campbelltown LGA as a consequence of lateral drilling in the subsurface areas			✓	The RtS states that a subsidence report prepared in regard to Stage 2 identified that subsidence impacts were minimal and that this was expected to be the case for Stage 3 given the similar geology
	The EA be amended to consider the potential for the upward migration of methane gas from the subsurface area given its location within the urbanised portion of the Campbelltown LGA.	✓			The RtS expresses the view the potential for upward migration of methane gas is minimum However, this conclusion is based on the hydrogeological conceptual model.
11 Issues associated with individual gas well extraction sites					
11.1 Potential impacts on biodiversity	The EA be amended to include a commitment that comprehensive surveys and assessment of impacts in accordance with OEH guidelines will occur for individual well sites prior to any site disturbance.		✓		The RtS has not included a commitment that specifically relates to Council's comment
11.2. Potential impacts on watercourses	Council considers it imperative that the proposed Soil and Water Management Plan consider direct and indirect impacts associated with each well site on all potentially affected drainage lines within a subcatchment context and that this Plan be prepared prior to any consideration of project approval	✓			The RtS states that "Site Layout Plans" will be prepared for individual well sites following approval.
	One well site (CU 26) is requested to be relocated due to unacceptably high potential for impacts on nearby watercourses	✓			This well site has been retained in the amended application.

Water Research Laboratory

Peer Review of Camden Gas Project Groundwater Investigations

WRL Technical Report 2012/26
December 2012

by
B M Miller and A M Badenhop

UNSW
THE UNIVERSITY OF NEW SOUTH WALES

Water Research Laboratory
University of New South Wales
School of Civil and Environmental Engineering

Peer Review of Camden Gas Project Groundwater Investigations

WRL Technical Report 2012/26
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By

B M Miller and A M Badenhop

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1. Introduction

AGL Energy Limited placed on public exhibition an Environmental Assessment (EA) accompanying a Development Application for Stage 3 of the Campbelltown Local Government Area (LGA) in December 2010. This application sought to extend operations associated with this project across most of the central and western areas of the LGA.

Campbelltown City Council (Council), as well as applicable Government Agencies, raised a number of concerns and potential deficiencies regarding the groundwater component of the EA. AGL subsequently has placed on public exhibition its "Response to Submission Report" that details their reply to issues raised in submissions received on the EA.

Council has sought a peer review of groundwater related issues of the AGL response from submissions received, to assist in its representations to the NSW Department of Planning and Infrastructure. The University of New South Wales, Water Research Laboratory (WRL), was commissioned by Campbelltown City Council in November 2012, to undertake this technical review.

The specific documents reviewed were downloaded from the "Response to Submissions and Amended Development Application" section of the Department of Planning's web page:

http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=2921

In particular the review has concentrated on:

- Appendix B: "Phase 1 Groundwater Assessment and Conceptual Hydrogeological Model – Northern Expansion of Camden Gas Project," December 2010, AGL Energy Ltd, Parsons Brinckerhoff
- Appendix C: Letter Report of the 13th August 2012 from Parsons Brinkerhoff to AGL Energy Ltd, "Update on the Camden North Phase 2 Groundwater Program - Denham Court Road"
- Appendix D: "Groundwater Management Plan for the Camden Gas Project", 16 July 2012, AGL Energy, Ltd

The questions posed to WRL by Council and addressed in this report are summarised as:

- Have the reports adequately addressed and investigated groundwater flow and aquifer behaviour?
- How appropriate is the conceptual model and have the uncertainties been identified?
- Are there any environmental risks to surface and groundwaters and, if so, have they been identified in the reports?
- Does the monitoring well configuration provide adequate data for a comprehensive analysis of groundwater flows and aquifer behaviour?
- Are the proposed monitoring triggers appropriate to prevent irreversible damage to groundwater resources?
- Is a mathematical model required to analyse groundwater flow and aquifer behaviour?

These questions are addressed throughout the body of the report and summarised in Section 6 – "Key Findings".

2. Literature Review

The AGL (2010) report contains a satisfactory review of the limited available groundwater investigations in the Campbelltown area. WRL completed a search for additional literature using the WRL Water Reference Library for reports and relevant academic articles to identify any additional information. It was outside the scope of this work to review in detail the background references used to form the conceptual model in the AGL report.

The majority of groundwater investigations performed in the area pertain to water resources within the Hawkesbury Sandstone, with many recent investigations being completed during the recent drought period within Sydney. There are no additional studies directly related to the area, however, studies from the Southern Coalfield further to the south give indications regarding the risk and uncertainties involved with the strata. For instance, during panel and pillar mining at the Wongawilli Mine, sudden inflows of water to the mine workings were found to be coming from the Avon Storage via a dyke acting either directly or indirectly as a conduit for water (Whitfield, 1988). In its natural state, most of the flow was found to be horizontal and confined within each strata due to low permeabilities, however mining was found to disrupt the groundwater regime over at least half the overlying strata, rather than the one third that had been assumed. The Stanwell Park claystone and Wombarra Shale are acknowledged to be thin in this area. This example lends weight to the statement that hydraulic pathways may be found through claystones. In this instance, depressurisation may lead to tensional effects with associated fracturing.

AGL (2010) acknowledged that there may be a small groundwater contribution to the baseflow of local stream headwaters. South Creek, a tributary of the Hawkesbury-Nepean, which has its headwaters within the study area may have 20-90% of baseflow sourced from the Wianamatta Shales (Markich & Brown, 1998), based on the study of water chemistry.

WRL was specifically requested to review the following four references.

NOW (2010) Draft Water Sharing Plan for the Greater Metropolitan Region unregulated river water sources: background document. NSW Office of Water, May 2010.

> This plan proposes rules primarily for governing the extraction of surface water. As there is little expected influence on any surface waters, this plan has limited relevance. The plan does refer to the more specific *Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2010*. The more specific plan is targeted primarily at determining the upper limit of possible extractions and describes rules for granting and managing access licences and siting of groundwater works. WRL considers that AGL have adhered to these rules for the Camden Gas Project.

SCA (2006). Groundwater – Investigations for Drought Water Supply. Metropolitan Groundwater Investigation Report GW026-06-06V1. Sydney Catchment Authority (2008).

> The conceptual models developed during the SCA investigations cover broader regions than those presented by AGL for the Camden Gas Project, but they do not consider interactions into the Narrabeen Group aquifer. Their work targets potential groundwater sources from the upper aquifers and the Hawkesbury Sandstone while concluding there are negligible losses to the Narrabeen Group. This supports the AGL general premise that there is limited interconnectedness between the lower aquifer layers.

Hawkesbury-Nepean CMA (2005). The River Health Strategy for the Hawkesbury Nepean Catchment. Hawkesbury Nepean Catchment Management Authority.

This strategy identifies groundwater as an important resource in particular for the health of some wetlands. However, it has limited relevance to the Camden Gas Project.

Hawkesbury Nepean Trust (1998). The Geomorphology of the Hawkesbury-Nepean River System.

This report was not available to WRL in time for this review. However, we do not expect that it would include any further information than already described in AGL (2010).

3. Conceptual Hydrogeological Model

3.1 Adequacy of the Conceptual Model

The conceptual model described in AGL (2010) can be summarised as four vertically layered aquifer systems (the alluvial surface aquifer, Hawkesbury Sandstone, Narrabeen Group and Illawarra Coal Measures) with low interconnectedness between aquifers.

The report adequately identifies the conceptual model of the aquifer systems present and is based on available information. However, as stated in the AGL report, there is no data available to address vertical connectivity between aquifers or to quantify horizontal gradients of flow within each aquifer.

The report states *"Of key relevance to understanding the potential impacts to shallow groundwater resources, groundwater dependent ecosystems and surface water, is the degree to which the Illawarra coal measures are in vertical connection with overlying aquifer zones within the Narrabeen Group, Hawkesbury Sandstone and thin alluvial deposits"*. WRL agrees with this statement and considers it the greatest uncertainty of the conceptual model.

The report also states that insufficient bore data was available to generate piezometric water level contours, so horizontal gradients within each aquifer are only based on the regional understanding of flows to the north or north-east.

The conceptual hydrogeological model has the underlying premise that depressurisation of the coal seams is unlikely to induce vertical flow of groundwater from the shallow beneficial aquifers due to the presence of low permeability claystone layers. The reports do not present any sensitivity testing of varying interconnectedness to demonstrate the range of potential impacts to the upper aquifers.

As such, the conceptual model has not described:-

- What depressurisation is expected from the 37 ML/annum that AGL are licenced to extract from the Illawarra Coal Measures and what is the lateral extent of the depressurisation?
- What lateral flows are expected within this aquifer and what ongoing extractions may be required to maintain the required depressurisation for coal seam gas extraction?
- What are the ranges of drawdowns in the upper aquifers possible/likely with varying degrees of interconnectedness?
- If there is a greater degree of horizontal or vertical interconnectedness, how will the projected pumping rates be affected?
- When extraction ceases, how long will it take for the Illawarra Coal Measures to re-pressurise?
- What flows might be expected through the aquitards if the pressure gradient remains for extended (>100 year) periods?

The existing conceptual model could be used to address these questions by sensitivity testing ranges of parameters. The uncertainty in the window of predictions could only be reduced with further data collection. Without such data collection, the accuracy of the conceptual model cannot be confirmed and therefore the findings must be presented as an envelope of possible outcomes.

3.2 Cumulative Influences

The cumulative influences of multiple extraction sites should be considered within the conceptual model. This is directly related to the first question above "What depressurisation is expected from the regulatory 37 ML/annum extracted from the Illawarra Coal Measures and what is the lateral extent of the depressurisation?"

The general concept of multiple activities behaving similar to single point activities should remain provided that the vertical conceptual model is reasonable over the entire lateral extent. No data exists to demonstrate this, so the reports should provide further justification and qualification of predictions.

Interaction with other activities can only be addressed by considering the lateral extent of depressurisation. This information has not been provided.

By undertaking multiple activities over a greater lateral region, the likelihood of finding some vertical interconnectedness is increased.

3.3 Interconnectivity with Surface Waters

The AGL Camden Gas Project groundwater reports state the following main points regarding connection with surface waters:

- "there may be a small baseflow or interflow discharge component to local stream headwaters during wet periods. Surface water-groundwater interactions in the wider area, however, are not well defined."
- No GDE's have been identified in the area.

WRL agrees with this understanding of surface water connectivity, with the exception that baseflows to South Creek from Wianamatta Shales were discussed in Markich & Brown (1998) (see Section 2).

However, the conceptual model is based on the premise of limited connectivity between aquifer systems. If it is assumed that depressurisation of the coal seams will not cause drawdown in the Hawkesbury Sandstone, it logically will not have any impact on surface waters. Consequently, the limitations of the AGL Camden Gas Project groundwater reports in defining any risks to surface waters are inherently the same as the limitations in defining risks to groundwaters.

3.4 Requirement for a Mathematical Model

WRL does not recommend that a groundwater computer model be developed at present. All models have inherent uncertainty depending on the boundary conditions and geometry and in this instance the greatest uncertainty is the interconnectedness between layered aquifers. Complex numerical modelling cannot reduce this uncertainty without commensurate field data collection. If substantially more data were collected in the future, then a computer model may provide refined process understanding.

A groundwater computer model would need to be run for an extremely large number of sensitivity scenarios and the outcomes would, in our opinion, have no more certainty than a desktop analysis.

WRL believes the report would benefit from an experienced hydrogeologist undertaking desktop assessment of the range of depressurisation likely in each of the aquifers with varying interconnectedness.

Specification of a data collection program required for the measurement and understanding processes for development of a computer model is beyond the scope of works for this review. However, it should include time series measurement of water levels and water chemistry in each strata at no less than four locations about the extent of the region being considered. These monitoring bores should measure variations in natural conditions and the response to induced drawdown (pumping trials).

Guidelines for the design of data collection programs for the development of numerical models can be found in the "Australian Groundwater Modelling Guidelines" (Barnett *et al*, 2012).

4. Groundwater Monitoring

4.1 Groundwater Monitoring Network

4.1.1 Monitoring Well Configuration

This review does not include the monitoring configuration for the existing Camden Gas Project (CGP) area, but relates only to the proposed Northern Expansion.

Details of the proposed groundwater monitoring network for Phase 2 investigations are described within AGL (2012) "Groundwater Management Plan for the Camden Gas Project". The Plan aims to "provide a framework which describes how AGL will assess any changes in the different groundwater systems located beneath the CGP area, particularly the shallow beneficial aquifers, due to dewatering of the deep coal seams." The shallow beneficial aquifers have been defined as the Wianamatta Shales and the Hawkesbury Sandstone. AGL have proposed installation of nests of three (3) monitoring bores at three (3) locations in the northern expansion area that will only target these shallow aquifers. The three (3) sites proposed are summarised in Table 1 and shown in Figure 1.

Table 1: Monitoring Bores in the Northern Expansion

Location	AGL Reason for Location	Status
Denham Court	Undisturbed strata. Within 400m of a well pad location to assess any connectivity and drainage from shallow aquifers	Installed RMB01 - Screen: 69-81 m.b.g. (Ashfield Shale) RMB02 – Screen: 135-147 m.b.g. (Hawkesbury Sandstone) RMB03 – Screen: 288-297 m.b.g. (Hawkesbury Sandstone/Newport Formation)
Currans Hill	Undisturbed strata. Within 400m of a well pad location to assess any connectivity and drainage from shallow aquifers	Proposed
Varroville	Control site will be distant from any well pad so as to avoid severe areas of depressurisation. Background location in area of minor faulting system. Any potential pathways between shallow and deep aquifers/water bearing zones as a result of the fault systems	Proposed

The plan also states that alluvial aquifers will be monitored where there is a gas production well within 1 km of the alluvium, however, no locations have been specified for such monitoring within the plan.

As stated within the AGL Groundwater Management Plan, the aim of the monitoring bores is only to assess impacts within the shallow beneficial aquifers. As such, it is not designed to provide data for a comprehensive analysis of groundwater flows and aquifer behaviour. At each location, it will be possible to obtain relative heads and likely vertical gradients within the shallow aquifers, however this will not provide any information regarding lateral flow. In areas dominated by fracture flow, it will be very difficult to determine the direction of groundwater flow.

The proposed monitoring well configuration in the northern expansion (AGL, 2012) will not give any information regarding groundwater flows and aquifer behaviour in lower aquifers and aquitards. It cannot provide any indication of whether the strata deemed as aquitards are behaving as aquitards or aquifers or how leaky they may be. To obtain this information, additional nested bores would be required, targeting underlying strata, including the claystones. AGL have given the following reasons for not monitoring the Bald Hill Claystones (AGL, 2012):

- "It is most unlikely there will be any beneficial groundwater resources below 300m depth.
- There is no historical use of any groundwater from depths greater than 300m.
- The groundwater at this depth is unlikely to be linked to any ecosystems.
- Groundwater in the Narrabeen Group sandstones will most likely be moving laterally rather than being recharged by shallow groundwater resources through the Bald Hill Claystone aquitard.
- There are two more aquitards/aquicludes below the Bald Hill Claystone (Stanwell Park Claystone and the Wombarra Claystone) that will inhibit vertical leakage.
- If the Bald Hill Claystone is leaky, the basal monitoring bore in the Hawkesbury Sandstone will also react to depressurisation and provide early warning of aquifer drainage."

These reasons neglect the inherent value of quantifying the groundwater processes and flows occurring in all of the strata. Should water level declines occur in the Hawkesbury Sandstone that are attributable to the dewatering of coal seams at depth, AGL have stated that they will install a monitoring bore into the deeper strata below the Bald Hill Claystone to confirm trends. However, this bore would not allow for baseline monitoring within the Bald Hill Claystone to obtain an understanding of groundwater processes that occurred pre-development.

Monitoring of the coal seams is also important to determine how the coal seams will be recharged in the future. While depressurisation may not cause immediate impacts on overlying strata, over time frames of decades or centuries, depressurisation will eventually drawdown overlying waters through leaky aquitards if the coal seams are not recharged. AGL proposes the use of depleted gas wells for monitoring the different aquifer systems in the current Stage 1/Stage 2 existing Camden CSG area, including the very deep groundwater in the Illawarra Coal Measures and the Narrabeen Group, as well as the Hawkesbury Sandstone aquifer. It may be possible to use this data to infer likely recharge mechanisms within the coal seams of the Northern Expansion area, depending on the configuration of wells used, however the groundwater monitoring network and program needs to be planned to encompass this purpose. AGL have also stated that they will monitor water quality at some production wells in the Northern Expansion area similar to the current program for the CGP. However, they have not nominated the number of sites nor which locations they will target.

The conceptual hydrogeological model described in AGL (2010) assumes that depressurisation of the coal seams is unlikely to induce vertical flow of groundwater from the shallow beneficial aquifers due to the presence of low permeability claystone layers. However, it is acknowledged that "the possibility cannot be ruled out that major fault zones could provide a hydraulic pathway through claystone horizons and that some shallow groundwater impacts may be observed close to those structures". As the proposed monitoring bore locations have not been overlain on the map showing the locations of faults, it is difficult to determine the exact intent of locations. The descriptions of the locations, however, suggest that it is only intended that one of the monitoring bores target minor faulting, and that this is intended to be a control site. Given the potential for faults to significantly influence groundwater flows, it is suggested that several nests of

monitoring bores should be located close to faults in the central area of the northern expansion, in as close proximity to intended wells as possible. It would be preferential to install these monitoring bores as soon as possible to allow collection of adequate baseline datasets. This would also help to characterise the spatial variability of groundwater quality across the site, as identified in AGL (2010).

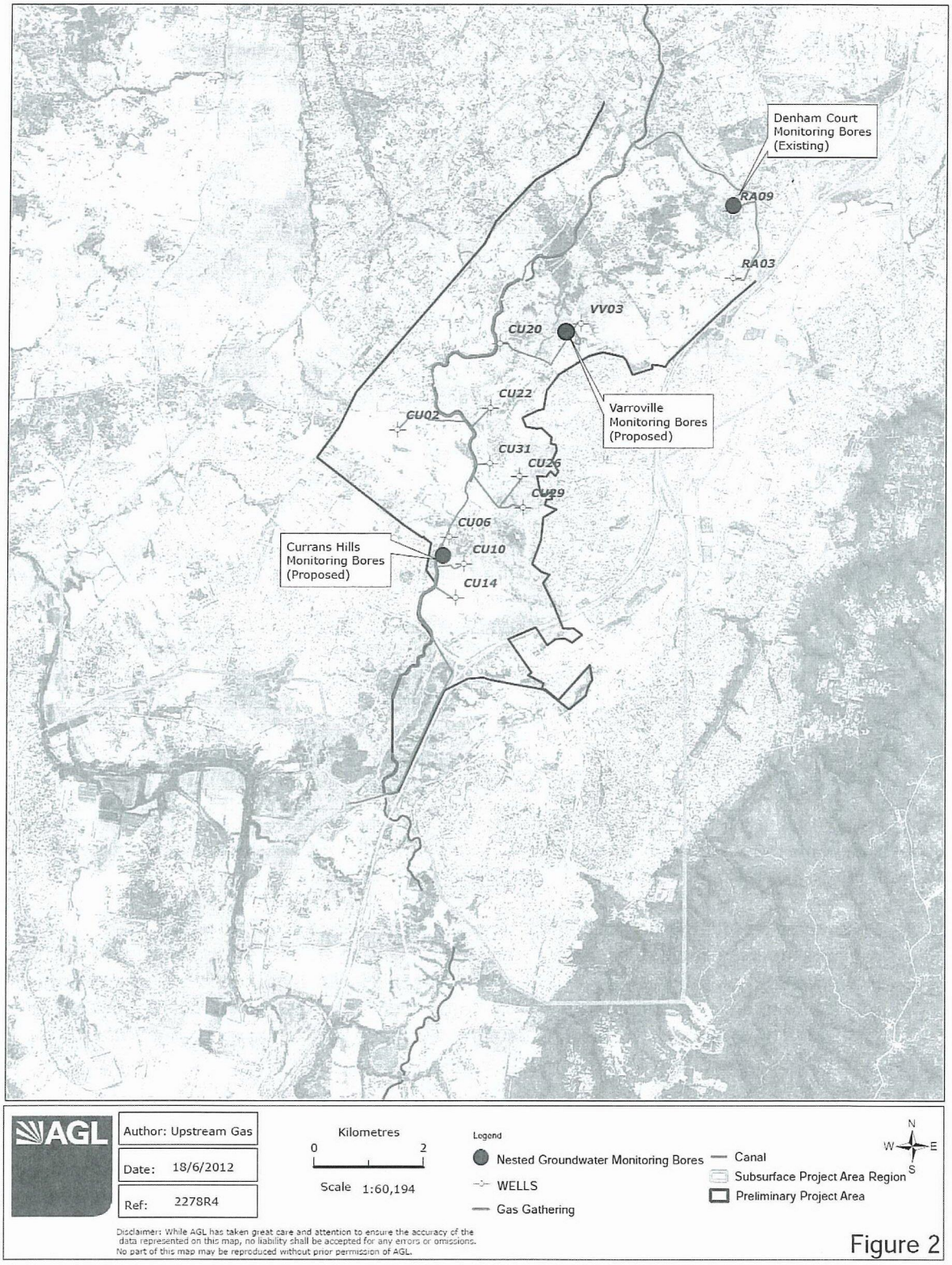

Figure 1: Monitoring Bore Locations (Source: AGL, 2012)

4.1.2 *Monitoring Triggers*

AGL (2012) proposes to use measured changes in water level, beneficial use (based on salinity) and water quality as triggers to induce management responses as defined in their Groundwater Management Plan. Monitoring triggers have not been finalised as baseline groundwater data is still being collected. However, AGL have proposed interim triggers, which WRL have summarised in Table 2.

Table 2: Groundwater Triggers

Trigger	Details	Data to be Collected
A change in beneficial use	• For "aquifers" –defined as the alluvial aquifer and Hawkesbury Sandstone in section introduction, but then described for Narrabeen Group and Illawarra Coal Seam water bearing zones. • Varies spatially throughout the aquifer. • Defined by matrix of yield and salinity • AGL will investigate cause if changes occur during project or within 3 years post-development.	2 baseline samples Sampling once every 2 years after development
Water level decline	• Of more than 5 m outside the normal range of water levels • In the Hawkesbury Sandstone	Continuous water level monitoring
Water quality variations (monitoring network)	• To be defined after more monitoring data has been collected and natural characteristics and trends identified	2 baseline samples Sampling once every 2 years after development
Water quality variations* (gas production wells)	• No information provided	Sampling 4 times per year for first 2 years, reduced to 2 times per year for each year after.

*It is unclear if this frequency of monitoring is only proposed for the Stage 1/Stage 2 existing Camden CSG area where there are no dedicated monitoring bores, or whether this will also be the expected regime for the Northern Expansion. It is also unclear how this data would be used.

Continuous monitoring of groundwater levels will provide a sound baseline dataset with which to compare ongoing monitoring post-development. However, the collection of only two baseline groundwater quality samples at each site is considered inadequate to assess groundwater conditions prior to development. The suite of analytes to be monitored is shown in Figure 2. This suite is considered to be adequate for purposes of monitoring groundwater quality and potential changes.

AGL have stated that they will investigate the cause of beneficial use change if changes occur during the project or within 3 years post-development. However, the impact of extraction may take many years to be fully realised due to the time lags associated with groundwater characteristics and the distance to the point of impact (CSIRO, 2007). Impacts may occur many years after post-development, at which point the trends cannot be reversed by ceasing extraction. Consequently, it is important to have a thorough understanding of the aquifer systems prior to development.

Category	Suites			Parameters	
Check on Field Parameters	Basic	Intermediate	Comprehensive	Electrical conductivity and TDS	
Major ions				*Cations* calcium magnesium sodium potassium	*Anions* chloride carbonate bicarbonate sulphate
Dissolved metals and minor / trace elements				aluminium arsenic barium beryllium boron bromine cadmium chromium cobalt copper iron	lead manganese mercury molybdenum nickel selenium strontium uranium vanadium zinc
Other analytes				Fluoride	Silica
Total Suspended Solids				TSS	
Nutrients				Nitrate Nitrite Ammonia	Reactive phosphorous
Dissolved gases				Methane	
Hydrocarbons				Phenol compounds Polycyclic aromatic hydrocarbons (PAH)	Total petroleum hydrocarbons (TPH)/ benzene, toluene, ethyl benzene and xylenes (BTEX)

Figure 2: Recommended Laboratory Analysis of Water Quality Samples (AGL,2012)

5. Statutory and Policy Framework

The most relevant policy framework is the recently released *"NSW Aquifer Interference Policy"*, NSW Government September 2012 (AIP). WRL has reviewed the AGL Camden Gas Project groundwater reports against this policy for technical components only.

This section does not attempt to summarise the AIP, but rather compares technical concerns already discussed in previous sections with requirements of the AIP.

5.1 Pressure Head Decline

Requirement:
For less productive fractured rock groundwater sources, Table 1 of the policy requires "a cumulative pressure head decline of not more than a 2 m decline at any water supply work". If exceeded, "... appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long term viability of the affected water supply works unless make good provisions apply."

Comments:
As discussed in Section 3 – "Conceptual Hydrogeological Model" of this review, no quantification of the pressure effects has been presented for various scenarios of aquifer interconnectedness. The conceptual model does not provide any prediction of pressure head declines either in the Illawarra coal measures or the upper aquifers. As such, no details for the potential water level drawdowns on nearby water users has been provided under scenarios where interconnectivity may exist.

5.2 Groundwater Monitoring

Requirement:
The policy refers to the need to establish baseline conditions.

Comments:
Section 4.1.2 – "Monitoring Triggers" of this review refers to WRL's concerns about the statistical integrity of the baseline monitoring proposed. Continuous monitoring of groundwater levels will provide a sound baseline dataset with which to compare ongoing monitoring post-development. However, the collection of only two baseline groundwater quality samples at each site is considered inadequate to assess groundwater conditions prior to development.

5.3 Contingency Plans

Requirement:
The policy refers to the need to provide "details of contingency plans or remedial measures to be employed where it is found that take by or impacts from the activity".

Comments:
AGL have stated that they will investigate the cause of beneficial use change if changes occur during the project or within 3 years post-development. However, the impact of extraction may take many years to be fully realised due to the time lags associated with groundwater characteristics and the distance to the point of impact (CSIRO, 2007). Impacts may occur many years after post-development, at which point the trends cannot be reversed by ceasing

extraction. By monitoring only for possible changes from baseline in the upper aquifers, contingencies plans would be difficult to apply.

5.4 Hydraulic Connection Between Aquifers

Requirement:
The policy refers to the need to report on any potential to cause or enhance hydraulic connection between aquifers.

Comments:
If the pressures are reduced in the Illawarra Coal measures, fractures or interconnectedness may be enhanced. No comment has been made regarding this potential in the AGL Camden Gas Project groundwater reports.

5.5 Other Policy Aspects

Specifically for coal seam gas activities, the policy refers to the methods for installation and operation of bores, effects of fracturing on hydraulic conductivity and the disposal of extracted water. These issues have not been included in our review as they were outside our scope.

6. Key Findings and Recommendations

The key findings are summarised below.

1. The report adequately identifies regional geological and hydrogeological settings and WRL is not immediately aware of any other information that could be included.

2. The report adequately describes the conceptual model of the aquifer systems present. The report states *"Of key relevance to understanding the potential impacts to shallow groundwater resources, groundwater dependent ecosystems and surface water, is the degree to which the Illawarra Coal measures are in vertical connection with overlying aquifer zones within the Narrabeen Group, Hawkesbury Sandstone and thin alluvial deposits"*. WRL agrees with this statement and considers it the greatest uncertainty of the conceptual model. In the absence of local information, WRL recommends taking a precautionary approach by assuming that some vertical interconnectedness may exist. Other aspects of the conceptual model that have not been described in the AGL report are found in Section 3.

3. Without local data collection, the accuracy of the conceptual model cannot be confirmed and therefore the findings and conclusions must be presented as an envelope of possible outcomes. The existing conceptual model could be tested under a range of parameters to address uncertainties in depressurisation, lateral and vertical flows, pumping rates and the long term recovery of pressures. This information has not been provided.

4. The report identifies that there is minimal present groundwater use (mainly from the upper aquifers) or groundwater dependent ecosystems. WRL agrees that this may minimise the effective impact of any depressurisation of the upper aquifers but does not preclude that extraction bores (in particular deeper ones) may be influenced by Coal Seam Gas extraction.

5. The reports state that the maximum extraction would be 37 ML/annum with the possibility of a further 30 ML/annum in the Northern Expansion Project. The report states that this extraction will cause depressurisation of the coal seam water bearing zones, however no estimate of the range of possible depressurisation either in the Illawarra coal measures or the upper aquifers is provided, nor how projected ongoing extractions may need to vary if horizontal or vertical recharge flows are greater than expected (Section 3). As such, no details for the potential water level drawdowns on nearby water users has been provided under scenarios where interconnectivity may exist, as discussed in Section 5.1.

6. WRL concludes that the monitoring network is aimed at monitoring the shallow beneficial aquifers for any effects. It does not aim to, nor will it, identify the groundwater flows and aquifer behaviour in the lower aquifers and layers described as aquitards. As such the proposed monitoring network does not identify processes but only observes impacts once they have occurred. This monitoring network will not yield any information suitable for refinement of the conceptual model. WRL recommends further consideration be given to collect data which helps understand the processes occurring, such as monitoring bores measuring time series of pressure heads and water chemistry in each strata at no less than four locations within the Northern Expansion area.

7. The continuous monitoring of pressure heads for baseline studies appears adequate for groundwater level conditions. However the collection of only two water quality samples is insufficient for characterising baseline water quality conditions. WRL recommends baseline water quality monitoring be expanded.

8. WRL does not recommend that a groundwater model be developed. All models have inherent uncertainty depending on the boundary conditions applied and in this instance the greatest uncertainty is the interconnectedness between layered aquifers. Complex

numerical modelling cannot reduce this uncertainty without commensurate field data collection. However, desktop assessments of the range of depressurisation likely in each of the aquifer systems could be undertaken by experienced hydrogeologists to quantify the possible range of effects.

References

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