Douglas Partners
Geotechnics | Environment | Groundwater

Supplementary Expert Report in Response to Matters of Disagreement from the Joint Expert Report

Land Court of Queensland Proceedings MRA082-13 and EPA083-13. Objection to Mining Lease and Environmental Authority for the Alpha Coal Mine

Prepared at the request of Allens Linklaters (Lawyers)
on behalf of Hancock Coal Pty Ltd

Project 80204.00
August 2013

Integrated Practical Solutions

Summary

The key areas of disagreement between expert witnesses examining the hydrogeology of the Alpha Coal Project and its potential impact on groundwater resources include:

- The nature of the Conceptual Hydrogeological Model (CHM) underpinning the numerical model used to assess impact on the groundwater system;
- The assignment of boundary conditions for the numerical model;
- The potential for impact of Alpha Mine on groundwater resources of the Great Artesian Basin (GAB); and
- The potential for impact on water resources north of the mine, particularly Degulla Lagoon and Albro Springs.

In regard to these matters, I find the following:

1. The CHM put forward by Dr Webb in preference to the CHM of URS (2012) is flawed because:

(a) The anticline / syncline structure of the Webb (2013) model is not supported by drilling data. The easternmost syncline and anticline (at least) which underpin the Webb (2013) CHM do not exist; and

(b) The boundaries and extent of several geological formations (notably the Moolayember Formation and Clematis Sandstone) do not accord with published geological mapping. The published geological mapping has been ground-truthed (in part) by myself and Mr Mark Stewart (URS) during a site visit to Cudmore National Park.

I confirm that the CHM developed by URS (2012) is appropriate and adequately reflects the hydrogeological setting of the Alpha Coal Project and surrounding area. The URS (2012) CHM is similar to CHMs developed for other coal projects in the Galilee Basin.

2. Boundary conditions of the numerical model of URS (2012) are correctly applied in my view. The western and eastern boundaries are appropriately simulated as no-flow boundaries. The western boundary is a groundwater divide, and the eastern boundary coincides with the low permeability Joe Joe Formation.

The southern and northern boundaries are appropriately set as constant head boundaries in order to replicate the groundwater flow regime of the area. All boundaries are set a sufficient distance from the mine, so that they do not have an influence on model outcomes.

3. I do not agree with the constant head boundary condition for the western boundary of the Alpha Model as suggested by Dr Mudd. The western boundary is a groundwater divide which is more appropriately simulated as a no-flow boundary.

4. In regard to potential impacts of Alpha Mine on the surrounding groundwater regime, I consider that:

a. The potential for Alpha Mine to adversely affect aquifers of the GAB is not realistic. The Rewan Formation and Dundas Beds (aquitards) overlie the Bandanna Formation and Colinlea Sandstone and should provide an effective barrier, which would prevent the expansion of drawdown westwards into the GAB; and

b. Degulla Lagoon and Albro Springs will not be adversely affected by Alpha Mine. Numerical modelling by URS (2012) shows that drawdown will not extend to these areas 35 km and 50 km north of Alpha Mine within the life of the mine and for the period of 300 years after mining ceases. I do not agree with Dr Webb's contention that the influence of the mine will continue northward virtually indefinitely. A new balance between rainfall recharge and evaporation post-mining will result in the cone of depression around the mine reaching a quasi-steady state.

Table of Contents

Supplementary Expert Report in Response to Matters of Disagreement from the Joint Expert Report

Land Court of Queensland Proceedings MRA082-13 & EPA083-13. Objection to Mining Lease & Environmental Authority for the Alpha Coal Mine

1. Expert's Details & Qualifications

1.1 Name

My name is Iain Donald Hair.
I am Principal Hydrogeologist at Douglas Partners Pty Ltd.

1.2 Address

My business address is:
439 Montague Road,
West End Qld 4101.

1.3 Qualifications

I hold the following qualifications:

- (a) Bachelor of Science (Hons.) Geology, University of Queensland;
- (b) Grad. Diploma Applied Hydrogeology, Queensland Institute of Technology; and
- (c) Master of Science (Environmental Science), Griffith University.
- (d)

Appendix A to this report is my curriculum vitae, which sets out my professional qualifications.

2. Introduction

Hancock Coal Pty Ltd is proposing to develop the Alpha Coal Project, which includes the Alpha Coal Mine. The Alpha Coal Mine is proposed to be an open cut operation within Mining Lease Application (MLA) 70426. MLA 70426 is located approximately 50 km north of the Township of Alpha in the Galilee Basin in Central Queensland.

The Alpha Coal Mine has transitioned through the EIS Process, has been assessed by the Coordinator-General (subject to conditions) and has received approval from the Commonwealth Government (subject to conditions). The MLA and draft Environmental Authority are the subject of proceedings in the Land Court. Several parties have objected to the MLA and draft Environmental

Authority, citing concerns over the level of impact on groundwater resources, the adequacy of groundwater investigations undertaken as part of the EIS Process, and other issues.

3. Expert Witness Assessment & Reporting of Groundwater Issues – Alpha Coal Mine

Each of the parties in this matter have commissioned expert witnesses to assess groundwater issues for the Alpha Coal Mine and advise the Land Court of Queensland.

Acting for Hancock Coal Pty Ltd., Allens Linklater (Lawyers) commissioned Mr Mark Stewart, Principal Hydrogeologist of URS Australia Pty Ltd., to address various questions in regard to the hydrogeology of the Alpha Coal Mine and provide a report. Mr Stewart produced a report on 30 May 2013.

Allens Linklater (Lawyers) also commissioned myself, Principal Hydrogeologist of Douglas Partners Pty Ltd., to review groundwater investigations undertaken for the Alpha Coal Mine during the EIS process, and provide a summary report on various aspects of the hydrogeology of the Alpha Coal Mine and surrounding areas. My report was provided on 29 May 2013.

Grant & Simpson Lawyers commissioned Dr Gavin Mudd, Senior Lecturer in Environmental Engineering at Monash University, Melbourne, to advise on groundwater matters in relation to the proposed Alpha Coal Mine. Dr Mudd provided his report on 30 June 2013.

Dr John Webb, Associate Professor in Environmental Geoscience at La Trobe University, Melbourne, was commissioned by the Environmental Defenders Office (Qld) Inc., on behalf of Coast and Country Association of Queensland Inc., to advise on groundwater matters in relation to the proposed Alpha Coal Mine. Dr Webb produced his report on 27 June 2013.

All experts met in Brisbane on 17 July 2013 for a Joint Experts Meeting, and a Joint Experts Report was produced on 2 August 2013, outlining areas of agreement and areas of disagreement in regard to the hydrogeology of the Alpha Coal Mine and the potential impacts of the mine on the groundwater system.

This report is a Supplementary Expert Report produced by myself in response to Matters of Disagreement from the Joint Expert Report of 2 August 2013.

4. Matters of Disagreement Between Experts

4.1 General

Matters of disagreement between the experts in regard to the hydrogeology of Alpha Coal Mine and its potential impact can be collated into 4 general topics, namely:

- Regional geology and the Conceptual Hydrogeological Model;

- Numerical modelling and boundary conditions;
- Groundwater recharge; and
- Assessment of impact.

4.2 The Conceptual Hydrogeological Model (CHM) for Alpha Coal Mine

A Conceptual Hydrogeological Model (CHM) is a collation of geological and hydrogeological data for an area which describes:

- The nature, thickness and extent of groundwater bearing units (aquifers), such as sands and gravels, sandstones, vesicular and fractured rock units and limestones;
- The nature, thickness and extent of aquitards (geological units which are not capable of storing and transmitting significant volumes of groundwater, e.g. clays, silts, claystones, siltstones, mudstones and shales);
- The mechanisms of recharge of the groundwater system (primarily from rainfall);
- Groundwater discharge zones (to streams, lakes or the ocean);
- Groundwater levels and flow directions;
- Groundwater quality; and
- Groundwater use (pumping for water supply and baseflows to streams, waterbodies and wetlands).

Data utilised in the compilation of a CHM for a project area can be obtained from:

- Geological and topographic mapping;
- Aerial photography;
- Data from drilling programs such as mineral, coal, petroleum and gas exploration;
- Stratigraphic drilling by State and Federal Government departments / agencies;
- Geophysical surveying;
- Groundwater databases such as that maintained by the Queensland Department of Natural Resources and Mines;
- Meteorological data from the Bureau of Meteorology; and

- Information from previous geological and hydrogeological studies.

The CHM is used as the basis of a numerical groundwater flow model, which is often constructed for assessing the impact of a proposed development on the groundwater system, or in assessing the quantum and sustainable use of groundwater resources within a basin.

4.2.1 The CHM of URS (2012)

Information for the CHM of URS (2012) was derived from a number of sources including:

- The Salva Resources Geological Model (Salva Resources, 2009);
- Data from coal exploration drilling programs undertaken by Hancock Coal within the Alpha and Kevin's Corner leases;
- Published geological mapping at 1:250K scale;
- Previous geological and hydrogeological investigations including Carr (1973), AGC (1983), Longworth & McKenzie (1984), JBT Consulting (2010) and 4T Consultants (2011); and
- Several regional geological and hydrogeological investigations of the Eromanga, Galilee and Drummond Basins.

The salient feature of the URS (2012) CHM is a series of Permian and Mesozoic formations dipping shallowly from the east through the Alpha and Kevin's Corner leases to the west beneath strata of the Eromanga Basin. The URS (2012) CHM is illustrated by a schematic cross-section reproduced as Figure 1 below, and also in Appendix A of the Joint Experts Report (JER, 2013).

Some of the units of the URS (2012) CHM are, or contain aquifers with significant groundwater potential; including the Clematis Sandstone, the Bandanna Formation and the Colinlea Sandstone. Other units in the sequence are essentially aquitards (Moolayember Formation, Rewan Formation and Joe Joe Formation).

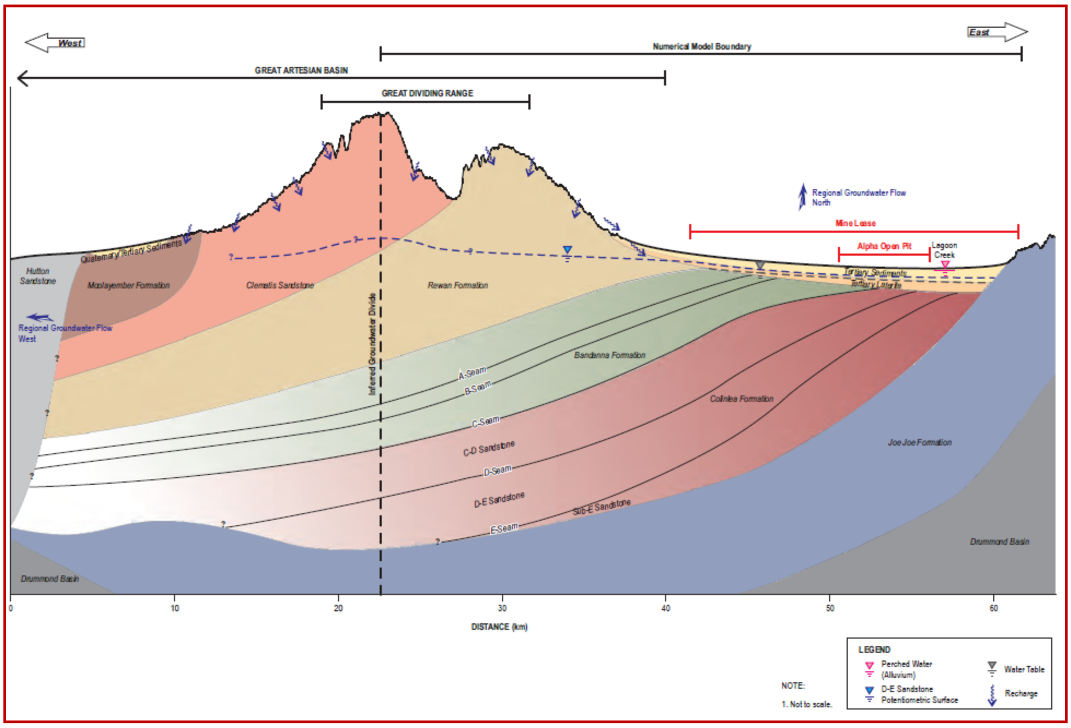


Figure 1: The Conceptual Hydrogeological Model of URS (2012)

4.2.2 The CHM of Webb (2013)

Webb (2013) dismisses the CHM of URS (2012) and proposes an alternate, the salient feature of which is a series of NNW – SSE trending anticlines and synclines, extending from beneath the Great Dividing Range (GDR) to the west of the Alpha lease, to the eastern boundary of Alpha lease (Figures 2 and 3).

The CHM of Webb (2013) is derived from:

- Remote sensing imagery including airborne radiometric and magnetic data, Landsat 5 imagery and Google Earth imagery;
- 1:250K Geological Mapping (Jericho Sheet SF55-14);
- Observations made and photographs taken during an overflight in a light plane; and
- Discussions with local landholders.

The CHM of Webb (2013) is illustrated in cross-sections shown in Figure 8 of Webb (2013). It is understood that Dr Webb did not undertake any physical ground inspection to confirm surface geology in support of his preferred CHM.

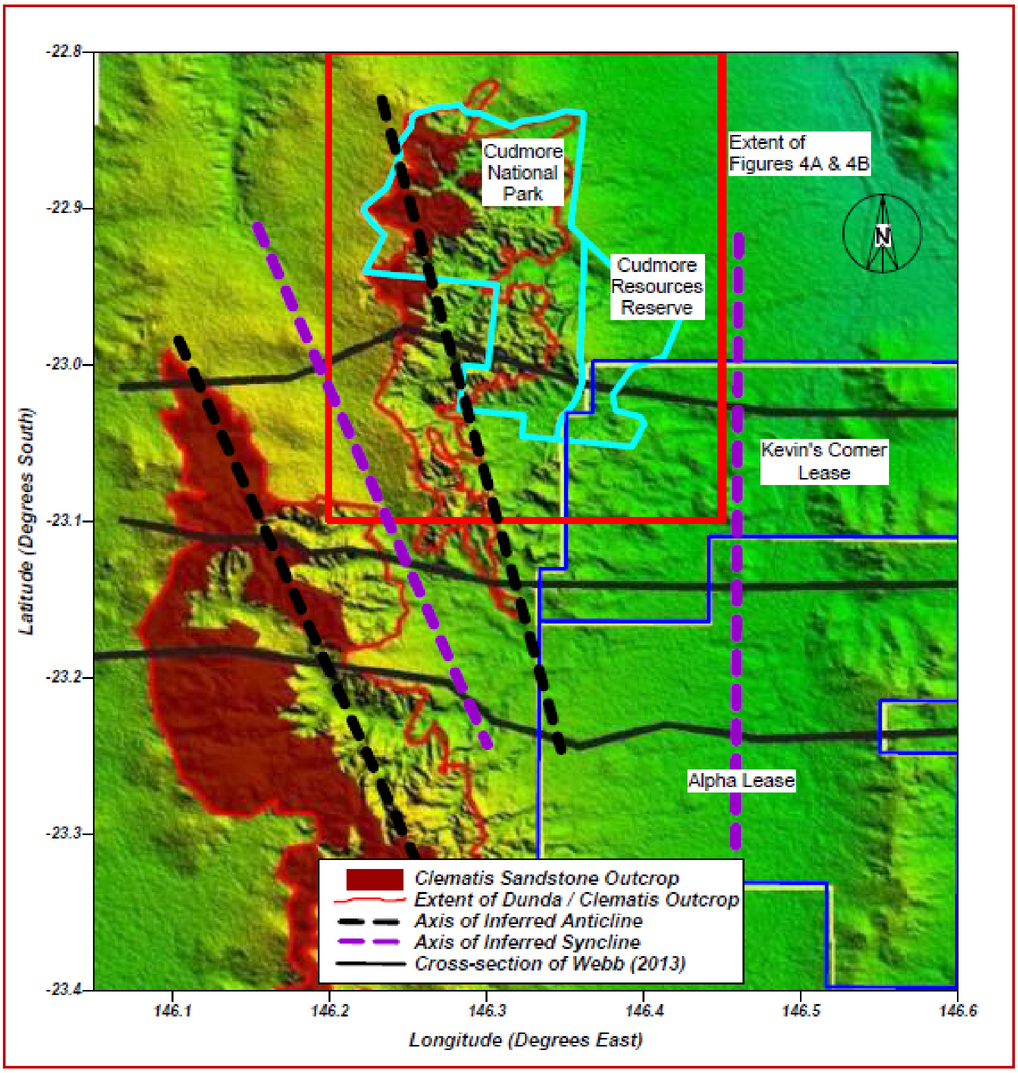


Figure 2: The Conceptual Hydrogeological Model of Webb (2013); After Figures 4c & 4d of Webb (2013)

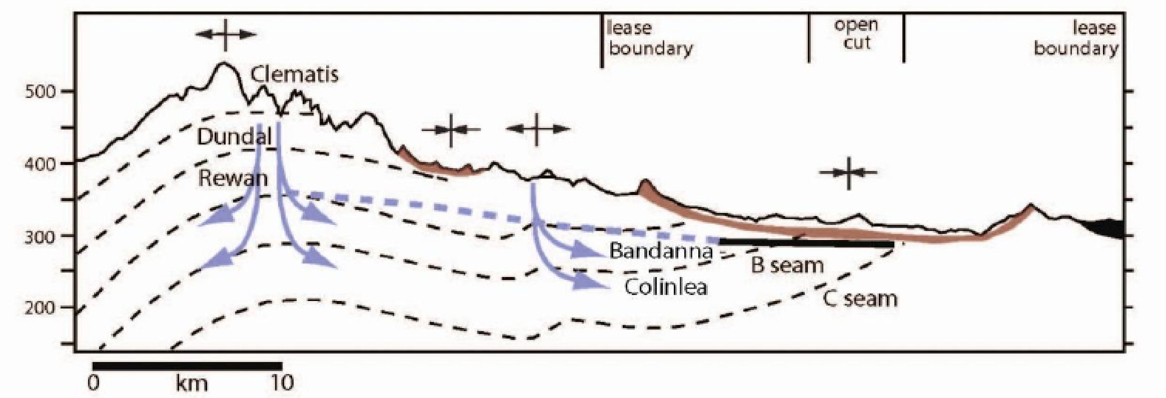


Figure 3: Middle Cross-section of the Conceptual Hydrogeological Model of Webb (2013); After Figure 8 of Webb (2013)

It is considered that the CHM of Webb (2013) is flawed because:

(a) it does not take into account or accord with drilling data derived from coal exploration drilling programs undertaken within the Alpha and Kevin's Corner leases, and

(b) the geological mapping of the Webb CHM (shown in Figure 4 of Webb (2013)) does not accord with 1:250K scale regional geological mapping, particularly in regard to the extent of the Clematis Sandstone and the geological boundary between the Clematis Sandstone and the Dunda Beds / Rewan Formation unit within Cudmore National Park.

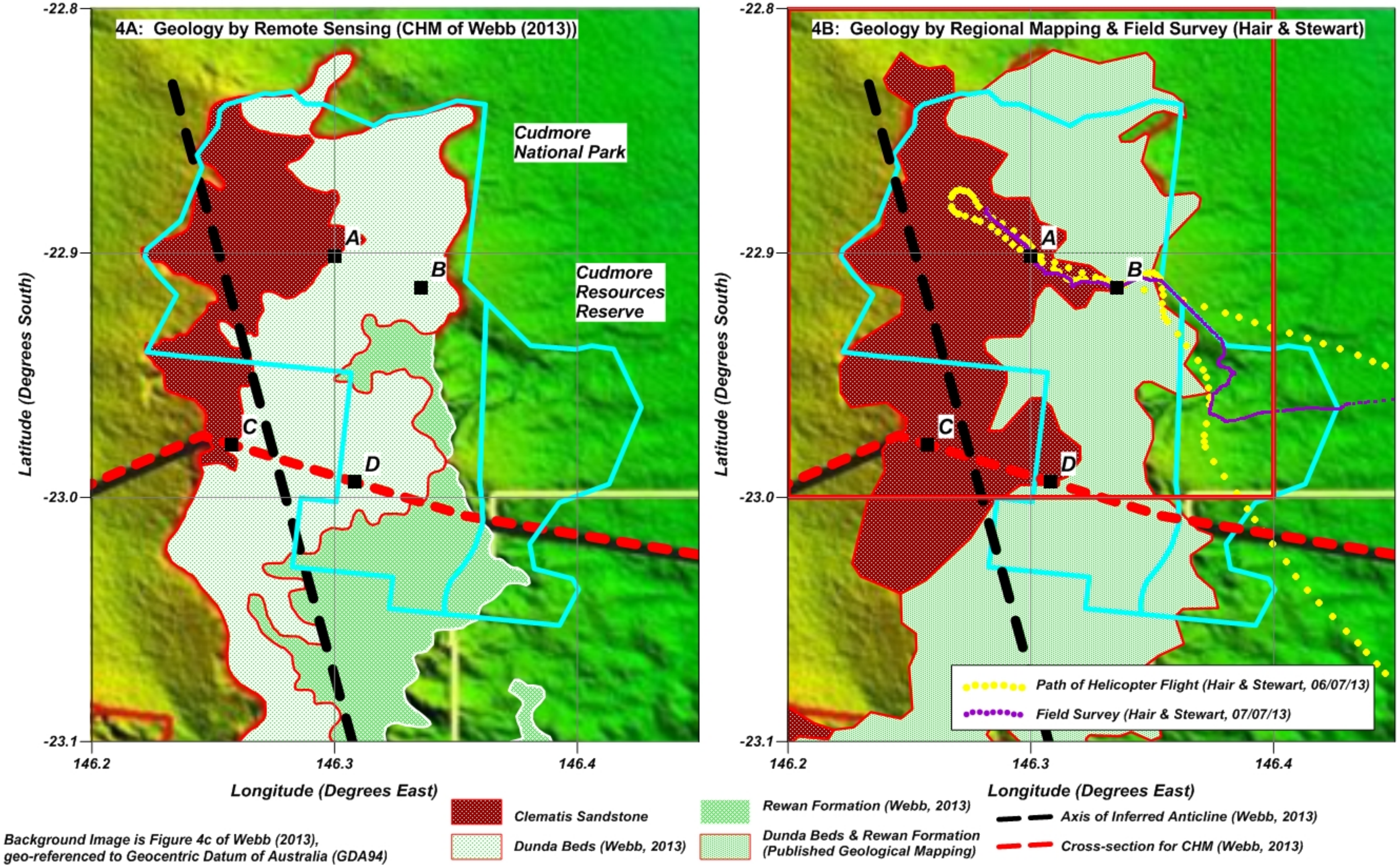
Point (a)

In regard to Point (a) above, the CHM of Webb (2013) shows a NNW – SSE trending anticline within Cudmore National Park extending southward into the Alpha lease (Figure 4d of Webb (2013)). If this anticline existed, it would be evident in geological cross-sections derived from drilling data as easterly dipping strata in the western portion of the Alpha lease. The geological cross-sections do not provide any indication of easterly dipping strata. Instead, they show a strata sequence gently dipping in a westerly direction across the lease, in keeping with the CHM of URS (2012).

In addition, Figure 4d of Webb (2013) suggests the existence of a syncline trending N – S through the Alpha lease. The geological cross-sections referred to above do not provide any indication of a synclinal structure in this area.

Point (b)

In regard to Point (b) above, the extent of the Clematis Sandstone within Cudmore National Park is much less in Figure 4c of Webb (2013) than the extent of this unit as indicated in published geological mapping. In addition, the geological boundary between the Clematis Sandstone and the underlying Dunda Beds / Rewan Formation differs significantly between published geological mapping and Figure 4c of Webb (2013). Webb (2013) does not explain the differences between the geological interpretation derived from remote sensing, and regional geology as shown in the Jericho 1:250K geological map (Sheet SF55-14). The differences between geological mapping derived by Webb (2013) using remote sensing, and geological mapping as outlined in published geological mapping are shown in Figure 4 (4A and 4B) (below).



Background Image is Figure 4c of Webb (2013), geo-referenced to Geocentric Datum of Australia (GDA94)

Figure 4: Geology of Cudmore National Park

During a field inspection undertaken by myself and Mr Mark Stewart (Principal Hydrogeologist, URS) on 7 July 2013, the geological boundary between the Clematis Sandstone and the underlying Dunda Beds / Rewan Formation as shown in published geological mapping, was confirmed at Point B; whereas the CHM of Webb (2013) suggests that the boundary is at Point A. (Figures 4A and 4B, above).

The boundary is readily identifiable in outcrop. It is not gradational; it is quite sharp. There is also a distinct difference in the type of soil which has developed over Clematis Sandstone compared with that which has developed on Dunda Beds / Rewan Formation.

Soils on Clematis Sandstone are comprised of medium to coarse grained sands with a minimum of clay. Soils derived from the weathering of Dunda Beds / Rewan Formation are mid to dark brown and clayey. There is also a difference in the type of vegetation present on Clematis Sandstone and on the Dunda Beds / Rewan Formation. The Clematis Sandstone supports a eucalypt woodland vegetation type (Bloodwoods and Ironbarks); the Dunda Beds / Rewan Formation support a plant community characterised by Acacia scrub.

A number of photographs were taken during the field inspection of Cudmore National Park by myself and Mr Mark Stewart on 7 July 2013. All photographs (less duplicates; Photographs 4, 11, 18, 19, and 21) are shown in Appendix B of this report. Selected photographs are shown in Figures 5 and 6.

Figure 5: Outcrop of Dunda Beds / Rewan Formation.

Figure 6: Clematis Sandstone outcrop. Photo taken looking north. Apparent dip of strata to the west. Ironbark dominated Eucalypt Woodland

Figure 5 shows outcrop of Dunda Beds / Rewan Formation, and Figure 6 is a photograph of Clematis Sandstone outcrop. Figure 5 shows Acacia scrub developed on the Dunda Beds / Rewan Formation; Figure 6 shows a Eucalypt woodland characteristic of landscapes of the Clematis Sandstone.

Both photographs show bedding dip of strata to the west. The anticline postulated by Webb (2013) through the Cudmore National Park would require strata to be easterly dipping. No easterly dipping strata were observed during the field inspection undertaken by myself and Mr Stewart.

The boundary between the Clematis Sandstone and the Dunda Beds / Rewan Formation is clearly identifiable in outcrop, and on the basis of soils and vegetation. Within Cudmore National Park and to the immediate southwest, the CHM of Webb (2013) has this boundary incorrectly positioned.

Three cross sections are used to illustrate the CHM of Webb (2013). The northernmost section crosses through Cudmore National Park as shown in Figures 4A and 4B (above). The CHM of Webb (2013) has the boundary between the Clematis Sandstone and the Dunda Beds / Rewan Formation at Point C along this cross section, whereas published geological mapping suggests that the boundary would be at Point D. The discrepancy between Points C and D, and the discrepancy between Points A and B is of importance in regard to the cross-sections which form the basis of the CHM of Webb (2013).

Remote sensing using the methods utilised by Webb (2013) can only assess surface geology. These methods are not able to be used in assessing sub-surface geology. Cross-sections shown in Figure 8 of Webb (2013) are hand drawn, and infer sub-surface geology. These sections imply a credibility which is not justified.

In a contribution to the JER (2013), Dr Webb states that ***“These cross sections are schematic, in that the boundaries were hand drawn to fit with interpreted geological mapping and remote sensing imagery. However, the boundaries as interpreted from the remote sensing imagery are difficult to draw to agree with uniformly westwards dipping beds”*** (paragraph 71, page 21 of JER (2013)).

I re-affirm my belief that it is just as easy to draw the geological boundaries as uniformly westwards dipping beds as it is to draw the cross sections in order to illustrate a anticline / syncline / anticline / syncline fold structure. Figure 7 shows a re-drawing of the middle cross-section of Webb (2013) Figure 8.

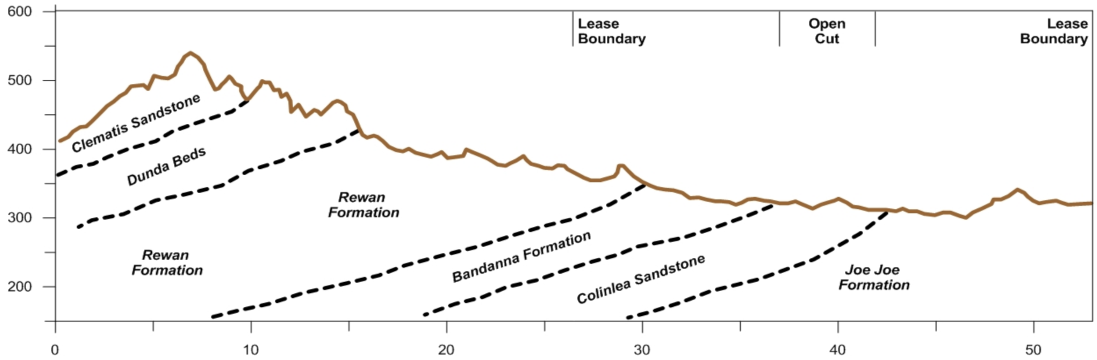


Figure 7: Re-drawing of the Middle Cross-section of Webb (2013) to illustrate a westerly dipping sequence

Figure 7 is more appropriate than the cross-sections of Webb (2013). The cross-sections of Webb (2013) indicate that all formations are of relatively equal thickness. Data from petroleum exploration well AOD Jericho #1, and from stratigraphic investigation bores QDM Hexham #1 and GSQ Jericho #1 show that the thickness of the Clematis Sandstone, Dunda Beds, Bandanna Formation and Colinlea Sandstone is of the order of 70 m to 100 m. The thickness of the Rewan Formation is, however, greater than 200 m. Figure 7 (above) reflects that situation.

Petroleum exploration well AOD Jericho #1 is located ~60 km SW of the Alpha Lease. Stratigraphic investigation bores GSQ Jericho #1 and QDM Hexham #1 are located approximately 45 km south of the Alpha Lease, and 55 km NW of the Alpha Lease, respectively.

It is important to note that there are only 2 points along each of the cross-sections of Webb (2013) that can be used to "tie-in" with geology, being:

- the boundary between the Clematis Sandstone and the Dunda Beds, and
- the boundary between the Dunda Beds and the Rewan Formation.

These are the only recognisable boundaries in outcrop to which boundaries between geological units in the subsurface could be projected.

Other geological boundaries (between the Rewan Formation and the Bandanna Formation, and between the Bandanna Formation and the Colinlea Sandstone) are buried beneath Tertiary cover. Projection of these boundaries towards the land surface on all 3 cross-sections is only a guess that has been made by Dr Webb without any supporting evidence from drilling data or other sources.

Given the discrepancy between geological boundaries assessed by remote sensing (Webb, 2013) and geological boundaries as indicated by published geological mapping (supported by ground-truthing), there can be little confidence in the use of the boundary between the Clematis Sandstone and the Dunda Beds as a "tie-in" point for the cross-sections of the Webb (2013) CHM.

The geological interpretation of Webb (2013) by remote sensing does not distinguish between the Moolayember Formation and the Clematis Sandstone on the western side of the GDR. By comparison the published geological mapping does distinguish between these formations. In paragraph 81 (page 24) of the JER, Dr Webb questions the published geological mapping and suggests that the western boundary of the GDR may have been incorrectly mapped.

Extensive geological mapping over much of Queensland (including the Alpha area) was undertaken in the 1960s, 1970s and 1980s by geologists of the Bureau of Mineral Resources and the Geological Survey of Queensland. This mapping is of high quality and was supported by extensive field investigations involving examination of rock outcrop, collection and identification of rocks, classification of rocks by visual inspection and thin section examination, supplemented with aerial photographic interpretation. Geological mapping compiled from these programs was ground-truthed. It is well regarded and is commonly used to this day.

In a contribution to the JER (2013), Dr Webb states that ***"The Waratah Coal China First EIS (E3 Consulting, 2010) used a similar geological model"*** (paragraph 68, page 21 of JER (2013)); i.e., a geological model similar to the CHM of Webb (2013). It should be pointed out that the CHM of E3 Consulting (2010) has been superseded by the CHM of Heritage Consulting (2013) in the Waratah Coal China First SEIS. The CHM of E3 Consulting (2010) relied on by Webb (2013) is no longer valid.

Conclusion

The CHM of Webb (2013) relies primarily on an interpretation of remote sensing imagery. The:

- published geological mapping;
- data from extensive bore drilling; and
- ground-truthed evidence,

do not support Dr Webb’s interpretation using remote sensing imagery.

The Waratah Coal China First EIS which was also identified by Dr Webb has been superseded with a CHM that is consistent with the Alpha CHM.

At its best, Dr Webb's CHM is only a theory that is not supported by hard evidence or published geological mapping.

4.2.3 The CHM of Mudd (2013)

Mudd (2013) originally supported the CHM of E3 Consulting (2010) developed for the Waratah Coal China First EIS (now known as the Galilee Coal Project), in preference to the CHM of URS (2012) for the Alpha Coal Project. The Galilee Coal Project is located to the immediate south of the Alpha Coal Project.

The CHM of E3 Consulting (2010) is characterised by an anticlinal structure beneath the Great Dividing Range (GDR). This is the model identified by Dr Webb as being supportive of his CHM. The Joint Experts Report identifies in the points of clarification that the CHM of E3 Consulting (2010) had been superseded in an addendum to the Galilee Coal Project SEIS by a revised CHM developed by Heritage Computing (2013) (see point 6, paragraph 17 of the Joint Expert Report).

It is understood that Dr Mudd now accepts the CHM of Heritage Computing (2013) in preference to the original CHM of E3 Consulting (2010) (Joint Experts Report (Appendix B of the Joint Expert Report, and paragraphs 73 and 111)).

The CHM of Heritage Computing (2013) for the (Waratah Coal) Galilee Coal Project is very similar to that of URS (2012) for the Alpha Coal Project.

4.3 Numerical Groundwater Flow Modelling for Alpha Coal Mine

4.3.1 Model Boundary Conditions

The numerical model of URS (2012) was a substantial revision on earlier numerical modelling for the Alpha Coal Project. The current model is bounded to the west by the groundwater divide beneath the Great Dividing Range, which is numerically simulated as a no-flow boundary. The eastern boundary of the model which coincides with the low permeability Joe Joe Formation (an aquitard) is also simulated as a no-flow boundary.

The northern and southern boundaries of the model have been set as constant-head boundaries, primarily to simulate the groundwater levels and groundwater flow patterns across the model domain. The prevailing groundwater flow direction, determined mainly from groundwater levels recorded in coal exploration holes and groundwater monitoring bores, is from SSW to NNE.

There is a considerable amount of disagreement between the experts in regard to the appropriateness of boundary conditions set for the Alpha Coal Project numerical groundwater flow model.

Mr Stewart supports the boundary conditions set for the model of URS (2012). I also agree that the boundary conditions set in the model are appropriate for the hydrogeological conditions at the Alpha Coal Project and within the region covered by the model.

Dr Webb is of the view that simulation of the western boundary of the model as a no-flow boundary is probably correct, however, he does not agree with simulating the southern and northern model boundaries as constant head boundaries.

Dr Mudd believes that the western boundary should be simulated as a constant head boundary, although he does state that more groundwater investigations are required in order to better determine the boundary condition that should be used. He has a similar comment in regard to the southern boundary, but makes no comment in regard to the northern boundary.

The setting of a constant head boundary at a groundwater divide (Dr Mudd's preference for the western boundary of the model) is inappropriate. Groundwater divides beneath topographically elevated areas (e.g. mountain ranges which separate surface water catchments) are commonly adopted as convenient limits of groundwater models. Rainfall on one side of a range recharges groundwater which then flows away from the range. Rainfall on the other side of the range recharges groundwater which then flows away from the range on the other side of the range.

The groundwater table directly beneath the range can rise and fall seasonally, and in the longer term; it is therefore not appropriate to simulate the divide as a constant head boundary. However, given the timeframes involved in any long term rise and fall in groundwater levels beneath the divide, the difference between simulation as a no-flow boundary or as a constant-head boundary would be minimal in this case.

In a contribution to the JER (2013), Dr Webb's comments in regard to simulating model boundaries (paragraph 147, page 39 of JER (2013)) are correct. Appropriate simulation of the margins of a numerical model is important, particularly for regional basin-wide models. However, the Alpha Coal Project model is an Impact Assessment Model (IAM) designed primarily to assess the impact of an open cut mining operation on the surrounding groundwater regime. Providing the boundaries are set a sufficient distance from the focus of the impact (i.e. the mine), boundary conditions have little influence on model outcomes.

When a mine void (open cut or underground) is developed below the groundwater table, groundwater will flow towards the void. Thus, all mining operations have an impact on the surrounding groundwater regime. A "cone of depression" in the groundwater system develops around the mine, and extends as mining progresses. When mining ceases, the cone of depression may continue to expand for a period of time, but will generally stabilise at a new equilibrium.

The primary aim of an Impact Assessment Model is to assess the extent of impact of a mining operation over time, both during and post mining. An Impact Assessment Model for a mining operation also seeks to establish the quantum of groundwater that will need to be pumped during the life of a mining operation.

When mining ceases, pumping ceases, and the extent of the cone of depression is then governed primarily by the long term balance of recharge to the groundwater system and losses by evaporation, particularly within the footprint of the mine and the mine void, where post-mining evaporative losses are permanently greater than during the pre-mining equilibrium. Post-mining, groundwater levels may still vary from season to season and from decade to decade, but around a new mean, which is a function of the balance between stresses on the groundwater system.

If the cone of depression does not reach the boundaries of a model domain during the course of the mining operation and in the period during which the new equilibrium is established post-mining, then boundary conditions have little influence on model outcomes.

However, if the cone of depression reaches a no-flow boundary which should have been simulated as a constant head boundary, the model will over-estimate the impact at that boundary, as the simulated boundary does not allow groundwater to flow into the model in response to the lowering of groundwater levels. On the other hand, if the cone of depression reaches a constant head boundary which should have been designated a no-flow boundary, then the model will under-estimate the impact at that boundary, as the constant head boundary will provide a constant inflow to the model at that boundary and will thereby maintain the cone of depression at the boundary.

The conservative approach for an Impact Assessment Model is to set boundaries a sufficient distance from the mining operation such that they do not influence model outcomes during the course of the simulation.

It is a condition of approval of the Alpha Coal Project that the Alpha Model be re-structured and re-calibrated at regular intervals during the mining operation, utilising monitoring data and additional hydrogeological data collected during that period. At each model re-structuring and re-calibration, boundary conditions are examined to ascertain whether they remain relevant, or require changing.

It should be kept in mind that the Alpha Model has been through a rigourous development and refinement during the EIS process. This refinement included transient model simulations using data obtained from a dewatering program undertaken for the construction of a trial bulk sample pit.

The model has been revised on several occasions in line with recommendations by Regulators and has been subject to a rigourous 3rd Party Audit Review by an independent consultant (PB, 2012).

4.4 Potential Impact of Alpha Coal Mine on Groundwater Resources

4.4.1 Potential Impact on the Great Artesian Basin (GAB)

The units which will be most adversely affected by the Alpha Coal Project are aquifers within the Bandanna Formation and Colinlea Sandstone. These units are separated from aquifers of the GAB (Clematis Sandstone and younger units) by the Rewan Formation and Dunda Beds, both of which behave primarily as aquitards.

Dr Webb is of the view that the Bandanna Formation and Colinlea Sandstone are recharged primarily through the Rewan Formation, a phenomenon which requires his CHM to be correct, and for there to be fractured Rewan Formation in the axes of anticlines beneath the GDR. Dr Mudd agrees with Dr Webb.

Section 4.2.2 of this report shows the CHM of Webb (2013) to be incorrect.

The transfer of groundwater through the Rewan Formation either as recharge or because of drawdown in the underlying Bandanna Formation and Colinlea Sandstone is problematic. The Rewan Formation is of low permeability. It is a regional aquitard. Mr Stewart estimates that water would take >6000 years to transfer through a 100 m thickness of Rewan Formation (paragraph 182, page 48 of JER (2013)). As discussed in Section 4.2.2 of this report, the Rewan Formation is ~200 m in thickness in the Alpha Mine region. Therefore, a period of >12,000 years would be required for water to seep through the formation. Fracturing of the Rewan Formation would not enhance the units ability to transfer water. The formation is comprised of rock types which weather to clays which would “heal” any fracturing.

I agree with the assessment of Mr Stewart. The Rewan Formation is an aquitard and will be an effective barrier to groundwater flow between the Alpha Coal Mine and the GAB.

4.4.2 Potential Impact on Springs and Degulla Lagoon

There is considerable disagreement between the experts on the potential for the Alpha Coal Mine to adversely impact on Degulla Lagoon and on Albro Springs to the north of the Alpha and Kevin's Corner projects.

Dr Webb is of the view that the Alpha Coal Mine will adversely impact on Degulla Lagoon and on Albro Springs, and that the springs are artesian. Dr Mudd supports Dr Webb's view that the Albro Springs are artesian but provides no reasoning for this support. Dr Mudd makes no comment in regard to the potential for Alpha Coal Mine to impact on Degulla Lagoon.

Based on the results of numerical modelling by URS (2012), Mr Stewart is of the view that the Alpha Coal mine will not affect the water resources of Degulla Lagoon or Albro Springs.

Degulla Lagoon is located ~35 km north of the Alpha Lease. It is known that Degulla Lagoon receives water primarily from flood flows of the Belyando River. It may also receive some contribution from groundwater seepage. Dr Webb's assertion that the lagoon is supported by groundwater from aquifers in the Bandanna Formation and Colinlea Sandstone has no supporting evidence. It is more likely that any groundwater seepage to the lagoon derives from the surrounding Tertiary and Quaternary alluvial sediments which would be recharged by flood flows during wet periods and discharge groundwater to the lagoon slowly during prolonged dry spells.

The Albro Springs are located ~50 km north of the Alpha Lease. Dr Webb's assertion that the springs are supported by groundwater from aquifers in the Bandanna Formation and Colinlea Sandstone has no supporting evidence. It is more likely that the springs are sustained locally by groundwater seepage at a break of slope.

In any case, the potential for these water features to be adversely affected by mining activity at distances of 35 km to 50 km has to be considered to be very low. Numerical modelling for the Alpha Coal Project shows that groundwater levels at Degulla Lagoon and Albro Springs should remain unaffected throughout the life of the mine and for a timeframe of at least 300 years thereafter.

Dr Webb contends that the cone of depression around the Alpha Mine would continue to expand northward over time, and that this is the underlying reason for his belief that Degulla Lagoon and Albro Springs will be adversely affected by the mine. I do not agree with this because the cone of depression will reach a quasi steady state after mining ceases. Further expansion will not occur because of a balance between rainfall recharge and evaporation loss within the mine affected area.

Statement by Expert Witness – Iain Donald Hair

I confirm the following:

(a) the factual matters stated in this report are, as far as I know, true;

(b) I have made all enquiries that I consider appropriate;

(c) the opinions stated in this report are genuinely held by me;

(d) the report contains reference to all matters I consider significant; and

(e) I understand my duty to the court and have complied with that duty.

Iain Donald Hair
20 August 2013

Douglas Partners Pty Ltd

References

4T Consultants Pty Ltd., 2011: Hancock Coal Kevin's Corner and Alpha Coal Projects. Field Report. Historic Data Collation and Field Survey of Surrounding Landholder Bores. Report prepared for URS Australia. July 2011. Included in the HPPL Alpha Coal Project Supplementary Environmental Impact Statement as Volume 2, Appendix O.

Australian Groundwater Consultants Pty Ltd., 1983: Alpha Coal Project (A to P 245C). Surface Water and Groundwater Aspects – Preliminary Evaluations. Report prepared for Bridge Oil Limited.

Carr, A.F., 1973: Galilee basin exploratory coal drilling – Wendouree area. Geological Survey of Queensland Record 1973/12 (unpublished).

E3 Consulting Australia Pty Ltd., 2010: Waratah Coal China First Groundwater Assessment. September 2010.

Hair, I.D., 2013: Expert Report to the Land Court. Hancock Coal Pty Ltd v Kelly & Coast & Country Association of Queensland and Ors. Report dated 29 May 2013.

Heritage Computing, 2013: Galilee Coal Project Groundwater Assessment. Report prepared for Waratah Coal Pty Limited. Report HC2013/7. March, 2013.

JBT Consulting, 2010: Alpha Coal Project Groundwater Technical Report. Report prepared for Hancock Prospecting Pty Ltd., and included in the Alpha Coal Project Environmental Impact Statement as Appendix G – Groundwater.

JER (Hair, I.D., Stewart, M., Mudd, G.M., & Webb, J.,) 2013: Joint Experts Report on Groundwater. The Land Court of Queensland. File Numbers: MRA082-13 & EPA083-13. Report dated 2 August 2013.

Longworth & McKenzie, 1984: Report on Geotechnical and Groundwater Investigation (1984) Area 2, ATP245C, Alpha, Queensland. Report prepared for Bridge Oil Limited.

Mudd, G.M., 2013: Expert Report to the Queensland Land Court. Proceeding MRA082-13 & EPA083-13. Report dated 30 June 2013.

Parsons Brinckerhoff Australia Pty Limited, 2012: Alpha Project groundwater modelling – Independent due diligence assessment. Report prepared for Hancock Coal Pty Ltd. March 2012.

Salva Resources, 2009: Summary of Galilee Regional Model (GAB). Internal Project Memorandum from Salva Resources to Hancock Coal Pty Ltd.

Stewart, M., 2013: Expert Report to the Land Court. Hancock Coal Pty Ltd v Kelly & Coast & Country Association of Queensland and Ors. Report dated 30 May 2013.

URS Australia Pty Ltd., 2012: Groundwater Modelling Report - Alpha Coal Project. Report prepared for Hancock Coal Pty Ltd. March 2012.

Webb, J., 2013: Expert report on groundwater impacts to the Land Court. Coast and Country Association of Queensland Inc. & Ors v Hancock Coal Pty Ltd. Land Court of Queensland Proceeding MRA082-13 & EPA083-13. Objection to Mining lease and Environmental Authority for Alpha Coal Mine. Report dated 27 June 2013.

Appendix A

CV – Iain Donald Hair
Principal Hydrogeologist, Douglas Partners Pty Ltd

Curriculum Vitae

IAIN HAIR
Principal Hydrogeologist

Bachelor of Science (Geology) (Honours), University of Queensland, I977
Graduate Diploma in Applied Hydrogeology, QLD Institute of Technology, I980
Master of Science (Australian Environmental Studies), Griffith University, I988

Memberships: Member, International Association of Hydrogeologists

Experience

2006 - Present	**Douglas Partners Pty Ltd,** Brisbane Principal Hydrogeologist Senior Associate
2005 - 2006	**Kellogg Brown & Root Pty Ltd (KBR),** Brisbane Principal Hydrogeologist attached to the Maritime / Environment and Water Resources Group
2004 - 2005	**Coffey Geosciences Pty Ltd,** Brisbane Principal Hydrogeologist / Australian Groundwater Manager
1998 - 2004	**Coffey Geosciences Pty Ltd,** Brisbane Principal Hydrogeologist / Groundwater Manager Queensland & NT
1995 - 1998	**Coffey Partners International Pty Ltd,** Brisbane Senior Hydrogeologist / Groundwater Manager Queensland & NT
1993 - 1995	**Woodward-Clyde Pty Ltd,** Brisbane Supervising Hydrogeologist
1990 - 1993	**Woodward-Clyde Pty Ltd,** Brisbane Senior Hydrogeologist
1988 - 1990	**Queensland Water Resources Commission,** Brisbane Project Hydrogeologist
1977 - 1988	**Geological Survey of Queensland,** Brisbane Geologist / Hydrogeologist.
1976 - 1977	**Thiess Mining Pty Ltd,** Brisbane Coal Exploration Geologist
1975 - 1976	**Brigalow Mines Pty Ltd,** Brisbane Coal Exploration Geologist

IAIN HAIR
Principal Hydrogeologist

Project Experience

- Enterprise Mine Project, Mt Isa, Queensland: Hydrogeological assessment of groundwater inflow problem during pilot hole drilling for 1000 m deep paste fill holes. Temporary securing of inflows in pilot holes, review of hydrogeological data, packer testing and wireline logging to identify inflow zones, assessment of results of testing program, input to design of a grouting program and completion of the paste fill holes. (Client: Tennent, Isokangas Pty Ltd; 2000)
- Yandi Iron Ore Project, via Newman, Western Australia: A major hydrogeological study involving the establishment of a network of monitoring bores, the development of a groundwater monitoring (water levels and quality) program, the design, construction, test pumping and equipping of water supply bores and large diameter dewatering bores, and the design and construction of a borefield reticulation system. The project also involved groundwater exploration for construction water supply for a railway line associated with the project. (Client: BHP Iron Ore; 1992)
- Wirralie Borefield, via Mt Coolon, Queensland: Test drilling and review of hydrogeological information, groundwater level and pumping data to locate an emergency water supply during a prolonged drought coincident with the end of mine life prior to moving processing plant to another mining operation. (Client: Ross Mining NL; 1993, 1994)
- Subera Sapphire Mine, via Emerald, Queensland: Development of a ‘regional’ scale groundwater flow model for an unconfined alluvial aquifer system to assess the potential for basal sand/gravel aquifers to provide an increased process water requirement. The model was also used to demonstrate the likely impact of increased pumping on groundwater based water supplies for the townships of Sapphire and Anakie. (Client: Great Northern Mining Corporation NL; 1994)
- Narran Vale Sapphire Project, Inverell, New South Wales: Hydrogeological assessment including test pumping of large diameter wells and the development of a ‘local’ scale groundwater flow model to assess groundwater resources for process water supply. The model was used to evaluate the impact that pumping from wells may have on groundwater levels in bores on neighbouring properties. (Client: Great Northern Mining Corporation NL; 1994)
- Braeside Borefield, via Nebo, Queensland: Regular review of groundwater level, groundwater quality and pumping data to assess the ongoing performance of the Braeside Borefield. Results of review studies are used in the management of the borefield, in varying pumping regimes to maintain borefield production and groundwater quality. (Client: BHP Australia Coal Pty Limited; 1990 to present)
- Century Zinc Project, via Mt Isa, Queensland: Extensive hydrogeological investigations comprising the establishment of a network of groundwater monitoring bores, development of data storage and retrieval systems, groundwater exploration, bore design and construction, long duration test pumping of bores, a ‘trial’ dewatering program, borefield and reticulation design and groundwater modelling to assess dewatering requirements and a groundwater based water supply for a proposed large-scale open cut mining operation. (Client: Minenco Pty Limited; 1991 to 1994)
- Sun Metals Zinc Refinery, Queensland: Exploration drilling and permeability testing of alluvial/colluvial deposits to assess practicality of wastewater disposal by land irrigation. Assessment of potential impact on groundwater regime and quality. Baseline groundwater quality analysis. (Client: Townsville City Council; 1998)
- South Grafton Landfill, Grafton, New South Wales: Preparation of the section of an EIS dealing with groundwater quality protection. Site hydrogeological assessment including drilling, construction of monitoring bores, groundwater monitoring and permeability testing. Design of an ongoing groundwater monitoring program. (Client: Brian J Mackney & Associates and Grafton City Council; 1997)
- No.1 Underground Mine, Tieri, Bowen Basin, Queensland: The construction of a 2-D vertical ‘slice’ model using finite element methods to assess the causal factors of a significant water inflow event to the underground mine following heavy rainfall in January 1996. In addition to

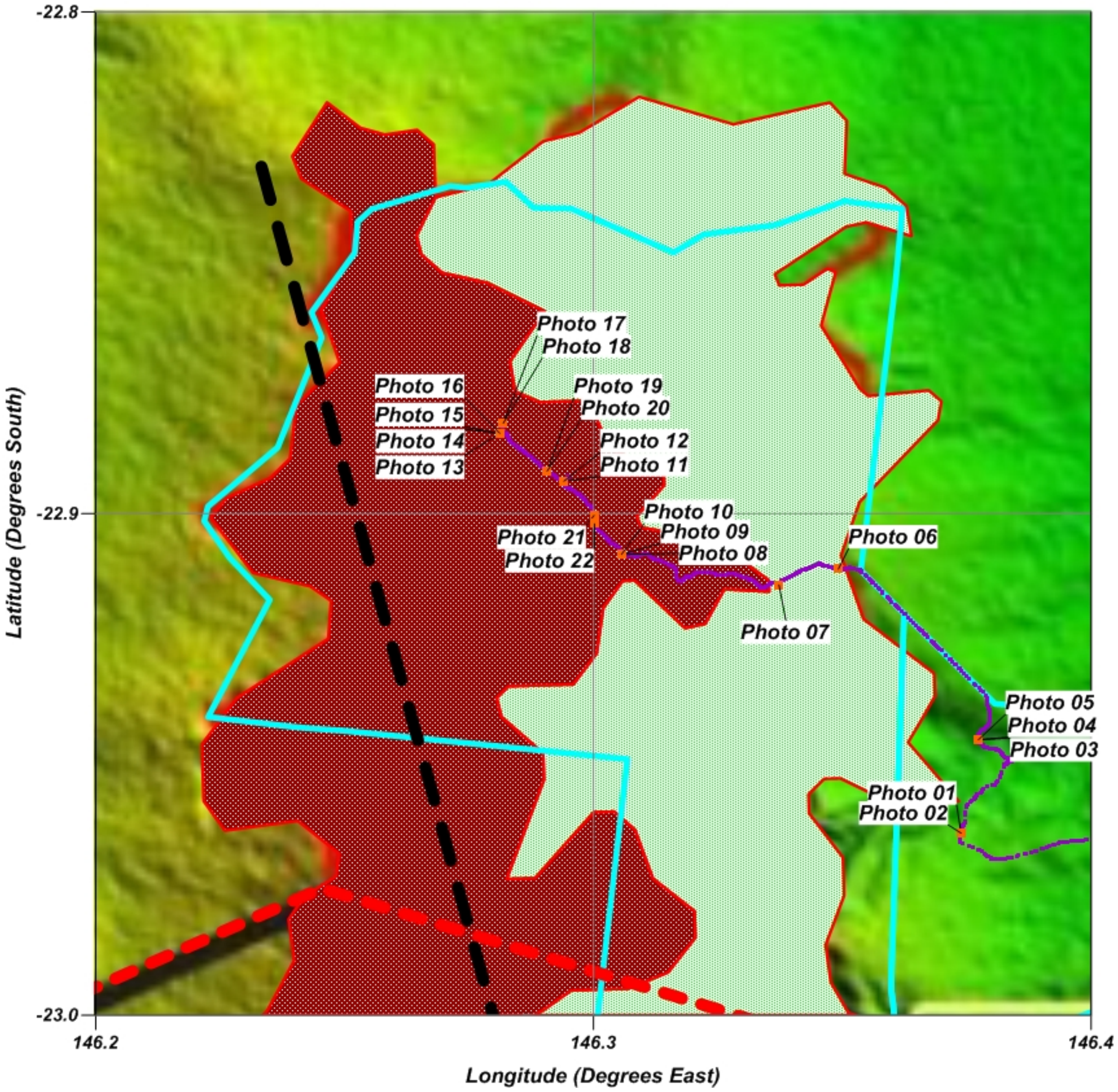
computer modelling, the project involved collation of climatic, hydrological and hydrogeological data to quantify the inflow event which caused disruption to longwall mining operations. (Client: Oaky Creek Coal Pty Ltd; 1995).

- Biloela Abattoir Upgrade, Biloela, Queensland: Analysis of existing data and assessment of possible impact of abattoir wastes on groundwater quality. Development of a groundwater management plan (including a groundwater quality monitoring program) and an irrigation management plan for licensing and approval of abattoir upgrade by state and local authorities. (Client: Divakarla & Associates; 1999)
- Moranbah North Coal Project, via Moranbah, Queensland: Review of inflow predictions to a planned longwall mining operation. Assessment of dewatering requirements for a Tertiary basalt aquifer overlying the mine. Development of a conceptual hydrogeological model based on coal exploration drilling data, recorded hydrogeological data (levels and water quality), the establishment of monitoring bores and the construction and test pumping of production/dewatering bores. Compilation of bore licence applications for submission to regulatory authorities. (Client: Moranbah North Coal Pty Ltd; 1998, 1999)
- Sun Metals Zinc Refinery, Queensland: Review, analysis and assessment of groundwater monitoring data (levels and water quality) to assess the level of impact of operations on the groundwater regime. (Client: Sun Metals Corporation Limited; 2005)
- Stuart Oil Shale Project, Gladstone, Central Queensland: Assessment of dewatering requirements for open cut excavation and potential for sea water intrusion. Assessment of potential impacts on shallow groundwater regime. (Client: Southern Pacific Petroleum NL; 1998, 1999)
- Noosa North Shore Resort, Noosa, Queensland: Design and implementation of a groundwater investigation to augment resort water supply. Work included review of geological mapping and aerial photography, selection of test drilling sites, completion of monitoring bores, groundwater sampling and analysis, hydraulic testing, analysis of data and reporting. (Client: Cardno MBK; 2004)
- Royal Palm Beach Estate, Tauranga, New Zealand: Numerical modelling of the impact of establishing lakes in a development on the hydrogeology of a coastal dune sands aquifer system. (Client: Burchill Bate Parker & Partners; 1995)
- Stuart Oil Shale Project (Stage 2), Gladstone, Queensland: Development of a conceptual hydrogeological model and management of the development of a numerical groundwater flow model to assess the impact of mining on local groundwater users, and potential inflows to a large scale open cut mining operation. Hydrogeological studies formed part of an EIS submitted to state government and federal government regulatory authorities. Submissions to government on behalf of the project proponent. (Client: Southern Pacific Petroleum (Management) Pty Ltd; 1998 to 2005)
- Reko Diq Copper Project, Baluchistan, Pakistan: Hydrogeological investigations to locate construction water supply and process water supply for a proposed heap leach SX/EW operation. Water supply of the order of 200 L/s was required. Investigations involved review of groundwater information for much of western Baluchistan, geophysical surveying, identification of groundwater exploration targets, design of a program of exploration drilling, wireline logging, test bore construction, test pumping, numerical modelling, data analysis and reporting. Investigations were also undertaken to assess likely inflows to an open cut pit and design of appropriate dewatering/groundwater control systems. Also responsible for managing surface water investigations by Halcrow Pakistan, involving flood modelling, catchment yield analysis, pipeline design and mine site water management. (Client: Tethyan Copper Company Limited; 2004, 2005)
- Baranj Coal Project, Maharashtra State, India: Assessment of the potential impact of a large-scale open cut mining operation on local groundwater resources. Assessment of the impact on water supplies for a major town and many villages, and the potential for subsidence at an industrial facility. Assessment of methods to mitigate impacts through varying mining scheduling and re-injection of pumped water. (Client: Rio Tinto Technical Services; 2001, 2002)

- Monywa Copper Project, Central Myanmar: Collection and assessment of groundwater, surface water and meteorological monitoring data at operational copper mine. (Client: Ivanhoe Myanmar Holding Ltd; 1996 to 1998)
- Chatree Gold Mine, Central Thailand: The project involved assessing dewatering requirements for a number of open cut pits, and the contribution to water supply that would be possible from dewatering operations. The need for an outside borefield was also assessed using mine water balance modelling for a number of varying climatic scenarios. A numerical groundwater flow model based on data from mineral exploration drilling was utilised to assess groundwater issues for the project. Further stages of work involved refinement of the groundwater model and assessment of monitoring data. (Client: Kingsgate Resources NL/Akara Mining Limited; 1999 to 2002)
- Gibson Island Plant Groundwater Quality Project, Brisbane, Queensland: Assessment of impact of fertiliser manufacturing plant on groundwater quality by establishing a network of 35 monitoring bores, sampling groundwater and conducting chemical analyses for an extensive range of potential pollutants. Development of an ongoing monitoring program conducted by the client company. (Client: Incitec Ltd; 1991)
- Cuu Long Rural Water Supply and Sanitation Project Feasibility Study, Mekong Delta, Viet Nam: The project involved assessing the feasibility of improving water supply and sanitation facilities for village (communes) and small rural towns in five provinces of the Mekong Delta—Long An, Ben Tre, Vinh Long, Bac Lieu and Ken Giang. Mr Hair’s role in this project was as groundwater specialist for studies involving three of the five provinces. The work included inspection of provincial level government agencies involved in water resources development and management, an overview of the groundwater resources of the Mekong Delta (including compilation of a conceptual hydrogeological model), data gathering, data analysis, discussion with stakeholders at national, provincial and commune level, design of appropriate groundwater extraction facilities and reporting. (Client: AusAID and Government of Viet Nam; 2000)
- Rapu Rapu Polymetallic Project, The Philippines: Audit review for project financiers of groundwater aspects of the project, including assessment of potential groundwater inflows to an open cut pit, dewatering requirements, groundwater component of mine water supply, and the potential for leakage from tailings storage facilities. Reviewed previous studies and the design level groundwater investigations of another consultant. (Client: RSG Global Mining Consultants; 2004, 2005)
- Pinkenba Site Groundwater Quality Project, Brisbane, Queensland: Assessment of impact of herbicide and pesticide manufacturing plant on groundwater quality by establishing a network of monitoring bores, sampling groundwater and conducting chemical analyses for an extensive range of potential pollutants. Development of an ongoing monitoring program conducted by the client company. (Client: Rhone-Poulenc Rural Australia Pty Ltd; 1992)
- Gladstone Power Station, Gladstone, Queensland: Assessment of the potential for power station ash disposal areas to generate pollutants, and the potential for pollutants to migrate off site with groundwater. The project involved exploratory drilling (hand auger methods), construction of monitoring bores, hydraulic testing of ash and impoundment walls, and sampling and analysis of groundwater, ash slurry water, river/estuary water and biota from the surrounding environment. (Client: Queensland Electricity Corporation; 1994)
- Moreton Island Groundwater Quality Study, Moreton Island, Queensland: The design and construction of 30 monitoring bores in and around the island communities of Kooringal, Cowan and Bulwer, to assess groundwater quality for a range of potential pollutants, including leachates from disposal of domestic wastes, microbiological contaminants and nutrient loadings from septic tanks and sullage trenches, and hydrocarbons from fuel storage facilities and fuel retail outlets. (Client: Brisbane City Council; 1994)
- Crinum Coal Mine, Bowen Basin, Queensland: Evaluation of potential for groundwater inflows to underground workings by numerical modelling. Installation of piezometer network to monitor groundwater levels and quality. Installation of interactive groundwater level logger to alert mining operations centre of rapid groundwater inflows due to longwall collapse. Installation of groundwater level loggers to assess impact of mining on local groundwater resources. (Client: BHP Coal Pty Ltd; 1996, 1997).

Appendix B

Photographs – Field Visit to Cudmore National Park on 7 July 2013



Locations of Photographs taken during Field Visit to Cudmore National Park by Iain Hair & Mark Stewart on 7 July 2013

Site 1: Photo 1 – Lateritised sediments, probably Tertiary in age.

Site 1: Photo 2 – Lateritised sediments, probably Tertiary in age.

Site 2: Photo 3 – Lateritised fine grained sandstone and conglomerate. Tertiary sediments or possibly Dunda Beds / Rewan Formation.

Site 2: Photo 5 – Lateritised fine grained sandstone and conglomerate. Tertiary sediments or possibly Dunda Beds / Rewan Formation.

Site 3: Photo 6 – Outcrop of fine grained sandstone and siltstone. Ferruginised. Dunda Beds / Rewan Formation.

Site 4: Photo 7 – Last outcrop of Dunda Beds / Rewan Formation along track. Looking SSW. Brigalow (Acacia) type vegetation. Note bedding dip to the west. This outcrop is on the eastern side of an anticline postulated by Webb (2013).

Site 5: Photo 8 – Outcrop of Clematis Sandstone at -22.908^{o}S / 146.306^{o}E. Looking north. Note apparent dip to the west.

Site 5: Photo 9 – Outcrop of Clematis Sandstone. Cross bedding apparent.

Site 5: Photo 10 – Outcrop of Clematis Sandstone.

Site 6: Photo 12 – Outcrop of Clematis Sandstone.

Site 7: Photo 13 – Eucalypt (Bloodwood & Ironbark) Woodland on soils derived from Clematis Sandstone.

Site 7: Photo 14 – Derelict Cattle Watering Trough abandoned Old Cudmore Outstation.

Site 7: Photo 15 – Waterbore at abandoned Old Cudmore Outstation. Has groundwater level.

Site 7: Photo 16 – Pump shed over Waterbore at abandoned Old Cudmore Outstation.

Site 8: Photo 17 – Clematis Sandstone outcrop. Photo taken looking north. Apparent dip of strata to the west.

Site 9: Photo 20 – Clematis Sandstone outcrop. Photo taken looking north. Apparent dip of strata to the west. Ironbark dominated Eucalypt Woodland.

Site 10: Photo 22 – Clematis Sandstone outcrop. Cross-bedding. Major bedding plane with apparent dip to the west. Photo taken looking south.