TO THE LAND COURT OF QUEENSLAND

Supplementary Individual Expert Witness Report: Groundwater Conceptualisation and Quality

Dr Matthew Currell

REGISTRY: Brisbane

NUMBER: EPA495-15

MRA496-15

MRA497-15

Applicant:	NEW ACLAND COAL PTY LTD ACN 081 022 380
	AND
Respondents:	FRANK AND LYNN ASHMAN & ORS
	AND
Statutory Party:	CHIEF EXECUTIVE, DEPARTMENT OF ENVIRONMENT AND HERITAGE PROTECTION

1. Introduction

This is a supplementary report to my individual expert report dated 24 February 2016[1] ('individual report') for the matter before the Land Court of Queensland. I was instructed to prepare this report in accordance with the letter of instruction attached (Annexure A), in light of new material provided to me by EDO Queensland in March and April, 2016.

The supplementary report is based on the following:

1. Additional evidence provided to me on 11/4/2016 and 21/4/2016 by EDO Queensland, in the form of two affidavits prepared of Mr Andrew Durick,[2] which contain material relevant to the following issues:
   a) Conceptualisation and modelling of faults in the groundwater model in the Revised Stage 3 Environmental Impact Statement (**EIS**); and
   b) Corrections to the groundwater model report showing the aquifer parameters that were adopted and modified during calibration of the groundwater model, during preparation of Additional Information to the Environmental Impact Statement (**AEIS**).
2. The results of the drilling program conducted on behalf of New Hope Group completed in March 2016, reported in the 'NAP GMIMP Drilling Completion Report' (Jacobs, 2016)[3], which was provided to me by EDO Queensland on 4 March 2016.
3. Additional review of a previous report supplied to me during the joint expert meeting process by Mr Duncan Irvine, by Waste Solutions Australia (WSA, 2013). This report is referenced extensively within the SKM, (2013) report reproduced in Mr Durick's second affidavit.[4]
4. Some additional review of groundwater bore logs from the 'Queensland Globe' database of DNRM bores.

2. Qualifications

My qualifications are set out in my individual report, and a copy of my academic CV is attached to that report at Annexure B.

3. Summary of My Conclusions

1. Additional evidence contained in the affidavits of Mr Andrew Durick, including a memorandum from Mr Brian Barnett and a report prepared by SKM in 2013, provide some additional insight into how the hydrogeological conceptualisation was developed prior to 2013, particularly regarding faulting. The results of the recent drilling program conducted in 2015-16 (Jacobs, 2016), and corrections to the modelling report made by Mr Durick (e.g., AD5, AD6 and AD7 of his second affidavit) also provide some new evidence to assess aquifer parameters. This includes new field data on the horizontal hydraulic conductivity of the Walloon Coal Measures. However, my opinions with respect to the hydrogeological conceptualisation following review of this information have not changed significantly relative to those expressed in my individual

[1] OCA.0021, Exhibit 435.
[2] Mr Andrew Durick affidavit of 11 April 2016 (**Durick First Affidavit**), NAC.0079 and Mr Andrew Durick affidavit of 21 April 2016 (**Durick Second Affidavit**), NAC.0080.
[3] NAC.0059, Exhibit 719.
[4] See Attachment 1 in AD2 of Durick's Second Affidavit, NAC.0080.

report. Specifically, I still believe that the hydrogeological conceptualisation is not based on adequate field data to inform a rigorous assessment of the following:

i) The major controls on groundwater flow patterns around the site, including the nature and impact of faulting, and other potential influences such as local-scale topography, geological structure, landholder pumping, and the impact of the existing mine pits (which may be causing mounding through enhanced recharge);

ii) Aquifer properties appropriate for the site, including horizontal and vertical hydraulic conductivity values and storage coefficients in the major aquifers in the vicinity of the project area (with the exception of horizontal hydraulic conductivity in the Walloon Coal Measures, for which there is now a reasonable evidence base); and

iii) Connectivity between the major aquifers in the vicinity of the project area; particularly vertical connectivity between the Walloon Coal Measures and both Quaternary Alluvium and Tertiary Basalt aquifers.

There is also some information in the affidavit which conflicts with, and should call into question, the conceptualisation of the hydrogeology of the area, particularly with regard to the water balance and controls on flow patterns in the major aquifers, as well as the field data used as a basis for calibration of the most recent version of the numerical model – in particular data on groundwater inflows to the mine pits ('pit inflows') - which informed the selection of aquifer parameters for the predictive modelling and impact assessment.

2. A number of other deficiencies in the hydrogeological conceptualisation that were raised in my individual report, the Joint Expert Report (**JER**) and the IESC's advice in 2014 and 2015[5] remain unresolved. These include:
   i) A lack of baseline water level data, including contour maps showing a range of time periods in each of the major aquifers, with comparison of water level patterns produced by the model (paragraphs 4.1 to 4.5 of my individual report);
   ii) Lack of baseline water quality data in all major aquifer around the Project (paragraph 2.17 of the JER);
   iii) An inaccurate and uncertain water balance which requires updating to include the large amount of existing groundwater extraction in the aquifers surrounding the project (e.g. refer to IESC advice, 2015, item 6), more robust estimates of recharge, and accurate data on the rates of groundwater inflow to the existing mine pits (section 3 and Annexure C of this report);
   iv) Field data (including water level data) to inform an assessment of the behaviour of the aquifers under conditions of long-term stress, such as vertical connectivity and leakage behaviour (paragraphs 2.6 of the JER and 3.1 to 3.6 of my individual report);
   v) Field data to inform a detailed assessment of potential groundwater dependent ecosystems in the region (discussed in 10.1.1 to 10.1.3 in my individual report, and further discussed in my analysis of New Hope Group's response to the IESC advice – attached as Annexure C).

   An analysis of the IESC's advice provided in 2014 and 2015, and whether New Hope has addressed all points raised in this advice written by myself and Professor Adrian Werner is provided as Annexure C of this report. This analysis finds many areas that have only partially been addressed or not addressed at all following the IESC's advice. The deficiencies in the field data underpinning the hydrogeological conceptualisation (and therefore groundwater model) as well as other issues that remain un-addressed create an unacceptably high level of uncertainty in the groundwater modelling and impact assessment.

[5] See Annexures C and D of my Individual Expert Report (OCA.0021, Exhibit 435) for 2014 and 2015 IESC advice.

3. The conditions set out in the Coordinator-General's Report (**CG's Report**) and Draft Environmental Authority (**Draft EA**) are therefore still based on an inadequate and overly uncertain groundwater impact assessment. These conditions may be inadequate to detect and avoid or mitigate potentially significant adverse impacts to groundwater surrounding the Project, including potential impacts to landholder bores, water quality and groundwater dependent ecosystems.

Summary of attachments to this report:

Annexure A: Letter of Instructions from EDO Queensland

Annexure B: Bore records from DNRM database (Qld Globe) for sites #42231530 and #42231603

Annexure C: Analysis of New Hope Group's responses to each point of IESC's advice from 2014 and 2015

4. My Opinion

In the following paragraphs I outline and explain my opinions related to the issues for which new evidence has been presented. There are three main areas discussed – firstly, the new evidence in relation to placement of faults in the model and assignment of fault hydraulic properties; secondly, new evidence regarding the ranges of hydraulic conductivity values used during calibration of the numerical model and comparison with ranges used in the Office of Groundwater Impact Assessment (OGIA) Surat Basin Model; thirdly, data on inflow rates to the mine pits presented in the SKM (2013) report, which was used as a basis for calibration of the groundwater model during revised modelling for the AEIS.

1. Justification for placement of faults and assignment of fault properties in the hydrogeological conceptualisation and numerical model

1.1 The memorandum from Mr Brian Barnett that was included in Mr Durick's Affidavit of 20 April 2016, along with a report prepared by SKM in 2013 provided in the affidavit (see AD2) and also in an earlier affidavit of Mr Durick from 11 April 2016, outline how and why a series of faults were added to the numerical groundwater model between 2009 and 2013 (during the preparation of the Stage 3 EIS). As a point of fact, it is written in Mr Durick's first affidavit that I had been provided with the SKM report during the joint expert meeting process (paragraph 13). However, I was not provided with a copy of this report during the joint expert meeting, or at any time between the meeting and receiving Mr Durick's first affidavit. The first time I saw this report was on 11 April 2016, being the same date that I first read Mr Durick's affidavit dated 11 April 2016. During the joint expert meeting with Mr Duncan Irvine (DI), Mr Andrew Durick (AD) and Professor Adrian Werner (AW) on the 4th and 5th of February 2016, I was provided by Mr Irvine with a USB drive containing a folder with a series of additional documents which I understood to contain all additional materials that Mr Irvine and Mr Durick had relied on during preparation of the Joint Expert Report **(JER).** The SKM (2013) report was not included in this material, nor was it provided at any stage subsequent to the JER.

1.2 It is clear from the evidence contained in both of Mr Durick's affidavits, including the memorandum from Mr Brian Barnett contained in his second affidavit (see AD2), that a number of faults have been included in the model in locations where they have not been mapped in the field, and that faults that were mapped in the field have not been included in the model (refer to Figure 1 of the memorandum of Mr Brian Barnett for detail).

1.3 The main justification provided for this is that the faults were placed in particular areas, in particular orientations and with particular hydraulic properties, in order to allow the model to better replicate observed water levels in bores surrounding the mine (Figures 2 and 3 of the memorandum).

1.4 This argument, and the evidence provided to support it contain many concerning aspects:

i) There are major problems with the way water level data has been presented in Figure 2 of the memorandum. For example, it is not clear how many water level measurements were taken at each site and/or when water levels were measured. Water levels at a given site may vary through time, and therefore it is vital that only levels taken on comparable dates are represented, rather than a series of measurements on a single map. Some of the measurements shown may be separated by years, during which significant variability could take place – this is evident in some locations where water level readings with differences of 10s of meters occur at the same location on the map.

ii) Surface topography and surface geology are not indicated on this map (or on Figure 3 of the memorandum). Topography and geology are critical to the interpretation of water level patterns, and not taking this into account can lead to major errors in the interpretation of water level data. When the water level data are shown in the context of surface geological and topographic data, it becomes clear that these water level measurements cover areas of significant topographic variation, and also changes in the dominant geologic unit occurring at outcrop (see Figure 1 and point 1.5 below). It also is not indicated what depth interval is being accessed by the bores from which the water level data were taken, or even which aquifer. The data appear to be a mixture of bores in the Walloon Coal Measures and Tertiary Basalt, and may also include other aquifer units (e.g. the alluvium). As an example, bore #42231530, which is used as justification for placement of significant faults in the model (Faults #1 and #3 in Figure 3 of the memorandum), appears to be screened in the Tertiary Basalt aquifer (see Attachment B to this report), while the majority of other bores are screened in the Walloon Coal measures. In cases where different aquifers are screened by monitoring bores, separate contour maps of water levels should be created for each aquifer, at which point an assessment can be made as to whether the different aquifers behave as a hydraulically connected hydrostratigraphic unit or not. As a result of these uncertainties, data which appear to be anomalies in water levels in Figure 2 of the memorandum (and which therefore led to the addition of faults to the model) may in fact relate to other factors, including differences in bore depths, lithology, topography and/or geology, and differences in the time period(s) covered by the measurements (see Figure 1 and point 1.5 below). What would be more helpful would be a series of water level contour maps in the relevant aquifer(s), along with side-by-side comparisons between modelled and observed head contours, as was suggested by the IESC in their 2014 advice (this is still yet to be done – refer to Annexure C). Such comparison maps could then be overlaid with the locations of mapped and/or inferred faults, to see whether the inclusion of faulting is consistent with the water level evidence and/or whether alternative conceptualisations might explain the flow patterns.

iii) Some areas in Figure 2 of the memorandum indicate localised areas where flow patterns are somewhat complicated (although, as noted above, the way these data are presented makes this difficult to assess with confidence). For example, there are areas of relatively high water level within the north of the mine lease and to the west of the lease. However, there are a number of possible explanations (and thus hydrogeological conceptualisations), other than the presence of low hydraulic conductivity fault planes, which could serve as alternative explanations for these observed water levels (see Figure 1 and point 1.5 below). Many influences may control water level patterns in a given area, apart from faulting. These include changes in topography, the presence of zones of preferential recharge and/or groundwater 'mounding' (which does appear to be a feature of the site that has not been accounted for); pumping of groundwater in particular areas (note that pumping data has to date never been included in the groundwater model); underlying geological structures such as basement highs or folding, as well as faulting. Such features, or a combination of these, could equally explain the water level patterns observed; as could alternative locations and/or extents for the modelled faults. Due to the non-unique nature of groundwater models, it is possible to achieve calibration using many different possible hydrogeological conceptualisations and sets of aquifer properties; what is thus important is that all aspects of the model ***are consistent with observed evidence from the field***. A series of additional field investigations – such as more detailed evidence on the nature, extent and hydraulic properties of faults; detail about the permeability of surface material and potential zones of enhanced recharge; information about nearby landholder pumping; structural geology such as the nature of any folding, basement highs or local topographic features – as well as further water level data therefore should have been conducted, rather than assigning low hydraulic conductivity faults to areas where these have not been mapped (and conversely, ignoring faults which have been mapped).

iv) It is stated by Mr Barnett in his memorandum that a number of faults that were not mapped in the field were added to the model *"where they were implied by significant changes in observed groundwater levels over short distances"* (page 14 of the Memorandum). However, the map presented (Figure 2 of the memorandum) is not consistent with this statement. For example, faults were added immediately south and west of bore #42231530, yet this is the only bore within the immediate area - the nearest other water level records are approximately 5km away. Additionally, in this area, water level data only exists on one side of the proposed fault, meaning the effect of the hypothetical fault on down-gradient water levels (to the south) is not clear. Addition of these fault planes is therefore highly speculative and may not be warranted at all. Before faults could be added at these locations, additional water level data (and preferably also geological data) would be required on the other side of the proposed fault, and other possible explanations should be considered. It appears that bore #42231530 and other bores to the northeast (e.g. #42231603) are located in a topographically elevated area where the Tertiary Basalt forms distinct hills in the landscape. It is therefore equally, or perhaps even more likely, that the 'anomaly' in water levels in this area, which was used as the basis for adding unmapped faults #1 and #3 (Figure 3 of the memorandum) is actually a function of topography (creating higher groundwater levels in this area) and/or the different outcrop geology.

v) In some cases, ‘mapped’ faults, such as the two major northwest-southeast trending faults to the south of the mine lease, appear to have little effect on water level patterns (Figure 2 of the memorandum), casting doubt on the conceptualisation of these faults as barriers to groundwater flow. Other problems with respect to these particular faults are:

a. Both faults have been included in the model with significant additional length beyond what is shown on New Hope Group’s fault mapping (Figure 1 and Figure 6 of the memorandum).
b. It is not clear where these and other faults that extend outside the mine lease have actually been mapped and/or verified using field evidence. The geological evidence for faulting would be expected to be detailed in the vicinity of the existing mine pits, whereas faulting outside the mine lease may simply be extrapolated and not validated by field evidence. The distinction between faults based on mapping, drilling or geophysical data and those inferred by extrapolation along strike lines should be clearly shown on New Hope Coal’s fault maps (e.g. Figure 1 in the memorandum, Figure 1.0 of NAC’s response to the IESC’s 2015 advice).

vi) Bores which are in the Walloon Coal Measures (e.g. east of unmapped fault #3) may be recharged through downwards flow from the Tertiary Basalt, resulting in similar water levels in the two aquifers – as appears to occur in the northern part of the mine lease. Evidence of such connection between the aquifers locally was described near bore #83P in the report by WSA (2013), where it was proposed that vertical connection between these layers is enhanced by faulting (e.g. page 10 of WSA, 2013). Currently, the model conceptualisation allows for limited connectivity between the Tertiary Basalts and underlying Walloon Coal measures, as vertical hydraulic conductivity values are lower than horizontal conductivities (and mostly less than 0.01 m/day - see ‘AD7’ of Mr Durick’s second affidavit). Also, all faults are given ‘barrier’ properties (e.g., lower hydraulic conductivity than the surrounding aquifer), as opposed to being tested as potential conduits. Alternative conceptualisations involving greater vertical connectivity and/or faults as conduits are also potentially plausible and should be tested carefully with field data and exploratory modelling.

vii) Groundwater mounding – generally caused by some combination of increased recharge and/or heterogeneous hydraulic conductivity at the surface does in fact appear to be a significant feature controlling water level patterns around the site. This mounding appears to centre on areas of active or past mining, as well as an area of topographic elevation in the Basalt to the west of the mine lease (see Figure 1 and Figure 2 below). If mounding is indeed occurring around the mine pits, then enhanced recharge through areas of active or past mining needs to be carefully investigated and incorporated into the conceptualisation (e.g. through assignment of higher recharge values in these zones). The mounding around areas of existing mining raises an additional concern about potential contamination of surrounding groundwater, and this should be taken into account in the groundwater monitoring and impact management plan (at this stage, it is the opinion of New Hope Group and their independent experts that the mine pit areas will all act as ‘sinks’ now and into the future).

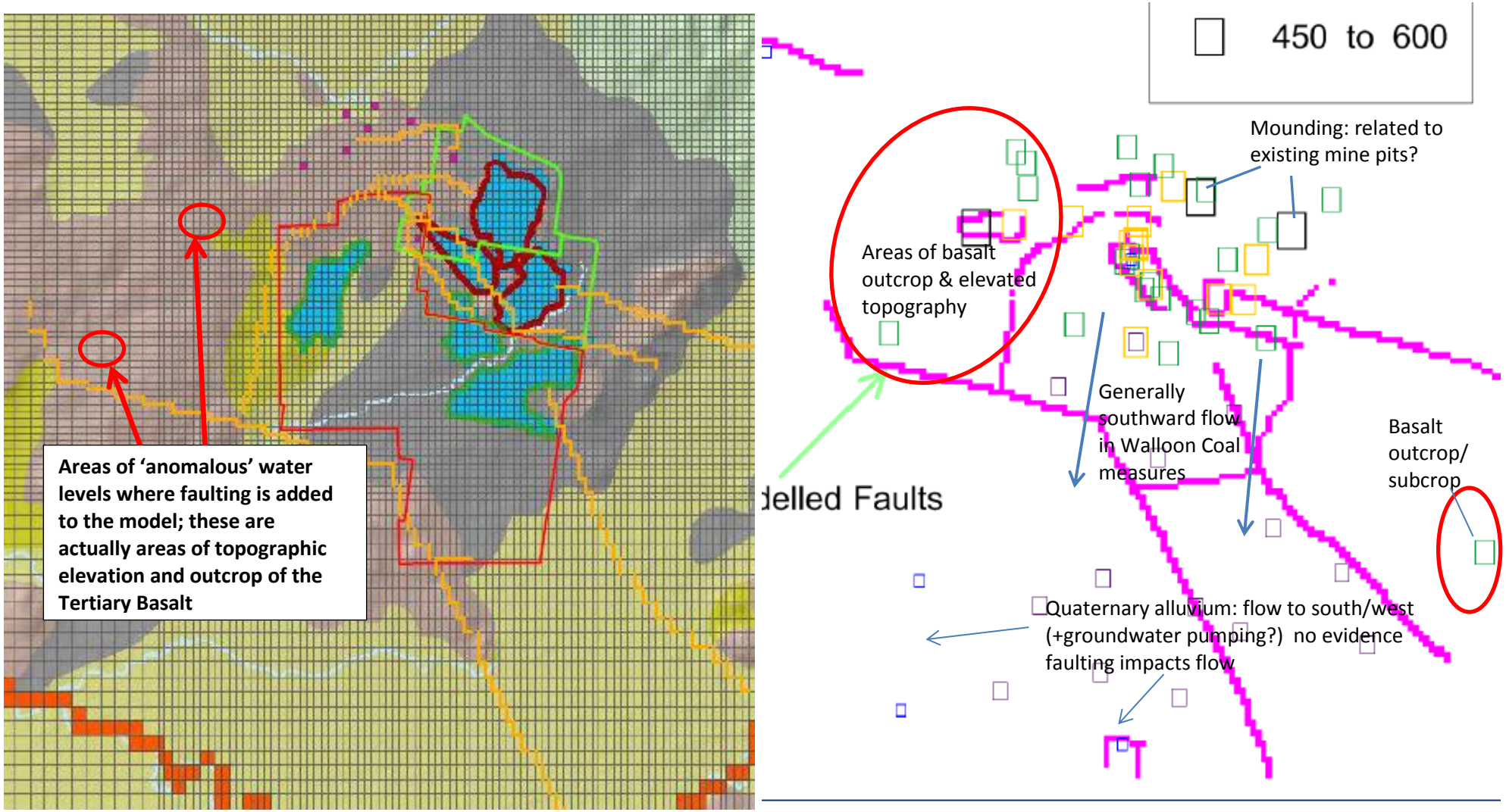

Figure 1 – Map showing geological/topographic features (left panel) relevant to interpretation of water level data presented in Figure 2 of Mr Barnett's Memorandum (reproduced on the right panel)

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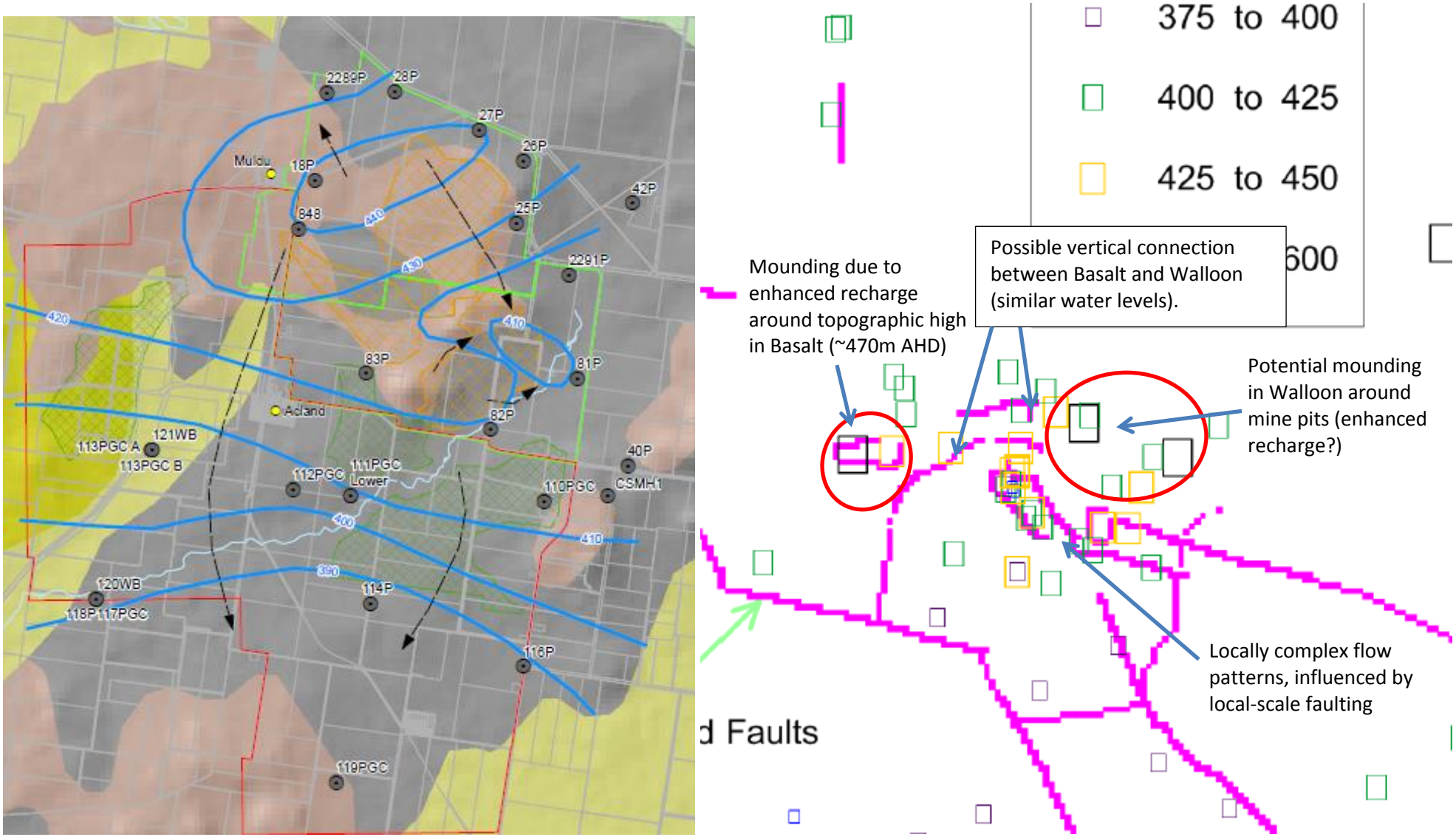

Figure 2 – Map of water levels in Walloon Coal measures as shown in Stage 3 EIS and water level data provided in Mr Barnett's memorandum, indicating areas of groundwater mounding, likely due to enhanced recharge through the existing mine pits.

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1.5 Alternative interpretations of the geological, topographic and water level data, which could potentially better explain the observed water level data are shown in annotated versions of Figure 2 in Mr Barnett's Memorandum (see Figures 1 & 2, above). This is based on assessment of water levels in conjunction with the mapped geology and topography presented in the EIS (Chapter 6)[6] and re-review of available bore logs (refer to Annexure B). It can be seen that areas of elevated water levels to the north, west and southeast of the mine lease coincide with areas of outcrop of the Tertiary Basalt and elevated topography (the two are related in this region as the basalt forms local highs in the landscape). If faults (e.g. unmapped Fault #1) were added to the conceptualisation based on an assumption that water levels in bores #42231530 and #42231603 and/or others in the basalt represented the Walloon Coal measures, then the conceptualisation is based on an erroneous assumption, and faulting has been included to explain patterns which could otherwise be attributed to differences in topography and lithology. Within the Walloon Coal Measures, groundwater flow appears to be generally southward, away from the existing mine pits, consistent with the water level map produced using monitoring bores around the mine site in the EIS (see left panel of Figure 2 above). It is noteworthy, that as described in paragraph 4.3 and Figure 3 of my individual report, that the groundwater model does not replicate these observed flow patterns well in the Walloon Coal Measures. Given that water level data presented in Figure 2 of the memorandum appear to represent a mixture of bores in the Walloon Coal measures and Basalts, there in fact appear to be some areas where water levels in the two aquifers are similar (e.g. to the north of the current mine site). This suggests that recharge to the coal measures from the Tertiary Basalt may be occurring, implying that at least locally, there is strong vertical hydraulic connectivity between the two aquifers (currently this is not part of the conceptualisation, see point 1.4(vi) above). This local connectivity is consistent with statements in WSA (2013), e.g., page 10:

> *"Monitoring bore 83P reacts to local rainfall recharge. The source of this water most likely originates from seepage through fractures within the basalt of Bottle Tree Hill and delivered to the aquifer (Walloon Coal Measures) via the fault that runs through this area. The groundwater signature of monitoring bore 83P bears more resemblance to basalt monitoring bores than coal bores".*

Page 4:

> *"The results of historical pump testing of groundwater bores in basalt in the southwest of the site show there is groundwater movement between the coal and basalt aquifers in this part of the site."*

At the local scale, near the mine pits (where there is a high density of bores), mounding of groundwater in the Walloon Coal Measures also seems evident, as discussed in point 1.4(vii) above. This indicates that enhanced recharge requires careful investigation and possible incorporation into the conceptualisation. Local faulting also produces complex patterns of flow at the local scale around the mine pits (as was discussed in WSA, 2013 – see p.4 and p.10), including in some areas appearing to act as barriers to flow, however the effect of this faulting on the overall regional pattern in the coal measures is still unclear (Figure 1). Groundwater flow in the southern part of the model domain appears to be largely towards the west and southwest; this area is where the Quaternary Alluvium is located and flow is probably dictated by a) the morphology of the alluvial stream channels within which the aquifer is deposited (generally deepening to the west) and/or b) groundwater pumping,

[6] New Acland Coal Revised Stage 3 EIS, Chapter 6, Groundwater Resources (EHP.0024, Exhibit 24).

which is known to be considerable in this aquifer. This is another aspect of the conceptualisation which is poorly accounted for in the current model.

1.6 While the conceptualisation described above at point 1.5, and presented in Figures 1 and 2 is not considered to be definitive and complete, I have included this to show that alternative conceptualisations also fit the field evidence, and that:

i) Further field data is clearly required in order to understand the role of faulting, as well as other controls on groundwater flow, including recharge to the basalt at topographic highs, mounding around the mine pits and recharge to the Walloon Coal Measures via the Tertiary Basalt. While Mr Durick suggests that a large scale "Pumping test" could be conducted by commencing de-watering and excavation of the mine, I believe there are significant additional steps that can and should be taken which would not require commencement of mining in order to better establish the hydraulic properties of faults and cross-aquifer connections. These include strategic placement of monitoring bores and purpose-designed pumping tests; better mapping of faults through geological and geophysical studies and other techniques discussed in Bense et al (2013).

ii) Alternative conceptualisations which place lesser emphasis on the role of faulting, allow enhanced recharge at particular areas, incorporate groundwater pumping and allow greater connectivity between the Basalt and Walloon Coal measures may be equally valid, and should be considered and tested during the development of a more rigorous conceptual and numerical groundwater model based on these field data.

1.7 There is no evidence that alternative conceptualisations of the hydrogeology, which could be equally or more consistent with field data - such as placing faults in alternative locations (e.g. their mapped locations), plus including areas of groundwater mounding, adding surrounding landholder water usage to the model and incorporating other potential effects on water levels (e.g. see point 1.4ii above) - have been investigated and modelled during the conceptualisation and calibration stages. This type of iterative approach to conceptualisation, backed by an increasing amount and detail of field data to support iterative changes, is the backbone of sound hydrogeological modelling and impact assessment, as is explained in numerous texts on groundwater modelling, including the Australian Groundwater Modelling Guidelines. No results showing how alternative conceptualisations (such as including the faults in the model at or close to the locations, orientations and depths where they have been mapped) are shown.

1.8 The ability for the model to replicate observed water levels is still poor, notwithstanding the purported need to include the faults in these locations to improve the model's ability to replicate water levels. As is shown in Figure 4.3 of the SKM (2013) report and Figure 6-23 of the EIS – reproduced below as Figure 3 - most bores in the Walloon Coal Measures still exhibited modelled water levels 10s of meters different from observed levels, even after modifications to the locations of faults, and some of the hydraulic properties were updated. While some observed water level patterns are matched in model hydrographs produced in the updated modelling (for the AEIS), the overall match between observed and modelled groundwater flow patterns in the Walloon Coal Measures, dictated by head contours, is still generally poor (as shown in Figure 3 of my individual report), and there are other areas where the match is poor in other aquifers also (as was pointed out by the IESC in 2015). This lack of replication of observed water levels by the model reduces confidence in the

hydrogeological conceptualisation, aquifer parameters and model predictions, and means that, in my opinion, additional field data and alternative conceptualisations must be investigated to shore up these aspects.

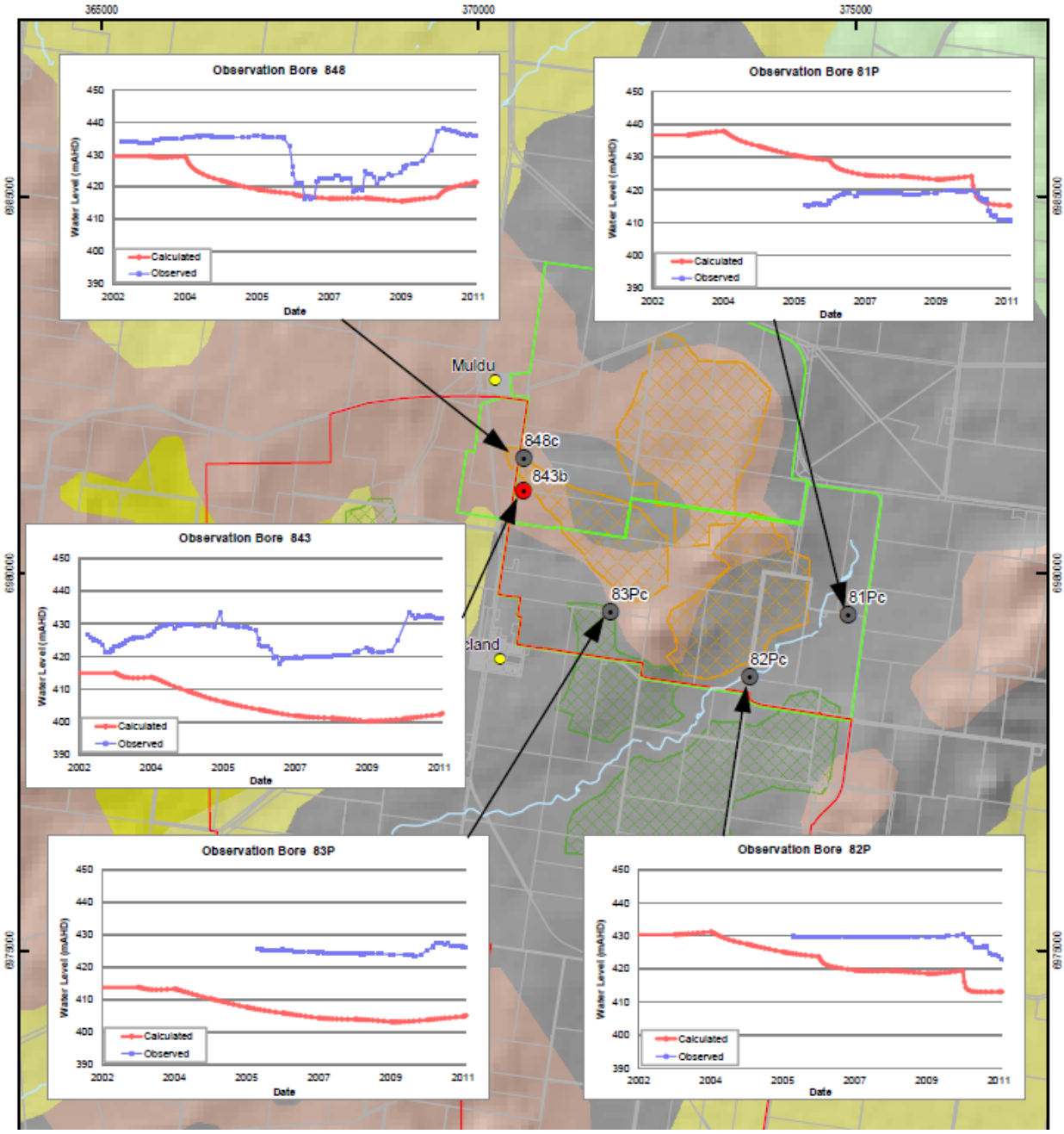

Figure 3 – Comparison of observed/modelled water levels in monitoring bores around the mine as of 2013, used as justification for updating the hydrogeological conceptualisation. Reproduced from Chapter 6 of the EIS (Fig 6-23).

1.9 All of the evidence in Mr Barnett's memorandum relates to the conceptualisation and modelling carried out between 2009 and 2013. This is prior to receiving the IESC's advice in 2014, after which a significant review and revision of the groundwater modelling was conducted (for the AEIS). The review and re-calibration of the model presented an opportunity to a) collect additional field data, and b) test alternative conceptualisations with respect to the faulting, such as placement of faults in locations that were truer to the fault mapping conducted by NAC and exploration of alternative controls on flow patterns. What

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is particularly concerning is that following the IESC's advice, few changes have been made to the conceptualisation of the hydrogeology with respect to faulting and groundwater flow patterns, even when review and re-calibration of the model was conducted, resulting in with significant changes to aquifer parameters. As is detailed in the attached analysis of New Hope's responses to the IESC advice of both 2014 and 2015, there are numerous parts of this advice which remain only partly addressed, or which have not been addressed at all (Annexure C of this report).

2. Assignment of aquifer properties in the model – field evidence base

2.1 The new data shown in Mr Durick's second affidavit, including the corrections made to the reporting of aquifer parameters in Appendix F of the AEIS [7]provide some additional clarity with respect to the aquifer parameters that were arrived at following calibration of the model, which in turn allows the ranges of parameters to be assessed against field data and previously reported estimates of these aquifer parameters

2.2 This includes showing clearly the updated ranges of both horizontal and vertical hydraulic conductivity used in the model for each of the aquifer layers that were used to make predictions of drawdown extend under future mining scenarios (shown as the ranges in AD7 and AD8 of Durick's second affidavit). It is my understanding that these ranges apply to the calibrated versions of the model, selected on the basis of the fit with water level data and pit inflows data (see section 3 below).

2.3 The recent drilling program (Jacobs, 2016) also provides new field data to inform assessment of the likely reliability of some of the aquifer parameters adopted in the conceptual and numerical model, particularly the horizontal hydraulic conductivity in the Walloon Coal Measures, for which a number of slug tests were carried out using new and existing monitoring bores.

2.4 The range of horizontal hydraulic conductivity values arrived at through model calibration appear to be generally consistent with the estimates arrived at through the slug testing. The median of the slug tests (0.52 m/day) for the Acland sequence appears to be close to the median value used in the Upper Walloon Coal Measures in the model (see AD6 of Mr Durick's second affidavit). The range is also consistent with values used in the OGIA Surat Basin model. In total, 15 bores were utilized for slug testing in the Acland sequence (upper Walloon Coal Measures), providing a reasonable level of reliability for this unit. In the other aquifers – including the lower sequences of the Wallon Coal Measures, Tertiary Basalt and Alluvium - there are limited numbers of tests carried out (1 or 2 tests in each), which means that while these data can provide some guide to expected K values, further data is required; preferably through pumping tests, which provide more reliable and less point-specific estimates of hydraulic conductivity compared to slug testing (e.g. paragraph 3.7 of my individual report)

2.5 While the new data provide some additional evidence on which to base the conceptualisation and model aquifer parameters, there remain significant deficiencies in the evidence basis required to inform the selection of appropriate aquifer parameters in the modelling. Of particular concern is the lack of data to make any site-specific assessments of vertical hydraulic conductivity and/or leakage behaviour of the major aquifers in the vicinity of the proposed mine (e.g. as agreed in paragraphs 2.5 and 2.6 of the JER; and further detailed in paragraphs 3.1 to 3.9 of my individual report). No new field evidence (other than

[7] New Acland Coal Revised Stage 3 AEIS, Appendix F, Updated Groundwater Technical Report (EHP.0103, Exhibit 103).

the water level data shown on Figure 2 of Mr Barnett's memorandum) is presented in Mr Durick's second affidavit to address this issue. Such information is vital to the prediction of vertical propagation of drawdown in response to mining, which in this case is critical for understanding the potential impacts on landholder bores in the surrounding region. This should be thoroughly investigated, ideally with the aid of pumping tests in purpose-designed nested monitoring wells.

2.6 The OGIA model provides some data with which to assess the vertical hydraulic conductivity (Kz) values of the aquifers in question, which is helpful to a degree. However, site-specific data (rather than general estimates) are critical to an assessment of Kz values appropriate for the model, due to the significant differences in the structural setting of the study area and the majority of the Surat Basin. Specifically, because the Acland site is at the margins of the Clarence Moreton Basin, where the units are significantly thinner, shallower and more faulted than the regional Surat Basin aquifers (for which the OGIA model was designed), the Kz values in the OGIA model are likely to be much lower, representative of values for these aquifers where they are deeper, less eroded and thicker. I would expect that the Kz values at the margins of the Clarence-Moreton Basin (e.g. where the Acland site is located) to be significantly higher than in the regional aquifers of the Surat Basin, where they are deeper and highly confined. While this is partly reflected in the values adopted in the model (e.g. values adopted for upper Walloon Coal Measures and Tertiary Basalts in the model appear to be towards the upper end of the ranges used in the OGIA model), this is not the case in all aquifers (see point 2.7 below) and the values used may still significantly under-estimate vertical connectivity between these units. As discussed earlier (e.g. 1.5), there is evidence that connectivity between the Basalt and Walloon Coal Measures may be very strong in at least some areas around the project site (as outlined in WSA, 2013); the values proposed for vertical conductivity (on the order of 10^{-4} to 10^{-1} m/d) used in these aquifers would not allow for such strong vertical connection in these areas.

2.7 Also, of significant concern are the much lower values of Kz used in the Quaternary Alluvium aquifer in the groundwater model, compared to the OGIA model (see AD7 in Mr Durick's second affidavit). The reasons for adopting a significantly lower range in this model compared to the OGIA model are not clearly outlined. If vertical conductivity in the alluvium is under-estimated in the model, then this would impact the degree of drawdown propagation between the Walloon Coal Measures and the Alluvium, in areas where the aquifers are in direct connection. This could mean that drawdown in the alluvium has been under-estimated significantly in the model predictions. As was agreed in paragraph 2.58 of the JER, New Hope Group do not have an authorisation to take or interfere with groundwater in the Quaternary Alluvium aquifer, and therefore this may be a significant issue of concern, in the context of the Murray Darling Basin Plan, and the large number of groundwater users with bores in the alluvium in the region.

3. Pit inflow data used during model development and calibration

3.1 An additional point relating to the field evidence that was used in the groundwater impact assessment is the fact that one of the key datasets collected to assist in calibrating the groundwater model, and select models with optimum hydraulic parameters, is pit inflow rates (e.g., the amount of groundwater flowing into the mine pits over time). This is explained in the SKM, (2013) report included in Mr Durick's second affidavit.

3.2 On inspection of the pit inflows data provided in the SKM, 2013 report, it appears that the values collected in the field are of a highly approximate and imprecise nature. For example, Table 1 from the WSA, 2013 report (Figure 4 below, also reproduced as Figure 4.2 in the

SKM, 2013 report shown in Figure 5 below) indicates that this inflow data actually represents a combination of groundwater inflow captured in the mine pits (ie, true pit inflow) plus any rainfall/surface runoff that accumulated in the pit over the same period. The flows from two separate pits are also summed in the total estimates.

Table 1. Monthly Pit Water Extraction Rates

	Month and Year	Total Monthly Extraction from Pit (kL)	Total inputs into pit (groundwater and rainfall runoff) (kL/day)	Monthly Rainfall for Oakey (mm)
South Pit	September 2011	17275	576	18.2
	October 2011	26427	853	83.6
	November 2011	12320	411	41.2
	December 2011	6655	215	43.2
	January 2012	26829	865	29.0
	February 2012	18865	674	88.6
	March 2012	21340	688	81.0
	April 2012	8745	292	24.2
	May 2012	NA	NA	17.6
	June 2012	NA	NA	91.8
	July 2012	NA	NA	23.4
	August 2012	8635	279	7.2
	September 2012	9185	306	9.0
	October 2012	3135	101	43.8
	November 2012	27500	917	56.2
	December 2012	14465	467	51.0
Centre Pit	June 2012	2530	84	91.8
	July 2012	990	32	23.4

Note: NA no data available

Figure 4 - Table 1 from WSA 2013 report showing pit inflow data, which is actually a combination of rainfall runoff and groundwater inflow.

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Figure 4.2 Measured rates of water extracted from the mining pit.

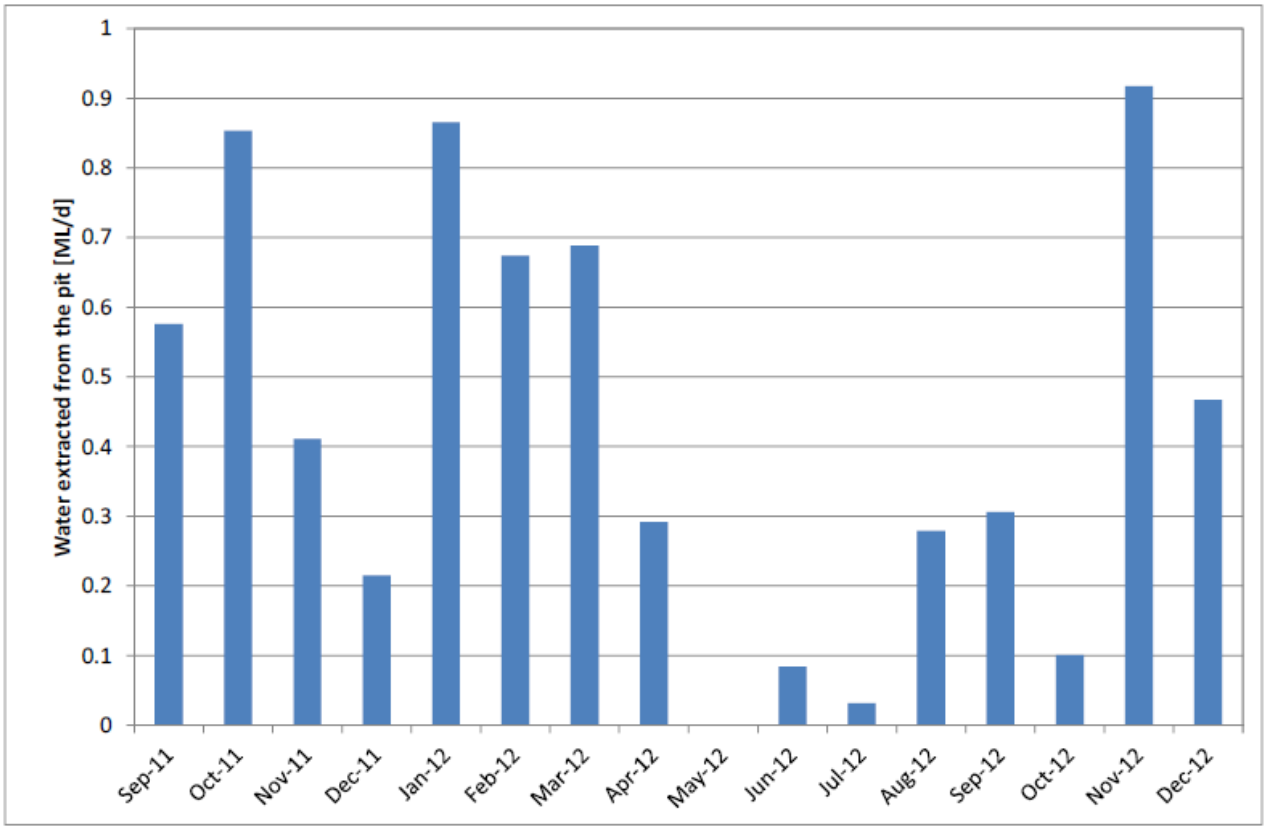

Figure 5 – Figure 4.2 from the SKM, 2013 report. Note that on the y-axis, 0.1ML/d is equal to 100m^3/d

3.3 During calibration of the updated groundwater model for the AEIS, pit inflow data was used as one of the key calibration targets. A large number of potential model parameter combinations were excluded from the final predictive modelling during this process, on the basis that they did not match the pit inflows calibration target of 300-400m^3/day (see page 27 of Appendix F of the AEIS). In fact, only once during the monitored period does the field data actually match this calibration target (see Figure 5). The highly approximate nature of this data (combining surface runoff and groundwater inflow) also means that it is very difficult to gauge true values of groundwater inflow to the pits (as is the intended calibration target), and as such the evidence base for the use of these values is poor.

3.4 The use of these pit inflows data as key calibration criteria during refinement of the model parameter values selected for making predictions in the groundwater impact is therefore very concerning. This was in fact pointed out in the SKM (2013) report:

> *"The "measured" pit inflows therefore include significant uncertainty and its use in calibration should be viewed as an approximate target (i.e. a sanity check) only"*

It appears that this advice has been ignored, and pit inflow data has in fact been used as a key calibration target during the selection of models from the Monte-Carlo analysis; the

models which were subsequently used to make predictions of impact to surrounding aquifers and groundwater users during revised modelling for the AEIS.

3.5 The lack of confidence in the accuracy of this dataset, combined with a generally poor fit between observed and modelled groundwater levels (e.g. see point 1.7 above) further undermines confidence in the aquifer parameter values and water balance used in the final groundwater conceptualisation and modelling in the AEIS, and the impact assessment conducted on this basis.

5. References

Bense V.F., Gleeson, T., Loveless, S.E., Bour, O., Scibek, J. 2013. Fault zone hydrogeology. *Earth Science Reviews* **127**: 171-192.

Jacobs (2016) New Acland Revised Stage 3 Project GMIMP Bore Drilling and Installation Program. NAP GMIMP Drilling Completion Report. 1st March, 2016.

WSA (2013). Stage 1 groundwater investigation at 81P and 82P, New Acland Coal Mine, Acland. Waste Solutions Australia Pty Ltd, May 2013

SKM (2013) New Acland Coal Mine. Groundwater modelling report – calibration to observed drawdown responses. 8th August 2013 (reproduced as part of the Affidavit of A. Durick, 20/04/2016).

6. Additional fact statement

Access to any readily ascertainable additional facts would not assist me in reaching a more reliable conclusion in this report.

7. Confirmation

I confirm that:

(a) The factual matters stated in the report area, as far as I know, true; and
(b) I have made all enquiries considered appropriate; and
(c) The opinions stated in the report are genuinely held by myself; and
(d) The report contains references to all matters I consider significant; and
(e) I understand the duty of an expert to the court and have complied with that duty;
(f) I have read and understood the Land Court Rules 2000 on expert evidence; and
(g) I have not received or accepted instructions to adopt or reject a particular opinion in relation to an issue in dispute in the proceeding

Dr Matthew Currell

6th May 2016

ANNEXURE A

EDO Qld.
Environmental Defenders Office
Using the law to protect our environment.
30 Hardgrave Rd WEST END, QLD 4101
tel +61 7 3211 4466 ***fax*** +61 7 3211 4655
edoqld@edo.org.au www.edo.org.au/edoqld

21 April 2016

Dr Matthew Currell
School of Civil, Environmental and Chemical Engineering
RMIT University
GPO Box 2476,
Melbourne VIC 3001
Sent by email: matthew.currell@rmit.edu.au

Dear Dr Currell

Oakey Coal Action Alliance Inc. – Supplementary report

In addition to the material with which you were briefed on 18 November 2015, we have now received further affidavit evidence from Mr Andrew Durick[1] and Mr Brian Barnett.[2]

1. **Instructions**

1.1 Further to the evidence you have given in these proceedings to date, you are instructed to review this letter and accompanying documents and prepare a supplementary report in response to the issues raised in Mr Durick and Mr Barnett's affidavits to the extent that they are relevant to groundwater conceptualisation and water quality issues in these proceedings.

1.2 We note that Professor Werner has also been instructed to prepare a supplementary report with respect to the modelling issues raised in the new evidence.

2. **Timing**

2.1 Further groundwater evidence is presently scheduled to be heard from 10 May 2016.

2.2 While we recognise you were not anticipating having to respond to fresh evidence, we would appreciate if you are able to prepare your supplementary report as soon as possible.

[1] The affidavit of Andrew Durick, sworn on 20 April 2016 is available on Dropbox – linked here.
[2] The affidavit of Brian Barnett, sworn on 20 April 2016 is available on Dropbox – linked here.

2.3 You may be required to participate in any further meeting of experts and appear to be cross examined on any supplementary statement of evidence.

3. Your duty to the Land Court

3.1 We enclose as **Annexure A** rules 22 to 24I of the *Land Court Rules 2000* which govern experts in the Land Court.

3.2 In particular we note that rule 24C of the *Land Court Rules 2000* provides that you have a duty to assist the Land Court which overrides any obligations you may have to our client.

3.3 We also emphasise that we and our client do not seek to influence your views in any way and we ask for your independent opinion to assist the Land Court. Consequently, please note that any statements of fact or opinion in this letter of instructions, the above documents, or anything given or said to you by us relevant to the issues in your report do not constrain you in any way and are not intended to influence your views. We ask you to form your own opinion about the relevant facts and circumstances for the purposes of your report.

3.4 Your supplementary report and any joint report you prepare should confirm that you understand your duty to the court and have complied with that duty.

4. Format of your statement of evidence (other than joint report)

4.1 We suggest for consistency that you adopt a similar format to your first individual report.

4.2 We would also appreciate if you can address the evidence of Mr Durick and Mr Barnett in separate sections of your report, to the extent practicable.

4.3 Your report must:

(1) be addressed to the Court;

(2) include your qualifications;

(3) include all material facts, whether written or oral, on which your report is based;

(4) include references to any literature or other material you relied on to prepare the report;

(5) include for any inspection, examination or experiment you conducted, initiated, or relied on to prepare your report—

a) a description of what was done; and

b) whether the inspection, examination or experiment was done by the expert or under the expert's supervision; and

c) the name and qualifications of any other person involved; and

d) the result;

(6) if there is a range of opinion on matters dealt with in your report, include a summary of the range of opinion, and the reasons why you adopted a particular opinion;

(7) include a summary of the conclusions you reached; and

(8) include a statement about whether access to any readily ascertainable additional facts would assist you in reaching a more reliable conclusion;

(9) include a confirmation at the end of the statement of evidence:

a) the factual matters included in the statement are, as far as the expert knows, true; and

b) the expert has made all enquiries considered appropriate; and

c) the opinions included in the statement are genuinely held by the expert; and

d) the statement contains reference to all matters the expert considers significant; and

e) the expert understands the expert's duty to the court and has complied with the duty; and

f) the expert has read and understood the rules contained in this part, as far as they apply to the expert; and

g) the expert has not received or accepted instructions to adopt or reject a particular opinion in relation to an issue in dispute in the proceeding.

(10) include your signature.

4.4 You should attach to the report:

(1) a copy of your Curriculum Vitae; and

(2) a copy of this letter.

4.5 Please number all pages and paragraphs of your report. You may wish to include an index.

4.6 If your report includes any photographs, measurements, graphs or illustrations these should be firmly attached to the report, and clearly identified and numbered.

5. Change of opinion

5.1 If for some reason, you change your opinion after delivering your report, please advise us as soon as possible. If that change is material, a supplementary report will need to be prepared, which explains the reasons for the change in your opinion.

6. Confidentiality and privilege

6.1 In accepting this engagement, you agree that:

(1) this letter and all future communications (whether electronically maintained or not) between us are confidential. These communications may be subject to client legal privilege;

(2) you must take **all** steps necessary to preserve the confidentiality of our communications and of any material or documents created or obtained by you in the course of preparing your report;

(3) you must not disclose the information contained in our communications or obtained or prepared by you in the course of preparing your report without obtaining consent from us;

(4) you must not provide any other person with documents which come into your possession during the course of preparing this report, whether created by you or provided to you by us or our clients, without obtaining consent from us.

6.2 The duty of confidentiality continues beyond the conclusion of your instructions.

6.3 If you are ever obliged by law to produce documents containing any of this confidential information (whether by subpoena, notice of non-party discovery or otherwise) please contact us immediately so that we may take steps to claim client legal privilege.

6.4 You should ensure that you retain copies of all drafts of your report together with all documents that you rely on in preparing your report. We will inform you when you are no longer required to retain them.

6.5 If requested, you must return to us all documents and other material (including copies) containing confidential information. Where any confidential information is in electronic form, we may require you to delete this information instead.

6.6 Any internal working documents and draft reports prepared by you may not be privileged from disclosure and may be required to be produced to the opposing parties in the litigation, and to the Court.

6.7 You may be cross-examined about any changes between your working documents and your report. The Court will be interested to understand the reason or reasons for any changes, and you should be prepared to, and able to, explain them.

7. Document management

7.1 Please ensure that all documents created pursuant to this retainer are marked "Privileged and Confidential: prepared for the purpose of the Queensland Land Court objection hearing to Stage 3 New Acland Coal Mine".

If you have any questions regarding your engagement or require further information, please do not hesitate to call us on 3211 4466.

Yours faithfully

Environmental Defenders Office (Qld) Inc

Michael Berkman

Solicitor

Part 5 Evidence

Division 1 Preliminary

22 Definitions for pt 5

In this part—

expert means a person who would, if called as a witness in a proceeding, be qualified to give opinion evidence as an expert witness in relation to an issue in dispute in the proceeding.

joint report, for a proceeding, means a report—

(a) stating the joint opinion of experts in relation to an issue in dispute in the proceeding; and

(b) identifying the matters about which the experts agree or disagree and the reasons for any disagreement.

meeting of experts—

1 A meeting of experts is a meeting at which experts in each area of expertise relevant to a proceeding meet, in the absence of the parties—

(a) to discuss and attempt to reach agreement about the experts' evidence in relation to an issue in dispute in the proceeding as it relates to the experts' area of expertise; and

(b) to prepare a joint report.

2 The term includes

(a) a resumed meeting of experts or further meeting of experts; and

(b) a meeting attended by the experts in either, or a combination, of the following ways—

(i) personally;

(ii) a way that allows contemporaneous communication between the experts, including by telephone, video link or email.

party, for a proceeding, means a party to the proceeding or the party's lawyer or agent.

statement of evidence, of an expert, see rule 24E.

Division 2 Meetings of experts

23 Application of div 2

Unless the court otherwise orders, this division applies in relation to a meeting of experts ordered or directed by the court at any time in a proceeding.

24 Party must ensure expert ready to take part in meeting of experts

Before a meeting of experts, a party to a proceeding must do all things reasonably necessary or expedient to ensure an expert chosen by the party is ready to take part fully, properly and promptly in the meeting, including by giving the expert—

(a) reasonable prior notice that the court has ordered or directed a meeting of experts; and

(b) notice of the contents of any order or direction about the meeting, including the time by which the meeting must be held; and

(c) reasonable notice of the issue in dispute in the proceeding to the extent it is relevant to the expert's expertise; and

(d) enough information and opportunity for the expert to adequately investigate the facts in relation to the issue in dispute in the proceeding; and

(e) written notice that the expert has a duty to assist the court and the duty overrides any obligation the expert may have to the party or any person who is liable for the expert's fee or expenses.

24A Experts attending meeting must prepare joint report

(1) The experts attending a meeting of experts must, without further reference to or instruction from the parties, prepare a joint report in relation to the meeting.

(2) However, the experts attending the meeting may, at any time before the joint report is completed, ask all parties to respond to an inquiry the experts make jointly of all parties.

(3) Despite subrule (1), any of the experts may participate in a mediation involving the parties.

(4) The joint report must—

(a) confirm that each expert understands the expert's duty to the court and has complied with the duty; and

(b) be given to the parties.

(5) The applicant or appellant must deliver to the registry, personally or by facsimile or email, a copy of the joint report received under subrule (4) at least 21 days before the date set for the hearing.

24B Admissions made at meeting of experts

(1) Subrule (2) does not apply to a joint report prepared in relation to a meeting of experts.

(2) Evidence of anything done or said, or an admission made, at a meeting of experts is admissible at the hearing of the proceeding or at the hearing of another proceeding in the court or in another civil proceeding only if all parties to the proceeding agree.

(3) In this rule—

civil proceeding does not include a civil proceeding founded on fraud alleged to be connected with, or to have happened during, the meeting.

Division 3 Evidence given by experts

24C Duty of Expert

(1) A witness giving evidence in a proceeding as an expert has a duty to assist the court.

(2) The duty overrides any obligation the witness may have to any party to the proceeding or to any person who is liable for the expert's fee or expenses.

24D Giving or accepting instructions to adopt or reject a particular opinion prohibited

A person must not give, and an expert must not accept, instructions to adopt or reject a particular opinion in relation to an issue in dispute in a proceeding.

24E Expert must prepare statement of evidence

(1) An expert must prepare a written statement of the expert's evidence (a statement of evidence) for the hearing of a proceeding.

(2) If the expert has taken part in a meeting of experts—

(a) a joint report prepared in relation to the meeting is taken to be the expert's statement of evidence in the proceeding; and

(b) a further statement of evidence in relation to any issue of disagreement recorded in the joint report is to be prepared by the expert.

(3) However, the further statement of evidence must not, without the court's leave—

(a) contradict, depart from or qualify an opinion in relation to an issue the subject of agreement in the joint report; or

(b) raise a new matter not already mentioned in the joint report.

24F Requirements for statement of evidence other than joint report

(1) An expert's statement of evidence, other than a joint report, must be addressed to the court and signed by the expert.

(2) The statement of evidence must include the following information, to the extent the information is not already contained in a joint report prepared for the proceeding—

(a) the expert's qualifications;

(b) all material facts, whether written or oral, on which the statement is based;

(c) references to any literature or other material relied on by the expert to prepare the statement;

(d) for any inspection, examination or experiment conducted, initiated or relied on by the expert to prepare the statement—

(i) a description of what was done; and

(ii) whether the inspection, examination or experiment was done by the expert or under the expert's supervision; and

(iii) the name and qualifications of any other person involved; and

(iv) the result;

(e) if there is a range of opinion on matters dealt with in the statement, a summary of the range of opinion and the reasons why the expert adopted a particular opinion;

(f) a summary of the conclusions reached by the expert;

(g) a statement about whether access to any readily ascertainable additional facts would assist the expert in reaching a more reliable conclusion.

(3) The expert must confirm, at the end of the statement of evidence—

(a) the factual matters included in the statement are, as far as the expert knows, true; and

(b) the expert has made all enquiries considered appropriate; and

(c) the opinions included in the statement are genuinely held by the expert; and

(d) the statement contains reference to all matters the expert considers significant; and

(e) the expert understands the expert's duty to the court and has complied with the duty; and

(f) the expert has read and understood the rules contained in this part, as far as they apply to the expert; and

(g) the expert has not received or accepted instructions to adopt or reject a particular opinion in relation to an issue in dispute in the proceeding.

24G Serving statement of evidence other than joint report

(1) This rule applies to a statement of evidence other than a joint report.

(2) A party to a proceeding intending to call evidence by an expert in the proceeding must deliver to the registry, personally or by facsimile or email, and serve on each other party to the proceeding, a copy of the expert's statement of evidence.

(3) A party must comply with subrule (2) at least 21 days before the date set for the hearing or, if the court directs a different time, within the time directed by the court.

24H Matters contained in statement of evidence not to be repeated

During examination in chief, an expert must not, without the court's leave, repeat or expand on matters contained in the expert's statement of evidence or introduce new material.

24I Evidence from only 1 expert may be called

Other than with the court's leave, a party to a proceeding, at any hearing of the proceeding, may call evidence from only 1 expert for each area of expertise dealt with in the hearing.

GROUNDWATER DATABASE

BORE REPORT

ANNEXURE B

REG NUMBER 42231530

REGISTRATION DETAILS

		BASIN	4223	**LATITUDE**	27-18-45	**MAP-SCALE**	
OFFICE	Toowoomba	**SUB-AREA**		**LONGITUDE**	151-35-57	**MAP-SERIES**	
DATE LOG RECD		**SHIRE**	6910-TOOWOOMBA REG	**EASTING**	361383	**MAP-NO**	
D/O FILE NO.		**LOT**		**NORTHING**	6978164	**MAP NAME**	
R/O FILE NO.		**PLAN**		**ZONE**	56	**PROG SECTION**	
H/O FILE NO.		**ORIGINAL DESCRIPTION**		**ACCURACY**	GPS	**PRES EQUIPMENT**	NE
				GPS ACC	20		
GIS LAT	-27.3125907	**PARISH NAME**	4943-WATTS			**ORIGINAL BORE NO**	WERTHS RD
GIS LNG	151.5990518	**COUNTY**	AUBIGNY			**BORE LINE**	-
CHECKED	Y						
						POLYGON	
						RN OF BORE REPLACED	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**	03/12/2001			**DATA OWNER**	MDS
STATUS	Existing	**DRILLERS NAME**	MILLER, ASHLEY WILLIAM				
ROLES	IN	**DRILL COMPANY**	NRMW				
	SM	**METHOD OF CONST.**	ROTARY AIR HAMMER				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	03/12/2001	1	Polyvinyl Chloride	3.300	WT	60	0.00	20.00
A	03/12/2001	2	Grout				0.00	3.50
A	03/12/2001	3	Gravel Pack				9.00	21.70
A	03/12/2001	4	Perforated or Slotted Casing				15.00	20.00
A	03/12/2001	5	Cuttings or other fill between casing and ho				3.50	8.00
A	03/12/2001	6	Cement or Grout Plug				8.00	9.00

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00		DARK BROWN - BLACK PLASTICY CLAY WITH
2		1.00	MINOR ORGANICS, ROOTS, ETC
3	1.00		DARK BROWN BLACK PLASTIC CLAY WITH

BORE REPORT

REG NUMBER 42231530

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
4			HARD WEATHERED BASALT, SECONDARY
5			MINERALISATION IN VOIDS (GLASSY AND
6		2.00	CLEAR)
7	2.00		WEATHERED BASALT ALSO WITH
8		3.00	SECONDARY MINERALISATION
9	3.00		BROWN TO BLACK WEATHERED BASALT
10		4.00	(SLIGHT MOISTURE IN SAMPLE)
11	4.00		BROWN WEATHERED BASALT OVERLYING DARK
12			GREY CRYSTALLINE FRESH HARD BASALT
13		5.00	WITH MINOR GLASSY SECONDARY MINERALS
14	5.00	6.00	CHOCOLATE BROWN CLAY, SOME GREEN CLAY
15	6.00		CHOCOLATE BROWN CLAY WITH SOME HARD
16		7.00	DARK BROWN RED WEATHERED BASALT
17	7.00		CHOCOLATE BROWN CLAY WITH WEATHERED
18		8.00	BROWN DARK GREY BASALT
19	8.00		DARK BROWN BLACK CLAY WITH HARD BLACK
20		9.00	BROWN BASALT (SMALL SOAK)
21	9.00		DARK BROWN BLACK CLAY WITH HARD BROWN
22		10.00	BASALT
23	10.00		DARK BROWN BLACK BASALT, HARD
24			SLIGHTLY WEATHERED WITH DARK BROWN
25		11.00	CLAY
26	11.00	12.00	DARK BROWN HARD BASALT
27	12.00	13.00	DARK BROWN BLACK HARD BASALT
28	13.00	14.00	BLACK HARD MASSIVE BASALT
29	14.00	15.00	BLACK HARD MASSIVE BASALT
30	15.00		BLACK HARD MASSIVE BASALT WITH RED
31		16.00	BROWN WEATHERED BASALT
32	16.00		BLACK HARD BASALT WITH RED PURPLE
33			WEATHERED BASALT AND CLAY (MINOR
34			VESICULAR LAYERS OF RED WEATHERED

BORE REPORT

REG NUMBER 42231530

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
35		17.00	BASALT)
36	17.00		BLACK HARD MASSIVE BASALT WITH MINOR
37		18.00	RED WEATHERED BASALT
38	18.00		BLACK HARD BASALT WITH MINOR RED
39		19.00	PURPLE WEATHERED VESICULAR BASALT
40	19.00		BLACK HARD BASALT WITH VERY MINOR RED
41		20.00	BROWN WEATHERED BASALT
42	20.00		BLACK HARD FRESH BASALT (HOLE NOW
43		21.70	PRODUCING ~ 5L/MIN)

STRATIGRAPHY DETAILS

****** NO RECORDS FOUND ******

AQUIFER DETAILS

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

PIPE	DATE	ELEVATION	PRECISION	DATUM	MEASUREMENT POINT	SURVEY SOURCE
A	03/12/2001	417.96	SVY	AHD	R	
X	03/12/2001	417.56	EST	AHD	N	

WATER ANALYSIS PART1

A	11/12/2001	1 GCL	209762	AI	GB	668	8.1	47	554.58	412.02	269	310	2.6	1.3	29	0.81

BORE REPORT

REG NUMBER 42231530

PIPE	DATE	RD ANALYST	QAN	DEPTH (m)	RMK	SRC	COND (uS/cm)	pH	Si (mg/L)	TOTAL IONS (mg/L)	TOTAL SOLIDS (mg/L)	HARD	ALK	FIG. OF MERIT	SAR	RAH
A	07/05/2009	1 CSA	276583	14.00	PF	GB	865	7.5	54		624.00		382			
A	18/05/2011	1 GCL	306272	15.00	PW	GB	936	7.8	65	700.00	548.00	375	353	3.4	1.1	0.00

WATER ANALYSIS PART 2

PIPE	DATE	RD	Na	K	Ca	Mg	Mn	HCO3	Fe	CO3	Cl	F	NO3	SO4	Zn	Al	B	Cu
A	11/12/2001	1	48.3	2.1	48.8	35.9	0.00	372.5	0.00	2.8	39.9	0.18	0.0	4.0	0.00	0.00	0.00	0.00
A	07/05/2009	1	47.0	2.5	75.3	42.9	0.07	381.6	< 0.10	0.0	72.9	0.10	0.1	1.3	< 0.05	< 0.05	< 0.10	< 0.05
A	18/05/2011	1	50.0	2.7	77.0	44.0	< 0.01	427.0	< 0.01	1.7	88.0	0.15	0.5	7.1	< 0.01	< 0.05	0.02	< 0.03

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE
A	11/12/2001	-9.33	R		NR	A	12/02/2002	-9.15	R		NR	A	01/10/2002	-9.43	R		NR
A	22/01/2003	-9.40	R		NR	A	12/03/2004	-8.98	R		NR	A	05/07/2004	-9.40	R		NR
A	01/11/2004	-9.53	R		NR	A	14/02/2005	-9.60	R		ACT	A	11/04/2005	-9.62	R		ACT
A	10/10/2005	-9.61	R		ACT	A	06/01/2006	-9.65	R		ACT	A	13/04/2006	-9.68	R		ACT
A	25/07/2006	-9.71	R		ACT	A	22/01/2007	-9.78	R		NR	A	01/03/2007	-9.78	R		NR
A	03/05/2007	-9.80	R		NR	A	10/09/2007	-9.84	R		NR	A	05/08/2008	-9.88	R		NR
A	15/12/2008	-9.89	R		NR	A	28/01/2009	-9.81	R		NR	A	07/05/2009	-9.89	R		NR
A	12/04/2014	-8.40	R		NR												

WIRE LINE LOG DETAILS

**** NO RECORDS FOUND ****

FIELD MEASUREMENTS

PIPE	DATE	DEPTH (m)	COND (uS/cm)	pH	TEMP (C)	NO3 (mg/L)	DO (mg/L)	Eh (mV)	ALK (mEq)	METH	SOURCE
A	11/12/2001		733							AI	GB
A	10/09/2007	-19.00	779		21.1					DH	GB
A	05/08/2008	-19.00	764		24.1					DH	GB
A	15/12/2008	-19.00	739		22.6					DH	GB
A	28/01/2009		849		22.7						

BORE REPORT

REG NUMBER 42231530

PIPE	DATE	DEPTH (m)	COND (uS/cm)	pH	TEMP (C)	NO3 (mg/L)	DO (mg/L)	Eh (mV)	ALK (mEq)	METH	SOURCE
										AI	GB
A	07/05/2009	-14.00	913	7.5	22.0		0.82	55		PU	GB
A	12/04/2014	20.70	1110	7.4						BA	GB

SPECIAL WATER ANALYSIS

PIPE A **DATE** 18/05/2011 **REC** 1

VARIABLE ********** Nitrate+nitrite as N soluble (FieldFilt)

MEASUREMENT 0.19000 **UNITS** Milligrams/Litre

DEPTH 15.00

WR ANAL NO 306272 **METHOD** PW **PRESERVATIVES** **PROJECTS**

BOTTLE E **ANALYST** GCL FR GDEWQ

COL AUTH DS

RECD AT LAB 18-MAY-11 **SOURCE** GB

COMMENT

PIPE A **DATE** 18/05/2011 **REC** 1

VARIABLE ********** Ammonia as N - soluble (Field filtered)

MEASUREMENT < 0.00200 **UNITS** Milligrams/Litre

DEPTH 15.00

WR ANAL NO 306272 **METHOD** PW **PRESERVATIVES** **PROJECTS**

BOTTLE E **ANALYST** GCL FR GDEWQ

COL AUTH DS

RECD AT LAB 18-MAY-11 **SOURCE** GB

COMMENT

BORE REPORT

REG NUMBER 42231530

PIPE A **DATE** 18/05/2011 **REC** 1

VARIABLE ********** Dissolved Organic Carbon

MEASUREMENT 3.20000 **UNITS** Milligrams/Litre

DEPTH 15.00

WR ANAL NO 306272 **METHOD** PW **PRESERVATIVES** **PROJECTS**

BOTTLE E **ANALYST** GCL FR GDEWQ

COL AUTH DS

RECD AT LAB 18-MAY-11 **SOURCE** GB

COMMENT

PIPE A **DATE** 18/05/2011 **REC** 1

VARIABLE ********** Total React P (Ortho P) - soluble (FldF)

MEASUREMENT 0.02400 **UNITS** Milligrams/Litre

DEPTH 15.00

WR ANAL NO 306272 **METHOD** PW **PRESERVATIVES** **PROJECTS**

BOTTLE E **ANALYST** GCL FR GDEWQ

COL AUTH DS

RECD AT LAB 18-MAY-11 **SOURCE** GB

COMMENT

PIPE A **DATE** 18/05/2011 **REC** 1

VARIABLE ********** Total Phosphorus- dissolved (Field- filtered)

MEASUREMENT 0.04100 **UNITS** Milligrams/Litre

DEPTH 15.00

WR ANAL NO 306272 **METHOD** PW **PRESERVATIVES** **PROJECTS**

BOTTLE E **ANALYST** GCL FR GDEWQ

COL AUTH DS

RECD AT LAB 18-MAY-11 **SOURCE** GB

COMMENT

BORE REPORT

REG NUMBER 42231530

PIPE A **DATE** 18/05/2011 **REC** 1

VARIABLE ********** Total Dissolved Nitrogen (Field- Filtered)

MEASUREMENT 0.23000 **UNITS** Milligrams/Litre

DEPTH 15.00

WR ANAL NO 306272 **METHOD** PW

BOTTLE E **ANALYST** GCL

COL AUTH DS

RECD AT LAB 18-MAY-11 **SOURCE** GB

COMMENT

PRESERVATIVES	PROJECTS
FR	GDEWQ

BORE REPORT

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OGIA Aquifer Attribution information is current as of: 05/04/2016

RN	PIPE	SOURCE AQUIFER
42231530	A	ALL ALLUVIUM AND BASALT

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GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 42231603

REGISTRATION DETAILS

		BASIN	4223	**LATITUDE**	27-16-35	**MAP-SCALE**	
OFFICE	Toowoomba	**SUB-AREA**		**LONGITUDE**	151-37-58	**MAP-SERIES**	
DATE LOG RECD		**SHIRE**	6910-TOOWOOMBA REG	**EASTING**	364685	**MAP-NO**	
D/O FILE NO.		**LOT**	22	**NORTHING**	6982198	**MAP NAME**	
R/O FILE NO.		**PLAN**	RP163253	**ZONE**	56	**PROG SECTION**	
H/O FILE NO.		**ORIGINAL DESCRIPTION**	BRY001	**ACCURACY**	GPS	**PRES EQUIPMENT**	NE
				GPS ACC	20		
GIS LAT	-27.2765117	**PARISH NAME**	4063-ROSALIE			**ORIGINAL BORE NO**	
GIS LNG	151.6328621	**COUNTY**	AUBIGNY			**BORE LINE**	-
CHECKED	Y						
						POLYGON	
						RN OF BORE REPLACED	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**				**DATA OWNER**	
STATUS	Existing	**DRILLERS NAME**	MCLEAN, WAYNE ROBERT				
ROLES		**DRILL COMPANY**	NRM				
		METHOD OF CONST.	AIR ROTARY				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	23/11/2005	1	Polyvinyl Chloride	3.300	WT	61	0.00	23.70
A	23/11/2005	2	Perforated or Slotted Casing	1.600	AP	61	22.70	23.70
X	23/11/2005	3	Grout			150	0.00	5.00
X	23/11/2005	4	Cuttings or other fill between casing and ho			150	5.00	7.00
X	23/11/2005	5	Bentonite Seal			150	7.00	8.00
X	23/11/2005	6	Gravel Pack	10.000	GR	150	8.00	27.00
X	23/11/2005	7	Bentonite Seal			150	27.00	28.00
X	23/11/2005	8	Gravel Pack	10.000	GR	150	28.00	67.00

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	0.50	BASALT, FE STAINED FRACTURES,

BORE REPORT

REG NUMBER 42231603

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
2			WEATHERED
3	0.50	1.00	BROWN BASALT, GREY & RED STAINED
4			FRACTURES, WEATHERED
5	1.00	3.00	BROWN BASALT, RED/ORANGE STAINED
6			FRACTURES, WEATHERED
7	3.00	4.00	BROWN BASALT, ORANGE FE STAINED
8			FRACTURES, WEATHERED
9	4.00	7.50	DARK GREY BASALT, FE STAINED
10			FRACTURES, WEATHERED
11	7.50	8.00	BROWN BASALT, FE STAINED FRACTURES,
12			LITHIC FRAGMENTS
13	8.00	9.00	RUST RED BASALT, CLAYEY, WEATHERED
14	9.00	11.50	ORANGE BROWN, CLAYEY, ALTERED BASALT
15	11.50	12.00	BROWN/GREY BASALT, FE STAINED
16			FRACTURES, LITHIC FRAGMENTS
17	12.00	13.00	BROWN BASALT, ALTERED TO CLAY,
18			WEATHERED, FE STAINED FRACTURES
19	13.00	14.00	BROWN/GREY BASALT, WEATHERED, CLAYEY,
20			ORANGE FE STAINED FRACTURES
21	14.00	15.00	GREY-GREEN BASALT, ALTERED TO CLAYS,
22			ORANGE FE STAINED FRACTURES
23	15.00	16.00	DARK BROWN BASALT, CLAYEY, ALTERED,
24			ORANGE FE STAINED FRACTURES
25	16.00	17.00	GREY BASALT, WEATHERED, LITHIC
26			FRAGMENTS, FE STAINED FRACTURES
27	17.00	18.00	BASALT
28	18.00	19.00	LIGHT BROWN CLAY, WEATHERED BASALT
29	19.00	20.00	GREY CLAYEY WEATHERED ALTERED BASALT
30	20.00	21.00	GREY/GREEN CLAY, ALTERED BASALT
31	21.00	22.00	*DARK BROWN & GREY CLAYEY ALTERED
32			BASALT

BORE REPORT

REG NUMBER 42231603

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
33	22.00	23.00	DARK GREY SHALEY CLAY, ALTERED BASALT
34	23.00	27.00	GREY CLAYSTONE, ALTERED BASALT
35	27.00	28.00	GREY CLAY, ALTERED BASALT
36	28.00	29.00	LIGHT BROWN/TAN SILTY CLAY, ALTERED
37			BASALT
38	29.00	30.00	MAUVE GREY CLAY, ALTERED BASALT
39	30.00	31.00	GREY CLAYSTONE
40	31.00	32.00	MAUVE/DARK BROWN CLAYEY ALTERED
41			BASALT
42	32.00	35.00	GREY CLAYEY ALTERED BASALT
43	35.00	36.00	LIGHT GREY CLAYEY ALTERED BASALT
44	36.00	38.00	DARK BROWN CLAYEY SHALE
45	38.00	43.00	GREY SHALE
46	43.00	44.00	BROWN GREY SHALE
47	44.00	45.00	BROWN CLAYEY SHALE
48	45.00	48.00	LIGHT GREY SANDY CLAY, FELSIC ORIGIN?
49	48.00	51.00	GREY BROWN SANDY CLAY
50	51.00	54.00	GREY SANDY CLAY
51	54.00	55.00	BROWN SHALE
52	55.00	56.00	DARK BROWN SHALE
53	56.00	61.00	GREY SHALE
54	61.00	63.00	GREY SHALE, LITHIC FRAGMENTS
55	63.00	67.00	BROWN SHALE

STRATIGRAPHY DETAILS

SOURCE	RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
DNR	1	0.00	36.00	TOOWOOMBA VOLCANICS
DNR	2	36.00	67.00	WALLOON COAL MEASURES

AQUIFER DETAILS

BORE REPORT

REG NUMBER 42231603

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
1	0.00	7.50					DRY		N	FR	TOOWOOMBA VOLCANICS
2	7.50	18.00					DRY		N	WZ	TOOWOOMBA VOLCANICS
3	18.00	36.00					DRY		N	WZ	TOOWOOMBA VOLCANICS
4	36.00	67.00	BSLT				DRY		N	PS	WALLOON COAL MEASURES
			BSLT								
			BSLT								
			SHLE								

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

PIPE	DATE	ELEVATION	PRECISION	DATUM	MEASUREMENT POINT	SURVEY SOURCE
A	22/11/2005	480.70	GPS	AHD	R	
X	22/11/2005	480.00	GPS	AHD	N	

WATER ANALYSIS PART1

****** NO RECORDS FOUND ******

WATER ANALYSIS PART 2

****** NO RECORDS FOUND ******

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE

BORE REPORT

REG NUMBER 42231603

PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE
A	10/12/2005	-15.88	R		NR	A	02/02/2006	-14.86	R		NR	A	14/02/2006	-15.13	R		NR
A	16/02/2006	-15.09	R		NR	A	02/03/2006	-15.40	R		NR	A	24/03/2006	-15.74	R		NR
A	22/05/2006	-15.86	R		NR	A	20/07/2006	-16.08	R		NR	A	08/09/2006	-16.17	R		NR
A	25/10/2006	-16.40	R		NR	A	22/01/2007	-16.36	R		NR	A	01/03/2007	-16.43	R		NR
A	19/04/2007	-16.64	R		NR	A	10/09/2007	-16.00	R		NR	A	05/08/2008	-15.17	R		NR
A	15/12/2008	-14.86	R		NR	A	28/01/2009	-14.35	R		NR	A	23/08/2010	-15.48	R		NR
A	29/10/2010	-15.24	R		NR	A	08/12/2010	-12.24	R		NR	A	11/07/2011	-9.12	R		NR
A	09/01/2012	-11.36	R		NR	A	01/05/2012	-16.03	R		NR	A	17/08/2012	-13.13	R		NR
A	30/10/2012	-14.36	R		NR	A	08/04/2013	-13.13	R		NR	A	06/06/2013	-12.90	R		NR
A	19/09/2013	-13.90	R		NR	A	09/12/2013	-14.60	R		NR	A	12/03/2014	-14.95	R		NR
A	17/06/2014	-14.52	R		NR	A	01/09/2014	-15.15	R		NR	A	17/12/2014	-15.51	R		NR
A	03/03/2015	-15.54	R		ACT	A	05/06/2015	-15.47	R		ACT	A	25/06/2015	-15.34	R		ACT
A	08/07/2015	-15.35	R		ACT	A	08/09/2015	-15.53	R		ACT	A	26/11/2015	-15.42	R		ACT
A	10/12/2015	-15.49	R		ACT	A	11/02/2016	-13.42	R	B	ACT	A	12/02/2016	-15.77	R		ACT
A	17/02/2016	-15.31	R		ACT	A	23/02/2016	-15.21	R		ACT						

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

FIELD MEASUREMENTS

PIPE	DATE	DEPTH (m)	COND (uS/cm)	pH	TEMP (C)	NO3 (mg/L)	DO (mg/L)	Eh (mV)	ALK (mEq)	METH	SOURCE
A	14/02/2006	-15.13	1282		23.5					DH	GB
A	10/09/2007	-22.00	1635		22.0					DH	GB
A	05/08/2008	-22.00	1595		25.0					DH	GB
A	15/12/2008	-22.00	1451		23.5					DH	GB
A	11/02/2016	21.00	1860	7.0	23.1		1.80			PW	GB

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

BORE REPORT

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RN	PIPE	SOURCE AQUIFER
42231603	A	MAIN RANGE VOLCANICS
42231603	A	WALLOON COAL MEASURES

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16. This agreement is governed by and will be construed according to the law applying in Queensland and the parties submit to the non-exclusive jurisdiction of the courts of Queensland.

**** End of Report. Produced: 26/04/2016 11:50:47 AM ****

ANNEXURE C

Dr Matthew Currell and Professor Adrian Werner – Analysis of whether IESC advice has been addressed by NAC

No.	Issue raised in IESC Advice	Analysis of NAC response
	First IESC Advice – 10 April 2014	
1.	Relevant data and information: key conclusions The following data and information are needed for potential impacts arising from proposed project to be fully assessed:	
2.	• A comparison between observed and modelled potentiometric heads, presented in a series of maps, to enable better assessment of the reliability of the groundwater flow model;	Not addressed. The comparison maps have not been provided in the revised project AEIS or responses to the IESC advice (Appendix N of the AEIS & New Hope Group, 2016). Maps of modelled potentiometric heads were included in the revised groundwater modelling report (Appendix F of the AEIS); however, there are no maps comparing these modelled heads with observed heads. Observed heads are only mapped in one aquifer on one occasion. Note that the recent affidavit of Brian Barnett refers frequently to steep gradients in groundwater levels (i.e. potentiometric heads) as the basis for placing artificial geological faults in the 2009 model. A proper evaluation of gradients requires a map of potentiometric contours (which is not included in his affidavit), so it would seem that the need for a potentiometric head map has existed since 2009 or earlier.
3.	• Measured flow data to improve confidence in the characterisation of Lagoon Creek's flow regime;	This is a surface water issue, and was therefore out of scope for the groundwater experts
4.	• Additional monitoring data, across a greater spatial and temporal extent, to more robustly characterise existing surface water quality in Lagoon Creek;	This is a surface water issue, and was therefore out of scope for the groundwater experts

No.	Issue raised in IESC Advice	Analysis of NAC response
5.	• Use of consistent salinity thresholds for discharges of mine-affected water to Lagoon Creek and inclusion of other key water quality indicators in the site water management system's release rules;	This is a surface water issue, and was therefore out of scope for the groundwater experts
6.	• Assessment of ecosystems associated with Oakey Creek and Myall Creek; and	This is a surface water issue, and was therefore out of scope for the groundwater experts
7.	• Identification and assessment of terrestrial groundwater dependent ecosystems within the predicted cone of depression.	Partially addressed. MC notes that additional terrestrial ecosystem mapping was conducted in response to the IESC advice, as provided in the report by Dr Andrew Daniel (Daniel, 2016) and Dr Daniel's contribution to the response to the most recent IESC advice (New Hope Group, 2016). This mapping identifies areas of vegetation that may be accessing groundwater, and which are predicted to be impacted by drawdown, near Lagoon Creek (see p.28, paragraph 1.21 of New Hope Group, 2016). However, the additional work is not adequate to identify and assess all potential GDEs within the predicted cone of depression, for the following reasons: 1. Not all areas previously identified as potential GDEs within the zone of predicted drawdown have been subject to mapping. Additional vegetation mapping has been conducted largely within the mine lease area (Figure 5 of Dr Daniel's report) and selected areas outside the mine lease (Figure 6; Figure 11). Some areas that were identified as being potential GDEs according to the WetlandInfo tool (Figure 2-14 & 2-15 of Appendix N of the AEIS) appear not to have been further subject to field based surveys. Dr Daniel's assessment also does not include vegetation mapping or seasonal water depth analysis in the areas adjacent to Oakey Creek and Myall Creek, and areas of basalt to the south of the mine lease, as was requested by the IESC's2014 advice and subsequent advice in 2015 (see 61 and 104 below). 2. The assessment does not identify whether or not mapped ecosystems are indeed groundwater dependent through systematic collection of field data (such as

No.	Issue raised in IESC Advice	Analysis of NAC response
		monitoring of groundwater levels and their diurnal fluctuations in the vicinity of terrestrial flora). The assessment relies on speculation that: a) vegetation is not likely to be accessing groundwater in areas where the groundwater level is more than 10m below the surface; b) predicted water levels are indeed below 10m in a number of areas in which there is no groundwater level monitoring data to confirm this (e.g. Figure 11 of Dr Daniel's report).
8.	<u>Application of appropriate methodologies: key conclusions</u> Confidence in the predictive capacity of the numerical groundwater model is low due to the adopted boundary conditions, anisotropic hydraulic conductivity and recharge values, and the lack of sensitivity testing of the model to these parameters.	Partially addressed. Each of the areas listed is discussed separately below: -**Boundary conditions:** these have been adjusted in the revised model (e.g. presented in Appendix F of the AEIS); however field evidence to justify the updated boundaries has not been provided in full. For example, the choice of constant head boundaries based on relationships between topography and water levels is not justified with reference to maps of groundwater levels that confirm this relationship around the site. For the alluvial aquifer, a value which is essentially arbitrary (13.5m below ground level) is set as a constant head condition, without justification. These boundary conditions may contribute to the poor capacity of the model to replicate observed water levels, and particularly the tendency to over-predict water levels in the alluvial and coal aquifers (see 92 below). AD checked the flow rates through the boundaries and found that they deviated only slightly with and without the mine included in the model. While this suggests that the boundary heads are probably at a sufficient distance from the mine not to impact drawdown directly, errors in boundary conditions still have the potential to influence model calibration, for reasons given in the paragraph above. -**Anisotropic hydraulic conductivity:** the anisotropy ratios (relating horizontal to vertical hydraulic conductivity) that are adopted in the model are relatively high (e.g. Freeze and Cherry, 1979). No field evidence has been presented to justify the use of these high anisotropy ratios, such as estimates of vertical hydraulic conductivity from pumping tests, or qualitative evidence on the degree of vertical connectivity between units. What limited evidence does exist (e.g. WSA, 2013) appears to suggest that there is relatively strong hydraulic connectivity between aquifers such as the Walloon Coal Measures and Tertiary

No.	Issue raised in IESC Advice	Analysis of NAC response
		Basalts, at least in some areas (e.g. WSA, 2013; p 4). While estimates of vertical hydraulic conductivity for the aquifers in question were provided in the OGIA Surat Basin model, and there is overlap with the ranges used in the model for this site (e.g. as shown in attachment AD7 of the affidavit of Andrew Durick), the significant difference in the structural setting of the Project site - at the uplifted margins of the Clarence-Moreton Basin, rather than deep within the regional Surat Basin - mean that more site-specific estimates are needed. Alternative conceptualisations with lower anisotropy ratios (greater vertical connectivity between aquifers) should be tested during model development and calibration, and field evidence should be collected to better inform this, as it is critical to the prediction of drawdown propagation between aquifers. -**Recharge values:** These initially adopted a uniform percentage of rainfall with some adjustments made to particular zones during the updated model calibration (Appendix F, AEIS). However, little field evidence is provided to justify assigning recharge rates, such as independent estimation using chloride mass balance or other techniques. It appears the rates adopted are higher than other published studies from the same region (e.g., Smitt et al, 2003) and that studies relevant to the topic, such as the Smitt et al (2003) study, have not been consulted. As discussed in the IESC's advice, independent techniques other than model calibration are required to justify the use of particular rates in the modelling (see 28 below). **Sensitivity analysis** of the model with respect to these parameters is not clearly presented in the updated modelling, although some graphs purporting to show the sensitivity of particular parameters is included in Appendix F of the AEIS (Figures 5-5 to 5-10). A thorough sensitivity analysis would report the relative impact of changes to values in the above parameters on key model predictions (such as the extent of drawdown in each aquifer), in a systematic way. It would then discuss which parameters have a larger/smaller effect on the predictions. This analysis is absent in the AEIS and responses to the IESC's advice (Appendix N; New Hope Group, 2016).
9.	The exclusion of other groundwater users within the model domain further limits confidence in the	Not addressed. The response to this part of the advice cited difficulty in assigning licensed groundwater entitlement volumes to specific bores (e.g. page 9 & 10 of IESC 2014 response,

No.	Issue raised in IESC Advice	Analysis of NAC response
	model's predictions.	Appendix N of AEIS). The entitlement volumes can in fact be determined for particular properties from DNRM's database. These entitlements therefore could be included into the model by simply assigning the allocated volume to a single bore at the centre of the property (for example). This would provide a far more rigorous estimate of the water balance than is currently in the model. The issue was raised again in IESC's 2015 advice but again has still not been incorporated into the modelling (see 99 below).
10.	A revised groundwater study is needed to improve confidence in the conclusions of the assessment documentation and enable development of appropriate measures to monitor and manage uncertainties and risks to water-related assets.	Not addressed. Some modifications to the groundwater model were made following this advice, as reported in Appendix N. However, this work does not constitute a 'revised groundwater study', which should include additional fieldwork, data collection and revision of the hydrogeological conceptualisation. Additional field data are required to update the modelling in line with the IESC's advice, such as new data on the horizontal and vertical hydraulic conductivity values, storage coefficients, hydraulic behaviour of faults, recharge estimates and groundwater discharge rates (including groundwater use in the region). Furthermore, the approach to model construction warrants significant revision, and reporting deficiencies need to be addressed as discussed in more detail below.
11.	<u>Reasonable values and parameters in calculation: key conclusions</u> Justification and/or further information are needed to support the proponent's approach or conclusions in relation to:	
12.	• Numerical groundwater model boundary conditions;	Partially addressed. see point 8 above
13.	• The substantial differences between vertical and horizontal permeability values used in the numerical groundwater model;	Not addressed, see point 8 above

No.	Issue raised in IESC Advice	Analysis of NAC response
14.	• The application of a uniform percentage for recharge from rainfall for each time step in the numerical groundwater model; and	Not addressed, see point 8 above
15.	• Uncertainties in the mine water balance resulting from:	
16.	○ The thresholds used for discharges of mine-affected water, which do not adequately consider ambient water quality or flow; and	This is a surface water issue, and was therefore out of scope for the groundwater experts
17.	○ The assumed flow regime in Lagoon Creek, which is likely to over-estimate opportunities for discharges of mine-affected water.	This is a surface water issue, and was therefore out of scope for the groundwater experts
18.	The IESC recommends that the proponent develop any further project assessment documentation in line with its Information Guidelines.[1]	
Question 1: What does the Committee consider are the key uncertainties and risks of the project in relation to water resources and water-related assets? What does the Committee consider are the features of a monitoring and management framework that would address these uncertainties and risks? In responding to this question, please consider the matters raised by the State and Commonwealth (Attachments B and C) as well as additional information contained in the RFA.		
19.	1. There are uncertainties and risks in the hydrogeological conceptualisation and	Partially addressed. While an attempt to address model uncertainties is inherent in the stochastic calibration of the AEIS model, model uncertainties have not been adequately

[1] Information Guidelines for Proposed projects Relating to the Development of Coal Seam Gas and Large Coal Mines where there is a Significant Impact on Water Resources available at: http://www.iesc.environment.gov.au/publications/information-guidelines-independent-expert-scientific-committee-advice-coal-seam-gas

No.	Issue raised in IESC Advice	Analysis of NAC response
	numerical groundwater model relating to design and implementation, which impact on the reliability of model predictions.	addressed to date, and the suggestion in the Appendix F report that the uncertainty of predictive results is minor is lacking in a scientific or logical basis. Areas for improvement in the calibration and uncertainty analysis are outlined in the individual and supplementary reports of Adrian Werner, and include the over-reliance of calibration on mine pit inflows, the excessive uncertainty in the application of faults, the lack of consideration of the degree of calibration in the uncertainty analysis, and weaknesses in the field data set, amongst others. Another critical area for improving the model design is the reduction in stress period lengths from annual to monthly, because the current use of yearly stress periods inhibits the AEIS model's capacity to study a number of important hydrogeological processes and potential impacts.
20.	An updated hydrogeological study that considers the following matters would enable risks to water resources to be more accurately evaluated. Suggested enhancements to the proponent's Groundwater Monitoring and Impact Management Plan (GMIMP) are provided in the response to Question 3. However, until the IESC's concerns about the groundwater model are addressed it is difficult to determine the appropriateness of the management and mitigation measures.	Not addressed. As pointed out in 10 (above), the additional work carried out does not constitute a substantive updated hydrogeological study, which would involve revision of the hydrogeological conceptualisation based on a body of significant additional field evidence, and addressing significant flaws and uncertainties that remain in the groundwater model and resulting predictions. These deficiencies preclude an assessment of the adequacy of proposed management/mitigation measures.
21.	<u>Conceptualisation</u> a. The absence of confining units of low hydraulic conductivity (with the exception of the Evergreen Formation) in the conceptual and numerical models will result in an unrealistic parameterisation of the	Partially addressed. The values chosen for vertical hydraulic conductivity have been revised, however they are still low by typical hydrogeological standards (e.g. Freeze and Cherry, 1979). This is justified on the basis of the conceptualisation presented in the Office of Groundwater Impact Assessment (OGIA) Surat Basin model; however this model applies to the same aquifers where they are much deeper and more confined than at the Acland

No.	Issue raised in IESC Advice	Analysis of NAC response
	hydrogeological regime. In particular, the low vertical hydraulic conductivities assigned to aquifers within the model will result in the underestimation of vertical drawdown propagation.	site. Values of vertical hydraulic conductivity that are between 10 and 5000 times less than horizontal conductivity have been used in the updated groundwater modelling (e.g. Table 5.1 of Appendix F, AEIS). There is no direct field evidence to support this conceptualisation; for example water level records from nested sites screened to different depths at the same location or pumping tests designed to capture vertical leakage behaviour and/or vertical hydraulic conductivity. Qualitative evidence included in the report by WSA (2013) indicates that the Basalt aquifer and Walloon Coal measures are in vertical hydraulic connection in at least some locations (e.g. p.4: 'The results of historical pump testing of groundwater bores in basalt in the southwest of the site show there is groundwater movement between the coal and basalt aquifers in this part of the site'), which contradicts this conceptualisation.
22.	Model Documentation b. Several predicted drawdown maps are provided; however, the pre-development head patterns have not been presented. A qualitative comparison between observed and modelled potentiometric heads, in a series of maps, would enable better assessment of model reliability. Modelled heads in each layer need to be presented, across the entire model domain, and at intervals representing pre-mining, the proposed project's operational phase, immediately post-mining, and longer term, in order to evaluate the modelled spatial and temporal pattern of groundwater flow.	Not addressed (see comment in response to 2 above). There is difficulty in determining pre-mining water levels, due to a lack of baseline data in the pre-mining phase of operations (e.g. Appendix N, response to IESC advice, 2014). The absence of this baseline data is regrettable; however notwithstanding the lack of data, some maps of water level patterns during more recent stages of mining (e.g. beginning with Stage 2 operations and continuing to the present) and comparison with modelled water level maps at the same stage in time can and should be provided to assess the model's ability to replicate historical water levels. There ought to also be an attempt to compare the model's ability to predict historical drawdown due to previous mining by comparing modelled estimates of drawdown to the observation wells in which drawdown has been observed. This would require a historical simulation without the effects of previous mining.
23.	c. Extension of the water balance to include predicted post-mining groundwater levels data would enable evaluation of long term risks. An indication of fluxes by aquifer is also	Addressed. Analysis of post-mining water balance is presented in the updated modelling (Appendix F, AEIS). The post-mining water balances do however raise potential concerns over long-term impacts of the project, such as the fact that one of the pits is expected to reach an equilibrium level that is higher than the current water levels at the site, posing a

No.	Issue raised in IESC Advice	Analysis of NAC response
	needed.	risk of becoming a contaminant source after mining ceases (see response to 98 and 115 below).
24.	<u>Boundaries</u> d. Constant head cells have been assigned along the northern, western, southern and part of the eastern margins of the model domain, which may result in unrealistic water budgets and laterally constrained drawdown within the model. Small variations in flow through these constant head boundaries may introduce large uncertainties in groundwater impact predictions.	Partially addressed. As discussed above in response to 8 (above) and 97 (below), field evidence for the setting of constant head boundary levels is either limited and/or questionable, particularly for the alluvium and basalt aquifers.
25.	e. The setting of boundary conditions has relied on one potentiometric head map for the Walloon Coal Measures that is restricted to the vicinity of the proposed project. Confidence in the adopted boundary conditions could be improved by incorporating potentiometric head maps from other hydrostratigraphic units as this would help to identify groundwater flow features and provide justification for the selected model boundaries. The use of the Queensland Government's Office of Groundwater Impact Assessment (OGIA)2 groundwater flow model would assist in determining the wider groundwater flow conditions.	Not addressed. Further potentiometric head maps have still not been produced other than the initial map referred to in this advice. See response to 2 and22 above.

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26.	f. Confidence in the groundwater model's predictive capability would be improved by providing and justifying the numerical values assigned to the constant head cells along the northern, western, southern and eastern boundaries. These values, in particular the relationship between the constant head values adopted at the same location but for different layers, may have a strong influence on the flow fields and heads, and hence the model's performance, including its predictive capability.	Partially addressed (see response to 24 above).
27.	g. Choices for groundwater model boundaries should be described with respect to the spatial distribution of water entitlements and developments. The model excludes wells associated with other developments within the model domain; for example, the 9,000 ML/year groundwater entitlements that exist within 8 km of the proposed project. These developments are likely to invalidate the assumed boundary conditions, resulting in model constraints that produce inaccurate water budgets and model predictions.	Not addressed (see response to 8 above). Groundwater entitlements are still not included in the model, despite this issue being again raised in the IESC's 2015 advice, and the fact that data are available (at least at the property by property level). The lack of incorporation of these data raises serious questions about the model's predicted water budgets and calibrated parameter sets.
28.	h. Modelling of recharge as a fixed percentage of rainfall is considered simplistic in a climate where evaporation exceeds rainfall for most of the year. As recharge is the largest inflow to the model, even small variations in recharge	Not addressed. Alternative recharge rates and zones were used in the updated modelling (Appendix N). However, no additional field based techniques (such as chloride mass balance) were used to assess the recharge rates as recommended by the IESC, and studies which do discuss recharge rates in the region were not referenced (e.g., Smitt et al, 2003) and therefore appear not to have been consulted. While recharge rates and zones have

No.	Issue raised in IESC Advice	Analysis of NAC response
	introduce large uncertainties in groundwater impact predictions. It is recommended that the magnitude of recharge be estimated using methods other than model calibration (refer to Scanlon et al., 2002) and that a sensitivity analysis be undertaken to explore the robustness of the model predictions to variations in recharge rates.	changed, this does not overcome the IESC concerns. Additionally, while a sensitivity analysis has been undertaken in the AEIS report, the sensitivity analysis of recharge shows that the model is almost completely insensitive to recharge, which is an unexpected and concerning outcome. That is, while sensitivity analysis has been undertaken in accordance with the IESC request, the results have produced a rather worrying indication of possible problems with the model. For example, it may imply that the model has excessive (i.e., potentially erroneous) rates of discharge to the land surface, which potentially have the same effect as fixed-head conditions, and thereby restrict the extent of drawdown. Exploration of the robustness of both model predictions and the model parameters arising out of calibration is needed in relation to variations in recharge rates, as requested here by the IESC.
29.	i. The evaporation rate and extinction depth adopted in the model are not described. Evaporation appears to be the second most important contributor to flows leaving the model domain and small variations in evaporation may introduce large uncertainties in groundwater impact prediction.	Partially addressed. Additional testing of alternative potential evaporation rates was conducted during updated modelling. However, the actual extinction depths adopted in the model are still not reported in the updated modelling or responses to IESC advice (AEIS, Appendix N and New Hope Group, 2016).
30.	j. Walls or flow barriers have been used to simulate faults in the model. While some faults may form barriers to flow, others may provide conduits for groundwater flow. Therefore, a justification for the use of flow barriers in the groundwater model is warranted.	Not addressed. Faults are still conceptualised as barriers to flow in some locations, without any significant field evidence to justify that these particular faults indeed act as flow barriers (notwithstanding additional water level data provided in the affidavit of Brian Barnett). Alternative conceptualisations, such as faults that act as leaky barriers, or even conduits, in the vertical plane, but partial barriers in the horizontal plane, should be tested in the model and further verified using field evidence. Preliminary field data presented in WSA (2013) appear to support the notion that faults may act as vertical and/or lateral conduits as well as horizontal barriers in some instances. The locations of many faults in the model do not match actual mapped locations of faults, even in the most recent updated modelling (e.g. New Hope Group, 2016). The affidavit of Brian Barnett confirms that some of the faults seem to have been incorporated without basis

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		and/or in error.
31.	k. Myall Creek is included in the groundwater model as a drain boundary condition despite evidence that groundwater elevations lay significantly below stream bed elevations. While it is noted that Myall Creek is situated to the north of the proposed project, justification is needed for the assumed boundary condition as it does not allow for seasonal flows to recharge groundwater.	Partially addressed. While Myall Creek was changed to being a 'River' boundary in the updated modelling, simply converting Myall Creek to a River condition does not solve the problem. There needs to be a transient water level applied to Myall Creek or else the Creek will artificially recharge the aquifer, or fail to recharge the aquifer when it flows. Or, in other words, it is not enough to simply switch from DRN (Drain) to the RIV (River) package without adequate explanation of the manner in which the RIV package has been parameterised. The report provides no guidance on the water levels used for creeks simulated by the RIV package.
32.	<u>Model Layers</u> l. An understanding of the conceptual hydrology across the entire model domain would improve understanding of lateral drawdown propagation from the Walloon Coal Measures to the Quaternary Alluvium. This may be achieved by inclusion of north-east to south-west cross-sections across the entire model domain and identification of the extent of each hydrogeological unit.	Partially addressed. The extents of the hydrogeological units as conceptualised in the modelling is now shown in a series of formation isopach maps in Appendix F. In terms of cross sections, one additional section was shown in the updated report; however this is 'not to scale' and the line of section is not clearly shown on any map. This section is oriented West-East, not northeast-southwest as suggested. Generally, the reporting still lacks any detailed cross sections, based on bore logs from the site (as agreed in the JER, paragraph 2.2).
33.	m. Information in relation to the geometry of the hydrostratigraphic units across the model, including the top, base and thickness of model layers, would aid understanding of how the numerical model parameterisation relates to the conceptual model. Individual model layers may include more than one unit which can result in an oversimplification of the	Partially addressed. MC notes that the formation isopach maps allow the extents and thicknesses of model layers used in the modelling to be determined (albeit with some difficulty – this could be aided by including a series of cross-sections in different orientations linked to the surface geology map). However, the zonation of model layers in terms of what aquifer properties were assigned within a given layer, and whether zones within a given layer were assigned in order to allow parameters to vary within a layer, is not described clearly.

No.	Issue raised in IESC Advice	Analysis of NAC response
	hydrostratigraphy; in particular, inaccurate representation of hydraulic conductivity values. A description of how the south-west dipping conceptual hydrogeology was incorporated in the groundwater model is also needed.	
34.	n. The Lower Walloon Coal Measures are conceptualised as separated from the Walloon Coal Measures by clays with low primary porosity, rather than low vertical hydraulic conductivity. Evidence, in the form of a potentiometric head map for the Lower Walloon Coal Measures, a comparison between heads from adjacent bores, or a head to elevation analysis within the Walloon Coal measures is needed to support this conceptualisation.	Not addressed. No potentiometric head map for the Lower Walloon Coal measures has been provided, nor has a systematic analysis of head levels in the upper and lower Walloon coal measures been conducted to determine their level of hydraulic connection across the site.
35.	<u>Model parameterisation and calibration</u> o. Calibrated model parameters indicate substantially higher horizontal and vertical hydraulic conductivity ratios than generally expected for alluvium, sandstone, and shale. Further, specific yield values are substantially lower than generally applied in groundwater models (for example, in Freeze and Cherry (1979)), which may underestimate unconfined aquifer storage. The rationale for the adopted values should be explained.	Partially addressed. Updated modelling involved adjustment of parameter values using a stochastic approach. However, the rationale for adopted values of anisotropy (ratio of horizontal to vertical hydraulic conductivity) is still not explained with reference to extensive field evidence (see response to 8 above). Nor has there been any updated discussion with regard to justifying the ranges of specific yield or specific storage values adopted in the model.

No.	Issue raised in IESC Advice	Analysis of NAC response
36.	p. The information provided in the assessment documentation does not appear to support a scaled Root Mean Square (RMS) value of 8 per cent. Further explanation of the scaled RMS errors, including an analysis of those across the entire model domain, at appropriate time intervals and for each model layer, would improve confidence in model calibration.	Addressed. AW notes that the SRMS of the revised calibration effort is 5% and SRMS errors are shown for each layer and each well, in addition to hydrographs showing the transient match between modelled and field water levels. However, the result of doing this was not to improve confidence in model calibration but served to highlight significant bias in the calibration results.
37.	Model predictions q. Given the uncertainties in determining recharge and the limited documentation of the constant head boundaries across which flow occurs, there is the potential for large variations in the predicted drawdown and pit inflows, and an uncertainty/sensitivity analysis should be undertaken.	Partially addressed. A basic sensitivity analysis for some key parameters has been reported in the updated modelling (Appendix F, AEIS; Figures 5-5 to 5-10). However, as discussed in the response to 8 above, this sensitivity analysis does not meet the objectives of a typical modelling sensitivity analysis, which is to determine the magnitude of variation possible in key model predictions (such as drawdown extent) when particular parameters are varied within realistic possible ranges. The sensitivity analysis needs to be more systematically conducted, reported and discussed so that it is clear which parameters are most important in controlling the extent of drawdown. On this basis, further field data collection and refinements to the model should then be carried out to improve confidence in these parameters. AW notes that the uncertainty analysis (Section 7 in Appendix N) requires improvement to key aspects of the methodology to be informative – e.g., one standard deviation is overly restrictive in seeking plausible drawdown extents, and 18 calibrated models is too few to produce statistically significant estimates of uncertainty ranges. The uncertainty analysis also needs to incorporate the calibration misfit in reporting drawdown - i.e. to show which results are from models that are best calibrated to the field measurements, and also which of the calibrated models have parameters that best match the knowledge of aquifer properties, because the best calibrated models are the most likely to produce more reliable estimates of drawdown.
38.	r. Predicted drawdown in 2030 indicates a steep	Not addressed. Additional analysis of model outputs and field evidence to inform the issue

No.	Issue raised in IESC Advice	Analysis of NAC response
	cone of depression in the Walloon Coal Measures and basalts. Given the comparatively high hydraulic conductivity assigned to the adjoining Oakey Alluvium at this location, and the potential presence of groundwater dependent ecosystems in the Oakey Creek catchment, the cause of the restricted lateral drawdown in all hydrostratigraphic units should be clarified.	of whether the drawdown propagation from the Coal Measures to the Alluvium is represented realistically was not included in the updated modelling. Of ongoing concern is that the vertical hydraulic conductivity values for the alluvium used in the model appear to be orders of magnitude lower than proposed in the OGIA's Surat Basin model (as indicated in attachment 'AD7' of the affidavit of Andrew Durick). The OGIA model should provide relatively reliable estimates of this parameter, as the Alluvium is a surficial, unconfined aquifer. In the case of the other aquifers, the OGIA data is unlikely to provide reliable estimates of vertical hydraulic conductivity for the Project site, as the values apply to the same aquifers at much greater depths, where vertical hydraulic conductivities generally tend to be lower.
39.	s. The presentation of drawdown contours for the Marburg Sandstone indicates that drawdown in this aquifer in the vicinity of the proposed project is greater than drawdown in the coal measures and basalts. This presentation is inconsistent with assessment documentation conclusions, which state that drawdown in the Marburg Sandstone is less that in the coal measures and basalts. This discrepancy should be reconciled.	Addressed. (provided in the updated modelling in Appendix F of AEIS)
40.	t. The presentation of drawdown maps should be reviewed and amended to ensure that groundwater drawdown predictions in the alluvium are accurate. The assessment documentation lacks clarity around why contour lines cross the Lagoon Creek Alluvium but do not cross the alluvium associated with Oakey Creek.	Partially addressed. Updated maps of alluvium drawdown are provided in Appendix F, which are consistent with model predictions. However, as noted above in response to 24 and 38, there is still uncertainty regarding how robust the estimates of drawdown extent in the alluvium are.

No.	Issue raised in IESC Advice	Analysis of NAC response
41.	u. The model predictions in terms of drawdown or stream depletion are shown in a deterministic manner; however, the model has considerable uncertainties in the calculation of the much larger components of recharge, flow across constant head boundary cells, and evapotranspiration. Inclusion of stochastic results or error/confidence intervals would better reflect the model uncertainties in the presentation of drawdown and stream depletions.	Partially addressed. AW notes that an attempt to report drawdown as the outcome of a stochastic calibration exercise has been made. However, uncertainty ranges of evapotranspiration fluxes and boundary inflows have not been reported in a similar manner to the reporting of uncertainty in other model outputs.
42.	v. Use of pan evaporation to assess the final void water balance may lead to overestimation of evaporation rates as void walls can protect water in the void from wind and sunlight. It is suggested that this effect is explored in the revised hydrogeological study and alternate evaporation rate factors are adopted if applicable; for example, Castendyk and Eary (2009) use a factor of 0.7 to account for the reduced evaporation from pit lakes. If the rate of evaporation is reduced in the model, the predicted post-mining drawdown will be smaller and the predictions for the post mining water levels in the Manning Vale West, Willeroo and Manning Vale East voids would need to be revised. Inclusion of either stochastic results or error/confidence intervals would better reflect the model uncertainties in the presentation of post-mining drawdown	Addressed. Alternative rates of evapotranspiration have been adopted for the post-mining simulation period and this has resulted in an updated water balance after mining ceases (see response to 23 above).

No.	Issue raised in IESC Advice	Analysis of NAC response
	and groundwater levels in the final voids.	
43.	w. The proponent states that the final voids will act as groundwater sinks and therefore will not permit pooled water to flow outwards into the regional groundwater system. This concept may apply to times when evaporation is larger than rainfall. If, however, episodic large rainfall events bring the pool level above that of the surrounding groundwater, there may be flow to the groundwater system; the probability of which would increase with a decreased model evaporation rate factor. Evaluation of the potential for groundwater recharge from the final voids would enable assessment of the proposed project's long term risks to groundwater quality.	Not addressed. The AEIS model runs on annual stress periods, whereas seasonality requires monthly (or shorter) stress periods. Therefore, the current model is not able to investigate the sorts of episodic events raised by the IESC. It is noteworthy that one of the pits (Willaroo) is now predicted to act as a source (i.e., not a groundwater sink, which is preferred to minimise groundwater contamination), notwithstanding the weaknesses in the approach to modelling mine pits. Also, current mine pits may be acting as areas of increased recharge/mounding, on the basis of Brian Barnett's Affidavit (see Figure 2 of the memorandum). Added to this, there has been no attempt to explore the change in water chemistry in the mine pits with time. In combination, these shortcomings render investigations to date somewhat uninformative on the potential for mine pits to contaminate the groundwater system. Therefore, significantly more consideration is needed of the influence of mine pits on the surrounding groundwater system.
44.	x. A sensitivity and uncertainty analysis of the major components of the proponent's groundwater balance would enable evaluation of confidence limits for model outputs.	Partially addressed. See response to 37 above. A basic sensitivity analysis with respect to recharge is conducted and presented in Appendix F. However, no sensitivity to changes in groundwater discharge (e.g. groundwater usage rates) has been conducted, as groundwater use is not included as part of the model's water balance (see response to 9 above).
45.	2. Additional characterisation of surface water resources associated with Lagoon and Oakey Creeks, as described below, would enable potential impacts on water quality and aquatic ecosystems to be more robustly evaluated.	The following issues (45 to 51) are surface water issues, and are out of scope for the groundwater experts
46.	<u>Existing Conditions</u>	

No.	Issue raised in IESC Advice	Analysis of NAC response
	a. Spatial and temporal limitations of the baseline monitoring program are not acknowledged in the assessment documentation. For example, characterisation of existing metals concentrations is based on one sampling event; however, the uncertainty associated with this limitation is not discussed. Consequently, existing conditions are difficult to ascertain and describe, which leads to reduced confidence levels when determining current state and condition; and attributing future impacts associated with the proposed works/activities. The following additional information would enable a more confident characterisation of the existing condition:	
47.	i. existing and background water resource conditions, including explicit identification of processes such as different flow, mixing, chemical and redox regimes;	
48.	ii. key water quality indicators and the appropriate sensitivity of measurement;	
49.	iii. temporal and spatial sampling frequency; and	
50.	iv. appropriate sample collection, sampling preservation and analytical methods.	
51.	b. Methods used to characterise	

No.	Issue raised in IESC Advice	Analysis of NAC response
	macroinvertebrate diversity in Lagoon Creek are not appropriate for dams or dry season pools. It is suggested that future sampling rounds are undertaken in accordance with the Queensland Monitoring and Sampling Manual 2009 (DEHP, 2013)3.	
52.	c. Groundwater dependent ecosystems, particularly those dependent on the alluvium and tertiary basalt aquifer, are not clearly identified in the assessment documentation. A map identifying seasonal groundwater depths and the vegetation present within the predicted area of groundwater drawdown would aid understanding of the extent and type of groundwater dependent ecosystems across the proposed project's area of influence. The identification of groundwater dependent ecosystems should be undertaken with reference to the Queensland Government's groundwater dependent ecosystem mapping in WetlandInfo.4 Quantification of groundwater dependent ecosystem water requirements as well as the reliance of terrestrial ecosystems on shallow groundwater systems would inform the evaluation of the risks to these ecosystems posed by proposed project development.	Partially addresses. MC notes that some additional mapping of vegetation has been conducted and an attempt to relate this mapping to water table depths is included in Dr Daniel's report (see response to 6 & 7 above). However, no maps showing seasonal groundwater depths in the alluvium or basalt aquifers (or indeed any aquifer) have been provided. The WetlandInfo tool was used to identify potential GDEs, as presented in figures 2.14 and 2.15 of Appendix N. However, these areas were not all systematically surveyed in Dr Daniel's report.
53.	d. Assessment of the dependency of threatened species, such as *Pteropus poliocephalus* (Grey-	This is a terrestrial ecology issue, outside the expertise of the groundwater experts

No.	Issue raised in IESC Advice	Analysis of NAC response
	headed Flying-fox) and *Phascolarctos cinereus* (Koala) on groundwater dependent vegetation would provide a more comprehensive understanding of the significance of groundwater dependent ecosystems in the proposed project's development area.	
54.	e. The assessment documentation would benefit from a review of published literature in relation to existing aquatic and terrestrial ecosystems in the region; for example, see Cosser, P. (1988)5.	This is a terrestrial ecology issue, outside the expertise of the groundwater experts
55.	<u>Water Quality Objectives</u> a. The proponent identifies three possible descriptors of aquatic ecosystem environmental values for Lagoon Creek; however, the 'slightly to moderately disturbed' value has been adopted without explanation. Further justification for adoption of this environmental value, with due consideration of the spatial distribution of the environmental values along potentially affected watercourses, would ensure that this watercourse has been appropriately classified.	This is a surface water issue, and was therefore out of scope for the groundwater experts
56.	b. Explanation of the rationale for using water quality objectives developed for south-eastern Australia and the Fitzroy Basin would enable evaluation of their applicability to the Lagoon	This is a surface water issue, and was therefore out of scope for the groundwater experts

No.	Issue raised in IESC Advice	Analysis of NAC response
	Creek and Oakey Creek catchments.	
57.	c. Evidence is needed to support the proponent's adoption of a water quality objective for electrical conductivity which is double the typical measured values in the upper reaches of Lagoon Creek. This should be informed by continuous, flow weighted electrical conductivity measurements.	This is a surface water issue, and was therefore out of scope for the groundwater experts
58.	Integrity and Limitations of the Data d. Limitations of the monitoring data should be described in the assessment documentation; particularly in relation to: the ability of the existing data to describe the water resources both spatially and temporally; data quality; discussion on the analytes collected (for example, the suitability of some analytes as indicators or surrogates for other analytes).	This is a surface water issue, and was therefore out of scope for the groundwater experts
59.	3. Aquatic and terrestrial ecosystem assessments are limited to Lagoon Creek and do not acknowledge the potential for the following groundwater drawdown-induced impacts.	
60.	a. The groundwater model predicts a reduction in baseflow for Oakey Creek and Myall Creek, indicating that there is a connection between the proposed project's operations and baseflow discharges to these watercourses.	Partially addressed. The updated modelling predicts no impact on baseflow in these two creeks. As highlighted in the groundwater experts' JER (paragraph 2.10), there was little justification provided as to why this has changed in the updated model. Some discussion of terrestrial ecosystems associated with these creeks is contained in Dr Daniel's report on terrestrial flora (Daniel, 2016); however it appears Dr Daniel is under the impression that

No.	Issue raised in IESC Advice	Analysis of NAC response
	Characterisation of the existing aquatic and terrestrial ecosystems associated with Oakey Creek and Myall Creek is needed, clearly integrating the hydrological and water quality characterisations with the hydrogeological and ecological characteristics of the catchment.	there is minimal likelihood that these areas will be impacted by drawdown from mining (paragraph 5.65) and therefore the ecosystems have not been assessed in detail in the report.
61.	b. The assessment of potential groundwater drawdown impacts on terrestrial vegetation is based on the depth to groundwater in the Walloon Coal Measures. It is suggested that consideration of groundwater drawdown in the alluvium and tertiary basalt aquifers would more appropriately inform risks to groundwater dependent ecosystems.	Partially addressed. MC notes that assessment of GDEs in Dr Daniel's report appears to be based on depth to water in the Alluvium (Figure 11). The depth to water in the Tertiary Basalts aquifer is still not shown. Also, no actual monitoring of water levels in the Basalt or alluvium has been conducted in areas noted to be potential GDEs in the response to this advice; the water level map is based on interpolation rather than actual field data (See Appendix N, figures 2.14 and 2.15 and Figure 11 of Daniel, 2016). AW notes that the assumption that alluvium groundwater levels are a uniform 13.5 m below land surface at the model boundaries should be considered in regards to the influence of this assumption of model depth-to-water levels across the alluvium. This may have implications for the evaluation of groundwater dependent ecosystems.
62.	c. If the studies suggested in Paragraphs 2(c), 3(a) and 3(b) above indicate that groundwater dependent ecosystems are present and would be affected by groundwater drawdown, the consequential impacts on threatened species should be evaluated.	Partially addressed. MC notes that Dr Daniel's report provides further assessment of the likelihood of GDE occurrence, however the assessment is at this stage still incomplete (see response to 6, 7, 60 and 61).
63.	4. The proposed project's site water balance and proposed discharge scenarios are likely to underestimate potential impacts on water resources. The site water balance should be updated to address the following matters:	

No.	Issue raised in IESC Advice	Analysis of NAC response
64.	a. The simulated daily flow regime in Lagoon Creek is a poor fit in comparison to the calibration data set. The flow duration curve for Lagoon Creek is not consistent with measured data at the Oakey Creek stream gauge, which indicates that the proponent has assumed higher and more frequent flows in Lagoon Creek than are likely to be the case. This creates uncertainty with respect to the modelled mine water balance and a mine water management system that relies on releases to Lagoon Creek. Real time flow and water quality measurements on Lagoon Creek would more effectively direct the release of water from environmental dams to Lagoon Creek and inform the significance of any potential impacts;	This is a surface water issue, and was therefore out of scope for the groundwater experts
65.	b. Salinity trigger values for discharge water quality exceed the measured salinity within Lagoon Creek and may be expected to result in water quality exceeding the water quality objectives. This assessment is supported by model predictions which indicate that water quality downstream of the mixing zone in Lagoon Creek will exceed the 500 µS/cm water quality salinity objective proposed by the proponent. Adoption of release rules that enable water quality objectives to be achieved would minimise risks to water quality and	This is a surface water issue, and was therefore out of scope for the groundwater experts

No.	Issue raised in IESC Advice	Analysis of NAC response
	water-related assets;	
66.	c. Inclusion in the water release rules of additional water quality indicators which can be measured reliably in the field, such as dissolved oxygen, turbidity, temperature and pH, would reduce the risk of adverse impacts to water quality and aquatic ecosystems. In addition, routine sampling of a more detailed list of analytes (e.g. metals) should be implemented to verify the effectiveness of mitigation and management measures;	This is a surface water issue, and was therefore out of scope for the groundwater experts
67.	d. Release rules that are specified in terms that relate to the measured ambient water quality in Lagoon Creek, in addition to flow rates during a release, could provide a more appropriate approach to avoiding environmental impacts, including changes to the flow regime; and	This is a surface water issue, and was therefore out of scope for the groundwater experts
68.	e. The provision of verified, measured electrical conductivity values for treated wastewater proposed to be imported for operational use by the proposed project would justify the proponent's adopted value of 250 µS/cm. This water will be managed as part of the mine water management system and potentially released to Lagoon Creek. Therefore, it is important that water quality parameters are accurately reflected within the site water	This is a surface water issue, and was therefore out of scope for the groundwater experts

No.	Issue raised in IESC Advice	Analysis of NAC response
	balance.	
69.	5. An investigation of the cause of the elevated copper concentration in Lagoon Creek is needed to understand whether these concentrations result from natural processes. The analysis of measured data from the mine water management system would inform this assessment. If a link with existing mining operations is suspected and expected to be continued under the proposed project, water quality management and monitoring strategies would be needed to minimise water quality risks.	This is a surface water issue, and was therefore out of scope for the groundwater experts
70.	6. An evaluation of the potential impacts of mine-affected water discharges on surface water users downstream of the proposed project would provide a more comprehensive analysis of risks to water-related assets.	This is a surface water issue, and was therefore out of scope for the groundwater experts
Question 2: Have cumulative impacts with other developments in the region that may impact water resources been sufficiently addressed?		
71.	7. The proponent has qualitatively considered cumulative groundwater impacts, which the IESC considers reasonably deals with 4 surrounding mines but not coal seam gas (CSG) activities, or entitlements. Confidence in the proponent's assessment of potential cumulative impacts on water resources and water-related assets would be improved by:	

No.	Issue raised in IESC Advice	Analysis of NAC response
72.	a. Describing the choice for groundwater model boundaries used in this model with respect to OGIA's groundwater flow model. In particular, CSG activities may affect the heads in the proponent's groundwater model, in particular along boundaries, which could render the proponent's boundary assumptions invalid; and	Addressed. The OGIA model results were examined during the revised modelling, and it was deemed that the drawdown relating to CSG impacts in the Surat basin will not have a significant cumulative drawdown effect with the project. The validity of this assumption should be re-examined as OGIA conducts updated modelling and monitoring in the Surat Basin in response to CSG development.
73.	b. Incorporating entitlements from other groundwater users in the model domain into an updated groundwater model. These entitlements represent over 9,000 ML/year of groundwater abstraction, which is large compared to modelled pit inflows. Therefore, their exclusion may result in inaccurate model predictions.	Not addressed. See response to 9 and 27 above.
Question 3: Are additional measures and commitments required to mitigate and manage impacts to water resources and water-related assets?		
74.	8. A number of additional measures and commitments are suggested to mitigate and manage impacts: a. Following revision of the numerical groundwater model, it is suggested that the proponent's GMIMP consider and incorporate:	
75.	i. Selection of key groundwater monitoring bores on the basis of criteria such as target aquifers, and potentially affected	Partially addressed. MC notes that new monitoring bore locations were proposed in the updated Groundwater Monitoring and Impact Management Plan, and some of these sites have now been drilled (Jacobs, 2016). However, there remain areas where no monitoring

No.	Issue raised in IESC Advice	Analysis of NAC response
	groundwater users and groundwater dependent ecosystems;	bores exist in key aquifers (e.g. Tertiary Basalts, Alluvium) in areas where drawdown is predicted to occur (as described in MC's individual report, paragraph 10.2.5 to 10.2.7). There are also regions where drawdown extent is still uncertain and where additional monitoring bores are warranted to obtain baseline water level and geological data, to improve the hydrogeological conceptualisation and to conduct future monitoring.
76.	ii. Selection of key groundwater monitoring bores and commencement of monitoring within a timeframe than enables seasonal and inter-annual measurement of groundwater flux;	Partially addressed. MC notes that new monitoring bores drilled in 2015 -16 (described in Jacobs, 2016) are fitted with pressure transducers, to allow time-series water level data to be collected. This will capture seasonal behaviour of water levels, although only in the locations where these bores exist (there are still important aquifers and areas which lack monitoring bores – see response to 75 above). In terms of inter-annual trends, a baseline monitoring period of minimum two years prior to the commencement of mining would need to be conducted in order to observe any inter-annual trends. Under the current draft Groundwater Monitoring and Impact Management Plan, it is unclear how long new bores are intended to be monitored prior to any mining activity.
77.	iii. Identification of modelled drawdowns and triggers based on the updated hydrogeological study suggested in this advice;	Not addressed. Modelled drawdowns have been produced in the updated modelling (appendix F); however, many aspects of the proposed hydrogeological study in this advice are still yet to be conducted (as described above and below), meaning the updated modelling has not been revised according to this advice in full and therefore revision of drawdown estimates still require updating. Additionally, in the draft Environmental Authority, trigger levels in monitoring bores are yet to be determined or proposed for either water levels or water quality.
78.	iv. Groundwater data from the existing New Acland Mine's monitoring program and/or other regional monitoring programs;	Partially addressed. Monitoring data from the existing monitoring program have been taken into account in the selection of new monitoring locations and in the updated modelling. However, maps of water levels and water quality have still not been presented and used to inform the model calibration and likely impact on water level patterns in the region qualitatively (e.g. see response to 2 above).
79.	v. A bore at coordinates 370000:6976000 to	Not addressed. MC notes that no bore at that location (or close to it) has been proposed

No.	Issue raised in IESC Advice	Analysis of NAC response
	monitor the predicted 20m drawdown in the Walloon Coal Measures between monitoring bores 114P and the unnamed monitoring bore to the west near Lagoon Creek; and	in the updated GMIMP, or drilled in the most recent drilling of monitoring bores for Stage 3 (Jacobs, 2016).
80.	vi. An additional monitoring bore in the Marburg Sandstone (near bores 5a and 5b), given the uncertainties in relation to predicted drawdown within this aquifer described in Paragraph 1(s);	Addressed. MC notes that this bore has been drilled in the recent drilling program (Jacobs, 2016).
81.	c. Real time flow and water quality monitoring stations on Lagoon Creek would enhance management of controlled releases from the proposed project's environmental dams. It is suggested that measured water quality parameters include turbidity, dissolved oxygen, pH and electrical conductivity, and that these are measured in the environmental dams, as well as near the release point and at the junction with Oakey Creek;	This is a surface water issue, and was therefore out of scope for the groundwater experts
82.	d. Risks to water quality would be minimised by updating the water balance to incorporate a more robustly calibrated representation of the flow and quality regime within Lagoon Creek. Based on the results of the updated study, the size of the environment dams and frequency and duration of releases may need to be reassessed;	

No.	Issue raised in IESC Advice	Analysis of NAC response
83.	e. Regular monitoring of wastewater treatment plant effluent quality would enable early detection of any changes to effluent quality over time;	
84.	f. Incorporation of suitable strategies to manage leachate from waste rock with elevated manganese concentrations into the proponent's environmental management plan would minimise risks to water quality;	
85.	g. Independent certification of infrastructure design by a practising erosion control or waterway specialist would provide a greater level of confidence that works within the floodplain would create minimal long term impacts;	
86.	h. Implementation of an environmental inspection program to identify emerging erosion and sediment mobilisation issues would enable early detection and management of potential impacts; and	
87.	i. Commitments for surface and groundwater monitoring should be presented as part of a water monitoring plan and should be consistent with the National Water Quality Management Strategy.	
88.	9. The Northland Inland Catchment has been identified as a Bioregional Assessment priority	

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	region. Data and relevant information from the proposed project should be made accessible for this Bioregional Assessment to assist the knowledge base for regional scale assessments.	
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89.	Key potential impacts The IESC's advice of April 2014 identified significant uncertainty in the proponent's groundwater model predictions. While the proponent's groundwater model has been improved, uncertainties remain in the hydrogeological conceptualisation and subsequent revised groundwater impact predictions including the magnitude of drawdown and the lateral extent of potential impacts. Based on the revised assessment documentation, key potential impacts resulting from the proposed project are to groundwater resources, groundwater and surface water users and groundwater dependent ecosystems (GDEs),	

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	including the EPBC Act-listed endangered ecological community Brigalow (*Acacia harpophylla* dominant and co-dominant).	
90.	Assessment against information guidelines IESC has considered (in line with the April 2014 advice) whether the proposed project assessment has used the following:	
91.	*Relevant data and information: key conclusions* Evidence of faulting to the south and east of the proposed open cut pits has not been provided. Hydrogeological monitoring data to validate the stated groundwater flow "barrier" effect of faults (including justification of existence and extent of faulting) has not been provided. The proponent has not included groundwater abstraction data from surrounding groundwater users in the groundwater model. Surface water quality objectives remain undetermined.	Not addressed. See responses to 95 and 99 below. The point on surface water quality objectives was out of scope for the groundwater experts.
92.	*Application of appropriate methods and interpretation of model outputs: key conclusions* Calibration hydrographs indicate the groundwater model has bias which results in frequent over-prediction of groundwater head in the alluvium and Walloon Coal Measures, when compared to observed data in monitoring bores. Updated modelling also predicts water levels within final voids will exceed the existing groundwater level,	Not addressed. See responses to 96, 97 & 98 below.

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	contributing to continued low confidence in the model conceptualisation and predictions.	
93.	Identification of GDEs, including EPBC Act-listed endangered ecological communities, has not occurred within the predicted lateral extent of groundwater drawdown, including outside of the proposed project area. Mapping of depth to groundwater and consideration of seasonal groundwater requirements of GDEs have not been provided.	Partially addressed. Updated terrestrial vegetation mapping and limited assessment of groundwater level data has been provided in Dr Daniel's report (see response to 7 above). However, this assessment did not include updated mapping of groundwater depths based on collection of additional water level data. No assessment of seasonal trends in groundwater levels was conducted or presented.
Question 1: The proponent has revised the groundwater modelling in response to the IESC advice of 10 April 2014, including a sensitivity and uncertainty analysis of the parameters and assumptions used within the original model. The revised modelling has been peer-reviewed and assessed by Queensland Government groundwater experts. *Does the IESC consider that the matters raised in its advice of 10 April 2014 are adequately addressed in the updated information provided in the proponent's EIS?*		
94.	<u>Response</u> 1. No. A number of key matters raised in the IESC's advice of April 2014 remain unresolved, including evidence for the existence and justification of hydraulic properties of faults; representation of model domain boundaries, final voids and groundwater users in the groundwater model; identification of surface water quality objectives; and appropriate identification of GDEs. The unresolved matters, particularly regarding the chosen hydrogeological conceptualisation (specifically	

No.	Issue raised in IESC Advice	Analysis of NAC response
	the representation of faults) and model calibration approach, which may be contributing to bias and over-prediction of groundwater heads, result in continued uncertainty in the proponent's groundwater model and hence impact assessment.	
95.	<u>Explanation</u> *Groundwater modelling* 2. Evidence, characterisation and validation of the role of faulting with regards to lateral extent and magnitude of impacts to groundwater resources is needed, with particular emphasis on faults to the south and east of the proposed open cut pits. Assessment data and monitoring bores are required to validate the assumptions made regarding faults. Monitoring bores need to be strategically positioned so that the influence of faults on groundwater head and flow can be determined.	Partially addressed. Further field evidence, in the form of a map of known faults on the mine lease was provided in NAC's response to this IESC advice (New Hope, 2016). However, the groundwater model has not been updated accordingly to include faults in the locations where these have been mapped, meaning that these new data are yet to be incorporated into the conceptualisation and groundwater model. The fault map provided also lacks any indication of whether faults have actually been mapped along their full extent, or rather extrapolated along their lines of strike (and if so, to what degree). In general terms, the source of data for mapped faults is lacking. No further field data regarding the hydraulic properties of these faults has been collected, as is suggested by the IESC, using strategic placement of monitoring bores. Such bores would be needed either side of mapped faults, and water levels checked under current conditions and during pumping tests to provide evidence of fault hydraulic behaviour. This is despite claims in Brian Barnett's affidavit of steep hydraulic gradients being indicative of faults as reasoning for the original inclusion of faults in the 2009 version of the model. Some limited field work was conducted in one area of existing mining in 2013, which gave some indication of the hydraulic behaviour of faults (WSA, 2013). However, it appears this information has not been incorporated into the conceptualisation. The data in this report suggest that while faulting may restrict horizontal flow of groundwater between displaced coal seams in some areas, this is not always the case (e.g. Page 12) and that additionally, in the lateral and vertical directions, faults may in fact act as conduits for groundwater flow (Pages 10-13). These alternative conceptualisations of the faulting have

No.	Issue raised in IESC Advice	Analysis of NAC response
		not been incorporated into updated groundwater modelling. New monitoring bores have been included in areas which are likely to be within relatively close proximity to faults (e.g. within 100s of meters of a mapped fault) (Figure 8 of New Hope Group, 2016). However, there is no information given on whether the drilling at these sites indicates that faults do indeed occur near these locations or not. As yet it can't be assessed whether or not these monitoring locations provide useful information about the hydraulic properties of faults, or what subsequent testing will be carried out in order to assess this. We recommend siting bores in closer proximity to key faults, and including nested piezometers to study fault behaviour in multiple aquifers, to gain an appreciation of their hydraulic control on groundwater flow patterns.
96.	3. The presented calibration hydrographs indicate that the updated groundwater modelling consistently over-predicts groundwater heads, by tens of metres in some cases, particularly in the alluvium and Walloon Coal Measures (e.g. monitoring bores 116P, 40Pc, CSMH1 east of proposed project area). This results in a lack of confidence in the hydrogeological conceptualisation, model calibration and predictions across the model domain. Future modelling and monitoring should consider specific environmental objectives (for example, estimating volumetric take from Oakey Creek Alluvium) using relevant calibration targets to improve groundwater impact predictions.	Not addressed. Since the time of this advice (December 2015), there has been no subsequent attempt to refine the hydrogeological conceptualisation or re-calibrate the model to address the problem of significant over-prediction of water levels in parts of the study area. Updating of model parameters (based on additional field data) and water balance (including estimates of groundwater usage around the site) are required in order to address this point.
97.	4. In the updated modelling, the proponent has used a relationship between topography and head level to determine constant head boundary conditions, except for alluvium for	Not addressed. No new water level data in the vicinity of the model boundaries has been collected and used to revise the model boundary conditions. These conditions remain unchanged as per the most recent version of the model (Appendix F of the AEIS), and

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	which a set value of 13.5 metres below ground level was used. These estimates need to be validated with measured groundwater level data in the vicinity of the model boundary, especially the closer eastern and western boundaries which are likely to have greater influence over model predictions.	alternative boundary condition settings have not been attempted.
98.	5. The IESC considers there is a high degree of uncertainty regarding the scale of potential impacts associated with the proposed voids. This uncertainty is due to the predicted temporally variable source/sink status of the final voids, the associated potential seepage to the groundwater system, and the revised prediction that water levels will now recover to greater than pre-mining levels in Willeroo Pit (and Manning Vale East Pit in the 84th percentile prediction).	Not addressed. This uncertainty has been acknowledged in NAC's response to the IESC advice (New Hope Group, 2016). It is proposed that: 'A more detailed understanding of the final void conditions is considered likely as the mine progresses towards closure planning. The model will also become more refined with reduced uncertainty resulting in prediction of final void water levels being more accurate.' This uncertainty could however be addressed through updated modelling prior to mining (e.g. not towards closure planning), based on more detailed field data and updated/alternative conceptualisations of the site in accordance with the IESC's first question (paragraph 94, above). Further, we believe that a reasonable understanding of mine pit hydrology (and hydrochemical evolution) is necessary prior to the commencement of mining, in particular because of the inherent links to the potential impacts on other groundwater users.
99.	6. The proponent has not included surrounding groundwater user abstraction data in the groundwater model. All groundwater fluxes should be represented in the model, and differentiation of mine- and landholder-induced impacts on groundwater levels is needed for assessment of impacts on specific areas or bores.	Not addressed. Groundwater extraction from properties surrounding the mine is still yet to be incorporated into the models water balance (see response to 9 and 27 above). This is potentially a fundamental flaw in the modelling, particularly given the total entitlements are comparable to the overall recharge of the site (i.e., groundwater extraction is a significant part of the water balance).
100.	*Surface water quality* 7. Some physicochemical and nutrient monitoring	The following issues (100 to 101) are surface water issues and deemed to be out of scope

No.	Issue raised in IESC Advice	Analysis of NAC response
	data has been collected over a representative period. However, surface water quality monitoring for dissolved oxygen and contaminant metals from more than one sampling episode has not been undertaken. Representative surface water quality data (including dissolved oxygen and contaminant metals) is needed to determine the existing surface water quality within the project area because water quality of ephemeral rivers such as Lagoon Creek is typically highly variable with time. This data will then need to be used to determine downstream surface water quality objectives (see paragraph 16).	for the groundwater experts
101.	8. As noted in the IESC's April 2014 advice, the proponent agreed with the need for a study into the cause of elevated levels of copper in Lagoon Creek to determine if these concentrations are naturally occurring, mining-related or caused by an anomalous reading. The study has not been undertaken. Once complete, the study should be used to provide a better understanding of the existing water quality during periods of flow in Lagoon Creek, especially "first pulse" flows, and inform the assessment of impacts to ecosystems and water users downstream of the proposed project.	
102.	*Groundwater dependent ecosystems* 9. Consistent with the IESC's April 2014 advice,	

No.	Issue raised in IESC Advice	Analysis of NAC response
	GDEs need to be clearly identified within the zone of predicted groundwater impact. While the proponent utilised the Wetlandinfo tool, a systematic approach to identifying vegetation GDEs is still needed and should include:	
103.	a. using the hydrogeological conceptualisation to identify areas of shallow groundwater,	Partially addressed. MC notes that a map of depth to groundwater contours is presented in Dr Daniel's evidence, although this does not cover the whole site and excludes the basalt aquifer. The map is largely based on predicted and/or interpolated groundwater levels using the groundwater model, rather than actual monitored water levels. Therefore the map's reliability has not been validated with real measurements.
104.	b. maps that show depth to groundwater (ideally seasonal) contours in the basalt and alluvial aquifers, overlaid with vegetation and wetland mapping to aid identification of potential GDEs,	Not addressed. MC notes that no map of depth to groundwater in the basalt has been produced and no maps of seasonal changes in water level depths have been produced in any aquifer.
105.	c. application of this approach to the full extent of predicted drawdown impacts associated with the proposed project including outside of the project area, and	Partially addressed (as outlined above in 103 and 104).
106.	d. application of techniques from, for example, the Australian GDE Toolbox (Richardson et al., 2011) and Eamus et al. (2015), to confirm groundwater use by vegetation and groundwater discharge to surface water bodies.	Partially addressed. MC notes that Dr Daniel's report includes risk assessment based on the GDE Toolbox recommended methods. However, techniques outlined in Eamus et al., (2015) have only been used to a limited degree. Eamus et al., (2015) describe three major techniques which can be used to identify GDEs. These are: 1. Use of remotely sensed data (e.g. satellite imagery); 2. Observing fluctuations in depth to groundwater, associated with plant water use; 3. Stable isotope analysis of water in the transpiration stream.

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		Some limited use of remotely sensed data (1) has been used (e.g. aerial image anaylsis). However, there has been no analysis based on the other two techniques (2 & 3).
107.	10. Identification of remnant patches of the EPBC Act-listed endangered ecological community Brigalow (Acacia harpophylla dominant and co-dominant), a known vegetation GDE, is needed. Identification of, and assessment of potential impacts to, this endangered ecological community needs to occur within the predicted zone of groundwater drawdown, including outside the project area.	Partially addressed. MC notes that Dr Daniel's report identifies some areas of Brigalow, for example associated with the alluvial aquifer. Assessments of groundwater dependence and possible impacts from drawdown is not conducted systematically – for example through monitoring of groundwater depth fluctuations in these areas.
Question 2: The Queensland Coordinator-General has imposed, stated and recommended conditions to mitigate and manage impacts to surface and groundwater, at Appendices 1, 2 and 4 respectively of the New Acland Coal Mine Stage 3 project: Coordinator-General's evaluation report on the environmental impact statement (December 2014) and these are reflected in the draft Environmental Authority – New Acland Coal Mine (August 2015). *Does the IESC consider that the outstanding matters raised in its advice of 10 April 2014 in managing impacts to surface and groundwater are adequately addressed through the Queensland Coordinator-General's conditions of approval (December 2014)? If not, what outstanding matters are still required to be addressed?*		
108.	<u>Response</u> 11. The Queensland conditions proposed under the draft Environmental Authority and imposed, stated and recommended by the Coordinator-General address a number of issues raised in the IESC's advice of 10 April 2014 that were not resolved by the proponent's AEIS. Residual matters raised in response to Question 1 (and the IESC's April	

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	2014 advice) are outlined below.	
109.	*Groundwater* 12. The IESC has remaining concerns regarding the high degree of uncertainty over the role of faulting and its influence on propagation of drawdown impacts to areas surrounding the proposed project site. Specifically:	
110.	a. The groundwater impact assessment is lacking a geological map to show locations of faults. Without a detailed hydrogeological investigation it is difficult to determine the hydraulic nature of a fault, particularly whether it is a barrier or conduit to groundwater flow (as also noted by the peer review of the proponent's revised groundwater modelling (AGE 2014)). Geological maps and hydrogeological field investigations (such as groundwater head measurements on either side of modelled faults) should be provided to validate the proponent's conceptualisation of the nature of faults, including verification of their existence, vertical and lateral extent, hydraulic properties and how they are parameterised in the groundwater model.	Partially addressed. The response to the advice (New Hope Group, 2016) does include a map of fault locations, albeit the data sources of these are not explained. However, none of the suggested hydrogeological field investigation techniques (such as measurement of groundwater head on either side of faults) have been conducted to a) validate the location of the faults and b) determine their hydraulic properties. See response to 95 above.
111.	b. Further monitoring bores (in addition to those stated in the Coordinator General's	Partially addressed. Some bores additional to those outlined in the CG's report and draft EA have been either proposed and/or drilled in the recent drilling program (Jacobs, 2016).

No.	Issue raised in IESC Advice	Analysis of NAC response
	report and the draft Environmental Authority) are needed to validate the predicted lateral extent of drawdown propagation, which is controlled in the Walloon Coal Measures by the faulting.	However, there are also bores that were proposed in the updated GMIMP which have not been drilled, in some cases due to the fact that the predicted aquifer(s) were not all encountered where drilling was attempted (e.g. Tertiary Basalt to the west of the mine lease). Alternative drilling locations which do intersect the target aquifers should be identified and included in the monitoring network to ensure drawdown impacts in all aquifers and affected regions can be monitored.
112.	c. Future reviews of modelling should require validation of the existence and nature of faulting in terms of their effect on groundwater and a sensitivity analysis of their impact on predictions.	Partially addressed. A rudimentary 'sensitivity analysis' regarding the impact of faults on drawdown predictions has been conducted, by re-modelling the system without any faults. However, neither the simulation without faults, nor the simulation with erroneous faults are correct, and the true effect of faults may not simply lie somewhere in between. There are a number of alternative conceptualisations which should be included in a thorough sensitivity analysis with respect to faults in addition to this approach, including: 1. Modelling the system with faults included at the locations where they have actually been mapped (this has still not been conducted); 2. Testing the model with alternative hydraulic properties assigned to the faults, such as enhanced vertical permeability along with reduced (but not a complete lack of) horizontal permeability; 3. Testing enhanced flow along the face of the fault – i.e. enhanced hydraulic conductivity parallel to the fault in the horizontal and vertical directions; 4. Testing the effect of fault depth (e.g. depending on how many layers offset) on flow patterns, as the depth of faulting may be uncertain. This analysis should be conducted on the basis of improved field data to justify the location, extent and hydraulic properties of faults (see response to 95 above).
113.	d. Monitoring requirements should be targeted towards reducing the uncertainty of the predicted lateral drawdown extent. This will be particularly important when determining the	Not addressed. Additional monitoring locations in particular areas have been drilled during the recent program (Jacobs, 2016). However, the distribution of the monitoring well network is still not adequate to capture drawdown impacts in all aquifers over the full extent of potentially impacted areas – particularly in the Alluvium and Basalt aquifers. Specifically, there are only 2 new bores in the basalts and 1 new bore in the alluvial

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	proponent's offsets requirements for the Commonwealth Government's Murray-Darling Basin Plan aquifers (the Oakey Creek Alluvial aquifer and the Main Range Volcanics aquifer) and make-good requirements. Additional investigations and modelling are required to reduce uncertainties in predictions of scale of impact to these aquifer systems.	aquifer to monitor drawdown impacts. As discussed in MC's individual report (paragraphs 10.2.5-10.2.7) this is far from adequate to assess drawdown impacts in these aquifers, and additional locations are required.
114.	13. In addition to the Coordinator-General's Schedule 3, Condition 2 regarding requirements for Oakey Creek Alluvial aquifer, inclusion of other water users' take within the groundwater model is needed. Accurate representation of landholder water use within the model, appropriate model outputs and presentation would be required to facilitate differentiation of mine-induced impacts from landholder impacts for specific wells or areas of importance to local landholders.	Not addressed. See response to 9, 27 and 99.
115.	14. Further to the investigation into residual voids (draft Environmental Authority - Condition E20), inclusion of updated groundwater modelling and subsequent analysis of potential impacts associated with the final voids is needed. Such modelling and analysis would result in improved predictions of final water levels, changes in water quality with time, ongoing estimates of take via	Not addressed. No updated modelling has been conducted to improve the level of certainty with respect to final void conditions subsequent to this advice or examine evolution of water quality in these areas over time.

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	evaporation (and estimates of associated volumetric take from regulated alluvial and volcanic aquifers), and the scale and impact of seepage to surrounding aquifers. This would inform subsequent adaptive management measures that may need to be implemented during the proposed project.	
116.	*Surface water* 15. A large proportion of the water quality objectives for contaminants in surface waters and mine release waters has not yet been determined in conditions. Given the previously identified exceedances of pH, electrical conductivity as well as sulphate levels that are higher downstream of the existing mining operations in Lagoon Creek when compared to upstream, water quality objectives are needed to determine existing conditions and to allow identification of surface water quality impacts during the proposed project.	The following items (116 to 120) are surface water issues, out of scope for the groundwater experts
117.	16. Water quality objectives should be informed by monitoring data gathered from the existing mine. While preference would be to use local data or monitoring information, the use of ANZECC/ARMCANZ (2000) guideline values would be appropriate while baseline data is being gathered. The Queensland Monitoring and Sampling Manual 2009 (DEHP, 2013) presents details on the design and	

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	implementation of baseline sampling techniques, especially in ephemeral rivers such as Lagoon Creek.	
118.	17. A range of surface water quality variables, including dissolved oxygen and contaminant metals, should be included in conditions that detail the monitoring requirements for surface and discharged waters. The IESC's April 2014 advice identified contaminants that were naturally elevated (i.e. copper, manganese and aluminium) and would be mobilised into surface water during flow events.	
119.	18. Further to the currently proposed state conditions, and as identified in the IESC's April 2014 advice, existing surface water quality and flow monitors along Lagoon Creek should be upgraded to facilitate continuous monitoring during discharges and natural flow events.	
120.	19. Schedule C of the draft Environment Authority sets out the monitoring requirements for environmental dams. Further to these conditions, consideration should be given to setting regular water quality monitoring requirements including frequency of monitoring and specific parameters to be monitored (e.g. physicochemical, nutrients and contaminants) within hazardous waste and environmental dams. This information	

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	should be used to inform options for improving water quality prior to release.	
121.	*Groundwater dependent ecosystems* 20. Vegetation mapping and identification has largely only occurred within the project area. Identification of impacts to vegetation GDEs (including EPBC Act-listed endangered ecological communities containing Brigalow) caused by groundwater drawdown within the full extent of the proposed project's resultant impact (including outside of the mining lease area) is needed to support the existing proposed offset and monitoring conditions.	Partially addressed (MC).See response to 102 to 106 above.

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