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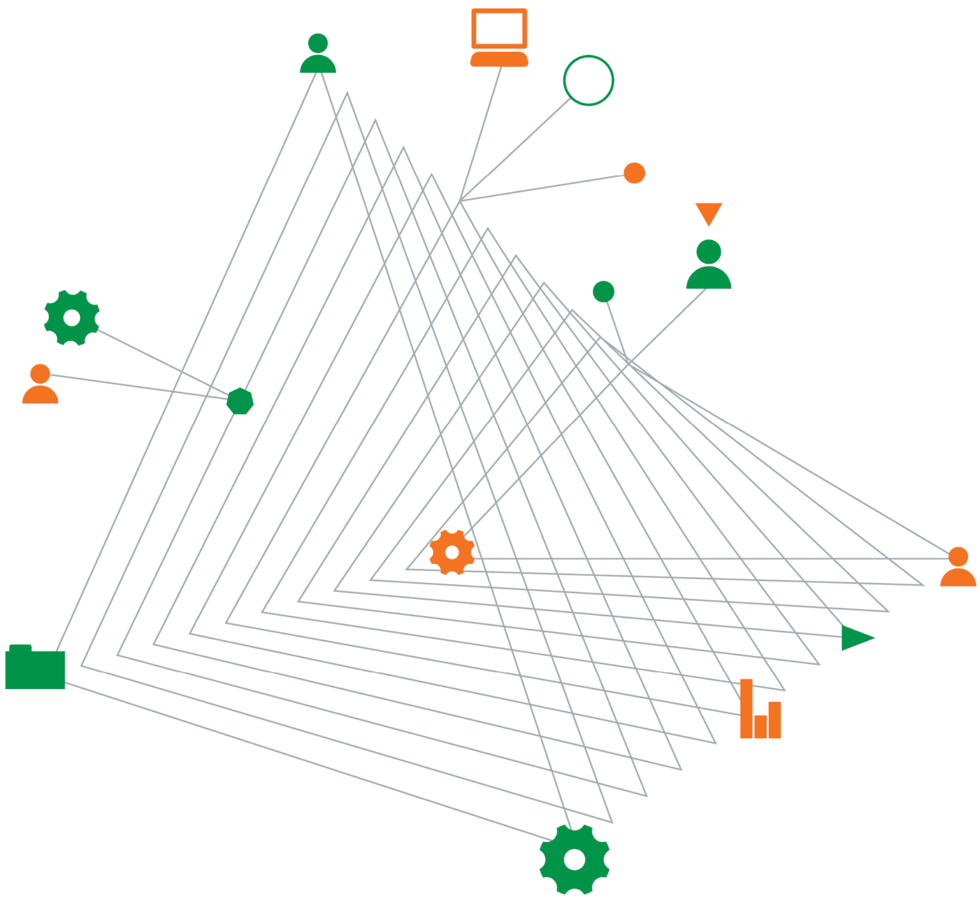
NSW Department of Planning and Infrastructure

Russell Vale Colliery (formerly the NRE No. 1 Mine) Underground Expansion Project

Groundwater Review

22 September 2014



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Russell Vale Colliery (formerly the NRE No. 1 Mine) Underground Expansion Project

Prepared for
NSW Department of Planning and Infrastructure

Prepared by
Coffey Geotechnics Pty Ltd
Level 19, Tower B, 799 Pacific Highway
Chatswood NSW 2067 Australia
t: +61 2 9406 1026 f: +61 2 9406 1002
ABN: 93 056 929 483

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For and on behalf of Coffey

Paul Tammetta
Associate Hydrogeologist

Quality information

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1. Introduction

This report presents the results of a review of the groundwater component of the Russell Vale Colliery (formerly NRE No. 1 Mine) Underground Expansion Project. The review was undertaken by Paul Tammetta of Coffey Geotechnics Pty Ltd (Coffey) for the NSW Department of Planning and Infrastructure (DPI). The scope comprised a review of the development, calibration, and use of a numerical groundwater flow model for the project. The subject of the review was the following report:

- GeoTerra Pty Ltd. 2014 (Geoterra). Russell Vale Colliery Underground Expansion Project, Preferred Project Report, Wonga East Groundwater Assessment. Report NRE1 - R1C GW prepared for Wollongong Coal Ltd. June.

This review follows two previous reviews for the same project (Coffey 2013a, 2013b).

Review of the electronic version of the model was outside the scope of this report. For the purpose of this review, an understanding of the functioning of the model has been based on the report only. It is recognised that there may have been time and budgetary constraints applied to the impact assessment which are not known to the reviewer.

This review also provides clarification, in relation to the results of Tammetta (2013), as they pertain to comments made in the Geoterra report. This is provided in Appendix A, and may be relevant for coal developments in the southern part of the Newcastle Coalfield.

2. Review

2.1. Conceptualisation

The Geoterra report (page 44) interprets that the pressure head profile at VWP site GW1 indicates a restriction to downward flow. Assuming a vertical 1-dimensional system (upon which the interpretation in the report appears to be based), a restriction would cause the basal pressure heads to increase, not decrease as is observed.

In Figure 13 of the Geoterra report, packer testing from bore GW1 is shown. Hydraulic conductivity (*K*) decreases with depth. From four tests (out of 22) at this location, the Geoterra report interprets that the Stanwell Park Claystone has lower lateral *K* than adjacent strata. Although these four test results are consistent, they are closely spaced and lie within the statistical band of variation in *K* for that location, as indicated by the rest of the results. The interpretation in the Geoterra report is therefore considered tenuous (Coffey 2013a).

The Geoterra report (page 52) discusses the results of Tammetta (2013) (referencing the digital version of Tammetta 2013, dated 2012, which is identical to Tammetta 2013) and states that the "assumption" that the geology of the overburden strata plays a minor role in caving is questionable (referring to a personal communication from Seedsman RW, page 52). In Tammetta (2013) an analysis of piezometer water level data from 18 locations found that for those locations, observations of the maximum height of desaturation above the panel (at centre panel), referred to as *H*, could be reproduced to better than 8% RMS error without requiring knowledge of the lithology of the consolidated overburden, by use of a fitted empirical equation. Tammetta (2013) noted that this had been observed by other researchers in the literature. The finding is not an assumption, as stated in the Geoterra report, but is a result (of the analysis that relates to *H* over centre panel). Tammetta (2013) discussed super-strong dolerite sills in South Africa which showed *H* slightly lower than calculated using the equation. Despite a thorough search of the literature, no other published data could be found to show significant deviations from the equation. This issue is further discussed in Appendix A, where groundwater monitoring data from the Mandalong mine are analysed and shown to provide a good example of accord with the equation of Tammetta (2013), and to results from Springvale Colliery. The analysis of observations from Mandalong are used to highlight the importance of ensuring that adequate review is carried out on estimates made by proponents of heights of desaturation for underground mining projects, so that unrepresentative or erroneous results are not incorporated into impact assessments. The accord between Mandalong results and those of Tammetta (2013) will be relevant for coal developments in the southern Newcastle Coalfield.

In Section 8.3.1 of the Geoterra report, use is made of the equation of Tammetta (2013) for the height of complete groundwater drainage (*H*) above mined longwall panels, and concludes that the equation overestimates observed *H* at GW1. Coffey (2013a) tested the interrelationship between estimated collapsed zone heights for previous workings (using the results of Tammetta, 2013) and the hydraulic head information collected by the proponent. GW1 is located over Bulli seam pillar extraction workings and just off the edge of Balgownie LW7.

For the Balgownie panel, GW1 is in a location similar to that over chain pillars with a mined panel on one side only, and its u parameter is so small that the height of desaturation contributed by Balgownie LW7 at nest GW1 was conservatively assumed to be nil in Coffey (2013a). *H* at GW1 is thus assumed to be due only to Bulli pillar extraction. From the GW1 pressure head profile, *H* is assessed to be 225m (overburden thickness) minus 170m (base of saturation), giving 55m. This fits the distribution in Figure 4 of Tammetta (2013), and is shown in Figure 1 below (from Coffey 2013a). GW1 is slightly off the centreline of the Bulli block so H is less than the maximum. Therefore, we disagree with the conclusion in the Geoterra report that the equation overestimates the observed *H* at GW1.

The following aspect of the hydrogeological conceptual model presented in the Geoterra report (page 76) is considered tenuous:

- That the “deeper” Hawkesbury Sandstone is hydraulically separate from overlying and underlying units at Wonga West (presumably because of the presence of the Bald Hill Claystone (for the underlying units)).

This interpretation requires an unsaturated zone between the sandstone and Bald Hill claystone, which is not supported by data. However, this assumption may not impact the project since in the numerical simulation all model layers communicate hydraulically with adjacent layers via the vertical hydraulic conductivity parameter (or its unsaturated function).

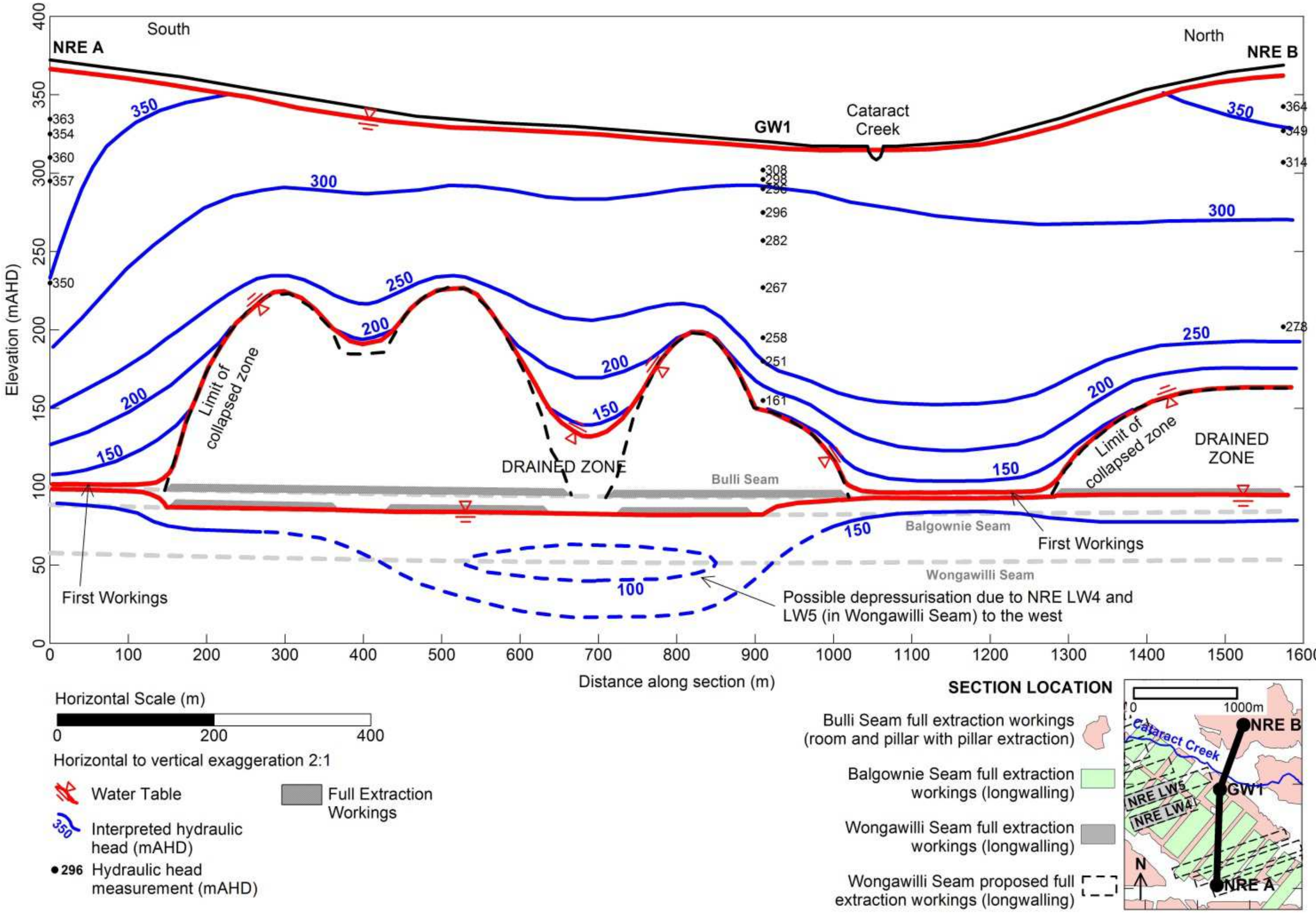

Figure 1. Interpreted hydraulic head distribution (broadly representative of early 2012) along a cross section through the area (after Coffey 2013a).

2.2. Model Development and Use

The model domain boundary is shown as a rectangle in Figure 30 of the Geoterra report. However, the description of the boundary conditions at the domain boundary suggests the domain is not rectangular. The textual description of the type of boundary conditions suggests they are reasonable.

We consider that the model code is adequate for the required purpose, the grid is reasonable, and calibration to hydraulic heads is reasonable.

Calibration to mine inflows has not been demonstrated, nor has calibration to stream baseflows. The water balance for the calibrated model lists only an instantaneous flow for what appears to be an aggregated discharge to all the workings present in the model domain. Likewise, discharge to streams is a single value. Table 13, well into the predictive section, lists two modelled values for inflows to the workings, with a single comparison for modelled and observed inflow at the end of LW5. Figure 63 shows predicted inflows, with values for the calibration period. It is not known if the calibration period data are modelled or observed.

The calibrated model indicates a net loss from streams of about 16ML/day (Table 11 of the Geoterra report). We consider that this value should be compared to an estimate made from streamflow observations, derived from a baseflow assessment.

Rainfall recharge and the hydraulic conductivity field are positively correlated. Therefore, we consider that demonstration of reasonable matching of model discharges to observed deep and shallow discharges is an important part of the model calibration process. Reasonable matches should be established to demonstrate adequate representation of the *K* field (particularly the vertical anisotropy, or the ratio of vertical *K* to lateral *K*, which is a crucial distribution for impact assessment).

The strategy of predictive simulations appears reasonable, however, given the conceptualisation presented in the report, a clear demonstration of reasonable matching of modelled to observed deep and shallow discharges should be made before the model is considered fit for use.

3. Conclusions

In our opinion:

- There are some tenuous interpretations made for the conceptual model, which are not supported by observation. The discussion in the report regarding hydraulic isolation of the medium, and the distribution of losing and gaining stream segments, are conspicuous in this regard. However, the interpretations may not detract from the aims of the groundwater study if the model is acceptably calibrated.
- The model structure appears reasonable, however the domain boundary that is shown appears inconsistent with the applied boundary conditions at the extremities.
- Calibration to hydraulic heads is reasonable.
- The predictive approach appears reasonable.
- A clear demonstration of the matching of shallow and deep discharges has not been made. We recommend that baseflow for the model domain be estimated using measured streamflows. Adequate matching of calibrated model output with measured mine inflows and the baseflow estimate for the model domain should then be demonstrated by the proponent before model results are considered fit for use.

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Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

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Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

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The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

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Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

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* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Appendix A - Clarification

Clarification

The Geoterra report (page 52) discusses the results of Tammetta (2013) (referencing the digital version of Tammetta 2013, dated 2012, which is identical to Tammetta 2013) and states that the “assumption” that the geology of the overburden strata plays a minor role in caving is questionable (referring to a personal communication from Seedsman RW, page 52). In Tammetta (2013) an analysis of piezometer water level data from 18 locations found that for those locations, observations of the maximum height of desaturation above the panel (at centre panel), referred to as *H*, could be reproduced to better than 8% RMS error without requiring knowledge of the lithology of the consolidated overburden, by use of a fitted empirical equation. Tammetta (2013) noted that this had been observed by other researchers in the literature. The finding is not an assumption, as stated in the Geoterra report, but is a result (of the analysis that relates to *H* over centre panel). Tammetta (2013) discussed super-strong dolerite sills in South Africa which showed *H* slightly lower than calculated using the equation. Despite a thorough search of the literature, no other published data could be found to show significant deviations from the equation.

It is understood (pers. comm, C. Watson, Office of Water Science, 14/08/2014) that groundwater monitoring data from the Mandalong Mine may have been considered by others as a basis for questioning the results of Tammetta (2013). We understand that the interpretation in Tammetta (2013) of water level monitoring data from piezometer nest BH22 at Mandalong Mine has been questioned, but we have not been provided with the basis of the question. Ross Seedsman (pers. comm., 6 December 2013) indicates his disagreement with the interpretation of water level data from BH22 in Tammetta (2013), but has provided no counter-interpretation for comment.

Further, CA (2014) provide the following peer review comment:

> “Ross Seedsman believes that some of the larger figures for complete height of groundwater drainage (CHGD) provided in Tammetta (2012) should be considered in relation to a paper by Guo et al. (2007), which provides a different interpretation. Ross suggests that the representation of the collapsed zone in Figure 7.10 is questionable and also that there is a fundamental difficulty in using complete groundwater drainage as a measure of impact as it is difficult to allow for the time factor. The dilated zones in the current models allow for a temporary drop in piezometric level, which may take an extended period of time to recover if the pre-mining hydraulic conductivities are low.”

The issue of water level monitoring data from Mandalong Mine (particularly BH22), and their interpretation, will be discussed in detail in this appendix. While no published observations could be found that could support the peer review comments above, many of the issues raised by Mr Seedsman will be reserved for discussion in a journal publication at some time in the future, as clarification of these issues is of fundamental importance for regulatory agencies attempting to determine coal mining applications.

Mandalong Mine is located near Wyee and Moonee Collieries. These mines are located in a localised area around Lake Macquarie, characterised by horizontal stresses with magnitudes about 5 times the vertical stress (McNally 1995). Li et al. (2006) cite Chappell et al. (1984) as measuring horizontal stresses of between 5 and 7 times the vertical stress at Kangy Angy. This stress field does not eliminate caving but does retard it, creating difficulties in forecasting roof falls (Iannacchione et al. 2005). These horizontal stress magnitudes are far in excess of those commonly seen in the near surface around the world (where the horizontal stress is commonly about 2 to 3 times the vertical stress). This stress regime is a phenomenon of the near surface (from ground surface to depths nearing 1000m, depending on topographic relief). It is common in hilly terrain and is prominent in the eastern USA and eastern Australia. Figure A1 shows measured principal horizontal stresses in the eastern USA (Dolinar 2003) as a typical example. Several of the results from Tammetta (2013) were from this area.

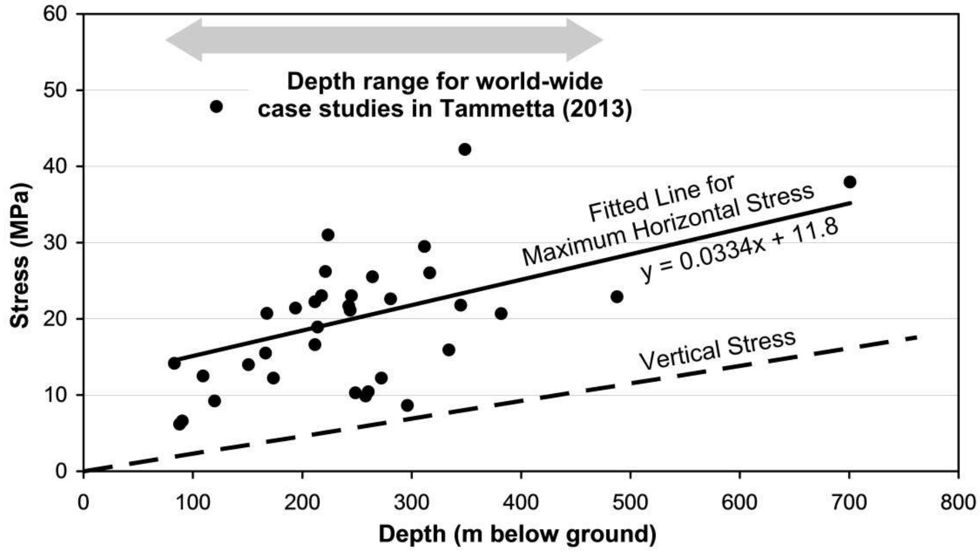


Figure A1. Maximum horizontal stress versus depth in the eastern United States (after Dolinar, 2013).

Thus, the Lake Macquarie area is an anomalous zone in relation to the ratio of vertical to horizontal stress in the near surface.

The Teralba and Munmorah Conglomerates are frequently reported as the units which, in the Lake Macquarie area, have the capability to create spans larger than seen elsewhere, immediately after caving. The uniaxial compressive strength (UCS) of these units is unremarkable, ranging between about 40 and 80MPa (McNally 1995) (typical UCS of sandstones and shales range between 10 and 70 MPa, and rarely to 120MPa). The spanning creates a highly unstable stress state which may seek to redistribute itself at even the smallest opportunity offered by small-scale seismic activity. This is probably the main reason for the difficulty in forecasting roof falls. The area is seismically active. The horizontal stress regime likely plays a significant role in allowing transient spanning.

Super-strong dolerite sills in South Africa (UCS ranging between 250 and 390MPa) are known to create larger than normal spans following caving of pillar extraction and longwall panels, however eventual failure occurs, with the same difficulty of forecasting span failure (Wagner and Schumann 1991).

Piezometers BH22, BH6, and BH7

At Mandalong Mine, several groundwater monitoring piezometer nests have been undermined. Three of the most recently undermined nests, based on AGE (2012), are BH6, BH7, and BH22. Based on Drawing 1, and coordinates supplied, in AGE (2012), only BH22 is located over centre panel. Table A1 below lists data from AGE (2012) that are pertinent to this discussion. BH22 is located over LW9, BH6 over LW7, and BH7 over LW11, all with a void width of 160m.

Table A1. Piezometer Completion Details and Reported Water Levels at the Mandalong Mine.

Piezo-meter	d* (m)	Ground Elevation (mAHD)	Estimated distance from panel edge (m)	Screen (mbgl)		Water Level for Dec. 2011 (mAHD)	Screened Lithology	Comment
				From	To			
BH6A	194	12.27	23	22.5	25.5	2.03	Sandstone	
BH6B	194	12.13		71.0	75.0	Dry	Sandstone	Dry since undermining by LW7 in Jun. 2009.
BH7A	218	12.79	11	46.0	49.0	-18.64	Rock	
BH7B	218	12.89		96.0	99.0	Dry	Sandstone	Dry since undermining by LW11 in Nov. 2011.
BH22B	222	12.91	73 (Centre Panel)	31.0	34.0	0.74	Rock	
BH22	222	12.89		56.0	59.0	Dry	Sandstone	Originally undermined by LW9 in Jun. 2010. Dry since Jun. 2011.

* Denotes overburden thickness, as calculated from Figure 2 of Centennial Coal (2010).
NOTE: mbgl denotes metres below ground level.
Panel width is 150m, void width is 160m.

Figure A2 shows the data from Table A1 plotted as pressure head versus height above the seam. Dry piezometers are plotted as zero pressure at the location of the screen. Given the mass of data available from other piezometers, and the severe gradient in water level fall at BH6B and BH22 when undermined, saturation below dry piezometers is considered highly unlikely. BH18 also overlies a panel, however it went dry with dh/dt typical of a far field sink, and is not incorporated into these calculations.

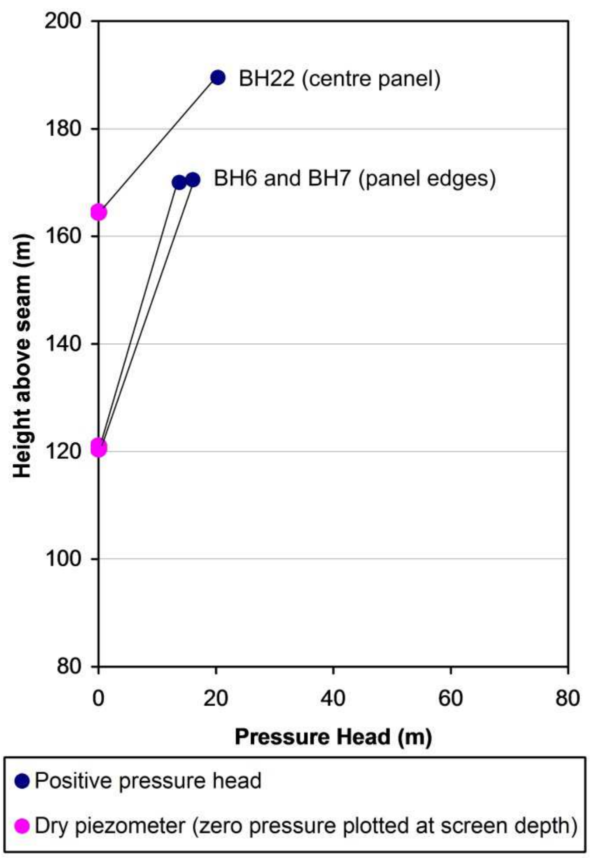


Figure A2. Pressure head versus height above the mined seam for fractured rock media at Mandalong Mine.

From Figure A2, the height above the seam at which pressure head becomes zero is as follows:

- BH6 nest: Between 121m and 170m (average of 146m)
- BH7 nest: Between 121m and 171m (average of 146m)
- BH22 nest: Between 165m and 190m (average of 178m)

The height of desaturation at BH6 and BH7 became fully developed immediately after undermining. However, at BH22 (centre panel), *H* became fully developed about 1 year after undermining, probably related to the time required for the stress field to fully redistribute itself.

The average observed H at BH22 is 178m. The equation of Tammetta (2013) predicts an *H* of about 190m. These results accord well with the results of Tammetta (2013), and constitute a good example of demonstrating the base of saturation over centre panel, and also in moving away from centre panel. Tammetta (2013) incorporated monitoring data from BH22 in that study, interpreting an *H* of 175m. Figure A3 shows the estimated boundary of the collapsed zone specifically for a Mandalong panel, with an average overburden thickness of 211m (the average for BH6, BH7, and BH22), and the estimated heights at which pressure head becomes zero.

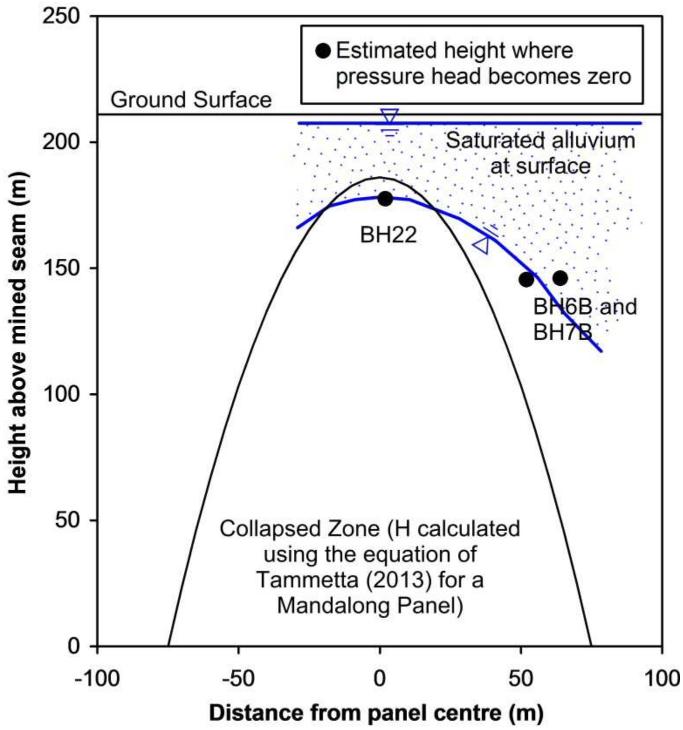


Figure A3. Results from water level monitoring in fractured rock media at the Mandalong Mine, for piezometer nests BH6, BH7, and BH22. The height where the pressure head becomes zero is estimated as the midpoint between the last saturated and first dry piezometer moving down the profile.

Figure A4 shows the data from Figure A3 plotted with the results from Springvale Colliery (see Tammetta 2014). The data are normalised to allow comparison (that is, the height above the seam is divided by *H* and the distance from centre panel is divided by *w*). The location of the inverted phreatic surface, and its proportional extension down the chain pillar, is in accord with results from Springvale Colliery (see Tammetta 2013). The height of desaturation above pillars from Springvale is actually smaller than for Mandalong, indicating that at Mandalong, caving causes higher desaturation at panel edges . The Mandalong data therefore provide a good example of accord with the equation of Tammetta (2013), and observed *H* at other mines, especially Springvale Colliery.

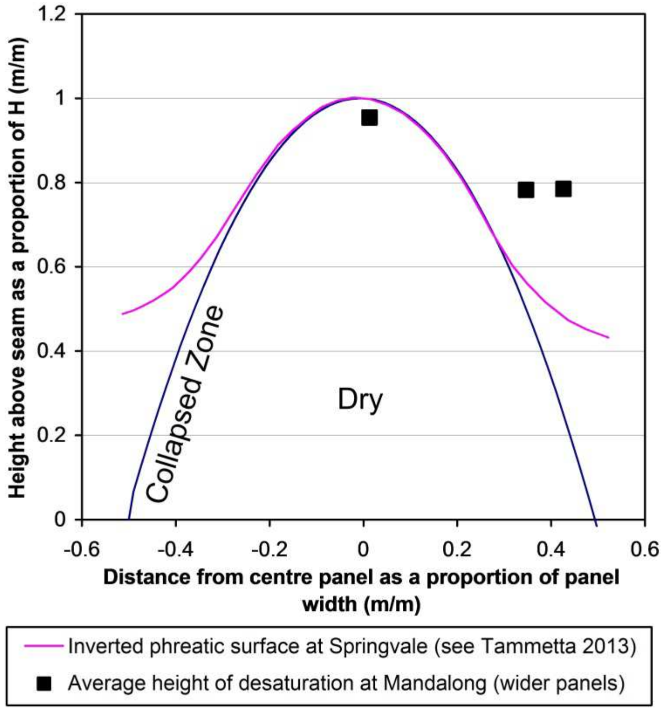


Figure A4. Comparison of heights of desaturation at Mandalong and Springvale Mines, using normalised heights above the seam and normalised distances from centre panel, to allow comparison.

Guo et al. (2007)

Seedsman, in CA (2014) commented that results in Tammetta (2013) should be considered in relation to a paper by Guo et al. (2007), believing that the Guo et al. (2007) interpretation provides a different interpretation to Tammetta (2013).

Guo et al. (2007) (an ACARP report) carried out a study of impacts on the groundwater system at Springvale Mine from longwall mining. In relation to observations, they make comment only on "Aquifers" AQ4 and AQ5, located from about 200m above the mined seam to surface. They make the following observations (our comment on each Guo et al. 2007 observation follows each observation):

- *Aquifer AQ4 is only marginally affected by the extraction of LW409 as indicated by the negligible drop in water head of piezometer P8 located in SPR31 at a depth of 90 m from the surface (292m above the mining seam).*

  The results from the top most piezometer (P8) at SPR31 (located 292m above the seam, over centre panel) appears to be extended by Guo et al. (2007) to the base of AQ4, ignoring vertical anisotropy and the continuum-type behaviour of a groundwater system. Figure 62 in Guo et al. (2007) shows the extrapolations made to observations in arriving at their conclusions later in their report.

- *The extraction of LW411 seems to be having an increased impact on aquifer AQ4 as shown by the head drops of piezometers P2 of SPR32 and P8 of SPR39. This could be mainly attributed to the increase in the panel widths from 260 m (LW409) to 315 m (LW411).*

  These piezometers are located over chain pillars and cannot be used to calculate H. As for SPR31, these piezometers were analysed in detail in Tammetta (2013). We accord with the interpretation of greater impact due to larger panel width.

- *The topmost aquifer AQ5 seems to be unaffected by the 315 m wide panel LW411 as shown by negligible head drops at piezometers P1 in SPR32 (located at 30m below ground) and P9 in SPR39 (located at 50m below ground).*

These locations are a height of about 320m above the mined seam or higher, and outside the collapsed zone.

Guo et al. (2007) conclude the following:

The piezometer monitoring data indicate that the zone of influence of longwall extractions can extend as high as 250 m and 275 m above the mining seam for 260m and 315m wide panels respectively. The influence of longwall extraction in the lateral directions ahead of the mining face can be seen to extend even further up to a distance of 350 m closer to the mining seam horizon.

The quantitative definition of the hydrogeological characteristics of the "zone of influence" do not appear to be provided by Guo et al in defining this zone. H calculated using the equation of Tammetta (2013) at the location for SPR31 is 258m above the mined seam. There appears to be no conflict between the interpretation in Tammetta (2013) and that in Guo et al. (2014).

Piezometers BH2, BH20, and BH21

A localised cluster of piezometer nests further northeast (BH2, BH20, and BH21, see Figure A5) have also been undermined but appear to show maintenance of saturation. These piezometers are located over panels LW1 to LW3, which are thinner (void width of approximately 120m from AGE 2012) than panels underlying the piezometers analysed above. These piezometers are located down topographic gradient where the surface alluvium may be thicker (alluvial thickness measurements were unavailable) and may constitute the presence of a potential high conductivity saturated body at the surface, which could reduce *H*. Figure A5 shows the piezometer nest locations. The average *H* calculated from Tammetta (2013) is approximately 145m at these locations.

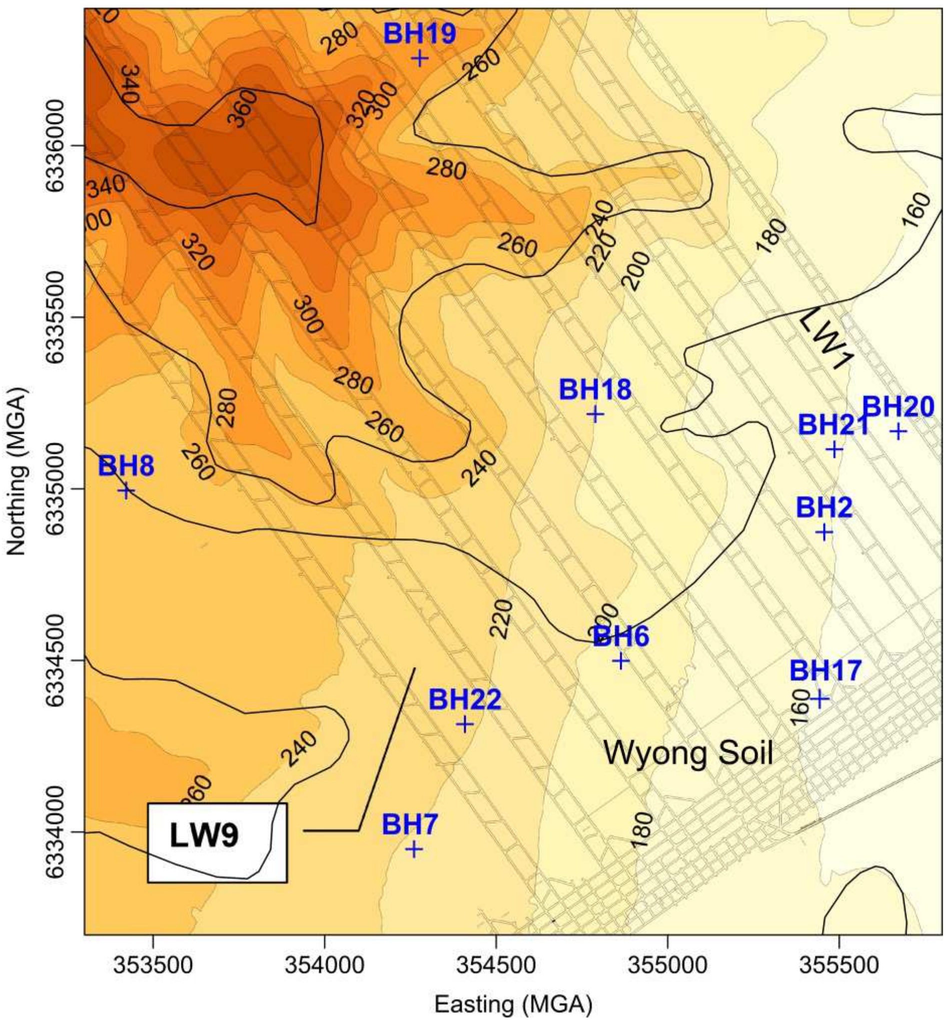


Figure A5. Locations of piezometer nests and longwall panels, and boundary of the Wyong soil. The figure base is from Figure 2 of Centennial Coal (2010).

Records in AGE (2012) indicate the presence of a fault that was intersected at LW1 (see Figure A5) in mid-2005 and which appears to have markedly accentuated the drawdown at BH17. The statement that intersection was at the outbye side of the panel, and taking into account the impact vector to BH17, suggests the fault forms a small angle with the panel (and possibly runs nearly north-south, parallel with a water course about 500m to the east) and would therefore be of little influence at the locations of BH6, BH7, and BH12 further west.

The fault may accentuate the role played by the alluvium (with potentially high K) in reducing *H* at the locations of BH2, BH20, and BH21, by increasing the vertical downward flux from the alluvial body to the fractured rock media, thereby reducing *H*. Figure A6 shows the pressure heads for BH2, BH20, and BH21, versus mined height. Observations indicate H of between about 100m and 110m above the mined seam. This is about 40m lower than the calculated H. This accords strongly with other locations where in Tammetta (2013) where the panel underlies a flowing river or saturated high permeability alluvium. The other locations indicate a height of desaturation which is consistently 40m to 50m smaller than for the ordinary case (see Tammetta 2013). The Mandalong data demonstrate another example of this situation.

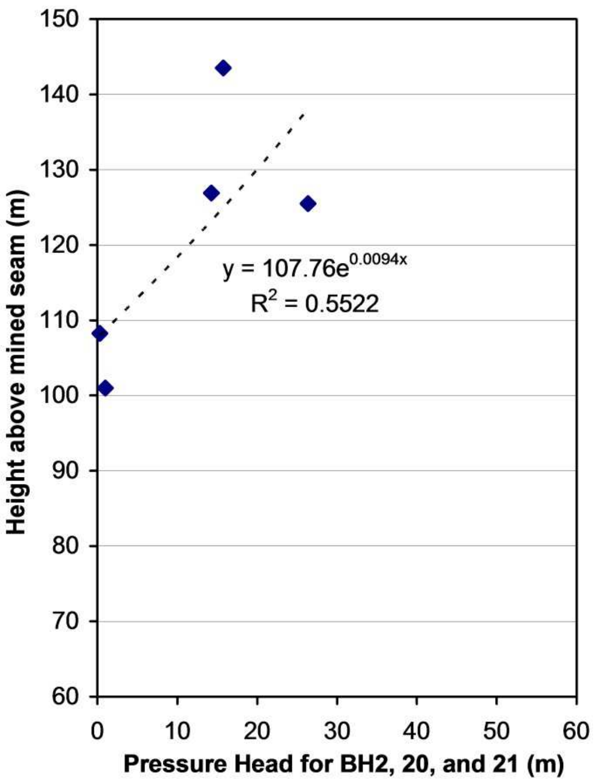


Figure A6. Pressure heads versus height above the mined seam for BH2, BH20, and BH21.

Recent Monitoring Data

Recent monitoring data from Mandalong groundwater piezometer nests BH9 and BH25, in AGE (2014) provide further insight. BH9 is located over LW12, about 23m from the edge, and was undermined in January 2013. BH25 is located approximately over the centre of LW14 (about 70m from the edge), was undermined in July 2013, and is located at the end of the panel, only about 80m from the final face position (it is approximately equally spaced between the final face, and either panel edge), so that 2-dimensionality in impacts from caving cannot be assumed. Nest locations are shown in Figure 1 of AGE (2014), provided in Appendix A. Overburden thicknesses are estimated from

Figure 2 of Centennial Coal (2014) as about 255m and 234m for the BH9 and BH25 nests respectively. Relevant piezometer information is listed in Table A2.

Figure A7 shows the data from Table A2 plotted as pressure head versus height above the seam, compared to pressure heads for VH6, BH7, and BH22.

Table A2. Recent monitoring results for piezometer nests BH9 and BH25 at the Mandalong Mine

Piezo-meter	d * (m)	Ground Elevation (mAHD)	Estimated distance from panel edge (m)	Screened Interval (mbgl)		Water Level for Dec. 2013 (mAHD)	Screened Lithology
				From	To		
BH09A	255	18.07	23	29	33	1.92	Mudstone/Sandstone
BH09B	255	17.95		54	60	-1.66	Mudstone/Sandstone
BH25B	234	14.31	70 (Centre Panel)^	20	30	9.89	Sandstone
BH25C	234	14.43		52	58	5.13	Mudstone/Sandstone

* Denotes overburden thickness, as calculated from Figure 2 of Centennial Coal (2014).
^ BH25 is 80m away from the final face position.
NOTE: mbgl denotes metres below ground level.
Panel width is 150m, void width is 160m.

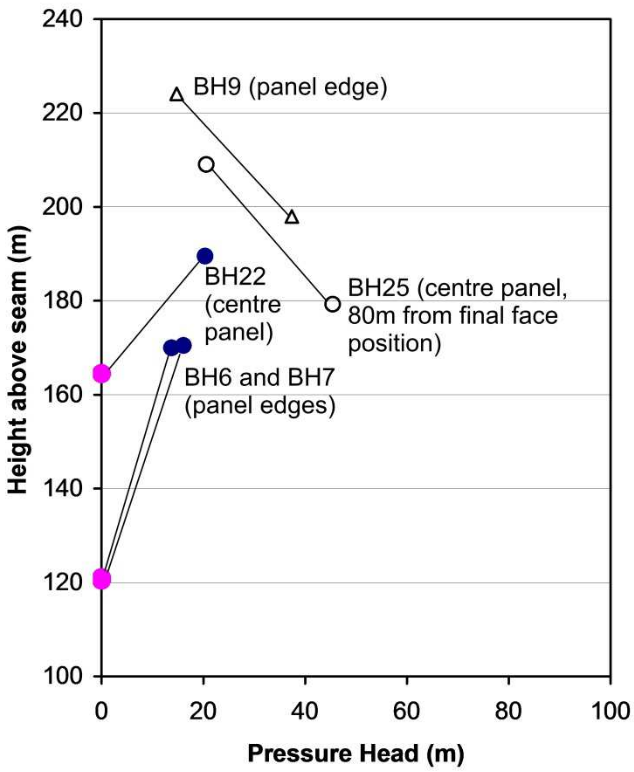


Figure A7. Pressure head versus height above the mined seam for fractured rock media at Mandalong Mine.

The average H calculated from Tammetta (2013) is approximately 190m at these locations. The following salient features are interpreted:

- The lower screen at BH9 is probably too high in the profile to show desaturation (the height of desaturation at BH9 will be markedly smaller than calculated *H*).

- Given the location of the BH25 nest, water levels at BH25 will behave as if it were near the side of a panel. This is because of the attenuation of deformation due to end effects. Thus, the height of desaturation at BH25 will be markedly smaller than calculated *H*. As a result, the lower screen at BH25 is likely to be too high in the profile to show desaturation either now or in the future. The reason for the behaviour at BH25 is due to the pattern of goaf compaction, which is an indicator of overburden deformation. The distribution of goaf compaction is as shown in Figure A8 (data from Wachell 2012). This pattern accords with field observations from drilling investigations (Zhang and Shen 2004, Xu et al. 2010, Bai and Elsworth 1989, and Zhang et al. 2011) where the shape of the goaf zone is interpreted as being squat in cross-section with vertically extended lobes near the panel edges. At the final face position, deformation is thought to be much reduced compared to centre panel further back along the long dimension of the panel.

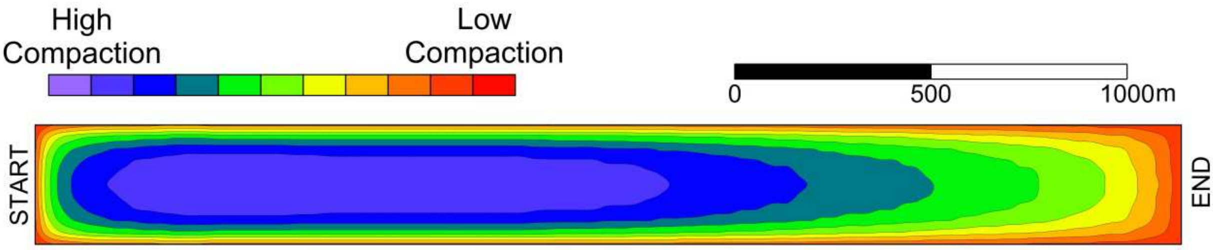


Figure A8. Typical simulated compaction of a longwall goaf (data from Wachel 2012).

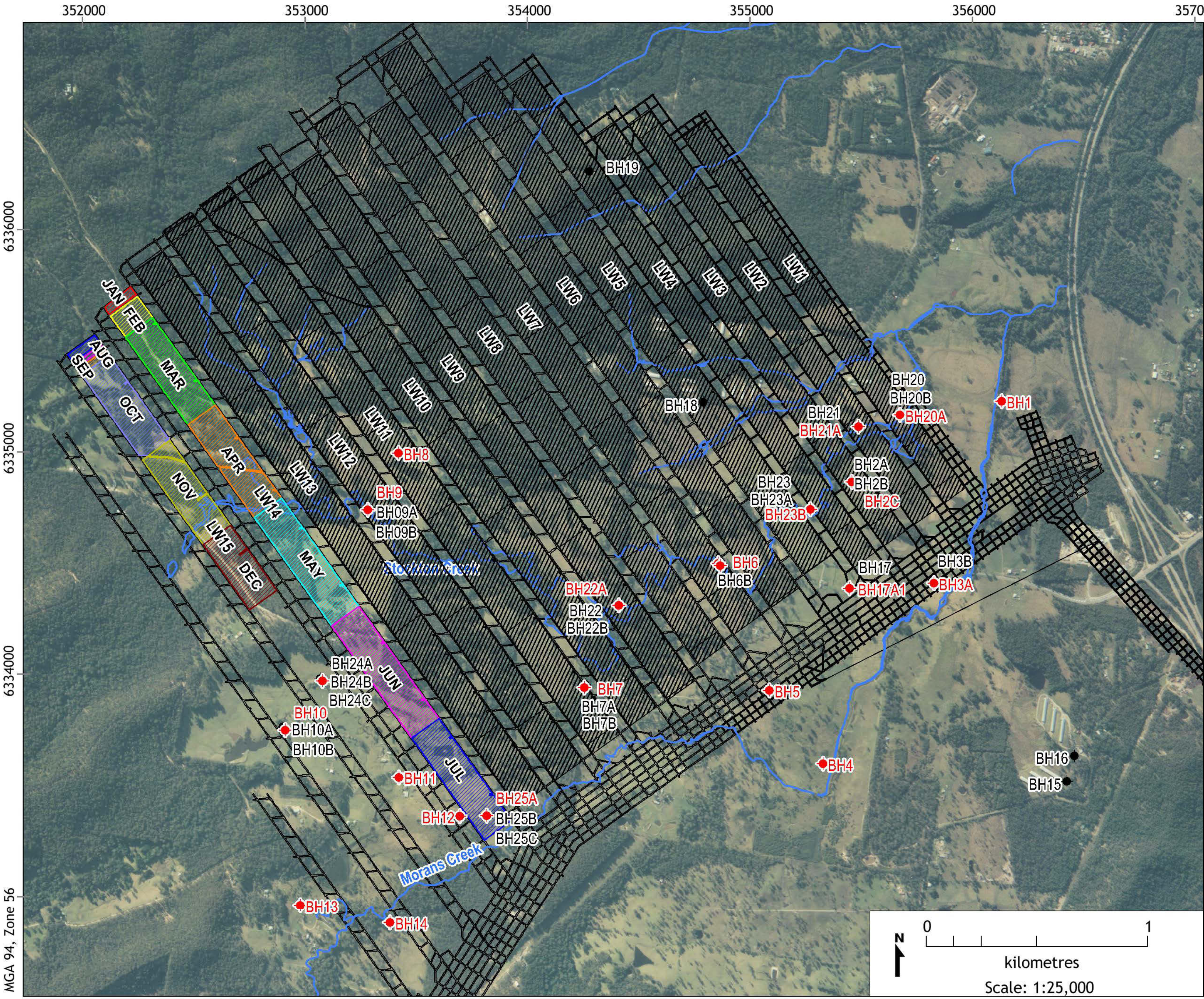
Conclusion

The example of the Mandalong water level database highlights the necessity of undertaking adequate review of estimates made by proponents of heights of desaturation for underground mining projects, so that unrepresentative or erroneous results are not incorporated into impact assessments. Despite the anomalous stress regime near Lake Macquarie, the behaviour of the groundwater system to longwall caving accords well with results from Tammetta (2013). This will be relevant for coal developments in the southern Newcastle Coalfield.

Comments made by Seedsman have been addressed in brief above. The time-series issue raised by Seedsman is discussed in a journal article due to be released.

A thorough discussion of the comments by Seedsman (in CA 2014) is not possible in the current report, however the issue of impacts on the groundwater system from longwall caving is considered to be of the utmost importance. Thus, it is anticipated that a more thorough discussion of the above will be compiled for journal publication.

Appendix B - Figure 1 of AGE (2014)



LEGEND:

- Monitoring Bore - Alluvium
- Monitoring Bore - Bedrock
- Creek
- Mandalong Mine Workings
- Panel Mined Before 2013

Mandalong - Groundwater Monitoring Review 2013 (G1455J)

Mine Plan 2013 and Monitoring Bore Locations

DATE:
17/1/2014

FIGURE No:
1