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Our Ref: 0001P.P1.L1
25 February 2022

EXPERT OPINION – NARRABRI UNDERGROUND MINE STAGE 3 EXTENSION PROJECT (SSD 10269)

Dr Steven Pells

INTRODUCTION

This advice has been prepared in response to a brief (the Brief) from Environmental Defenders Office (EDO) dated 28 January 2022 (ref: S2602). The Brief requests review of various documents in relation to the Narrabri Underground Mine Stage 3 Extension Project (Project) and to provide a report which addresses the following issues in regard to any groundwater and/or surface water impacts arising as a result of the Project:

a. any key impacts predicted to arise as a consequence of the Project;
b. whether the assessment of environmental impacts, as far as it relates to my areas of expertise, was appropriate and sufficient;
c. whether the assessment adequately considered any cumulative impacts arising from the Project;
d. what, if any, concerns I have about the environmental impacts of Project, bearing in mind the mitigation measures proposed; and
e. any further observations or opinions which I consider to be relevant.

I confirm that I am qualified to provide expert opinion on these matters of mining effects on groundwater and surface water and that the following letter contains opinions held by myself based upon review of the below-cited reports and data. A copy of my CV is attached to this letter as Appendix A. I also attach a copy of the Brief as Appendix B.

I have read and agree to be bound by Division 2 of Part 31 of the *Uniform Civil Procedure Rules 2005* (UCPR), and the Expert Witness Code of Conduct (Code of Conduct) contained in Schedule 7 of the UCPR.

My opinions addressing items a. to e. above are stated below in the section “Summary of Findings”. The scientific basis for each these opinions is supported by reference to sections of my “Report” below.

SUMMARY OF FINDINGS

Issue	Statement	Supporting Information
a. Key impacts predicted to arise as a consequence of the Project	The impacts considered in this advice relate to groundwater and surface water. The more valuable groundwater identified resources in the region are those stored within the Pilliga Sandstone and the Namoi Alluvium geological formations. Surface water relates primarily to tributaries to the Namoi River.	Section 1.2
	Depressurisation and dewatering of the coal seam before and during longwall mining will invoke seepage flow toward the mine and cause a wave of depressurisation to propagate outwards from the mined seam, causing associated depressurisation and dewatering of groundwater within adjacent geological formations.	This is an established understanding of mine effects. It is observed in data presented in Section 2.1.2.
	Depressurisation will affect the direction of groundwater flow in adjacent formations and where the direction trends downward to the mine it will reduce the standing water level available within bores for usage in farming, water supply or industry, and may redirect water from supplying water to other sources such as rivers and surface water bodies.	This is an established understanding of mine effects.
	Numerical groundwater modelling is used to estimate how far these impacts propagate, and at what rate. The predictions given in the EIS are presented in maps showing "drawdown" – which is a term to indicate change in pressure, expressed as meters of 'head' of water. These maps show extensive drawdown with the coal seam and adjacent seams. However, there are minor to negligible impacts predicted to the Pilliga Sandstone, and the Namoi Alluvium.	Section 3.2.7
	Longwall mining causes the geological formations above the mined coal seam to collapse into the void made after coal is removed. Hence the geological formations above the mine slump downwards and distort and crack. The ground surface above the mine also moves downward, known as 'subsidence'.	This is an established understanding of mine effects.
	A review of the suitability of the subsidence predictions presented in the EIS is beyond the scope of this present advice. Nonetheless, it is accepted that cracking and slumping is an effect of mining, and it is known that groundwater flow can rapidly move through areas subject to such cracking. In the vicinity of the mine, such cracking will enhance the rate and extent of dewatering. If	This is an established understanding of mine effects.

	cracking extends to, or occurs on, the surface, it can interrupt or drain surface water bodies or rivers, or at least cause reduction in rainfall runoff to water bodies or rivers. In addition, by changing the surface topography, subsidence can interrupt or change river flow gradients and directions, and cause ponding.	
	The EIS studies consider that such cracking extending to the surface "is unlikely to possible". Subsidence effects on redirection of creeks and rivers is not given clear discussion, although current survey data indicates it has happened in the past at this mine.	Section 4.
	The proposed mining extension would increase the currently approved mining area by approximately 180%. This would be expected to result in significantly larger impacts than predicted for the existing mine.	Section 1.1
Appropriateness and sufficiency of of the assessment of environmental impacts	In my opinion the predictions in the EIS showing that groundwater resources in the Pilliga Sandstone and Namoi Alluvium are unaffected by mining may be inappropriate. My reasons are:	
	• The conceptualisation of geology adopted in the groundwater modelling artificially isolates the Namoi Alluvium, reducing predicted impacts on the groundwater of the Namoi Alluvium. There is no justification provided for such representation, and it appears to be inconsistent with geology.	Section 3.2.1
	• The vertical hydraulic conductivity values adopted for the geology between the mine and Pilliga Sandstone are very low, having the effect to shield the Pilliga Sandstone from impacts. The values used are too low, in my opinion, and are not supported by due scientific observation. Specifically:	Section 3.2.2
	○ Adoption of values from laboratory testing of core samples is not suitable for advising vertical hydraulic conductivity in a regional flow model.	Section 2.2.1
	○ Field testing of hydraulic conductivity is insufficient and, in some cases, possibly erroneous.	Section 2.2.2
	Uncertainty testing of numerical modelling presented in the EIS does not adequately represent cases with higher hydraulic conductivity, as these are presented as having lower probability of occurrence.	Section 3.2.6
	It is further noted that the extent of subsidence-induced cracking assumed in modelling will affect	Section 3.2.3

	the predicted impacts on the Pilliga Sandstone. The extent of cracking assumed in groundwater modelling is not clearly discernible and should be presented clearly.	
	Monitoring of mining effects over the last 10 years should provide a basis for calibration of the groundwater model to address the above concerns. Calibration presented in the EIS is insufficient to dismiss the above concerns because:	
	• Monitoring in critical bores has been discontinued.	Section 2.1.2 Section 3.2.5
	• For all other bores, available groundwater data records are only considered up until 2019.	Section 3.2.5
	• The level of calibration achieved is insufficient to remove the non-uniqueness problem in groundwater modelling. Calibration results cannot be used to assert that the uncharacteristically low hydraulic conductivity values used in modelling are correct.	Section 3.1
	In my opinion the assessment of impacts to stream and creeks above the mine that have already occurred due to mining is inadequate.	Section 4
	The assessment of environmental impacts on streams from future mining effects is also inadequate.	Section 4
Adequacy of the assessment's consideration of cumulative impacts arising from the Project	The assessment included groundwater modelling scenarios that represented concurrent operation of the proposed Santos Narrabri Gas Project. It was stated that the method was based on adoption of water extraction volumes as supplied by Santos. I do not know whether these values are suitable for representation of the proposed Santos Narrabri Gas Project but I contend that there must be uncertainty about such volumes and such uncertainty was not addressed. Modelling of the Narrabri Gas Project did not include further consideration of hydraulic conductivity parameters over the Gas Project regions, and has not been calibrated against observations in that region.	Section 3.2.4
	Regardless of the above, the assumptions of groundwater modelling for the Narrabri Coal Extension apply equally to modelling of the Santos Narrabri Gas Project. The prediction of cumulative impacts therefore suffer from the same inappropriate aspects as detailed above.	Section 3.2.7
Concerns in relation to the environmental impacts of Project,	I have the following concerns: 1. That the actual impacts to the regional groundwater resources from the Narrabri	

after considering proposed mitigation measures	Coal Project will be significantly larger than predicted due to the inappropriate aspects of the groundwater modelling, as described above.	Opinion based on concerns listed in b. above
	2. That the cumulative impacts to the regional groundwater resources from the Narrabri Coal Project and the Narrabri Gas Project will be significantly larger than predicted due to the inappropriate aspects of the groundwater modelling, as described above.	Opinion based on concerns listed in b. above
	3. That monitoring will not observe or report actual impacts due to it being insufficient and / or being discontinued or not reported.	Section 2.1.3
	4. That there is no feasible means for cessation of such impacts during the ongoing undertaking of approved mine works.	Opinion
	5. That there is no feasible means for remediation of such impacts after mining other than a very long passage of time.	Opinion
Further relevant observations	There appears to have been relatively little additional field investigation or monitoring to support the Project, despite it being close to doubling of the mine size. There has been no additional field testing of hydraulic parameters. It is unclear to me if there is any formal incentive to ensure that monitoring of impacts is of sufficient extent and that it will be continued.	Section 2.1

REPORT

1. OVERVIEW OF NARRABRI UNDERGROUND MINE STAGE 3 EXTENSION PROJECT

1.1 Details of the proposed extension

The Project comprises an application to increase the extent of the existing Narrabri Mine. Approvals for the current mine cover an area of approximately 32 km^2, of which, to date, approximately 10 km^2 has been mined (Figure 1). The Project seeks to increase the mine footprint to approximately 57 km^2 (Figure 1).

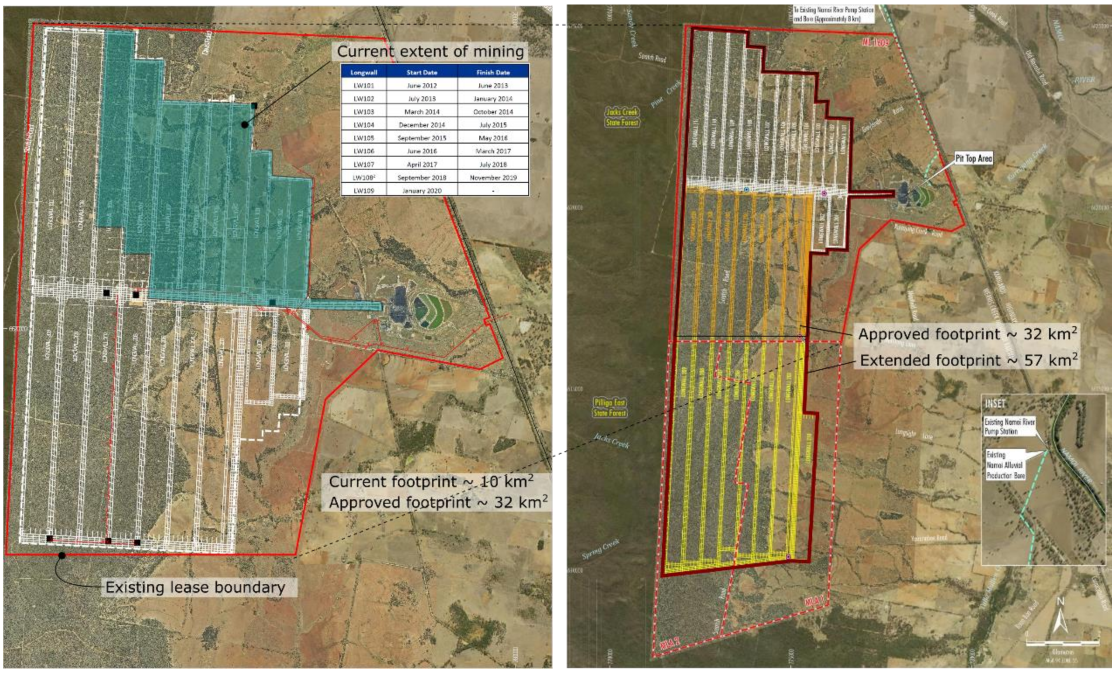

Figure 1 – Overview of the existing and approved mine and The Extension

1.2 Geological setting

The location of the approved mine and the Project is overlaid on the geological sheet (from the Environmental Impact Statement (EIS)) in Figure 2. A conceptual diagram of the geology as presented in the EIS is reproduced below it. Three key matters of note are made with regard to the geological plan:

a. The Project lies on the eastern extremity of the Great Artesian Basin (GAB). The geological formations of the GAB in the vicinity of the Project are slanted (‘dip’) toward the west, which results in each formation intersecting the natural ground surface. This area is identified as a ‘recharge zone’ for the GAB.
b. The Project lies adjacent to deep alluvial deposits adjacent to the Namoi River. These alluvial deposits create a valuable groundwater resource in the region. Depth contours of the alluvium shown in Figure 3 highlight its extent and proximity to the Project.
c. The Pilliga Sandstone is described in the EIS to create a “highly productive aquifer” of porous sandstone.

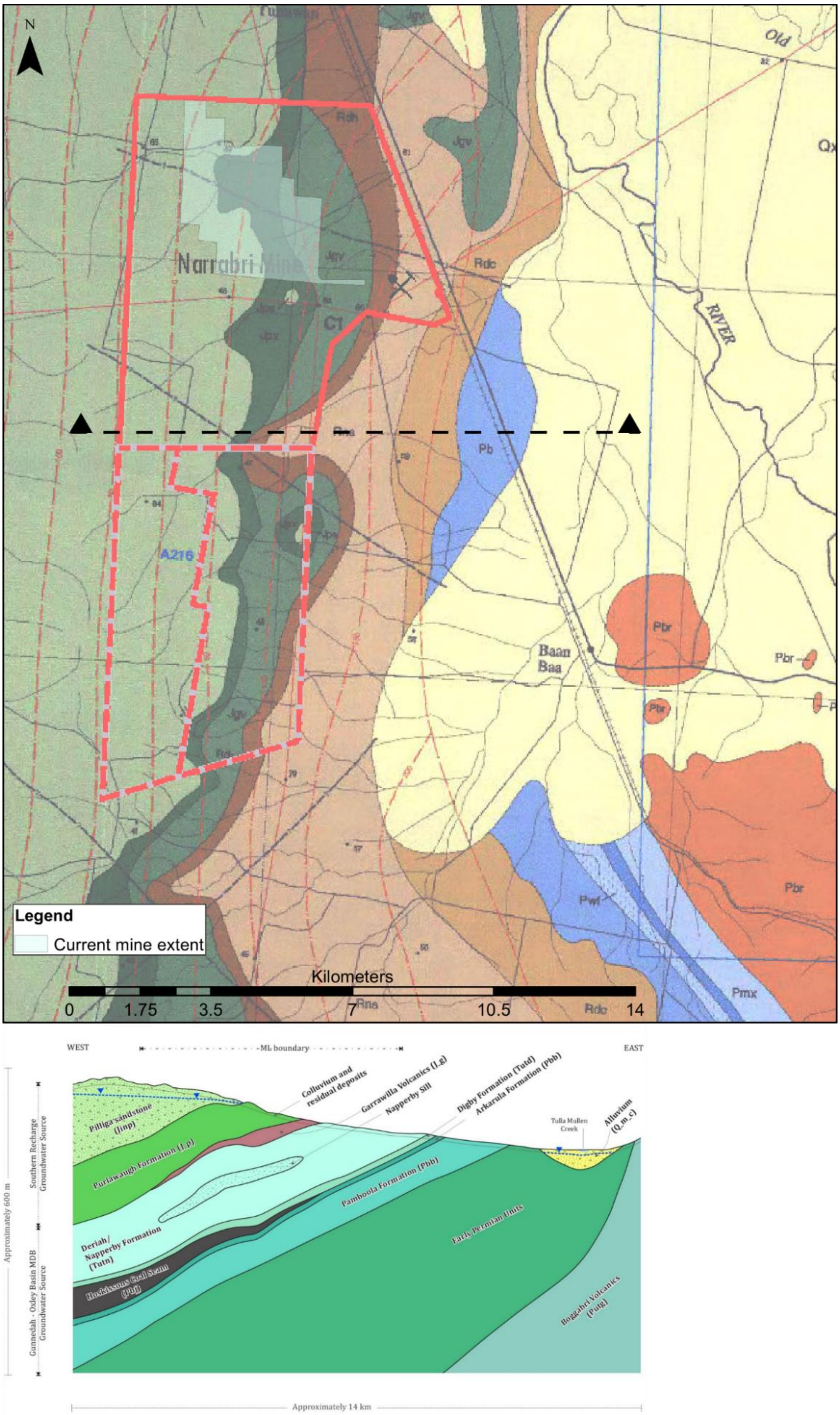

Figure 2 – Overview of regional geology with the approved mine and the Project and showing interpreted geological section as presented in the EIS (note: colours used in upper figure differ from those used in lower figure)

It was not possible in the scope of the present advice, to review in detail the interpreted geology shown in the cross section in Figure 2 (i.e. against bore data). It is noted that:

1. The exaggerated vertical scale in the conceptual cross-section visually over-emphasises the dip of the strata.
2. In my experience, hydrogeologists tend to expect flow to follow along geological sequences with flow between sequences seen as a secondary process or even an aberration requiring special labelling as "connectivity" or similar, whereas in reality, water moves from high potential to low potential with no regard to such simplifications of geology as imposed by humans. Such a conceptualisation, if adopted in the modelling, would diminish representation of connection between mining in the Hoskissons seam and the alluvium.
3. The extent of alluvium is greatly under-represented in the conceptual cross-section.

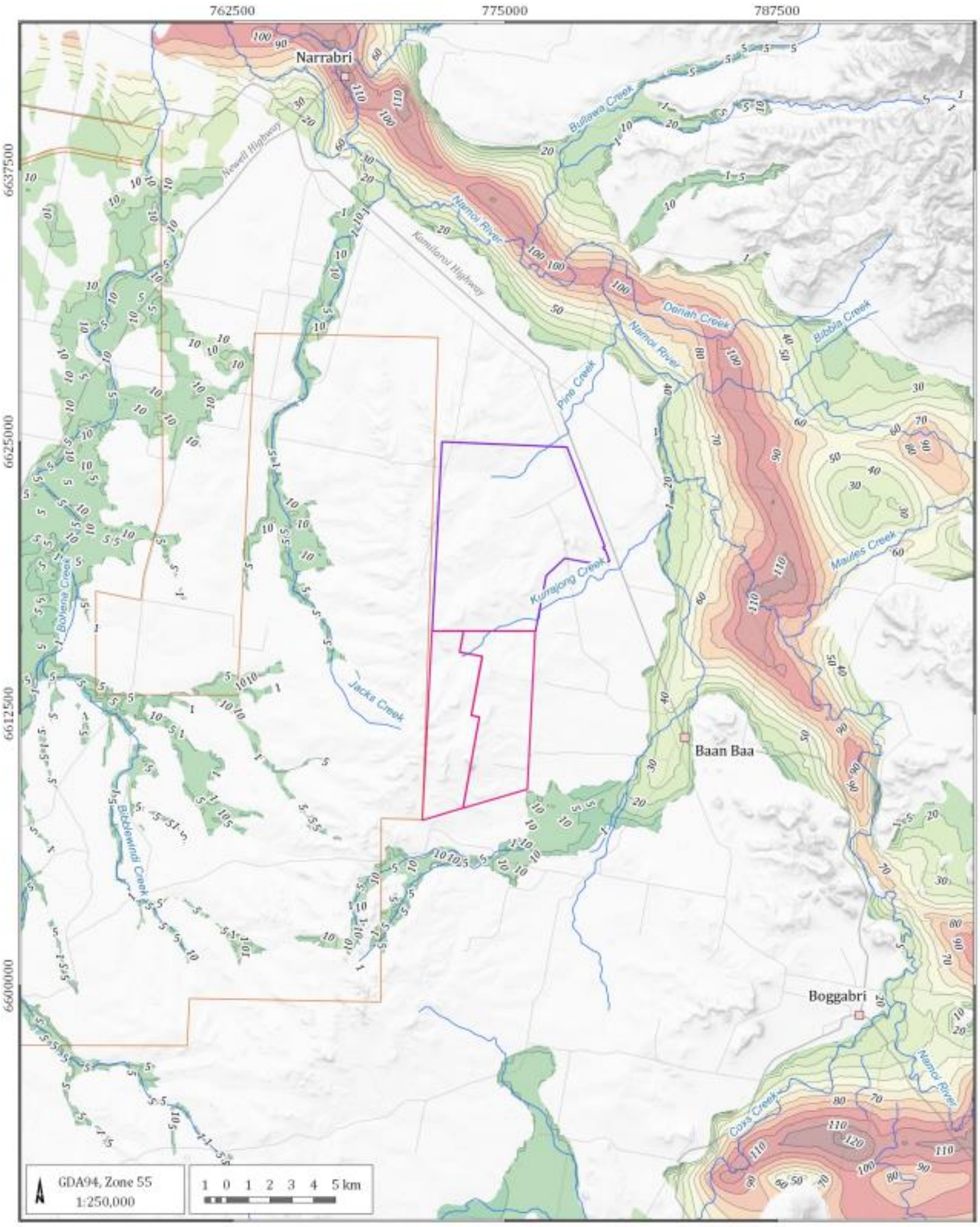

Figure 3 – Depth contours of the Narrabri alluvium showing proximity to the Project

2. REVIEW OF GROUNDWATER DATA

2.1 Groundwater level monitoring

Groundwater level monitoring is undertaken through routine recording of water levels or water pressure in boreholes. Water levels are recorded in open wells ('standpipes') and water pressures in closed wells, which are typically filled with grout but with a pressure-recording instrument called a vibrating wire piezometer (or 'VWP') installed within the grout. Standpipes have the advantage that the standing water can be accessed for water quality sampling and/or aquifer testing, such as pumping or slug tests (discussed below), but have the disadvantage that the water level in the well is some averaged reflection of pore water pressures over the length of the well screen. Water in bores featuring grouted-in-place VWPs cannot be accessed, but the recorded pressure is a measurement at a known depth. Additionally, multiple VWP instruments can be installed in a single grouted bore, which allows observation of the vertical distribution of pressure – a matter that is essential when assessing changes to regional flow patterns – in particular downward flow to underground works such as longwall mines.

A catalogue of standpipes and VWPs that have been installed for monitoring around Narrabri Mine are presented in the EIS for the Project (and associated technical studies) as well as the Project's Gateway Application. A summary of the chronology of development of groundwater monitoring data is presented in Figure 4.

A spatial presentation of the groundwater level monitoring locations is presented in Figure 5.

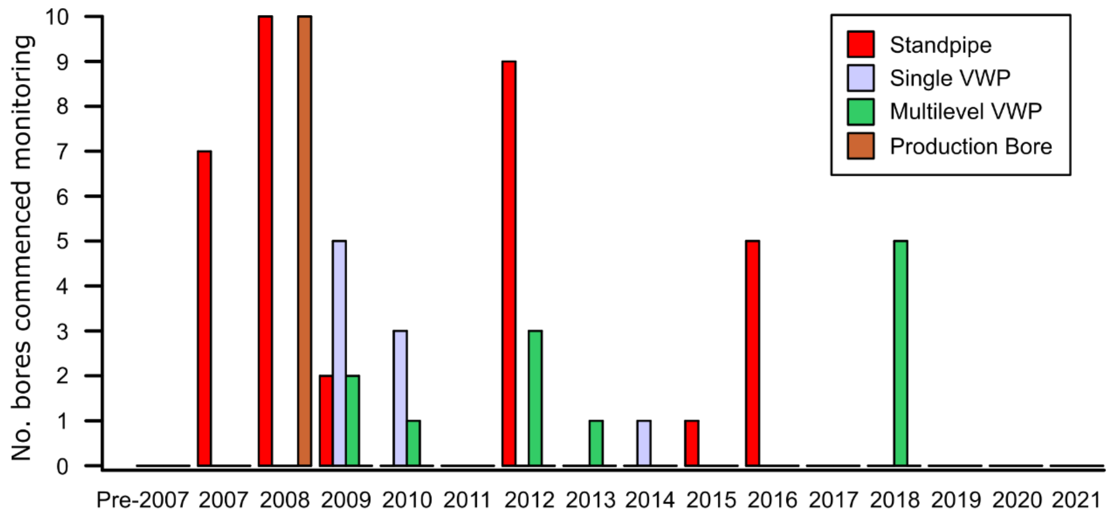

Figure 4 – Chronology of development of groundwater level monitoring for the Project

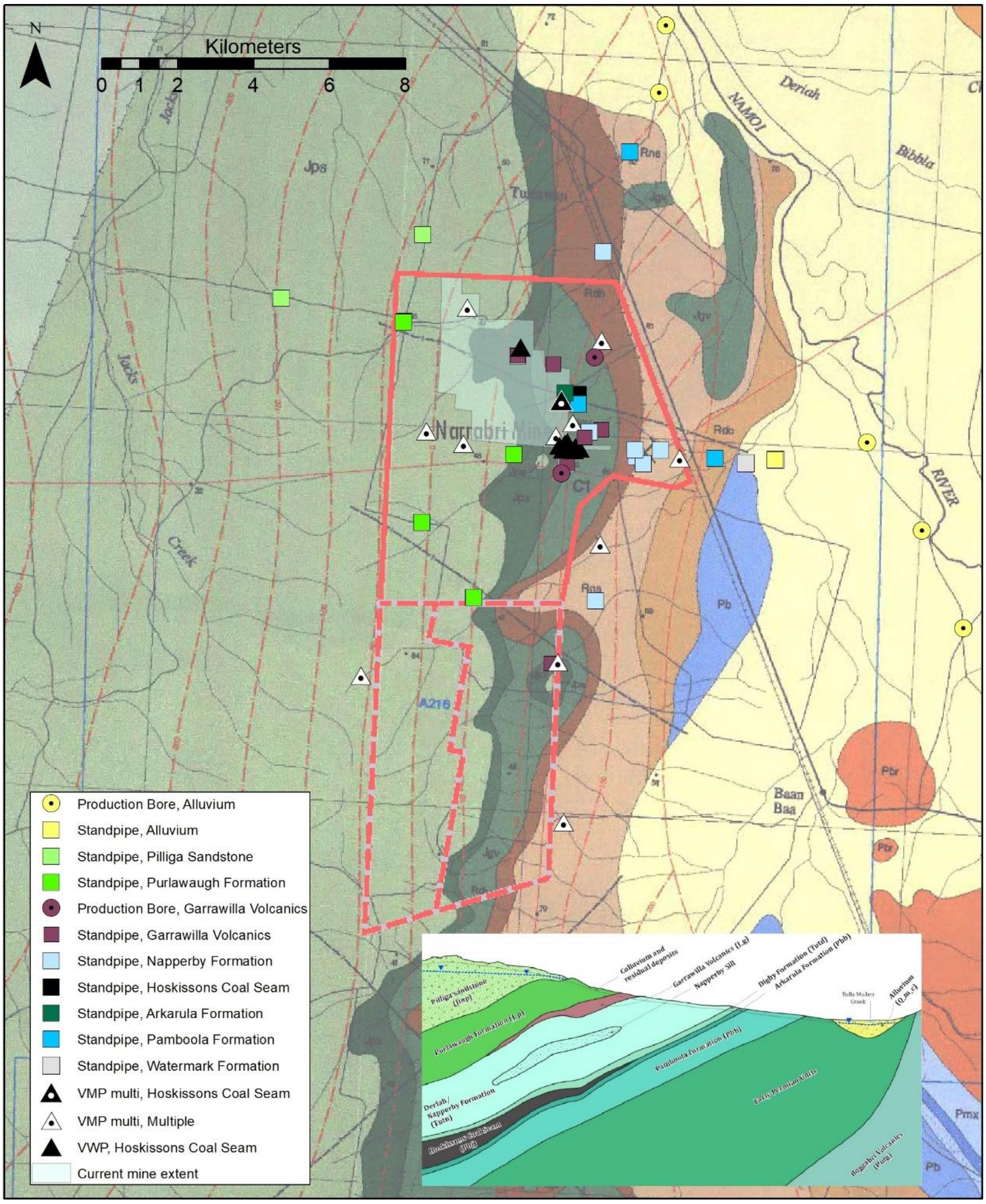

Figure 5 – Locations of groundwater monitoring listed in the EIS

2.1.1 Baseline conditions

For the effects of the Project upon groundwater levels to be known, it is necessary to know what the groundwater levels were prior to mining – i.e. the 'baseline conditions'. Although the mining progressed over a number of years subsequent to 2012, degassing prior to mining and the lateral propagation of mining effects means that, in my opinion, measurements of bores after 2012 may not reliably represent baseline conditions.

From Figure 4 it can be seen that before commencement of mining in 2012, water levels could be monitored in 19 standpipes, 8 single VWP's and 3 multilevel VWPs. A total of 10 production wells were also established in the Alluvium. A spatial presentation of the installations prior to 2012 is shown in Figure 6. There is a reasonable scatter of observation points, although close examination shows that not all geological sequences are represented with multiple wells, a matter that, in my opinion, should be be considered in assessment of mining impacts.

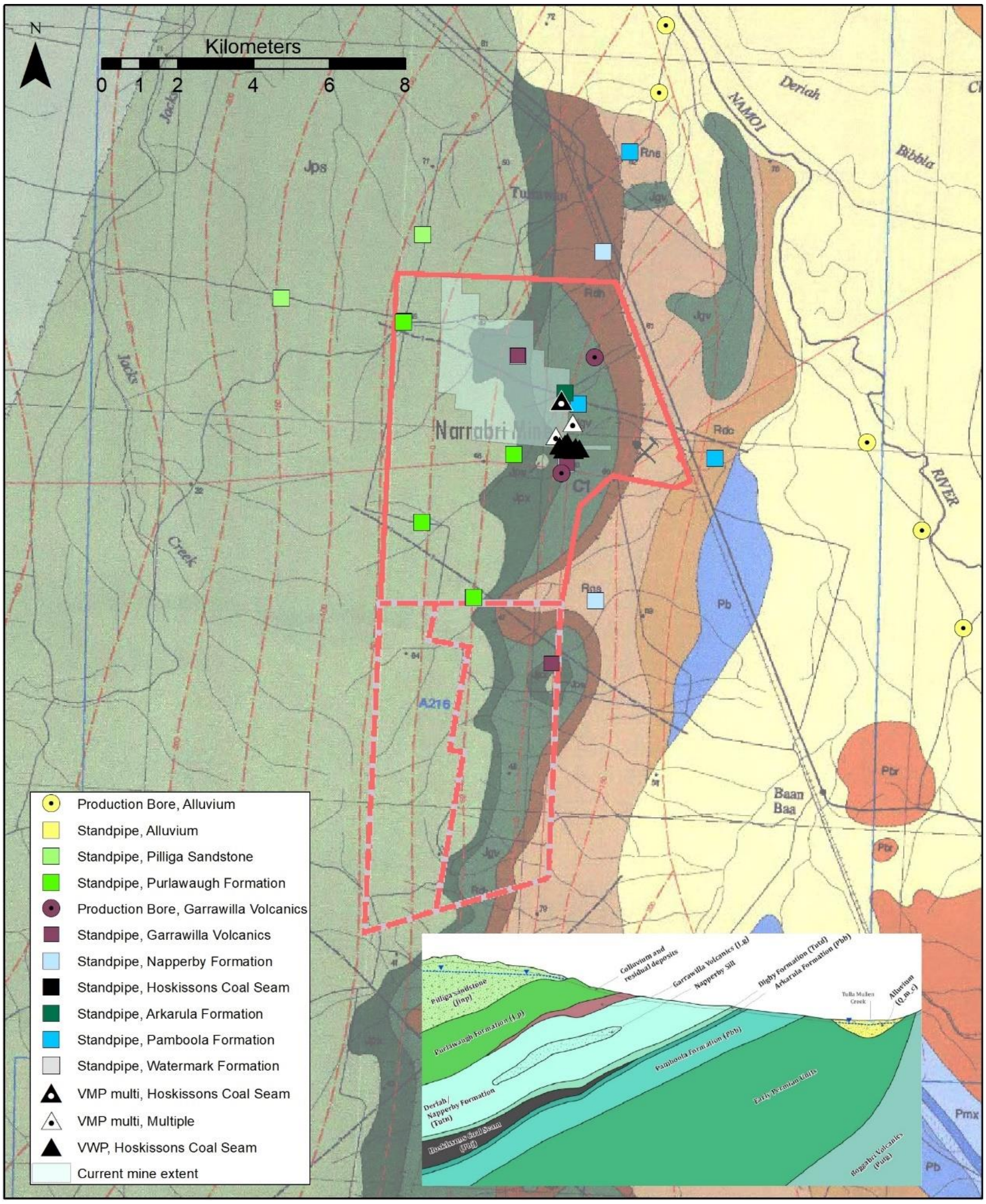

Figure 6 – Locations of groundwater monitoring commencing prior to 2012

2.1.2 Observed effects of past mining

Assessment of impacts from the Project should consider the observed impacts from existing mining. Observations in the wells constructed before 2012 are presented in Figure 7. Monitored levels in multi-VWP's at P23, P24 and P40 are presented in Figure 8.

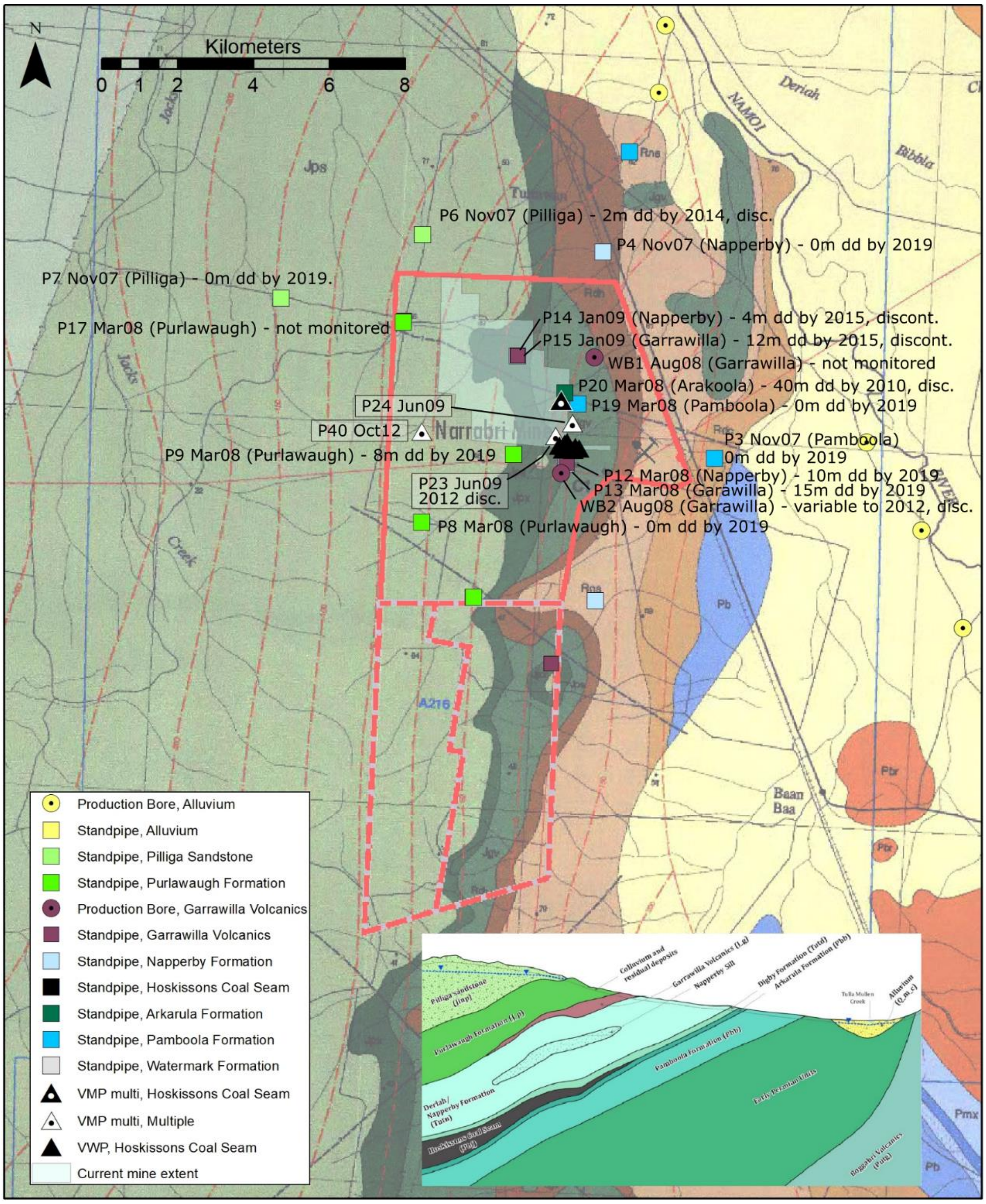

Figure 7 – Observation of groundwater monitoring in wells commencing prior to 2012 (dd=drawdown; disc.=discontinued)

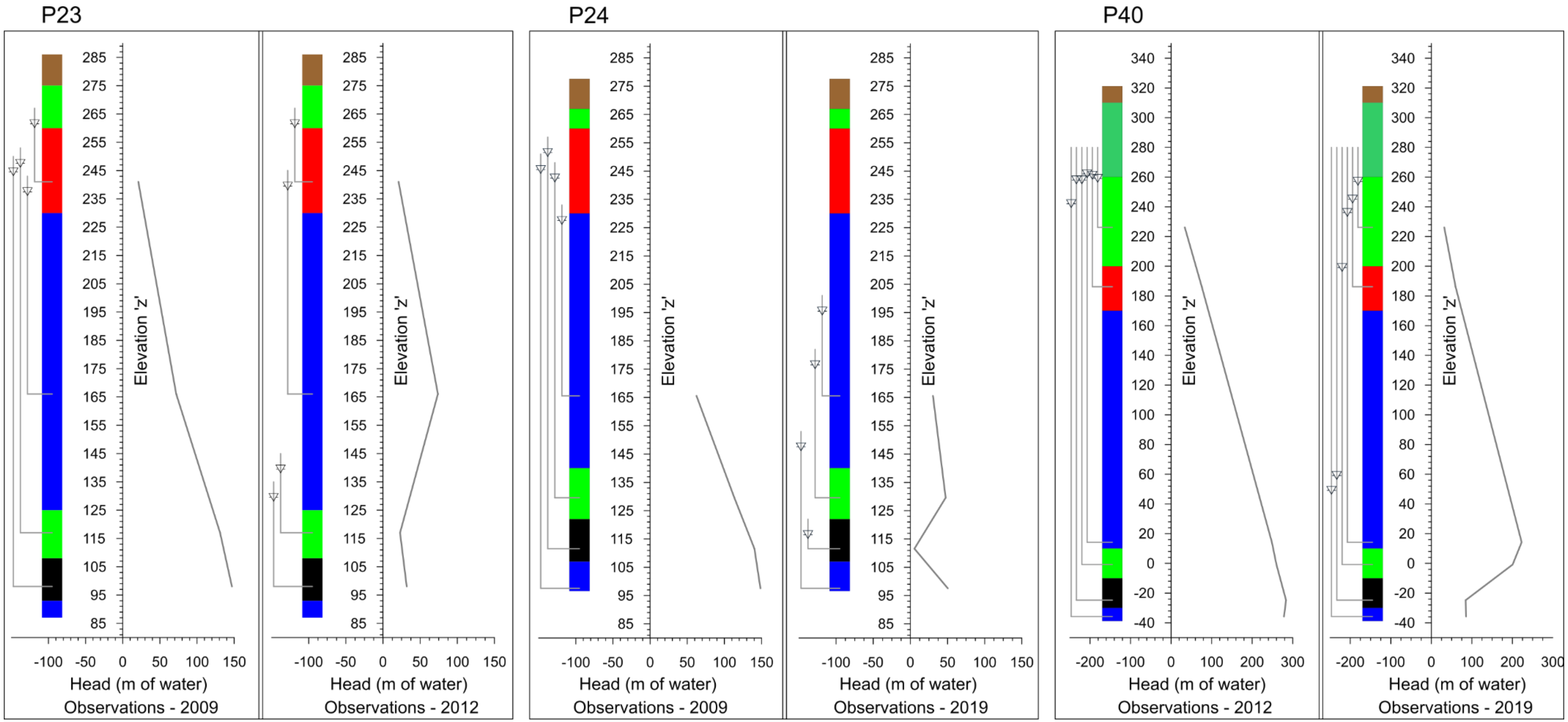

Figure 8 – Observation of groundwater monitoring in VWP's P23, P24 and P40 (geological strata are approximate)

Drawdown is observed in most wells and VWP data show that conditions are approximately hydrostatic prior to mining, with development of a flow toward the coal seam from above and upward from below once mining progresses - that is typically observed in longwall mining. Unfortunately monitoring in many wells has been either absent or discontinued. Only a single well (P2) appears to continue monitoring within the Pilliga Sandstone. VWP data for P23 is not available for the last 10 years. There is no data after 2019 presented at any of the monitoring points.

2.1.3 Capacity to observe future effects

It can be seen in Figure 5 that few wells exist to characterise baseline conditions and then monitor impacts from the Project. In my opinion there are insufficient monitoring locations to support obtaining "detailed baseline data" as required by Section B35 (iv) of the Draft Conditions of Consent for the Project. It is also of concern that monitoring of previous bores has been unreliable and has ceased in many locations. The Draft Conditions of Consent for the Project require what I consider to be a reasonable ongoing monitoring requirements, but are unclear what consequences for non-compliance are so as to enforce ongoing and reliable monitoring of groundwater in accordance with the conditions

If the Project is approved, the existing VWPs around the Project perimeter will be invaluable to monitor mining effects and should be maintained and be replaced if broken.

2.2 Field and laboratory testing

2.2.1 Overview of testing

Assessment of impacts using groundwater modelling relies upon suitable representation of the hydraulic characteristic of the ground – primarily the ease with which water can move through the ground (the 'permeability' or 'hydraulic conductivity') but also how much water is stored underground and how much of it can be released from storage (storage parameters, being 'specific yield' and 'specific storage'). These hydraulic parameters can be examined by tests including: tests undertaken *in situ* ('field tests'), and; sampling of material to be tested in laboratory.

Flow through rock (such as at the Project) occurs as a combination of flow through the rock substance and also through defects (i.e. joints and cracks) in the rock substance. Typically, the flow through defects greatly exceeds the flow through the substance, but the two flow-types are not individually represented in groundwater modelling. Rather, they are lumped together, by adoption of hydraulic conductivity (and storage) values that present the net effect of both flow processes (i.e. through defects and through the substance). This is usually a reasonable representation at a large enough scale.

Field tests comprise making a controlled change to the groundwater system by creating a controlled disturbance (such as by introducing or removing water) and then monitoring the change. Parameters can then be calculated from the observations. Field tests have the advantage that they test the conditions as they lie in place, and typically can test a larger area of rock, thereby giving a better approximation of a hydraulic conductivity represented by the combination of flow through rock mass defects and flow through its substance.

Laboratory testing offers a more controlled and detailed test, but the disadvantage is that it is taken on a small sample of ground which cannot reliably be considered representative of the hydraulic parameters suitable for a regional flow model. Typically a small intact core sample suitable for testing will be free from defects and is therefore representative of the substance permeability of a rock mass - with a value of hydraulic conductivity far lower than a value suitable to represent the whole rock mass. However, if the core sample happens to include a defect, its' test may be skewed to over-represent defect flow – a far higher value. For this reason, in my opinion, laboratory testing of hydraulic conductivity should not be used to determine values adopted in regional-scale groundwater flow models. It is noted that previous consultants for the Project also held this view:

> Core samples from the Digby Formation, Hoskissons Seam, Arkarula Formation, Brigalow Formation and Pamboola Formation from exploration holes NC123R, NC125, NC126 and NC127 were submitted to CSIRO for permeability testing. Core testing was undertaken to provide data on the matrix permeability of the different formations. However, as groundwater flow is largely dependent on fracture permeability, values of matrix permeability were of limited value in the evaluation of hydraulic conductivity for the numerical groundwater flow modelling.

Excerpt from Narrabri Coal Stage 2 Hydrogeological Investigation, Aquaterra, November 2009

Field tests rather than laboratory (core) tests should therefore be relied upon to inform suitable hydraulic conductivities for regional scale groundwater modelling. Common methods of field tests include:

- Pumping tests: these tests involve removing water from a larger well and monitoring the response within the well and also within adjacent wells. The test is often continued for a period of a number of days. This type of test gives estimates of ground condition over a larger area and therefore provides the more reliable estimates than other field methods. By monitoring adjacent wells over time, estimates of 'storage' values can also be made. The disadvantage is that it requires more time and cost.
- Packer (or "DST") tests: these tests are done in open (unlined) boreholes in rock, usually during or just after core drilling. Inflatable seals ('packers') are used to hydraulically isolate a section of bore hole, and water is pumped into the ground under pressure into the isolated section of borehole. Data on flow rate versus pressure is used to analyse the hydraulic conductivity of the ground, typically reported in 'lugeons' (1 lugeon ~ a hydraulic conductivity of 1 x 10^{-7} m/s (~ 1x 10^{-2} m/day) (Burgess, 1983)). The advantage of the test is that it is relatively rapid and it is possible to target specific locations in the ground. The disadvantage is that the measurements depend on the nature of defects that are encountered in the test section, and the test arguably tests only horizontal hydraulic conductivity. Also, for formations with very low hydraulic conductivity, very accurate measurement of the small water flow is required to obtain a measurement, such that the test typically only reports hydraulic conductivity down to 1 lugeon or at very best 0.1 lugeon (~a hydraulic conductivity of 1 x 10^{-8} m/s).
- Slug tests: these tests involve causing a sudden change to the water level in an open standpipe (such as by adding water or using air pressure and sudden release) and then monitoring the recovery of standing water back to its original position. Analysis of the rate of recovery allows an estimation of hydraulic conductivity. The advantage of the test is that it is simple and quick to undertake. The disadvantage is that it creates only a small disturbance and may only represent the ground immediately adjacent to the standpipe and may be skewed by the nature of standpipe construction.

It is good practice to have completed enough pump tests to provide reliable estimates of parameters. Numerous packer tests and slug tests can then provide additional guidance.

2.2.2 Testing data adopted in the EIS

A number of field tests have been undertaken for previous stages of the Narrabri Mine. It is my understanding that testing was undertaken for prior approvals, and no further testing was undertaken to support the Project.

The groundwater studies for the Project compiled previously undertaken field data. The data that was considered came from packer tests, slug tests and laboratory core tests. These data are presented in Figure 9. The following comments are made:

1. No pumping test data was included.
2. Packer (DST) tests typically cannot measure hydraulic conductivity below 1 x 10^{-7} m/s – perhaps extending to $1x10^{-8}$ m/s with special equipment. Tests presented in the EIS reported packer test measurements below this, and even down to $10x10^{-10}$ m/s. This appears to be implausible and suggests error in interpretation and / or units. I was unable to access the source data for these tests (eg cited as Sigra, 2006 in the EIS) to review this.
3. Laboratory tests on core samples typically report significantly lower hydraulic conductivity values (with some instances of very high values) - this is consistent with the commentary in Section 2.2.1 above.
4. It is unclear how laboratory tests were able to be demarcated into measurements of hydraulic conductivity in the horizontal direction (k_H) and in the vertical direction (k_V) (it is difficult to obtain horizontal core samples, for example). I was unable to access the source data for these tests (eg cited as Weatherford, 2009 and Core Laboratories Australia, 2018 in the EIS) to review this.

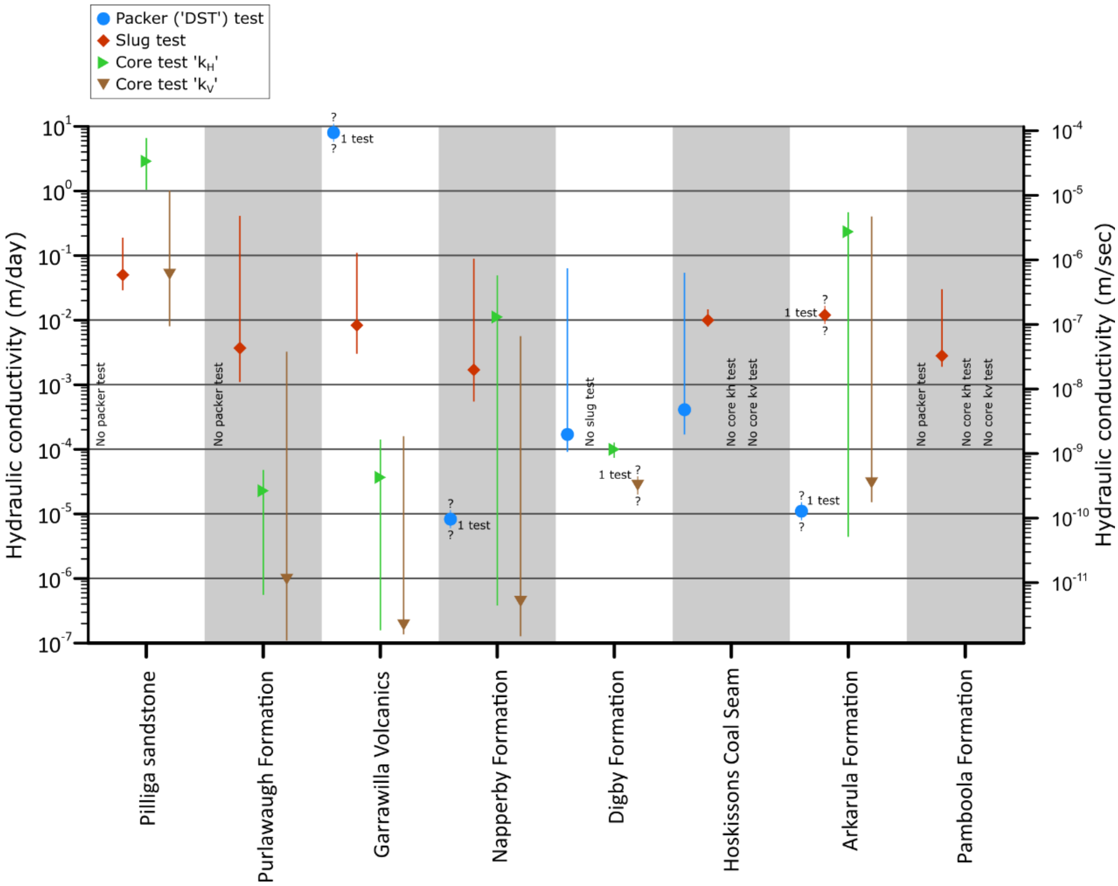

Figure 9 – Hydraulic conductivity data referenced in the EIS Groundwater study

With reference to my comments in Section 2.2.1 above, it is evident that the dataset of field testing is poor, because of the lack of pumping tests, which I consider to be the most appropriate, and because there appears to be an issue with the undertaking or interpretation of the packer tests. As shown below, groundwater modelling then relies heavily upon laboratory tests, which I do not consider to be appropriate as described above. The consequence of this is a limited certainty around suitable hydraulic conductivity (and other) values. The basis of science is testable hypotheses, and there is a limited basis to scientifically defend the values adopted in modelling against test.

3. REVIEW OF GROUNDWATER MODELLING

3.1 Preliminary comments on groundwater modelling

Groundwater modelling involves solving the equations of groundwater motion in three dimensions by representation of the geology with a numerical grid. There are numerous parameters to choose to represent the manner in which water can flow through and be stored in rock and representing an average of the characteristics of the rock substance and its defects. Arguably the most significant parameter is the hydraulic conductivity, and predictions of the flow of water and the change in pressure in response to disturbances (such as mining) are very sensitive to the parameters of hydraulic conductivity chosen.

It is important to understand that groundwater modelling creates a non-unique representation of reality. By analogy, the two 'scales' presented in Figure 10 below could be both said the be balanced, although the mass in each case is different.

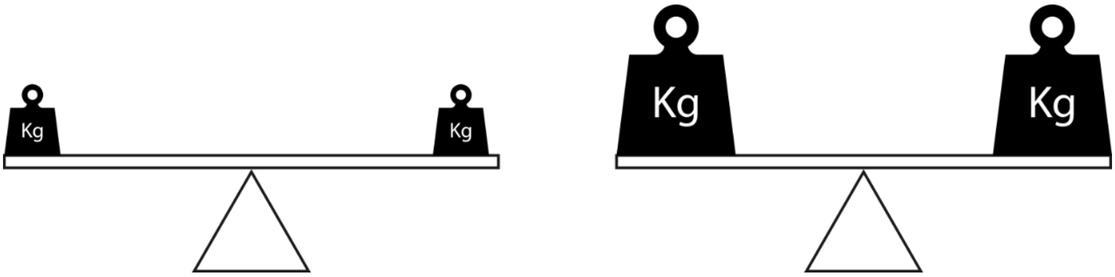

Figure 10 – Example of non-uniqueness – both systems are balanced but have different mass

Groundwater modelling has this problem, in that the amount of recharge (excess rainfall percolating into the ground) must be balanced against the flow to and from the model. This can be achieved, for example, with a small amount of recharge and a correspondingly small outflow from the model, or a large recharge and large outflow from the model (e.g. Figure 11).

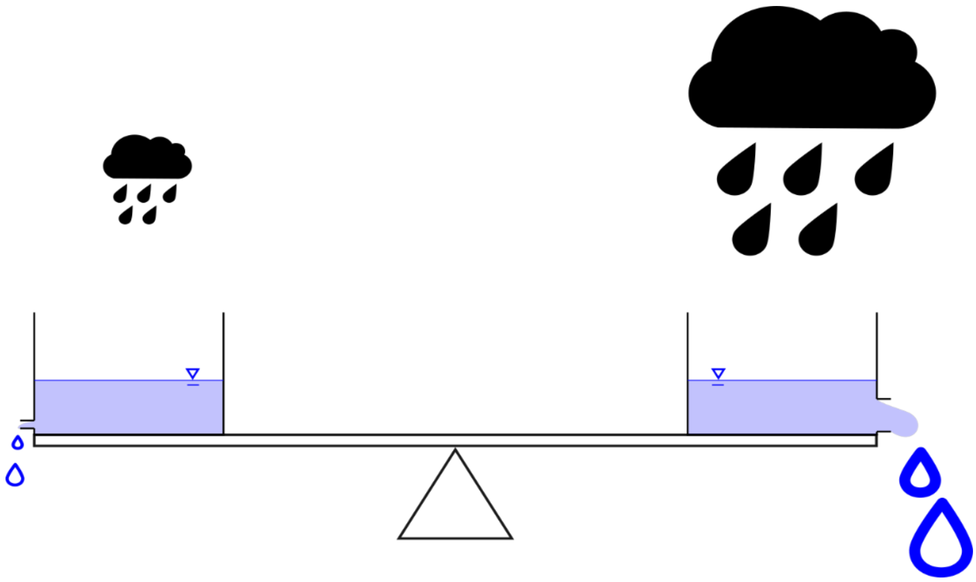

Figure 11 – Groundwater modelling requires balance of recharge versus outflow for a given water level – this could be achieved with low recharge and low outflow (left) or high recharge and high outflow (right), or various possibilities in between.

Additionally, a groundwater model typically has multiple layers of geology and, for each region, there are various ways in which water can be represented to flow in and out of and be stored in the region, requiring a myriad of values for its mathematical representation. There may be infinite possible representations (Figure 12).

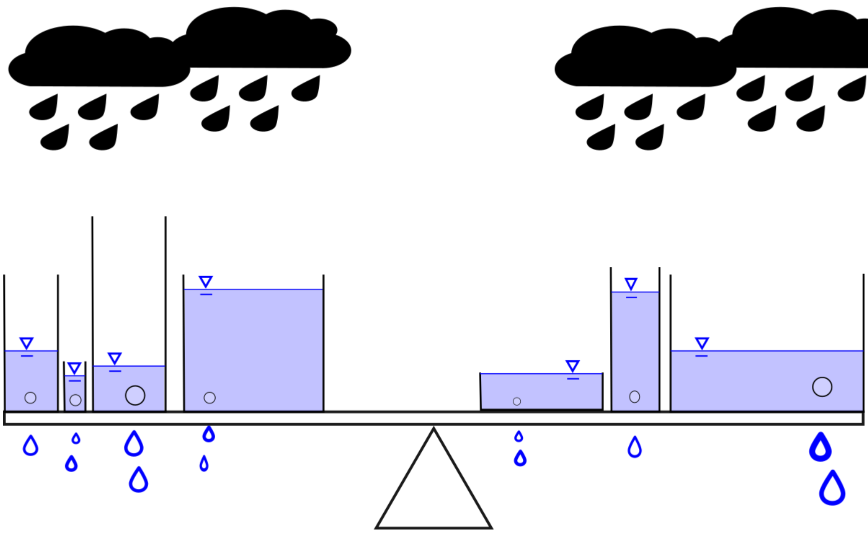

Figure 12 – With multiple geological regions (or 'aquifers'), similar flow 'systems' can be represented by numerous possibilities

The process of calibration of a groundwater model seeks to find one particular combination of values which are broadly compatible with the field test data, geological understanding and the observations of groundwater levels within boreholes and/or water bodies. The match achieved is imperfect.

This discussion does not dismiss the importance of calibration. It can be said that a calibrated groundwater model is one possible, coherent representation of reality. The corollary is that it cannot be said that calibration of a groundwater model proves the values adopted (e.g. of hydraulic conductivity) to be singularly true. To reduce the possibility of poor prediction, model values should be plausible and should be based upon measured data.

The reason I include the discussion above is because in my opinion the values for vertical hydraulic conductivity adopted in modelling (presented below) are too low. The above reasoning explains why I reject a counter argument that the values are validated by calibration.

3.2 Review of groundwater modelling for the Project

3.2.1 Representation of geology and boundary conditions

The groundwater study in the EIS presents the cross section reproduced in Figure 2 above as the 'conceptual model'. However, the groundwater modelling represents geology differently to this concept. A cross section from the numerical model is presented adjacent to the conceptual model in Figure 13. The groundwater model appears to conform more to the conceptual model in Figure 14, as adopted in previous groundwater modelling. Notably:

1. The groundwater model does not include the geological layers below the Pamboola Formation. As such, there is a no-flow boundary along the base of the Pamboola Formation.
2. The Pamboola Formation is represented as folding under the alluvium, effectively cupping the alluvium.

This conceptual model limits the possible impact of mining on the alluvium aquifer as an *a priori* assumption, because it wraps the alluvium within the Pamboola Formation, and the no-flow boundary under the Pamboola limits the connection with the alluvium. No reasoning for this representation is given in the EIS, and the geological basis for representation of the Pamboola Formation in this manner is unclear.

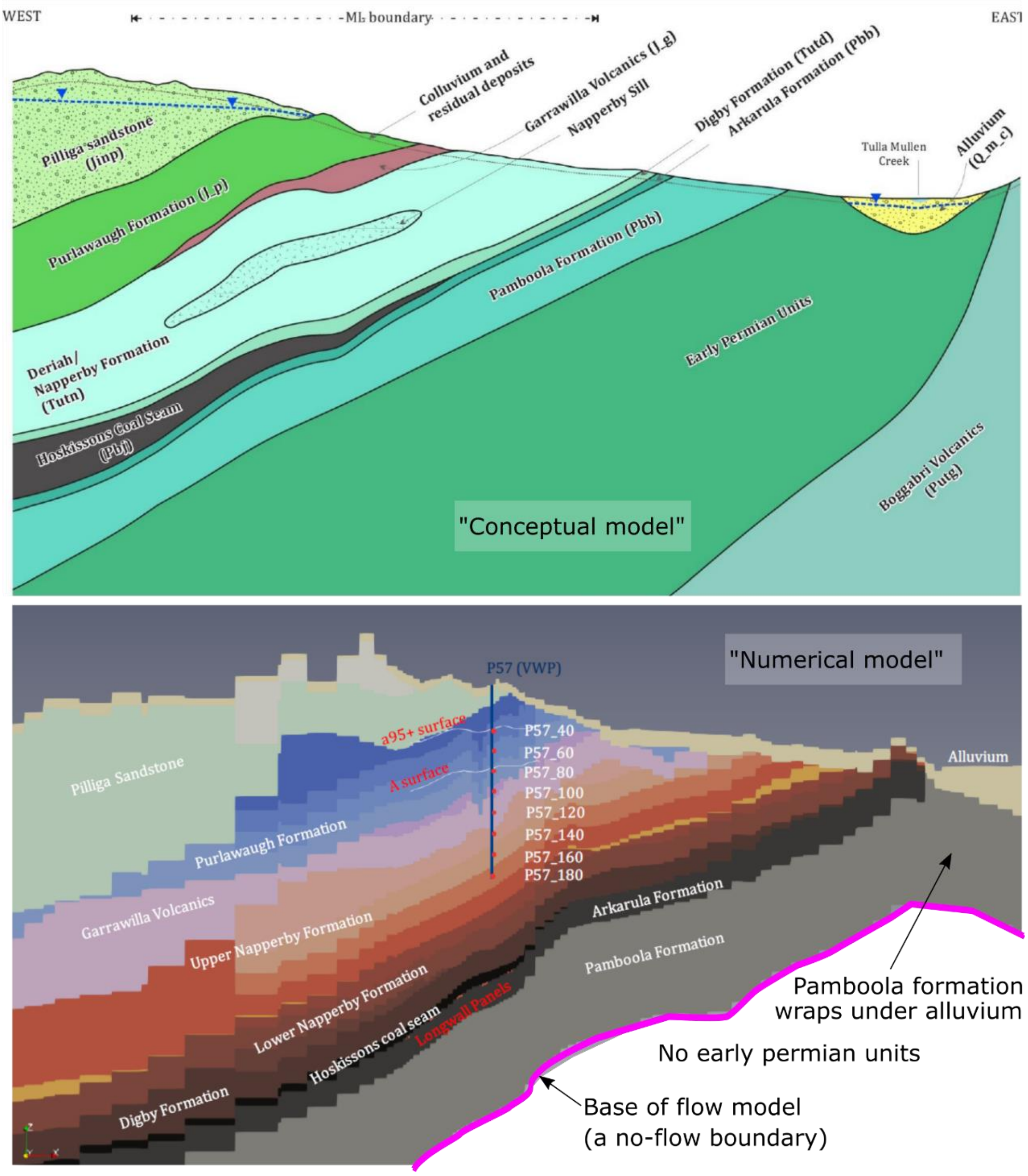

Figure 13 – Conceptual model (above) versus groundwater model (below) (additional annotations shown)

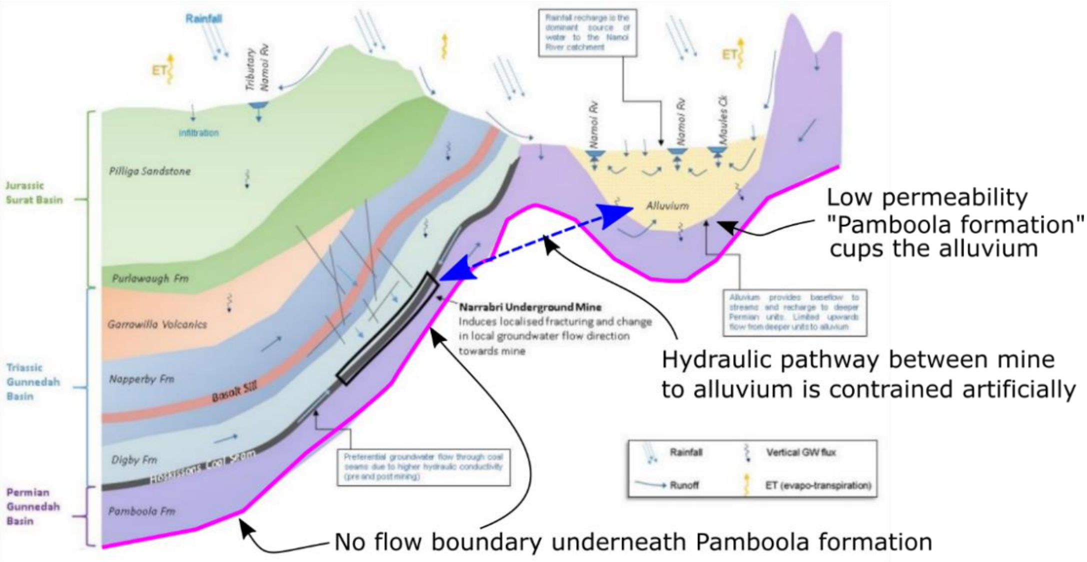

Figure 14 – Conceptual model from previous numerical modelling of the Project (Hydrosimulations 2019) (additional annotations shown)

3.2.2 Representation of hydraulic conductivity 'k'

The values of hydraulic conductivity adopted in the groundwater modelling for the EIS are presented in Figure 15 alongside measured values.

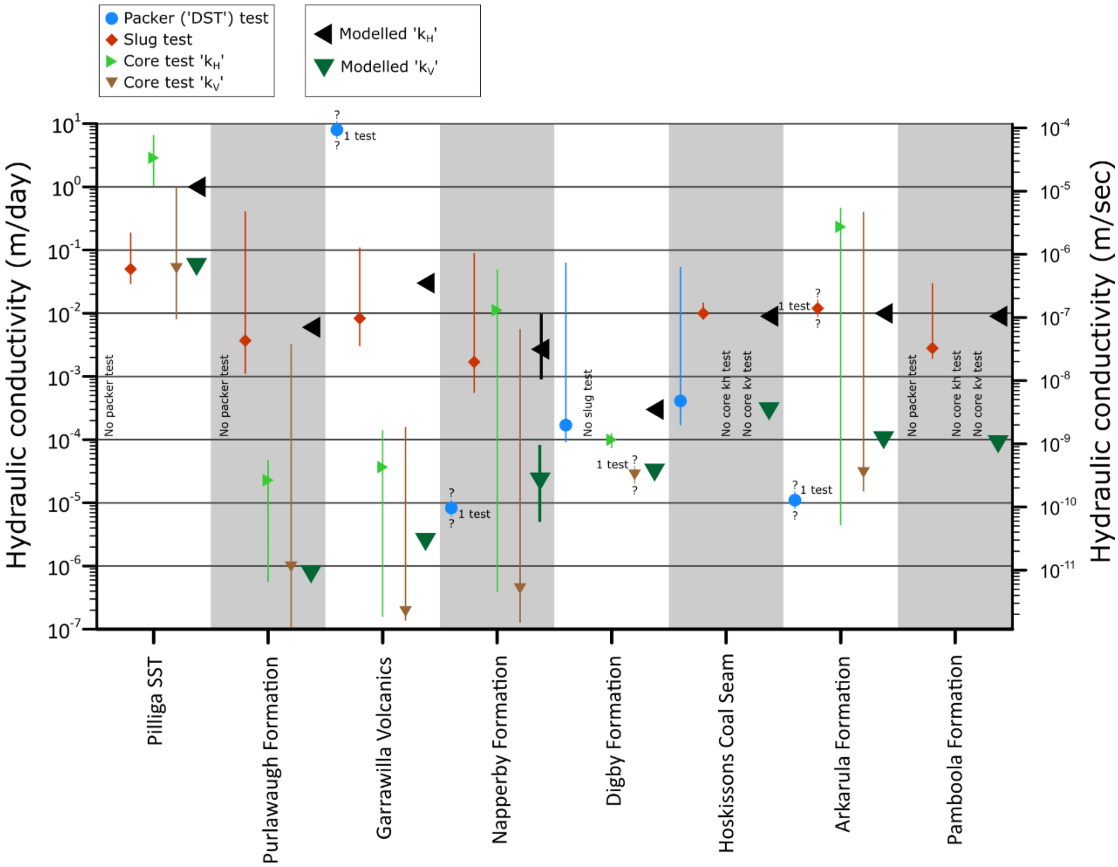

Figure 15 – Hydraulic conductivity values used in the EIS, presented alongside tested values

The adopted values for horizontal hydraulic conductivity 'k_H' typically approximate the slug test data. Of the available data, this is probably the most reasonable, as the packer test data appears to be erroneous (see Section 2.2.2) and laboratory core data is not a reliable guide to regional groundwater models (Section 2.2.1). However, it is disappointing that such a significant groundwater model should be underpinned by only this relatively rudimentary test data, and a project of such scale should be supported by quality pump testing data and a large suite of reliable packer (DST) tests.

The adopted values for vertical hydraulic conductivity 'k_V' are very low. The groundwater study for the EIS makes an argument that 'k_V' values are proportionally lower than 'k_H' by the same ratio that exists "*between the median value from slug or DST tests and the median vertical hydraulic conductivity value from core tests*" (pg 63). I do not consider this to be a robust line of reasoning given the significant differences in test characteristics. For example, the ratio between horizontal laboratory core tests and field tests (i.e. *in the same direction*) is similarly low. It is also creating a mathematical reliance upon a small dataset of highly variable data sources. The end result is that 'k_V' is taken at a small fraction of 'k_H' – up to 10,000 times less, and this results in very low 'k_V' values. In my opinion it is untenable to adopt such extreme ratios, especially in the absence of clear measurements to support it.

These low vertical hydraulic conductivity 'k_V' would have the effect of minimising predicted effects of the mine to the upper layers, such as the Pilliga Sandstone. It would also minimise downward drainage from the Namoi Alluvium.

Given the significance of these values on the predicted effects, my view is that:

1. Large scale pumping tests are warranted to provide more reliable estimates of 'k_H'. Well planned pumping tests can also allow estimation of 'k_V' values.
2. A precautionary principle should be adopted in the case of uncertainty about 'k_V' values, which would lead to adopting of more standard kv/kh ratios of the order of 5 to 10, rather than the speculative and uncommonly high ratios adopted of up to 10,000.

As a side note, it is known that hydraulic conductivity changes as a function of how saturated the geology is. This is a technical discussion beyond the scope of this present advice, but it is noted that the values used to represented such "unsaturated" characteristics are important, particularly where there is vertical flow to a mine in the context of highly 'layered' representation of hydraulic conductivity. The unsaturated parameters adopted in modelling are not presented or discussed in the EIS.

3.2.3 Representation of subsidence

Subsidence above longwall mining is known to increase hydraulic conductivity through fracturing. The groundwater model for the EIS adopts detailed mathematical representation of cracking through calculation of the extent and aperture of cracking and subsequent adoption a series of drainage boundary conditions to simulate the process. It should be noted that it is difficult to get an absolute appreciation of the increase in flow capacity by the usage of a 'conductance' term – as it is relative to the cell size that it is applied to. What is clear is that:

- The assumed extent of cracking and associated increase in hydraulic conductivity is paramount to the simulation of mining effects.
- Whilst the EIS argues that the representation of these effects "is calculated empirically based on the expected intensity of fracturing at any given model cell, rather than being assumed" – in reality it is still an assumption, as the parameters used in calculation are numerous and largely guided by empirical estimations and interpretation.

In my opinion, it would be of great assistance if a cross section through the model could be used to present clearly the locations of boundary conditions and / or relative increase of hydraulic conductivity used to simulate fracturing. This at least would show visually the extent of cracking assumed. Additionally, calculations should be done to present a graph that shows the effective hydraulic conductivity values that are represented.

External review of the simulation of subsidence effects on groundwater in the EIS is not impossible without further explanation.

3.2.4 Representation of cumulative impacts with adjacent coal seam gas

Modelling of cumulative impacts from concurrent operation of the adjacent Narrabri Gas Project was undertaken by applying “base case” water extraction rates (from the coal seams) as supplied by Santos. Within the scope of this present review I cannot comment on how well these “base case” rates represent the planned coal seam gas (CSG) works. Nonetheless, the water extraction rates are speculative and in reality there must be some uncertainty in their prediction as the encountered geological conditions cannot be known with certainty– and this uncertainty is not considered in the EIS. It is also my understanding that the hydraulic conductivity values of geology over the large region of the Narrabri Gas Project are not considered or reviewed in modelling. There are also no observations over the region of the Narrabri Gas Project used to calibrate this part of the groundwater model.

3.2.5 Model calibration

The groundwater study for the EIS contains numerous pages of plots comparing predicted groundwater levels to observed levels. In some cases the match is reasonable, in others it is poor. In many cases the ability to calibrate is compromised by discontinuation of groundwater level monitoring. In my opinion, the calibration achieved is consistent with a typical groundwater model for this type of project – it demonstrates some predictive capacity but certainly does not provide closure to the non-uniqueness problem. The model included calibration to VWP data in P24 and P40 (as presented in Figure 8 above), although P23 was absent without explanation. A comparison between observed and predicted values for P24 and P40 is presented in Figure 16.

In these cases the numerical model tends to over-predict drawdown in the formations directly above the seam (i.e. the Napperby and Digby formations), but underpredict formations below the seam (i.e. the Pamboola). The over-prediction in the Digby and Napperby formations may be due, at least in part, to the very low vertical hydraulic conductivity in the overlying Garrawilla and Purlawaugh formations – as very little flow would be simulated to be drawn from these to maintain pressure above the coal. The VWP does not allow verification of this: P24 does not monitor within the Garrawilla and Purlawaugh formations; P23 is not reported from modelling; data from P40 commenced in 2012 it appears that mining effects had not yet propagated to these upper formations by 2019.

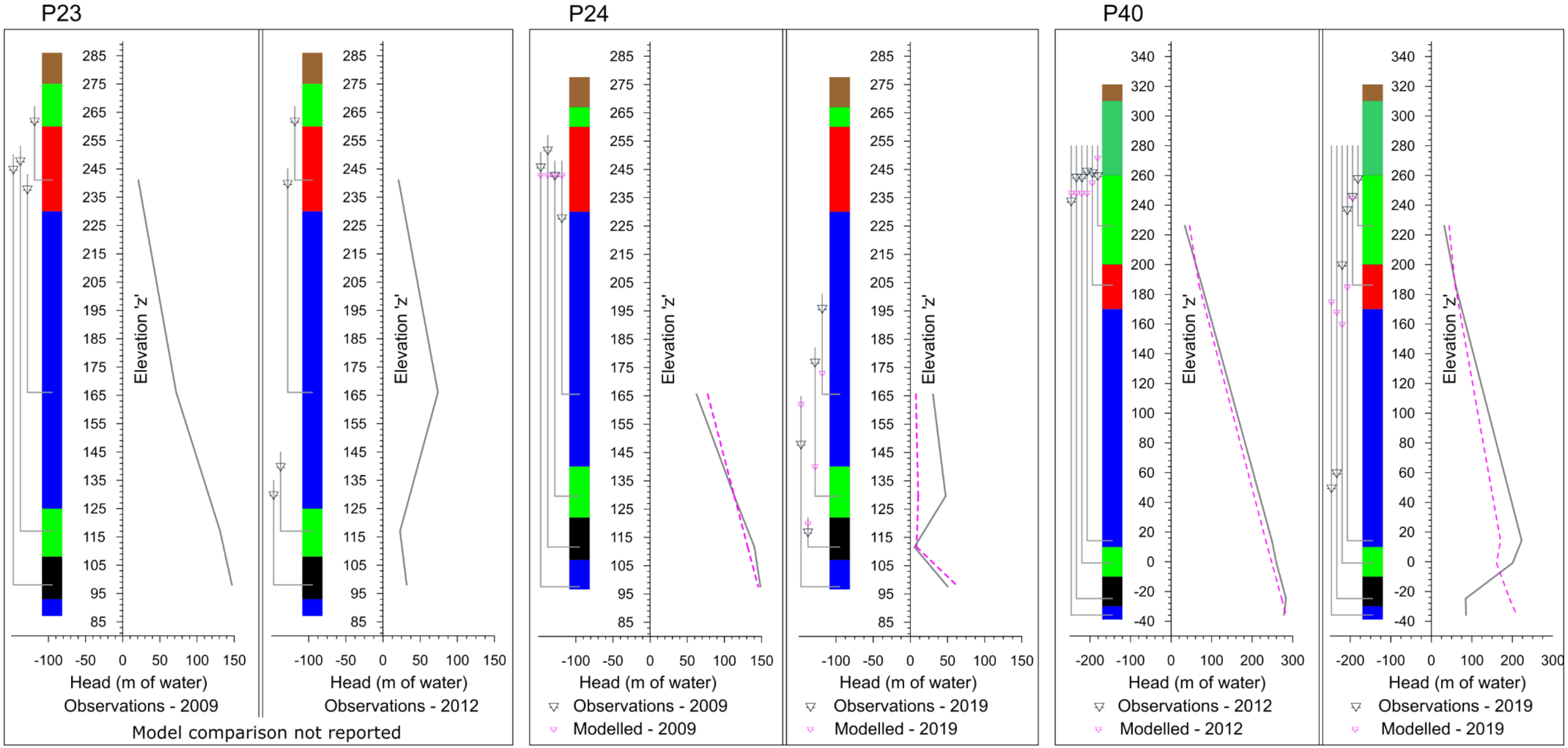

Figure 16 – Observed and predicted responses in P24 and P40 VWP's (geological strata are approximate)

3.2.6 Model uncertainty

A process that has been adopted in more recent times is to undertake 'uncertainty' analyses, in which selected model parameters are adjusted to provide a probabilistic framework to the model predictions. This process gives some recognition to the non-uniqueness of groundwater model predictions, although the range of uncertainty is expressed as a deviation from the initial model – inferring that the initial model is true, which it may not be. This is logically problematic. For example, the uncertainty analyses in the EIS assume that the low k_v values used in modelling are the most probable, and that model results with higher values, for example, are relatively less probable. In my view, it is the low k_V values that are assumed at the outset which are improbable.

3.2.7 Predicted impacts

The predicted impacts from the groundwater model are presented in the EIS as drawdown plots for each of the geological formations. Selected maps from the EIS are reproduced in Figure 17.

In summary, the model predicts extensive drawdown in all locations - except the Pilliga Sandstone and Namoi Alluvium which are predicted to be largely unaffected.

The minor drawdown predicted for the Pilliga Sandstone is a result of small vertical hydraulic conductivity values adopted for the Napperby, Garrawilla and Purlawaugh formations, and assumed extent of cracking, which I understand is assumed to not connect with the Pilliga Sandstone. It is noted again that there is only a single monitoring point (P7) in the Pilliga Sandstone to reference, for which data is only presented to 2019. Data in P6 appeared to show up to 2m of drawdown in the Pilliga Sandstone by 2015 (exceeding predictions), but was discontinued.

The easterly extent of drawdown in the Pamboola Formation is shown to end almost exactly at the edge of the alluvium. The prediction seems unexpected, given that the Pamboola is supposed to be modelled as extending underneath the alluvium, and the extent of drawdown (without the Narrabri Gas Project) extends a long way westwards. This could occur due to the Namoi Alluvium being represented as a constant head (or high recharge) boundary, but that is speculation on my behalf. In my opinion, cross sections through the model showing piezometric levels explaining the termination of drawdown in the Pamboola at this location are required.

Drawdown for the Namoi Alluvium is predicted to be almost negligibly small – a matter arising out of the easterly termination of the drawdown in the underlying Pamboola Formation. As stated above, further information should be provided showing piezometric levels to allow review of this unexpected result.

It is understood that these drawdown plots do not represent impacts with the simultaneous operation of Narrabri Gas Project.

Additional drawdown plots are presented in the EIS groundwater study, which include concurrent operation of the Narrabri Gas Project. These show much more extensive drawdown in the coal seam and adjacent formations, but almost negligible change to the drawdown in the Pilliga Sandstone. Again, this negligible impact prediction would arise as a result of small vertical hydraulic conductivity values adopted for the Napperby, Garrawilla and Purlawaugh formations.

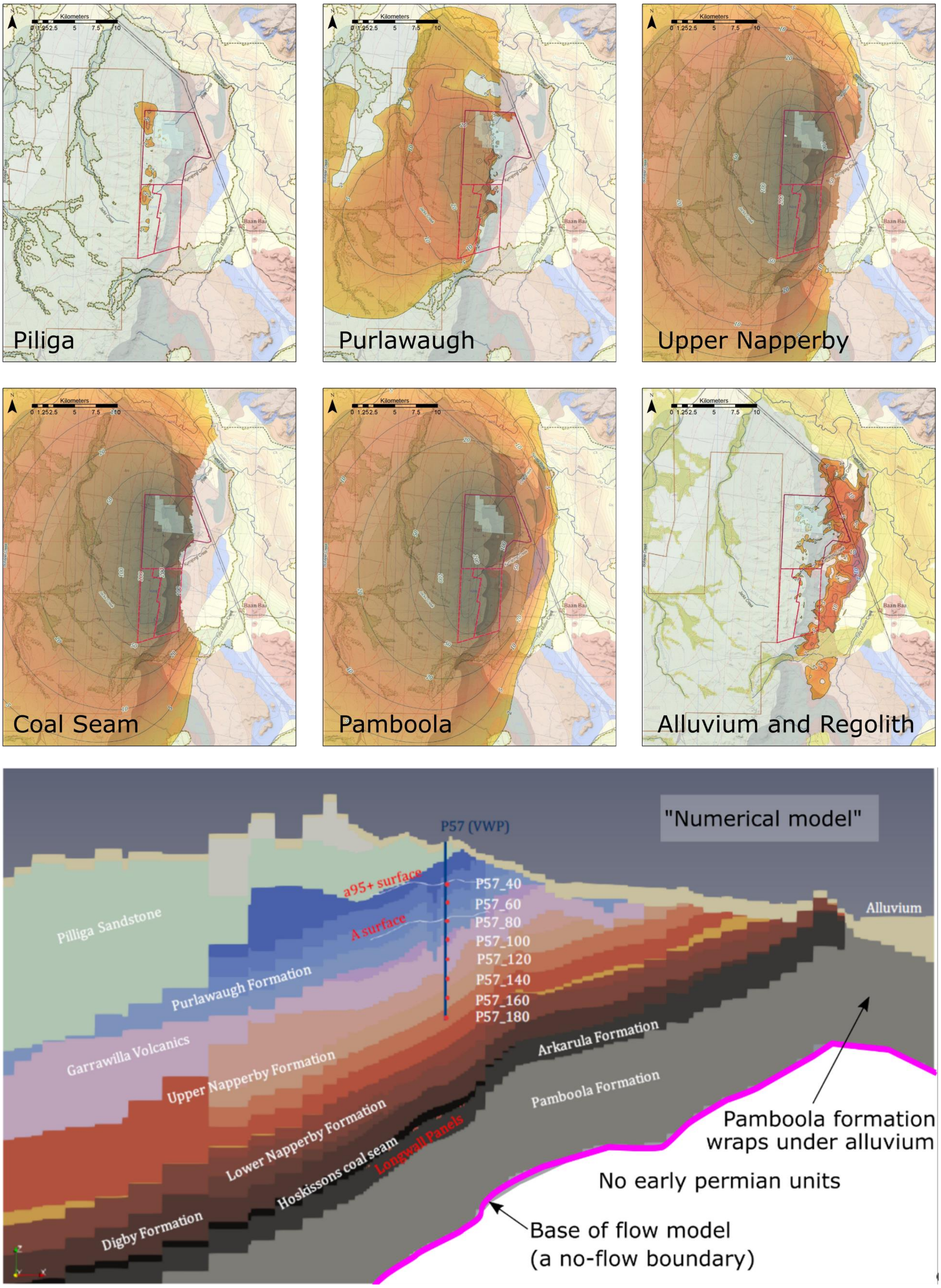

Figure 17 – Predicted drawdown maps in selected layers

4. REVIEW OF SURFACE WATER STUDIES

I have read the EIS Surface Water Assessment (Appendix C to the EIS) although in the scope of the present advice I have not been able to undertake a detailed review.

I have not addressed the aspects of the Surface Water Assessment that considers a mine water balance, but consider only the assessed impacts to surface water resources. An overview of these water resources above the existing mine and proposed extension is reproduced in Figure 18.

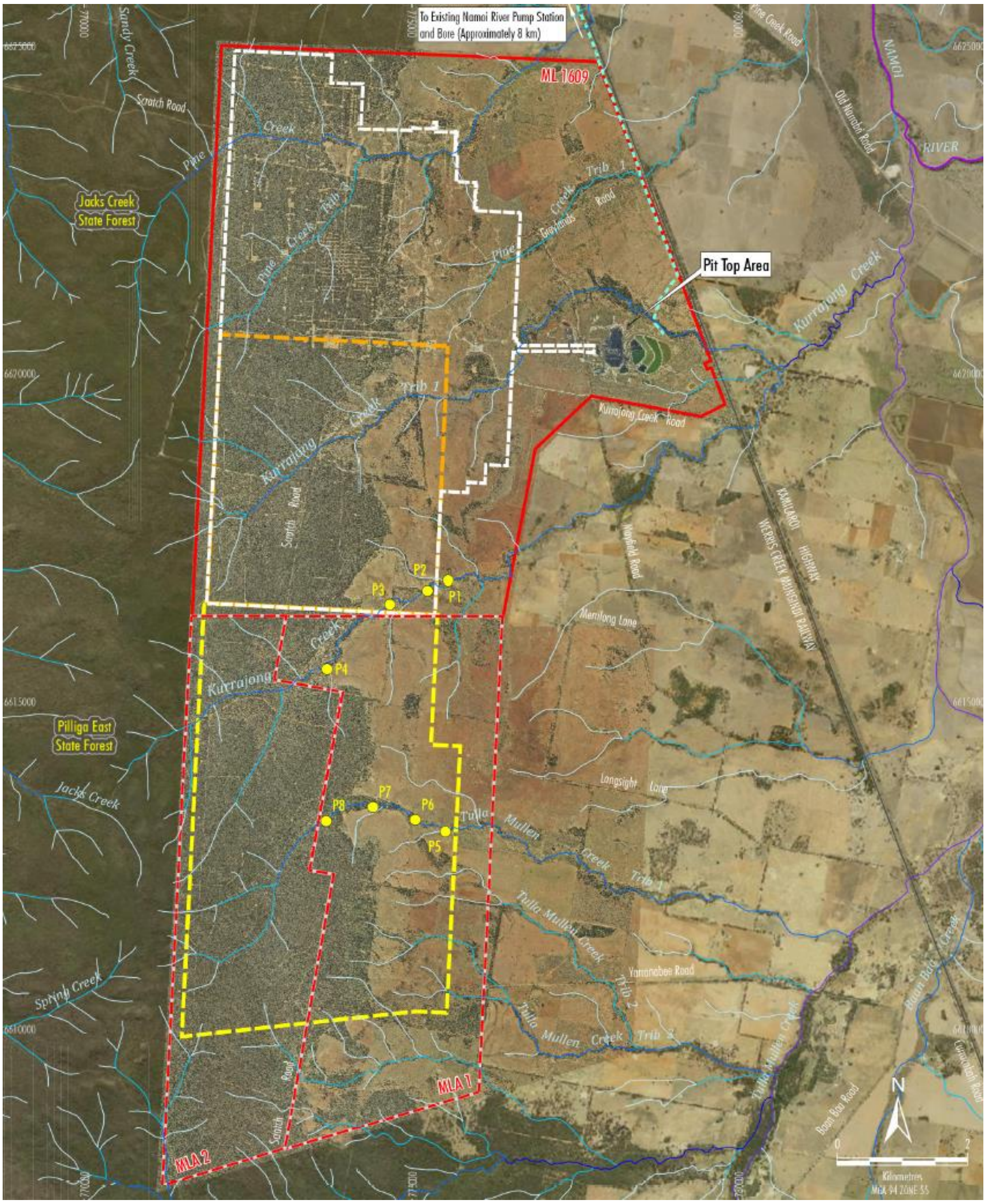

Figure 18 – Overview of surface water features above the existing mine and the Project

The Surface Water studies gives a brief factual account of the surface water environment in their Section 4. Within this, is a very brief (1 paragraph) account of “existing subsidence impacts” as:

> The surface water impacts in Pine Creek Trib1 and Pine Creek associated with existing subsidence (e.g. ponding) above Longwalls 101 to 109 are generally consistent with the predicted impacts (WRM, 2015), with maximum ground subsidence depths up to approximately 2.75 m.

Excerpt from the EIS Surface Water Assessment, pg 37

The report provides no further discussion or insight into the existing impacts from mining. In my opinion this is an unacceptably poor assessment of existing impacts. It provides no discussion of observation of flow characteristics in the creek and how they may have been impacted by mining, either subtle or severe. There is no discussion of cracking (either its presence or absence), or of changes to hydrology or runoff. There is no discussion of potential impacts from groundwater depressurisation on standing water bodies. No discussion of the nature of subsidence and how it may impact stream flow characteristics is given. In regards to ‘ponding’ that is mentioned, an interesting observation can be made by examination of Lidar data in the public domain. A digital surface model (at 1m grid spacing) is available from https://elevation.fsdf.org.au/ for part of the mine region, taken in October 2013. With application of a ‘hillshade’ filter, the outline of the subsidence above longwall panel LW101 and part of LW102 is clearly visible (Figure 19). It is also evident that a large pond of water has formed within LW101 corresponding with the point of crossover with LW101 at Pine Creek Trib 1, as annotated. This water body is not gazetted on topographic maps and is absent from photographs prior to mining, but can be seen in recent aerial photographs (Figure 20). This evidence suggests that the water has developed concurrently with subsidence. I do not have access to further data to verify if the water body has been purposefully constructed, but the location and shape is consistent with capture / interruption of the stream topography due to subsidence. The effect of such a capture would be decreased frequency of flow downstream of the capture point, and increased loss of water to evaporation.

The EIS Surface Water Assessment briefly lists possible impacts from mining on waterways, including possible surface cracking, change in gradients, potential hydraulic connection with the mine and additional ponding (Section 8.1.1), but it does not provide any quantification of the likelihood or impacts from these mechanisms, other that describing some of them as “unlikely to possible to occur”. The EIS states that a detailed assessment of the impacts of the mine on the flow regime of the drainage channels shown in Figure 18 is “not warranted” (Section 8.2.2). The reason given is the “unlikely to possible” nature of impacts, and the fact that the streams are ephemeral (i.e. are usually dry, flowing only during significant rainfall). The logic seems to follow that before mining the streams were mostly dry except during significant rainfall, and after mining the streams will be mostly dry except during significant rainfall, therefore there are negligible impacts.

In my opinion this assessment only ascribes value to the drainage features by virtue of their subjective ‘dryness’ – as if stealing is permissible if the victim is already poor. In contrast, my understanding is flora and fauna associated with these creeks are likely to be adapted to the specific flow characteristics that have prevailed prior to mining, and changes to those characteristics may result in impacts. Such impacts should be given assessment that goes beyond a subjective (and anthropocentric) discussion of ‘dryness’.

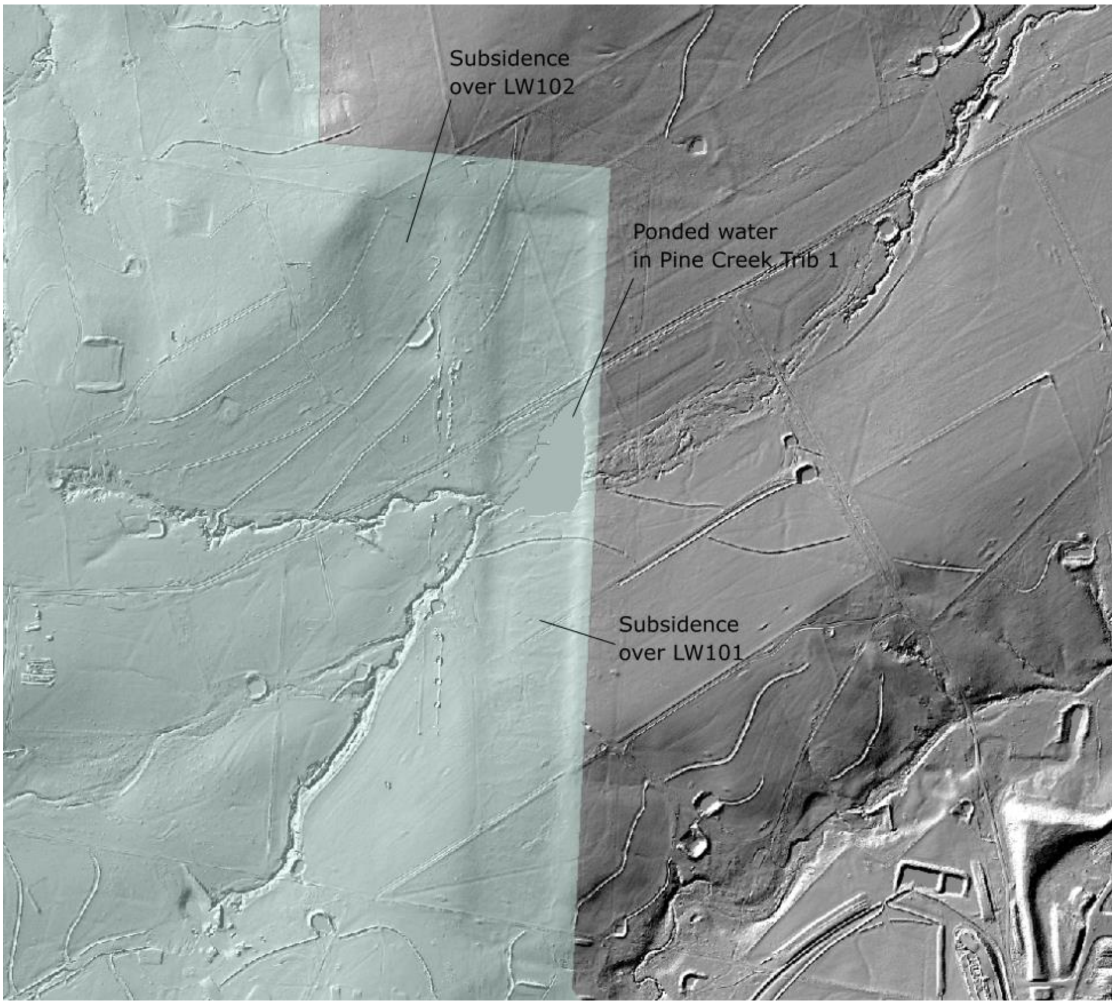

Figure 19 – Topography shown in Digital Surface Model, October 2013

Figure 20 – Development of water body on Pine Creek Trib 1

[redacted]

STEVEN PELLS
BE(Civil) MEngSc PhD

Pells Consulting

DR STEVEN PELLS

Educational Qualifications:

Bachelor of Engineering (Civil) (Hons), UNSW 2000
Master of Engineering Science, UNSW, 2001
Doctor of Philosophy, UNSW, 2016

Professional Associations:

Member, IAH - International Association of Hydrogeologists
Member, ANCOLD - Australian National Committee on Large Dams
Member, ASCE – American Society of Civil Engineers

FIELDS OF SPECIALISATION:

- Assessment and design of hydraulic structures
- Hydraulics of open channels, spillways and river systems
- Scour / erosion in chutes and spillways
- Hydrology and water resources
- Hydraulic scale physical models
- Groundwater modelling and groundwater investigations
- Impacts to water resources relating to mining and mine effects

Steve took over as director of Pells Consulting ` over 20 years' experience in civil hydraulics, hydrology and groundwater studies. Steven's formative years were spent crafting hydraulic scale models and various roles in consulting developed his particular specialisation in applying water engineering principles to geotechnical and civil engineering problems. In 2016, Steven completed PhD studies at the University of New South Wales, examining erosion and scour within chutes and channels, with particular focus on dam spillways. Steven has authored/co-authored over 30 papers in various fields of civil engineering, including hydraulics, hydrology, groundwater and rock mechanics. He undertakes adjunct lecturing on open channel flows and river systems at Sydney University. Steven remains engaged with research in hydraulic design and scour / erosion within the dams engineering community and in groundwater studies.

EMPLOYMENT:

2021 -	Director, Pells Consulting
2017 – 2021:	Principal, PSM
2016 – 2017:	Principal, Pells Consulting / Adjunct Lecturing, University of Sydney
2011 – 2016:	Associate, Pells Consulting; PhD Candidate, UNSW Australia
2009 – 2011:	Senior Project Engineer - WRL, UNSW Australia
2008 – 2009:	Senior Water Engineer - Cardno Willing
2006 – 2008:	Senior Water Engineer - Ove Arup Partners
2001 – 2006:	Project/Senior Project Engineer - WRL, UNSW Australia
1997 – 2001:	Graduate Geotechnical Engineer - Pells Sullivan & Meynink; Soils Technician (P/T) - Coffey Partners
1994 – 1997:	Carpenter/Joiner - LW Hough P/L

PROJECTS RELATED TO DAMS, HYDRAULICS AND HYDRAULIC STRUCTURES

Hydrologic analysis and dambreak studies	TSF, Batu, Sumbawa	Analysis for design flows and dam break assessments for concept design of a large TSF in Indonesia
Technical review panel	Multiple Dam CRAs, Queensland	Technical review of over 20 Comprehensive Risk Assessments (CRA's) in Queensland
Third party technical review	TSF, Runruno, Philippines	Technical review of spillway designs for closure and operation
Hydro-geotechnical scour risk assessment	Copeton Dam, NSW	Leading of a comprehensive prediction for scour vulnerability at Copeton Dam. Key task is development of a coupled multi-physics rock mass model and CFD hydraulic model to predict future scour for various design events.
Preliminary hydro-geotechnical Scour Risk Assessment	Blowering Dam, NSW	Review of historical scour at Blowering Dam and advice on ongoing scour risk, based on initial site inspections and application of comparative scour assessment techniques.
Specialist stability assessments	Murchison Dam, Tasmania	Specialist analysis of rockfill stability using a bespoke analysis through coupling of CFD simulations with a dynamic rock mechanics model, along with 3D seepage analysis through rockfill
Member of Technical Review Panel	Rookwood Weir, Queensland	Ongoing review of design and construction
Specialist guidance on CFD and Physical model studies, Rookwood Weir, QLD	Rookwood Weir, Queensland	Provision of specialist advice to regulators on the sufficiency of relying on CFD modelling alone for design purposes, and the possible need for additional physical hydraulic model studies
Technical Review Panel member	Mole Creek Dam, NSW	Technical review of designs for proposed dam
Preliminary hydro-geotechnical Scour Risk Assessment, Araing Dam, France	French Pyrenees	Review of scour risk at Araing Dam based on review of available geological information and CFD modelling.
Member of Technical Review Panel	Paradise Dam Improvement project	Ongoing review of analysis, design and construction
Guidance on scour assessments,	Teemburra Dam, QLD	Independent review of CFD studies and scour assessments at Teemburra dam

PROJECTS RELATED TO DAMS, HYDRAULICS AND HYDRAULIC STRUCTURES

Guidance on scour assessments,	Fred Haigh Dam, QLD	Independent review of CFD studies and scour assessments at Teemburra dam
Petit-Saut Dam,	French Guiana	Assessment and prediction of current and future risks from scour at the main dam outlet. Tasks included development of a geotechnical model, hydrodynamic modelling (1D, 2D and 3D CFD models) and scour risk assessments.
Review of scour potential and remediation options, Burdekin Falls Dam	Burdekin, Queensland	Member of technical review panel for assessing scour risk at Burdekin Falls Dam. Recommendations were provided on required stabilisation works based on UAV surveys, hydraulic studies, geotechnical assessments and scour assessments.
Review of erosion risk, and stability, Somerset dam	Brisbane, Queensland	Technical review and assessment of hydraulics regarding overtopping of abutments at Somerset Dam. Assessment of dam stability in sliding and overturning under extreme flood events.
Erosion of unlined spillways	PhD studies	An industry linkage grant was awarded to develop improved design methods for assessment of scour on unlined spillways. Investigations have been based on laboratory testing and field studies. Laboratory testing comprised detailed studies on pressure transients in open channel flows under various conditions, and relating the observed measurement to hydraulic indices such as tractive force and stream power dissipation. The measurements are used to develop kinematic models of stability of unlined rock chutes. Field studies included review of erosion at over 30 dam spillways in Australia, South Africa and the USA. Investigations include geological review and mapping, rock mechanics assessments and detailed hydraulic assessments, typically using HEC-RAS. New methods of assessment of erosion were developed based on these investigations
Expert review of embankment failure	Newnes, New South Wales	Expert (legal) review of overtopping / piping failure of a tailing facility. Tasks included forensic site inspection, supported by detailed hydraulic, seepage and stability analyses.

PROJECTS RELATED TO DAMS, HYDRAULICS AND HYDRAULIC STRUCTURES

Review and redesign of a 7.5 GL mine-water dam	Goonyella, Queensland	Expert (legal) review of embankment construction in expert witness context. Tasks essentially required complete re-design of the embankment, including material selection and placement, zoning, 3D visualisation and volume calculations, detailed seepage analysis, detailed stability analysis and various supporting hydraulic and geomechanics assessments.
Review of embankment seepage / stability	Wilton NSW	Review of potential piping failure, and detailing of solutions for a private embankment dam.
Hydraulic analysis of the Balikera tunnel	Hunter region, NSW	Hydraulic analysis of discharge through a stream-diversion tunnel, including assessment of the impacts on hydraulics from rock-falls / tunnel collapse.
Dam safety assessment	Narara, NSW	Undertaking of a dam safety assessment, and preparation of dam safety management plan for the Narara Horticultural Dam, New South Wales.
Dam safety assessment	Hazelwood, VIC	Undertaking of a dam safety assessment of the Hazelwood Cooling Pond, Victoria, in accordance with the Australian National Committee on Large Dams (ANCOLD) guidelines.
Expert Review of Embankment Dam	Dorrigo, NSW	Expert (legal) review of the embankment and hydrology of a 15 m earth embankment dam to advise legal proceedings; witness in court.
Physical Model of Outlet Works, Adelaide Desalination Plant	Adelaide, SA	Design, construction and testing of a physical model of the outlet works (drop structure) from a desalination plant. The model was primarily of clear acrylic piping and, at the scale of 1:6, was over 4 storeys in height.
Lined Storages - Caustic Soda	Gladstone, QLD	Hydraulic modelling and specialist advice on scale modelling of caustic soda storage and distribution networks.
Remediation of Tidal Weir Structures	East Trinity, Qld	Assessment of existing tidal control structures and design of new structures to support tidal flushing of acid sulphate remediation activities.
Testing of Tidal Energy Turbine	Australia	Laboratory testing of power output and efficiency from turbine designs.
Assessment of Hydraulic Forces on Causeway Structures	Queensland	Hydraulic assessments were used as a basis for preparation of guidelines.

PROJECTS RELATED TO DAMS, HYDRAULICS AND HYDRAULIC STRUCTURES

Physical testing of large diameter valves	Australia	Physical testing to determine headloss characteristics of large diameter flow valves.
Physical testing of large diameter pipe plug	Australia	Physical testing of the effectiveness of purpose built apparatus to plug and decommission an operating underground pipeline
Physical modelling of a detention basin / weir	Kellyville, NSW	Management, supervision, design and construction of a physical model of instream flood control basin.
Assessment of dam intake structures for Jindabyne Dam	Jindabyne, NSW	Management, design, construction and testing of a physical model to assess the performance of a proposed dam intake structure.
Design of scour protection for rock chutes	Australia	Large scale physical modelling and analysis to develop specifications for rock scour protection for weir structures.

PROJECTS RELATED TO WATER RESOURCES (HYDROLOGY AND HYDROGEOLOGY)

Prediction of tunnel inflows and groundwater pressures for tunnel design,	Various	Site investigations, interpretation, and various analytical and numerical (2D and 3D) modelling to predict inflows and design pressures to support design of various major tunnel works including Cross River Rail (Brisbane); Snowy 2.0 (NSW); Sydney Metro (Sydney); Westconnex (Sydney) and Northconnex (Sydney).
Lead hydrogeologist, design phase	Rozelle Interchange Project, Sydney	Lead hydrogeologist for design services of Rozelle Interchange Project. The role was to coordinate and provide design advice on tunnel inflows, drawdowns and design pressures for a network of 19km of road tunnels in the Sydney CBD based on supervision, undertaking and interpretation of site investigations and aquifer tests and 2D and 3D hydrogeological modelling.
Specialist hydrology and hydrogeology guidance,	Ok Tedi Mine, PNG	Provision of specialist guidance and training for ongoing hydrology and hydro-geological analyses at Ok Tedi Mine, Papua New Guinea.
Groundwater numerical modelling	Sutton Forest	3D numerical groundwater modelling for assessment of impacts to water resources from proposed underground mining operations
Review of groundwater impacts	Various	Review of predicted impacts to water resources from proposed mining operations, including presentation of findings at Planning Assessment Commissions – various locations.
River management, engineering and geomorphology	Lecturing	Adjunct lecturing on river management, Sydney University.
Prediction of mine inflows	Broadmeadow, Queensland	Review and prediction of groundwater inflows and risks for longwall mining operations
Mining impacts on water resources	Newnes, New South Wales	Detailed review of potential impacts on groundwater and surface water resources (ie endangered swamps) due to of dewatering, subsidence and cracking from longwall mining.
Mining impacts on water resources	Bylong, New South Wales	Review of predicted impacts on groundwater and surface water resources from proposed longwall mining.
Mining impacts on water resources	Williamtown, New South Wales	Review of predicted impacts on groundwater and resources from proposed sand mining.

PROJECTS RELATED TO WATER RESOURCES (HYDROLOGY AND HYDROGEOLOGY)

Mining impacts on water resources	Capertee, New South Wales	Review of predicted impacts on groundwater and resources from proposed longwall mining.
Flood studies	Various	Design flood levels and flood risk, various residential properties in Sydney
Expert review of coastal / seasonal groundwater	Ichthys project, NT	Expert (legal) review of groundwater dynamics and impacts to earthworks planning and progress.
Mine water balance assessments	Gregory / Crinum, QLD	Development of regional surface water models and preliminary groundwater models to examine site-wide water balances to guide a mine closure plan.
Groundwater impacts, Longwall mining	Moss Vale, NSW	Development of regional hydrogeological model and undertaking of 3D transient numerical groundwater modelling (MODFLOW) to assess impacts to groundwater from a proposed longwall mine.
Impacts to groundwater from coal seam gas extraction	Various	Independent review of predicted effects on groundwater from proposed coal seam gas (CSG) projects. Reviews typically supported by 2D and 3D numerical groundwater modelling.
Assessment of basement seepage issues	Maroubra, NSW	Appraisal of major seepage issues for a major development in the Botany Sands. Design of dewatering using 3D numerical groundwater model (MODFLOW). Representation of client at legal mediation.
Groundwater impact assessments	Various	Various minor projects to report on groundwater conditions and risks from proposed developments, including roads and pipelines to assist with EIS document preparation.
Review of surface and groundwater effects from longwall mining	Springvale Colliery, NSW	Field reconnaissance, data review and surface water modelling tools were used to provide advice on potential impacts to surface water systems from longwall mining effects.
Expert review of groundwater impacts from longwall mining	NRE Gujarat, NSW	Independent review of environmental assessments of impacts of mining subsidence on groundwater and surface water resources.
Review of hydrology of Thirlmere Lakes	Southern Coalfields, NSW	Undertaking of an independent review of the hydrology of Thirlmere Lakes, and on the evidence for impacts from longwall mining

PROJECTS RELATED TO WATER RESOURCES (HYDROLOGY AND HYDROGEOLOGY)

Ranger Uranium Mine – Flow Modelling of Post-Closure Conditions	Ranger, NT	Construction and calibration of a hydrologic and 1D hydraulic flow model of catchments adjacent to the Ranger Uranium Mine.
Groundwater Characterisation and Numerical Modelling for Rainbow Beach Estate	Rainbow Beach, NSW	Specification of a groundwater investigation and monitoring scheme for characterisation of a coastal aquifer near Port Macquarie. A 3D numerical groundwater model was assembled to simulate the aquifer and to assess impacts from a proposed development.
Design of flood detention ponds	Cecil Hills, NSW	Hydrologic analyses for design of flood detention ponds to support large residential subdivisions.
Urban flood hydrology	Stanmore, NSW	Development of 1D stormwater network models to assess flood risk and design flood mitigation options for an urban catchments in Sydney.
Flood modelling and design	Porters Creek, NSW	Supervision of hydrologic and 2D flood models for flood studies of the Porters Creek catchment.
Review of Catchment Processes	Flemington, ACT	Installation and operation of field equipment and development of water balance models for the catchment.
Review of seawater intrusion of coastal aquifers	Christchurch, New Zealand	Literature review on the processes, international experience and management of seawater intrusion of coastal aquifers to guide policy development in the Christchurch region, New Zealand.
Managed aquifer recharge investigations	Borambil Creek, NSW	Scoping studies to evaluate and advise on aquifer management, enhanced recharge and stream restoration, Borambil Creek in the Upper Namoi catchment, New South Wales.
Aquifer Storage and Recovery Feasibility Assessment	Ipswich, Qld	Desktop studies to assess the feasibility and potential yield of a proposed Aquifer and Storage Recovery Scheme near Ipswich, Brisbane.
Perth Airport Drainage Strategy, Review of Groundwater	Perth, WA	Review of surface water-groundwater in the superficial aquifers in the Swan Coastal Plain to assist with flood modelling of the Perth Airport site.
Review of Geothermal Heat Pump Applications, Energy Australia Building	Sydney, NSW	The design of a large ground-source heat pump system was reviewed based on site characterization and the derivation and application of analytical techniques to simulate heat transport.

PROJECTS RELATED TO WATER RESOURCES (HYDROLOGY AND HYDROGEOLOGY)

Design of Stormwater Capture and Treatment Ponds	Eraring, NSW	Desktop analysis of catchment hydraulics to prepare preliminary design of stormwater capture and treatment infrastructure.
Physical Modelling of flooding and evacuation, Penrith Lakes	Penrith, NSW	Management, supervision, design and re-construction of a physical model to examine flood characteristics, floodplain risk planning and evacuation timing for large lakes development scheme in Western Sydney.
Feasibility of flood harvesting	Broken Hill, NSW	Desktop studies and field investigations to assess feasibility of flood capture infrastructure.
Water Resource Assessments, Far North Queensland	Cairns, Qld	Preparation of a water supply strategy for the Far North Queensland region to meet regional forecast demands over 50 years. Technical sub-studies to assess the yield / reliability of supply options, ranging from large dams to residential rainwater tanks and stormwater harvesting.
Assessment of surface – ground water connectivity	Centennial Park, NSW	Field investigations, monitoring and analysis to provide recommendations to irrigators regarding the impacts to groundwater from the abstraction of water from a public lake systems.
Feasibility of Saline Intake Bores for Seawater Desalination	Central Coast, NSW	Detailed field investigations and interpretation to assess feasibility of large intake bores for a planned seawater desalination scheme. Tasks included undertaking resistivity surveys, drilling supervision, supervision and interpretation of aquifer pumping tests, slug tests and groundwater level and quality monitoring.
Assessment of Groundwater Pollution Sources	Confidential	Presentation and interpretation of resistivity survey data to assess location and extent of groundwater pollution from industrial sources. Advice was used to support litigation.
Groundwater System Characterisation	Blue Mountains, NSW	Supervision of field investigations to characterise groundwater hydraulics and quality in sandstone aquifers in the Blue Mountains, NSW for a proposed quarry. Tasks included supervision of drilling, bore logging, groundwater sampling, and undertaking packer and slug tests and associated analysis to estimate hydraulic properties.

PROJECTS RELATED TO WATER RESOURCES (HYDROLOGY AND HYDROGEOLOGY)

Impacts of Effluent Disposal on Groundwater in Coastal Aquifers	Various	Detailed field investigations into groundwater hydraulics and quality in coastal aquifers to support effluent disposal schemes at various sites in New South Wales, including Hat Head, South West Rocks, Iluka, Hastings Point and Sussex Inlet.
Assessment of Groundwater Seepage for Tunnel Design	Sydney, NSW	Undertaking of permeability testing of sandstone bores in the CBD of Sydney. Results were interpreted to provide parameters to support design of tunnelling works.
Design of a Groundwater Effluent Disposal Scheme	Iluka, NSW	Detailed field investigations and associated interpretation to assess feasibility and support design of an effluent disposal scheme. Tasks included supervision and interpretation of aquifer pumping tests, and assessment of planned infrastructure development locations with respect to coastal processes.

PROJECTS RELATED TO COASTAL ENGINEERING

Geotechnical design of a coastal island	Taren Point, NSW	Site inspections, geotechnical analysis and construction specifications for a manufactured island for fauna habitat.
Seawall design and coastal stability assessments	Various	Site inspection, site characterisation and stability analysis supporting design of seawalls, public access and coastal revetments.
Review of dredging and excavability	Darwin, NT	Expert (legal) analysis of field data to support legal proceedings related to dredging.
Design of geobag seawalls	Byron Bay, NSW	Numerical finite-element and kinematic stability assessment of geo-bag seawall designs
Risk assessment of seawalls	Manly, NSW	Review and risk assessment of geotechnical stability of 18 seawalls in accordance with statutory procedures.
Physical Modelling of Desalination Brine Outlet	Perth, WA	Design, construction and application of a physical model to examine diffusion processes of brine discharge from a large scale desalination plant.
Foreshore Embankment Stabilisation	Penrith, NSW	Provision of specialist advice on options for stabilisation of foreshore regions against erosion around a series of inland lakes.
Appraisal and Design of Coastal Protection Structures	Green Island, Qld	Project manager for the review of the function and condition of a sediment control groyne on Green Island (Great Barrier Reef).
Assessment of Greenwater Overtopping of Offshore Structures	Browse, WA	Technical studies to investigate the extent and impacts of green water overtopping of a number of large scale offshore structures.
Burwood Beach Ocean Outfall Modelling	Newcastle, NSW	Detailed analyses of meteorological conditions were undertaken to predict the statistical frequency of pollution events at beaches adjacent to an ocean outfall.
Review of Sub-Aerial Landslide Tsunami Generation and Propagation, Lihir Gold Mine	Papua New Guinea	A tsunami event, caused by a sub-aerial landslide, was recorded at a local tidal monitoring station. Analyses of the characteristics of the tsunami event were undertaken and used to postulate on the extent, velocity and timing of the landslide.
Breakwater / Revetment Design, Sydney Airport	Sydney, NSW	Undertaking physical model studies for optimisation of toe scour protection requirements for a breakwater / revetment structure at Sydney Airport.
Estuarine Numerical Modelling	Auckland, New Zealand	Set up and calibration of 2D numerical hydrodynamic model for examination of tidal currents and estuarine processes in a region of Auckland Harbour to allow examination of impacts of proposed developments.

PROJECTS RELATED TO COASTAL ENGINEERING

Numerical and Physical Modelling of Mooring Structure	Darwin, NT	Numerical and physical modelling studies to assess amplification or modification of currents adjacent to a large wharf structure during the mooring of large sea vessels.
Ocean Outfall Assessment	Wollongong, NSW	Undertaking physical modelling of a section of proposed outfall design for examination of saline intrusion.
Wind-Wave Growth and Dissipation Studies and Research	Australia	Physical testing and research to investigate the physics of wind – wave interactions and the processes of wave growth and dissipation. Studies resulted in the publication of new research into the growth and dissipation of wind waves.
Seawall Assessment and Design	Manly, NSW	Detailed assessment of the stability and long term performance of a public seawall in Manly, Sydney.
Coastal Erosion Assessment	Glenelg, SA	Numerical assessment of coastal longshore sediment transport to support expert advice for litigation following coastal erosion issues at Glenelg, Adelaide.
Design of Wave Paddle System	Australia	Design, construction and calibration of a wave generation system for undertaking wave basin modelling studies.
Assessment of Sediment Response to Offshore Reef Structures	Australia	Research into the shoreline response to offshore reef structures. Tasks included design, supervision and testing of a movable bed physical model.

PROJECTS RELATED TO CIVIL AND GEOTECHNICAL DESIGN

Flood studies, and flood evacuation advice	Shoalhaven, NSW	Flood studies and flood evacuation plans to support proposed developments
Drainage design for mine closure	Various	Design of drainage for stable landforms of mine emplacements (dumps) for various projects such as Ok Tedi (PNG), PanAust (Laos) and various mines in the Pilbarra region of Australia. Projects included design for estimation of sediment loads and design for control of sediment in very challenging steep landforms
Design of rip-rap lined chutes	Various	Hydrologic and hydraulic analyses for sizing of chutes and designing appropriate lining for resistance to erosion at various mining sites.
Long-term hydrodynamic analysis of scour	Various	Analysis of headcut development and long-term channel scour to support various mine closure studies.
Residential subdivision civil works designs	Narara, New South Wales	Various tasks including site investigations, retaining wall design, foundation design, design of underground tanks systems, to support a residential subdivision
Testing of rock anchors	New South Wales	Design and implementation of specialist rig for testing of stress-strain failure characteristics of specialist rock anchors
Forensic investigation of tunnel failure	South Australia	Forensic review of failure of cut and cover railway tunnel, including specialist seepage and stability analysis and physical modelling.
Review of longwall mining design	Mandalong	Assistance with expert review of legal claim pertaining to planning and design of longwall mining excavations.
Review of tunnel design	Wynyard Walk	Assistance with expert review of design of pedestrian tunnel.
Jet grouting / excavation	Cowper Wharf, NSW	Expert (legal) review of claim regarding jet-grouting and excavatability and disposal of material.
Tunnel construction supervision	Point Piper, NSW	Routine inspection of construction of private pedestrian tunnel
Forensic investigation of piping failure	Yalourn, VIC	Support for expert review of piping-failure of embankment at Yallourn. Tasks included: compilation and management of detailed GIS database of all data relevant to the claim; development of 3D conceptual models; finite element stability assessments, and; numerical seepage modelling.

PROJECTS RELATED TO CIVIL AND GEOTECHNICAL DESIGN

Review of site development options	Hornsby, NSW	3D GIS mapping of geology and earthworks and detailed analysis to assess excavation design and quantities for a legal claim at Hornsby Quarry.
Mine effect monitoring	Wollongong, NSW	Member of technical committee panel for monitoring and protection of public infrastructure (roads) for impacts from longwall mining.
Review of major pit failure	Mulia, Indonesia	3D GIS mapping of geology and earthworks and undertaking finite element analysis to examine options for responding to major earth slip at a mine site
Review of excavation designs	Sydney Opera House, NSW	3D GIS mapping of geology and earthworks and detailed analysis to assess excavation design and quantities for a legal claim at the Opera House carpark.
Review of basement design	Dee Why, NSW	Review of basement piling and waterproofing to support legal claim.
Excavation stability appraisal	Sydney CBD	Review of potential settlement from planned deep excavation in Sydney CBD.
Tunnel lining investigations	M2 tunnel, NSW	Forensic investigations of existing tunnel lining through undertaking of specialist coring and fourier analysis of drummyness testing.
Pond design	Kenny, ACT	Design of pond lining options for proposed in-stream basin.
Residential access tunnel	Point Piper, NSW	Routine monitoring of a residential tunneling project
Yamba Hill Groundwater and Slope Stability Monitoring	Yamba, NSW	Supervision of drilling and installation of groundwater monitoring bores and inclinometers to assess slope stability at Yamba.
Tunnel excavation monitoring	NSW	Routing review of tunnelling monitoring apparatus during construction of the Eastern Distributor Tunnel, Sydney.

PUBLICATIONS

JOURNAL PAPERS / RESEARCH REPORTS

1. **DOUGLAS, K, PELLS, S.E., FELL, R. and PEIRSON, W.L. (2018).** The influence of geological conditions on erosion of unlined spillways in rock. Quarterly Journal of Engineering Geology and Hydrogeology, vol. 51, pp. 219 - 228, http://dx.doi.org/10.1144/qjegh2017-087
2. **PELLS, S.E and DOUGLAS, K. (in publication)** Hydro-geotechnical assessment of scour of rock Book chapter from an international workshop on behalf of the European Group of ICOLD and the French Committee on Dams and Reservoirs, Aussois, France, 11th to 14th December 2017
3. **PELLS, P.J.N., BIENIAWSKI, Z.T., HENCHER, S., PELLS, S.E. (2017).** RQD - Time to rest in peace. Canadian Canadian Geotechnical Journal, 2017, 54(6): 825-834, https://doi.org/10.1139/cgj-2016-0012
4. **PELLS, S., DOUGLAS, K., PELLS, P.J.N., FELL, R., PEIRSON, W.L. (2016)** Rock mass erodibility. J.Hyd.Eng. ASCE. HYENG-9857
5. **PELLS, S.E., 2016**. Erosion of Rock in Spillways (Doctoral Thesis). UNSW Australia, Kensington, N.S.W. http://handle.unsw.edu.au/1959.4/56008
6. **PELLS, S.E. and PELLS, P.J.N, 2015** Application of Dupuit's Equation in SWMM to simulate baseflow. Technical note, ASCE Journal of Hydrologic Engineering,
7. **PELLS, S.E. and PEIRSON, W.L. 2014** DISCUSSION**:** "Evaluation of Overtopping Riprap Design Relationships" by Steven R. Abt, Christopher I. Thornton, Bryan A. Scholl, and Theodore R. Bender *Journal of the American Water Resources Association* (JAWRA) 11 Nov 2014.
8. **PELLS, S.E. and PELLS, P.J.N, 2012**- Impacts of longwall mining and coal seam gas extraction on groundwater regimes in the Sydney basin Part 1 – Theory. Australian Geomechanics Journal Volume 47, No. 3, p.35, September 2012
9. **PELLS, S.E. and PELLS, P.J.N, 2012**- Impacts of longwall mining and coal seam gas extraction on groundwater regimes in the Sydney basin. Part 2 – Practical applications. Australian Geomechanics Journal Volume 47, No. 3, p.51, September 2012
10. **PEIRSON, W L, FIGLUS, J, PELLS, S E and COX, R J 2008** - Placed Rock as Protection against Erosion by Flow down Steep Slopes Journal of Hydraulic Engineering. Volume 134, Issue 9, pp. 1370-1375, 2008.
11. **PEIRSON, W L and PELLS, S E 2004** - A Laboratory Study Of Wave Growth And Air Flow Behaviour Over Waves Strongly Forced By Wind. WRL Research Report 219 on behalf of the United States Army, European Research Office Funding under contract number N62558-04-M-0002, 2004.
12. **PEIRSON, W L, GARCIA, A W and PELLS, S E 2003** - Water Wave Attenuation Due to Opposing Wind Journal of Fluid Mechanics 2003 Vol 487, pp 345 -365, 2003.
13. **PELLS, S E & FELL, R, 2003** - Damage and Cracking of Embankment Dams by Earthquake and the Implications for Internal Erosion and Piping 21st ICOLD Congress 2003 Montreal Q83 83/R18 18.
14. **PELLS, S.E & FELL, R, 2002** - Damage and Cracking of Embankment Dams by Earthquake and the Implications for Internal Erosion and Piping. UNICIV Report Vol 408, 220 pages. UNSW 2002.

PUBLICATIONS

SELECTED CONFERENCE PAPERS

1. **PELLS, S.E and DOUGLAS, K. (2019).** Guidelines for assessment of scour in unlined spillways. Africa 2019, conference for the International journal on hydropower and dams, 2-4 April 2019, Windhoek, Namibia
2. **PELLS, S.E. 2016** - Assessment and surveillance of erosion risk in unlined spillways. Proceedings, 84th ICOLD Annual Meeting, International Committee on Large Dams 15 - 20 May 2016, Johannesburg, South Africa
3. **PELLS, P.J.N., PELLS, S.E. and VAN SCHALKWYK, M. 2016** A tale of two spillways. Proceedings, 84th ICOLD Annual Meeting, International Committee on Large Dams 15 - 20 May 2016, Johannesburg, South Africa
4. **PELLS, S., FELL, R., DOUGLAS, K., PEIRSON, W. 2016** Erosion Of Unlined Spillways In Rock. Proc. 20th Cong. Asia Pac. Div. Int. Assoc. Hydro Env. Eng. & Res. IAHR APD 2016, August – 28 to 31 2016. Colombo, Sri Lanka\
5. **PELLS, PJN and PELLS, S.E. 2016** The water levels of the Thirlmere Lakes. Proc. 20th Cong. Asia Pac. Div. Int. Assoc. Hydro Env. Eng. & Res. IAHR APD 2016, August – 28 to 31 2016. Colombo, Sri Lanka
6. **PELLS, S.E, PELLS, P.J.N., PEIRSON, W.L., DOUGLAS, K. and FELL, R. 2015** Erosion of unlined spillways in rock – does a 'scour threshold' exist? Proceedings, ANCOLD annual conference, Brisbane, 5-6 November 2015
7. **PELLS, P.J.N and PELLS, S.E. 2015** Hydrogeologists and Geotechnical engineers – lost without translation AGS / IAH Symposium, Sydney 13 November 2015
8. **CARLEY, J. T., MARIANI, A., COX, R., SHAND, T., & PELLS, S. 2013.** History and Future of Seawalls in the Manly Local Government Area. In I. L. Turner (Ed.), Coasts and Ports 2013: 21st Australasian Coastal and Ocean Engineering Conference and the 14th Australasian Port and Harbour Conference. Manly NSW Australia.
9. **PELLS, S.E 2010**- Potential impact of sea-level rise on coastal aquifers. Groundwater 2010 Conference, 31 Oct – 4 Nov 2010, Canberra.
10. **PEIRSON, W L; FIGLUS, J; PELLS, S E and COX, R J. 2008** - Large Rock Protection against Erosion by Flow Down Steep Slopes. In: 9th National Conference on Hydraulics in Water Engineering: Hydraulics 2008. Barton, A.C.T.: Engineers Australia, 2008: [142]-[148].
11. **PELLS, S.E 2008** - Desktop Estimation of Yield For Aquifer Storage Recovery Schemes. In: Lambert, Martin (Editor); Daniell, TM (Editor); Leonard, Michael (Editor). Proceedings of Water Down Under 2008. Modbury, SA: Engineers Australia ; Causal Productions, 2008: 1037-1048.
12. **TIMMS, W., GLAMORE, W & PELLS, S.E. 2005** - Groundwater Quality Impacts Of On-Site Effluent Disposal On-Site '05 Conference Proceedings 2005.
13. **PELLS, S.E., TIMMS, W and TURNER, I.L. 2004** - Managing Groundwater in Coastal Sand Aquifers NSW Coastal Conference Proceedings, 2004.

NUMERICAL MODELLING EXPERIENCE / CAPABILITY

Steven has kept record over the years of specialist software he has utilised in engineering. Some software is now redundant but remains indicative of his skillset.

Hydrogeology	3D Flow	GMS
		FEFLOW
		Groundwater VISTAS
		Visual MODFLOW
		MODFLOW-SURFACT
		SEEP3D
	2D Flow	SEEP/W
		Groundwater in Slide and Phases
	Field Test Analysis	WTAQ
		Aqtesolve
		AquiferTest
Hydrology	WSUD	AQUALM
		MUSIC
	Flood hydrology	XP-RAFTS
		WBNM
		RORB
	Characterisation	Basejumper, HAART
	Continuous	RRL (Simhyd, AWBM)
Hydraulics	1D Hydraulics	XP-SWMM
		Mike 11
		EPA-SWMM
		HEC-RAS
		DRAINS
	2D Hydraulics	XP-SWMM2D
		TUFLOW
		SOBEK
		RMA2
		HEC-RAS 5.0 and later
	3D Hydraulics (CFD)	Flow3D
Pipelines	Network Analysis	EPANET
		WaterGEMS
Geomechanics	Slope stability	Roscience SLIDE
		SLOPE/W
	Deformation	Phase2
		SIGMA/W
Spatial Analysis and Presentation	GIS	MapINFO
		ArcGIS
		QGIS
		Global Mapper

NUMERICAL MODELLING EXPERIENCE / CAPABILITY

	Photogrammetry	Pix4D
	Drafting	Rhinoceros
		AutoCAD
		Sketchup
		Grapher
		Surfer
General Analysis		Excel
		Matlab

Environmental Defenders Office

28 January 2022

Dr Steven Pells
Pells Consulting

By email: [redacted]

CONFIDENTIAL AND PRIVILEGED

Dear Dr Pells

Brief to Expert – Narrabri Underground Mine Stage 3 Extension Project (SSD 10269) Public Hearing

1. We act for Lock the Gate in relation to the proposed Narrabri Underground Mine Stage 3 Extension Project (SSD 10269) (**Project**) by Narrabri Coal Operations Pty Ltd.

2. The Narrabri Coal Mine is an existing underground thermal coal mine located approximately 25 kilometres (**km**) south-east of Narrabri and approximately 60 km north-west of Gunnedah. Coal production using bord and pillar and partial extraction methods commenced in 2010. Stage 2 of the existing mine has been extracting coal by longwall methods since June 2012 and allows for the production and processing of up to 11 million tonnes per annum (**Mtpa**) of run-of-mine (**ROM**) coal until 26 July 2031. The Project proposes to continue longwall mining in a major southern extension area until 2044. The Project also seeks the continued use of existing underground and surface infrastructure, including use of the existing Coal Handling and Preparation Plant (**CHPP**) at 11 Mtpa.

3. The Project has now been referred to the Independent Planning Commission (**IPC**) for determination with a public hearing. Our client wishes to ensure the IPC receives independent expert advice on the Project. Accordingly, our client wishes to retain your services to act as an expert, to provide an expert report for submission to the IPC and to present your expert views to the IPC public hearing.

Primary purpose to provide independent expert advice

4. We note as a preliminary matter that our primary purpose in briefing you to prepare your report is to provide independent expert advice in your area of expertise. We do not ask you to be an advocate for our client. You are requested to prepare an independent report that is clear and well-written.

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5. In this respect, we draw your attention to Division 2 of Part 31 of the *Uniform Civil Procedure Rules 2005* (**UCPR**), and the Expert Witness Code of Conduct (**Code of Conduct**) contained in Schedule 7 of the UCPR, both of which govern the use of expert evidence in NSW Courts (**attached**). We understand that the IPC public hearing is not a Court proceeding, however, we are of the view that the same Code of Conduct should be adhered to in this instance.

6. In particular, clause 2 of the Code of Conduct states that:

> *"An expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person retaining the expert witness, to assist the court impartially on matters relevant to the area of expertise of the witness."*

7. Your expert report must contain an acknowledgment that you have read the Expert Witness Code of Conduct and that you agree to be bound by it.

8. Your expert report will be used as evidence in chief of your professional opinion. Information of which you believe the decision maker should be aware must be contained in your expert report.

9. In providing your opinion to the decision maker you must set out all the assumptions upon which the opinion is based. This may include, for example, facts observed as a result of fieldwork or 'assumed' facts based on a body of scientific opinion. If the latter, you should provide references which demonstrate the existence of that body of opinion.

10. Your expert report must also set out the process of reasoning which you have undertaken in order to arrive at your conclusions. It is insufficient for an expert report to simply state your opinion or conclusion reached without an explanation as to how this was arrived at. The purpose of providing such assumptions and reasoning is to enable the decision maker and experts engaged by other parties to make an assessment as to the soundness of your opinion.

Overview of work requested

11. We request that you undertake the following work:

    a. review the documents listed below;
    b. prepare a written expert report that addresses the issues identified below ('Issues to address in your expert report'), and ensure that the work is prepared in accordance with Part 31, Division 2 of the UCPR; and
    c. appear as an expert witness at the IPC public hearing for the purpose of giving oral evidence.

Documents

12. We enclose the Code of Conduct and Part 31 Division 2 of the UCPR.

13. Full Project documentation is available at the following websites:

a. NSW Government Planning Portal: https://www.planningportal.nsw.gov.au/major-projects/project/10731
b. IPC: https://www.ipcn.nsw.gov.au/projects/2021/12/narrabri-underground-mine-stage-3-extension-project-ssd-10269.

14. The following documents relating to the Project are provided for your particular consideration:

Environmental Impact Statement

a. Executive Summary: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021123.529%20GMT
b. Table of Contents: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021124.977%20GMT
c. Section 1 - Introduction: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021125.593%20GMT
d. Section 2 - Project Description: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021126.211%20GMT
e. Section 6 - Assessment of Impacts: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021129.246%20GMT
f. App A – Subsidence Assessment: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021139.762%20GMT
g. App B - Groundwater Assessment: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021150.054%20GMT
h. App C - Surface Water Assessment: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201023T021155.966%20GMT.

Response to Submissions

a. Submissions Report (pp. 21-60, Attachment 2, Attachment 5, Attachment 6, Attachment 7): https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=EXH-10425089%2120210531T070053.430%20GMT.

Amendments

a. Narrabri Stage 3 Project - Amendment Report (Appendix A): https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120210531T065545.008%20GMT.

Relevant Agency Advice

a. DPE Water - Advice on EIS: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=PAE-10521206%2120210117T233808.869%20GMT
b. DPE Water - Supplementary Advice on EIS: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120210420T044124.837%20GMT
c. DPE Water - Advice on Submissions and Amendment Reports: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=PAE-21182850%2120210811T223934.014%20GMT
d. DPE Water - Supplementary Advice on Submissions and Amendment Reports: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=PAE-28882133%2120211029T045639.756%20GMT
e. EPA - Advice on EIS: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=PAE-10521210%2120201208T020013.486%20GMT
f. EPA - Advice on Submissions and Amendment Reports: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=PAE-21182854%2120210615T054144.338%20GMT
g. IESC - Advice on EIS: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120201215T041319.148%20GMT.

Additional Information

a. NCOPL response to IESC advice: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120220119T060415.097%20GMT
b. NCOPL Response to RFI - Mining Panel Advice - 23 Sep 21: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120210927T091549.882%20GMT
c. NCOPL Response to DPIE Water - Submission & Amendment Reports Advice - 20 Sep 21: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120210927T065529.875%20GMT.

Department's Assessment Report

a. Department's Assessment Report (pp. vi-xv, 25-42): https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120220119T051727.890%20GMT
b. Recommended Conditions: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10269%2120220119T051728.236%20GMT.

15. Please let us know as soon as possible if you require further information for the purpose of giving your expert opinion.

Issues to address in your expert report

16. We ask that your report address the following issues in regard to any groundwater and/or surface water impacts arising as a result of the Project:

    a. Please summarise any key impacts predicted to arise as a consequence of the Project.
    b. In your opinion, was the assessment of environmental impacts, as far as it relates to your areas of expertise, appropriate and sufficient?
    c. In your opinion, has the assessment adequately considered any cumulative impacts arising from the Project?
    d. What, if any, concerns do you have about the environmental impacts of Project, bearing in mind the mitigation measures proposed?
    e. Provide any further observations or opinions which you consider to be relevant.

Key dates

17. The IPC public hearing will be held remotely from **Monday 14 February 2022** with registered speakers participating via tele- and/or videoconference.

18. To speak at the electronic public hearing, you must complete the registration form on the IPC website by no later than **12pm AEDT on Wednesday 9 February 2022**. Registration can be completed at: https://www.ipcn.nsw.gov.au/speaker_registration_form?project_id=32bf6906-1c50-4915-ba46-1ae160e57da6.

19. The IPC will accept written comments on the Project until **5pm AEDT on Monday 21 February 2022**.

20. To assist our clients to prepare for the public hearing, we request a draft of your expert advice by **Friday 11 February 2022**.

21. Please provide your final expert advice by **Friday 18 February 2022**.

Duty of confidentiality

22. Please treat your work as strictly confidential until your expert report is provided to the IPC, unless authorised by us.

Terms

23. Please note the following terms:

    a. your work will only be used by EDO to relation to this matter;
    b. our client may choose to make your expert advice publicly available. Any public release of your report, whether by our client or by way of publication on the IPC's

website, may result in disclosure of any works in your report over which you may claim copyright;

c. EDO will take all reasonable steps to prevent your work being used for purposes other than that mentioned above, but we accept no responsibility for the actions of third parties;

d. regardless of the above points, EDO may choose not to use your work; and

e. you will not be covered by the EDO's insurance while undertaking the above tasks.

24. If you would like to discuss this brief further, please contact the author on (02) 9262 6989 or email matthew.floro@edo.org.au (cc megan.kessler@edo.org.au).

We are grateful for your assistance in this matter.

Yours sincerely
Environmental Defenders Office

[redacted]

Matt Floro
Special Counsel

Reference number: S2602