

9 June 2016

Mr David Kitto  
Executive Director  
Resource Assessments & Business Systems  
Department of Planning and Environment  
GPO Box 39  
SYDNEY NSW 2001

**Subject: Springvale Mine Extension Project – Extraction Plan for Longwall 419**

Dear Mr Kitto,

I write on behalf of the Independent Monitoring Panel (the Panel) to offer the Panel's advice on the commencement of Longwall Panel 419 (LW 419) as part of the Springvale Mine Extension Project. The Panel is constituted by Dr Wendy Timms, Dr Barbara Mactaggart and myself.

## **1. Introduction**

The Panel has been requested to provide advice on various component management plans of the Extraction Plan for LW 419, as required under the conditions of development consent for the mine. This current advice relates specifically to the following reports received from Centennial Coal on 10 May 2016 and 12 May 2016:

- Preamble
- Volume 1 – LW419 Extraction Plan
- Volume 2 – Plans
- Volume 3 – Management Plans
- Proposal for Monitoring Far-field Horizontal Movements

The advice is premised on field inspections and discussions with a range of stakeholders, including Centennial Coal, government agencies and Mr Keith Muir. These were undertaken for the purpose of familiarising the Panel with the surface environment and the factors that could impact it. They were supported by research, inquiries and analysis undertaken by Panel members that have had regard to a range of published information, some of which is listed in Appendix 1 – Bibliography. The Panel has also reviewed information relating to the mine approval process and information contained in a suite of reports and other documents received over a period of months from Centennial Coal.

## **2. Status of Panel Advice**

It is not feasible for the Panel to undertake a complete review of all the latest documentation within the timeline set for providing advice specific to the commencement of LW 419. However, a considerable portion of the information relevant to the Panel's Terms of Reference has been available for some time in the form of draft documentation received in late February 2016 and, conscious of providing timely advice, the Panel has already provided preliminary feedback on some of this information.

The Panel has directed much of its attention to the very significant drop in the water level of Carne West Swamp and the cessation of flow in the watercourse through this swamp, with consequential drying out of the swamp and loss of the waterfall at the downstream end of the swamp. These changes begun to be detected when mining was up to 700m away, well outside of the impact zone predicted in the Environment Impact Statement (EIS) for mining in this region of Springvale Mine.

In late February and early March 2016, the Panel inspected a number of other swamps near and over previous mining areas in the region, some of which had been inspected by Dr Mactaggart in years past. This prompted the Panel to request additional information from Springvale Mine and to review groundwater monitoring generally in the region.

The outcomes have caused the Panel to question if swamps located on lineament zones may be responding to mining in ways not fully accounted for in the extensive studies undertaken by Centennial Coal that support the EIS and Centennial Coal's concept of adaptive management. It appears that these studies and mine design concepts were focused on the development of vertical fracturing and uniformly distributed surface strains in intact (unfractured) strata and on the definition of zones of influence based on the lateral extent of vertical movements. However, lineament zones constitute pre-existing zones of deep and intense fracturing that, furthermore, are subjected to far field horizontal movements.

Hence, fracturing models developed from numerical modelling and field monitoring of areas not affected by a lineament zone may not hold true within lineament zones, whilst horizontal movements may concentrate at a well defined crack(s) rather than being more uniformly distributed at much lower values. These matters were discussed by the Panel with Centennial Coal during briefing sessions and site visits, prompting the company to undertake a preliminary review of past behaviours and impacts in and around swamps and to test a number of hypotheses. The outcomes of this back analysis are detailed in Part 2 of the Preamble that constitutes additional material provided to the Panel on 10 May 2016.

Part 1 of the Preamble lists a number of factors that Centennial Coal contends must occur together in order for a mining related impact to manifest itself within a Temperate Highland Peat Swamp on Sandstone (THPSS).<sup>1</sup> In the absence of supporting data, the Panel does not concur with this contention.

In general, it is now concluded by Centennial Coal in Part 2 of the Preamble that mine subsidence interactions with lineament fault zones at Springvale Mine do appear to impact standing water levels well outside the designed buffer zone (defined by a 26.5° angle of vertical draw or a 20 mm vertical subsidence contour, whichever produces the widest buffer) and, furthermore, these water levels do not fully recover. In some cases, the impacts extend for more than three times the width of the designed buffer zone. The study findings are not inconsistent with a range of conclusions independently drawn by the Panel including, for example, that the discharge of mine water into the watercourse running through East Wolgan Swamp may have masked the development of other, longer term, mining impacts at the time.

Galvin (1996) reported on the association of lineament zones with poor mining conditions and two rapid convergence events at the neighbouring Angus Place Colliery. Subsequent state-of-the-art monitoring and plotting of roof movements by Centennial Coal at the working seam horizon in Springvale Mine indicate anomalous (excessive) ground displacement at depth within lineament zones. Surface subsidence monitoring has also revealed anomalous (excessive) vertical displacement at the surface over lineament zones. Surface subsidence predictions have had to be increased by 25% in these zones, although no explanation for the mechanism to account for this behaviour appears to have been developed to date. However, the behaviour is not unexpected from a geotechnical

---

<sup>1</sup> Preamble, page 29, first paragraph.

engineering perspective when consideration is given to the reduction in stiffness of the superincumbent strata that can occur when it is dissected by a fault zone. Increased vertical displacements on fault zones are well documented, as are enhanced vertical and horizontal fluid conductivities within these zones.

Further studies are required to confirm and to develop a mechanistic understanding of how lineament zones and associated natural features (including ecology) may be impacted well beyond the angle of draw. The identification of behaviour mechanisms and the monitoring of ground displacements are important as they give insight into the likelihood, nature and expression of impacts and their consequences in the long term. These activities are relevant and important to the Panel being able to fulfil its terms of reference in relation to providing advice on matters such as data collection, performance measures, and avoidance measures. This is one reason why the Panel does not concur with Centennial Coal's description of the functions of the Panel and Centennial Coal's proposed decision making matrix.<sup>2</sup> That matter is left to the Department to resolve.

### **3. Reference Definitions and Performance Criteria**

During the last eight years, the impacts of mining on natural features has been the subject of a number of independent inquiries, including the Southern Coalfields Inquiry (DoP, 2008), the Metropolitan Coal Project Planning Assessment Commission (DoP, 2009) and the Bulli Seam Operations Planning Assessment Commission (DoP, 2010) (for all of which I was a panel member). The Springvale Mine approval reflects the development in thinking arising out of these inquiries.

The Panel has had regard to definitions and performance criteria from these inquiries and some other contemporary documentation when considering the approval conditions for Springvale Mine, in order that the Panel's current and future advices align to an established foundation that is not inconsistent with the intent of the approval conditions for the mine. Some of the more important of these are:

#### **DoP, 2010**

- *Effect* – describes the subsidence (or ground movement; for example, horizontal displacement)
- *Impact* – any physical change to the fabric of the ground, its surface, or man-made feature (for example, development of a crack or an increase in the width of an existing crack)
- *Consequence* – any change in the amenity or function of a feature that arises from an impact (for example, diversion of water flow into a crack). In turn, as recognised in DoP (2009), some consequences may give rise to *secondary consequences* (for example, change in ecology due to loss of surface water)
- *Negligible* – small and unimportant, such as to be not worth considering
- *Safe* – no dangers to users
- *Serviceable* – means available for its intended use
- *Repairable* – means damaged components can be repaired economically
- *For swamps to experience adverse environmental consequences, changes to swamp hydrology would have to occur that were large enough and of sufficient duration to create conditions that were favourable for drying, erosion, fire, or changes in species composition. In the case of*

---

<sup>2</sup> Preamble, pages 17 and 18.

*species compositional change, there may be a substantial biological lag (up to decades) before any impact is apparent.*

- A performance criterion of negligible subsidence-related impact for a swamp means that before mining can occur under or adjacent to a swamp:

*(a) a Swamp Risk Management Plan (SRMP) must be developed as part of the Extraction Plan. This SRMP must demonstrate to the satisfaction of the Director-General of Planning that, for the proposed mining arrangement, subsidence predictions for conventional and non-conventional subsidence are within limits that will ensure the hydrology of the swamp will not be affected such that there is no potential for change in the size or functioning of the swamp, including potential changes in species composition or distribution within the swamp. This means that water will not drain from the swamp or part of the swamp as a result of any mining-induced subsidence, nor will water be re-distributed within a swamp or part of a swamp as a result of any mining-induced subsidence to an extent where such potential changes could occur;*

*(b) a monitoring program is designed and implemented that will provide both a platform for understanding the hydrology of swamps and advanced warning of any potential exceedances of the subsidence predictions, detect any actual exceedances of subsidence predictions and detect any impacts on the hydrology of the swamp and underlying hard rock strata. Especially important is the need to characterise the relationship between swamps and their role in recharging the regional groundwater systems; and ...*

- *“Negligible impact” for rivers and streams requires that the hydrologic, ecologic, environmental quality and amenity values ascribed to the rivers and streams are not perceptibly altered (i.e. “small and unimportant, such as to be not worth considering”).*
- *The definition of “negligible impact” for rivers and streams should be “no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, minimal gas releases and continued maintenance of water quality at its pre-mining standard”.*

#### **EPBC 2011/5949 (Commonwealth Government, 2012)**

- *“Severe impact” is defined as impacts to THPSS that indicate a long term change in swamp hydrology, water quality or flora composition. This includes fracturing of the rock strata beneath the swamp, evident through an extended (longer than that recorded in reference sites during the same period) reduction in groundwater levels.*

#### **Draft Biodiversity Offset Policy for Major Projects (NSW Government, 2015)**

- *‘Negligible environmental consequences’ is considered to mean one or more of the following:*
  - *negligible change to the shallow groundwater regime of a swamp compared with control swamps*
  - *negligible change to the composition of swamp dependent vegetation communities and threatened species*
- *If consent is granted, then conditions of consent must include performance measures preventing greater than negligible environmental consequences. Monitoring is required to measure compliance with these performance measures.*

#### **4. Subsidence Monitoring Program**

An extensive surface and subsurface displacement monitoring program has been in place for a number of decades at Springvale Mine and its adjacent sister mine, Angus Place Colliery. This has greatly assisted in developing an understanding of subsurface and surface subsidence behaviour. However, monitoring has been restricted and limited across lineament zones, apparently due to difficulties in gaining approvals to install and monitor instrumentation within the swamps that form along lineament lines in valleys.

With the emerging realisation that surface and subsurface response to mining may change in lineament zones and that this could have implications for predicted impacts and consequences of ground subsidence on surface and near surface features, it is highly desirable that subsidence survey lines be installed as soon as practicable through potentially affected swamps. This is consistent with approval condition 10 (h) 1 that the Subsidence Monitoring Program be prepared to, among other things, validate the conventional and non-conventional subsidence predictions.

While the EIS and supporting subsidence documentation acknowledge the occurrence of far field movements, apparently these have not been measured in any detail to date at Springvale Mine. Based on behaviour in the Southern Coalfield, reported in the EIS, these movements can be quite substantial (up to 100mm at a distance of 700m from the edge of a longwall panel). As such, it is not possible at this point in time to eliminate this behaviour as a contributing or major cause of subsidence impacts on swamps.

It is important to measure far field movements since theory suggests that they may concentrate along lineaments and extend to a greater depth and in the opposite direction to valley closure movements. These factors are conducive to extension and, therefore, enhanced conductivity beneath the base of swamps. Field evidence in the vicinity of Springvale Mine and elsewhere indicates that these impacts and some of their consequences may be permanent. In this regard, there is a need to plot piezometer readings in a manner that is not shown to flat line once water level drops below the depth of the sensor head.

#### **Panel Advice**

1. The Panel endorses the Subsidence Monitoring Program as complemented with the emailed amendment of 12 May 2016 (this amendment providing for installing a far field monitoring system prior to the start of LW 419 as an initiative to test the hypothesis that far field movements may be causing changes to standing water levels in swamps on the Newnes Plateau).
2. Given the emerging uncertainty regarding the distance and timing of impacts on swamps, the Panel considers that it would be judicious to increase both the time and the distance requirements associated with the following monitoring approval condition until this uncertainty is better understood:

*If, after 12 months of completion of all mining under this consent within 400 metres of any of these shrub swamps [Gang Gang South West, Gang Gang East, Pine, Pine Upper, Paddy's, Marangaroo Creek Upper Swamp], monitoring demonstrates that no greater than 'negligible environmental consequences' have resulted to the swamp from mining under this consent, to the satisfaction of the Secretary, then the Applicant will not be required to secure the offset or retire the credits relating to that swamp.*

## **5. Swamp Monitoring Program**

### **5.1 Groundwater**

Groundwater levels in the downstream area of Carne West swamp have been monitored since May 2005 by shallow piezometers CW1 and CW2. The holes for these instruments were drilled by low-impact hand augering techniques to depths of refusal in sand/weathered rock of 1.35 and 1.2 m below ground level, respectively. The piezometers were installed with screen intake lengths of 0.75 metres, sand packs of 0.55 meters, and bentonite seals near the surface. Presumably, an end cap was fitted at the base of each screen intake. In October 2011, two additional shallow piezometers, CW3 and CW4, were installed in the upper area of Carne West swamp.

CW1 and CW2 data loggers began to record a drop in water pressure around September 2013 (also a declining rainfall period) followed by a more significant drop around September 2014 (during a stable rainfall period). This trend has continued and the piezometers now record flat-line responses, indicative of air pressure and/or residual water within the end-piece of the piezometers, so that the actual depths to the saturated zone (or water table) are no longer known. It is imperative that additional monitoring be installed to determine the depth of the saturated zone, albeit that the Panel is aware there are constraints on gaining access to optimally located drill sites. Given that hand-augers experienced refusal within sandy material at the top of weathered rock, this horizon might form the top of the saturated zone. Drilling with a powered rig (possibly located along the access track near the base of the swamp) is required to accurately confirm the depth of the saturated zone within the weathered rock zone.

The advice of the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) (IESC, 2015) recommended that at least five piezometers are installed in each swamp (3 on a longitudinal transect and 2 on a cross-sectional transect) with at least 2 years of baseline monitoring data. At least one piezometer is required to be installed in the area where swamp sediment is thickest. However, this requirement does not appear to have given due consideration to practical aspects and associated impacts on swamps in determining this location. The Development Consent (DC) for the Springvale Mine Expansion Project (part 10v) requires “*further consideration of.... installation of upslope and downslope piezometers in all swamps...*”

At this point in time, there are two shallow piezometers in Gang Gang South West swamp (GW1 and GW1) and one shallow piezometer (GG1) on the western side of Gang Gang East swamp, away from the wettest part of this swamp edge. The Panel considers that this current monitoring regime is inadequate. A minimum of three monitoring piezometers, including upstream and downstream locations, should be installed in each of these large valley swamps using negligible impact hand-augering methods. However, the Panel would prefer that at least five piezometers are installed in each swamp, consistent with the recommendations of IESC noted earlier.

In general, there is a lack of groundwater level monitoring in the lower and upper areas of the swamps, particularly for Gang Gang South West swamp. In contrast, there are a large number of groundwater monitoring locations (SPR1111, SPR1104, RCW-SV05, SPR1107, SPR1108, SPR1113, PRR1112, SPR66) established on the ridges within the catchment of these swamps. This extent of monitoring of regional water levels is considered to be adequate.

### **5.2 Soil Moisture**

The hydrologic regime of the swamps reflects the degree of wetness in the swamp substrate, the periodicity and duration of wetness and the spatial patterning of these variables and, therefore, is fundamental to the function and characterisation of swamps. Currently, the groundwater monitoring program does not adequately measure these parameters in either time or space.

The existing piezometers capture vertical groundwater movement at very few point locations within each swamp. This information is significant in understanding gross changes to the swamps groundwater status at saturation but it does not provide useful information about the moisture status in the top 1 - 1.5 m, where biological activity is concentrated. It is well established that the Newnes Plateau swamps can be hydrologically heterogeneous, both within a swamp and between swamps. Therefore, the monitoring program needs to adequately reflect this potential for variation in moisture content.

There is currently a knowledge gap in the status and dynamics of moisture content in the top 1 - 1.5 m of the substrate of the swamps, with the most critical gap being in the 0.0 to 0.5 m zone, which is the zone of greatest biological activity. Monitoring the moisture status of the swamp substrate in conjunction with piezometer data is critical as it can provide an early trigger for detecting the drying of a swamp.

There is no information available to the Panel on the status of soil moisture monitoring since July 2013 at sites of relevance to assessing the impacts of mining at Springvale Mine. Soil moisture monitoring adjacent to swamp piezometers was recommended by the IESC (IESC, 2015). This included investigation of spatial and temporal variations in 20 cm depth intervals.

Four moisture monitoring installations are proposed by Centennial Coal in East Wolgan Swamp (a control site) and two in each of Narrow Swamp and Carne West Swamp. Each installation is to be equipped with five water potential sensors over the depth of the swamp sediment profile. However, the Panel is of the view that the lack of soil moisture monitoring proposed for Gang Gang South West swamp and Gang Gang East swamp is unacceptable. The Panel recommends two soil moisture monitoring installations, similar to that proposed for Narrow Swamp and Carne West Swamp, to monitor Gang Gang South West swamp and Gang Gang East swamp.

Methods for monitoring vertical moisture content profiles from the surface to a depth of approximately 2 m over time in a peat swamp (with these being converted if need be to moisture potential and vice versa for specific sediment type) include:

- Neutron probes (monthly or quarterly points-in-time) to measure hydrogen ion content of the soil. Repeated vertical depth profiles at access cases installed in a swamp using a hand held probe with radioactive source of neutrons to determine water content of soil and peat. This is the only method that appears to have been trialled to date at the Springvale site.
- Frequency domain or time domain sensors (hourly to daily monitoring) to determine permittivity (or dielectric constant) that is related to water content. Examples of these are time domain reflectometry (TDR) probes and capacitance type sensors installed at specific depths, with the capability for wireless remote monitoring systems.
- Temperature sensor arrays (hourly to daily monitoring) and data analysis from arrays of vertical data points to determine water content variation.

There are also a number of 2D survey techniques for near-surface soil moisture that are being developed at a suitable scale for swamp monitoring. Some of these 2D survey techniques also appear to be feasible for peatland swamps with limited accessibility and variable vegetation cover.

### **Panel Advice**

3. Centennial Coal needs to demonstrate that base groundwater level performance trigger values for Carne West swamp piezometers are based only on data collected before Carne West swamp started to be impacted by mining. (It appears to the Panel on the basis of the information provided to it that this swamp may have started to be impacted by mining at around July 2013.)
4. It is imperative for the purpose of determining the extent of any offsets in the future that additional monitoring is installed to determine the new depth of the saturated zone beneath Carne

West swamp and trends in this depth over time. Ideally, this additional monitoring should be installed as soon as possible.

5. Given the change in depth of the saturated zone observed at Carne West swamp, it is also recommended that deeper piezometers are installed in Gang Gang East and Gang Gang South West swamps. Ideally, this additional monitoring should be installed as soon as possible and definitely before the commencement of LW 420.
6. It is noted that the piezometer loggers are set for daily water level logging which is considered the minimum data frequency. High frequency (15 minute or hourly intervals) of data logging would enable more advanced hydrogeological interpretations to be made regarding the functioning of the system.
6. Early baseline monitoring of substrate moisture status is recommended in Gang Gang East and Gang Gang South West swamps as well as for the reference swamps (Barrier Swamp and Carne Central). Increased spatial distribution of hand-augered piezometers within the upstream and downstream areas of the four swamps named above is also recommended. One piezometer located relatively close to the edge of a swamp (eg. GG1) is not acceptable monitoring of a relatively large valley swamp that generates significant discharge to the creek. In addition, there is a need to install moisture sensors in Gang Gang East and Gang Gang South West swamps that log the moisture status (from wet to dry) of the swamp substrate at daily time intervals and a maximum of 20 cm vertical intervals from the swamp surface to the depth of refusal for hand augering.
7. The May 2016 version of the Swamp Management Plan (under review) would benefit from the following edits:
  - i. Header refers to the plan as the ‘Mine Environmental Management Plan’
  - ii. Section 2 ‘Purpose’ refers to the plan as the ‘Water Management Plan’
  - iii. Section 8.2.3 Method – refers to Biodiversity Management Plan instead of ‘Swamp Management Plan’
  - iv. Re-formatting of TARP tables

## **6.0 Water Management Plan**

Water flow monitoring in the Carne Creek catchment, downstream of swamps is highly recommended to assist in evaluation of potential cumulative changes on discharge and catchment yield. However, plans to establish a new station immediately below Carne West swamp may now be out-of-date due to the significant decrease in water flow that has occurred at this location over the last two years, making flow too low to detect (see Table 4 and Figure 6 of the Water Management Plan).

### **Panel Advice**

8. The Panel endorses the installation of an additional surface water gauging station in lower Carne Creek (as proposed by the Water Management Plan).
9. It is recommended that pygmy flow meter monitoring devices used in locations where flow monitoring structures are not possible are replaced with acoustic Doppler velocimeters, so as to overcome constraints associated with low flow rates.

## **7.0 Biodiversity Management Plan**

The time period for establishing ecological baseline data has, in some cases, been inadequate in both previously impacted swamps and those that may be impacted. There are inconsistencies in methods used to collect data across swamp sites and this compromises impact determinations.

Much of the baseline floristic characterisation is founded on poor data and analyses derived from the pre-existing and longstanding modified Braun Blanquet flora methodology. The floristic data has not taken into account relative biomass at each swamp and how this may change over time.

The plant species, Dean's Boronia (*Boronia deanei*) and the faunal species, Giant Dragonfly (*Petalura gigantea*) and Blue Mountains Water Skink (*Eulamprus leuraensis*), are examples of threatened species (the Giant Dragonfly is only listed in the *Threatened Species Conservation Act (NSW)* (1995) that are obligate swamp species. When the swamps dry, these species are highly likely to become locally absent as individuals or breeding populations.

The Giant Dragonfly requires a zone of water at saturation in the top 0.5 m of substrate for the aquatic larval stages of the insect to survive. The Blue Mountains Water Skink is restricted to less than 40 fragmented swamp sites in the Blue Mountains and Newnes Plateau and their distribution is confined to sites with water bodies. They have low dispersal capabilities and, therefore, recolonisation of swamps would be very slow (Dubey & Shine, 2010).

To date, there has also been a general lack of baseline data derived for the hanging swamps in order to fully assess subsidence-related impacts. For the Sunnyside East and Carne West hanging swamps, already undermined, comprehensive baseline data will benchmark the post-mining state; however, this would still provide important information for future referencing. Piezometers are unlikely to be of value in these systems, particularly where substrate depth is shallow and the swamps are never or only periodically saturated.

### **Panel Advice**

10. In concert with quantitative swamp monitoring data being collected, each swamp and its boundary conditions (i.e. immediate catchment) should be descriptively characterised to give an overview of the *whole swamp along its entire length*. In part, this is undertaken during the Rapid Assessment Methodology (RAM) as per Goldney et al (2010). However, the characterisation needs to more fully and comprehensively integrate the ecologic, hydrologic and geomorphologic features and evolutionary processes.
11. The RAM should be made following a reconnoitre of the whole swamp, with deductions and the final assessment made thereafter. It should be conducted across all remaining impact and reference swamps currently not undermined, during the same time period when they are all experiencing the same macro-climatic influences.
12. The Brownstein et al Flora Monitoring Program (Brownstein et al., 2014) should be adopted and applied to Carne West North, Gang Gang East, Gang Gang South West and Carne Central swamps as well as at Sunnyside East swamp for future reference.
13. Relying on the Bureau of Metrology data derived from the Bathurst Agricultural Station is not adequate for understanding the moisture budget for swamps. It is recommended to re-instate a meteorological station on Newnes Plateau.
14. There needs to be a continuing focus on fauna monitoring. In general, due to their mobility, likely problems with their detection in the field and lag responses, fauna are not suitable indicators in determining subsidence related impacts. However, they constitute an important

component for benchmarking biodiversity values. It is particularly important to acknowledge the Giant Dragonfly in benchmarking the biodiversity values of swamps.

15. As part of the baseline survey and ongoing monitoring, the swamp flora in hanging swamps should be surveyed using the FMP methodology in addition to the RAM assessment already undertaken.

## **8.0 Concluding Remarks**

This advice is not comprehensive and, therefore, should not be considered as a concluded advice. It has been prepared to the extent necessary to permit the Panel to recommend that the mining of LW 419 be allowed to commence subject to the implementation of the recommendations contained in this advice. The Panel's advice will be expanded upon prior to the start of LW 420 and in the light of monitoring outcomes during the mining of LW 419.

## **9.0 References**

- Brownstein, G., Johns, R., Blick, R., Fletcher, A., & Erskine, P. (2014). Flora Monitoring Methods for Newnes Plateau Shrub Swamps and Hanging Swamps. Centre for Mines Land Rehabilitation, University of Queensland.
- DoP. (2008). Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review. ISBN 978 0 7347 5901 6, pp. 168. Sydney: NSW Government.
- DoP. (2009). The Metropolitan Coal Project Review Report - Planning Assessment Commission. ISBN 978-0-9806592-0-7, pp. 282. Sydney: Department of Planning, NSW Government.
- DoP. (2010). Bulli Seam Operations - Planning Assessment Commission Report. ISBN 978-0-9806592-6-9, pp. 474. Sydney: Department of Planning, NSW Government.
- Dubey, S., & Shine, R. (2010). Restricted Dispersal and Genetic Diversity in Populations of an Endangered Montane Lizard (*Eulamprus Leuraensis*, Scuncidae). *Molecular Ecology*, 19, 886-897.
- Galvin, J. M. (1996). *Impact of Geology on Longwall Mining: A 20 Year Case Study*. Paper presented at the Symp. on Geology in Longwall Mining, pp. 21. Coalfield Geology Council of New South Wales.
- Goldney, D., Mactaggart, B., & Merrick, N. M. (2010). Determining Whether or Not a Significant Impact has Occurred on Temperate Highland Peat Swamps on Sandstone within the Angus Place Colliery Lease on the Newnes Plateau. Bathurst: Cenwest Environmental Services.
- ISEC. (2015). Advice to Decision Maker on Coal Mining: Further Advice on Impacts to Swamps. . Report No. 068: Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development.
- NSW Government. (2015). Draft Biodiversity Offsets Policy for Major Projects. Framework for upland swamps impacted by longwall mining subsidence. Sydney: NSW Government.

Yours sincerely



**Emeritus Prof. Jim Galvin**  
**Independent Monitoring Panel**

## Appendix 1

### Bibliography

Baird, I. R. C. (2012). *The Wetland Habitats, Biogeography and Population Dynamics of Petulura Gigantea (Odonata: Petaluridae) in the Blue Mountains of New South Wales*. The University of Western Sydney.

Baird, I. R. C. and S. Burgin. (2012). Conservation of a Groundwater-dependent Mire-dwelling Dragonfly: Implications of Multiple Threatening Processes. *Journal of Insect Conservation* **19**.

Benson, D. and I. R. C. Baird. (2012). Vegetation, Fauna and Groundwater Interrelations in Low Nutrient Temperate Montane Peat Swamps in the Upper Blue Mountains, New South Wales. *Cunninghamia* **12**:267-307.

Booth C.J. (2007). Confined-Unconfined Changes above Longwall Coal Mining due to Increases in Fracture Porosity, *Environmental and Engineering Geoscience*, Vol, XIII, No 4, 355-367.

Booth C.J., Spande E.D., Pattee C.T., Miller J.D. & Bertsch L.P. (1998). Positive and Negative Impacts of Longwall Mine Subsidence on a Sandstone Aquifer, *Environmental Geology*, 34 (2/3).

Cai W., Purich A., Cowan T., Van Rensch P. & Weller E. (2014). Did Climate Change–Induced Rainfall Trends Contribute to the Australian Millennium Drought? *Journal of Climate*, vol 27., pp. 3145-3168.

David K., Timms W., Mitra R. & Cai P. (2015). Groundwater Vulnerability Assessment using Comparison of Premining and Post Mining Conditions in the Coal Mining Environment, in Witkowski AJ.

Donnelly L.J. and Rees J.G. (2011). Tectonic and Mining Induced Fault Reactivation around Barlaston on the Midlands Microcraton, North Staffordshire, UK. *Quarterly Journal of Engineering Geology and Hydrogeology*, 34, 195-214.

Donnelly L.J, 2006. A Review of Coal Mining Induced Fault Reactivation in Great Britain. *Quarterly Journal of Engineering Geology and Hydrogeology*, 39, 5-50.

DoP. (2008). *Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review*. ISBN 978 0 7347 5901 6, pp. 168. Sydney: NSW Government.

DoP. (2009). *The Metropolitan Coal Project Review Report - Planning Assessment Commission*. ISBN 978-0-9806592-0-7, pp. 282. Sydney: Department of Planning, NSW Government.

DoP. (2009). *The Metropolitan Coal Project Review Report - Planning Assessment Commission*. ISBN 978-0-9806592-0-7, pp. 282. Sydney: Department of Planning, NSW Government.

DoP. (2010). *Bulli Seam Operations - Planning Assessment Commission Report*. ISBN 978-0-9806592-6-9, pp. 474. Sydney: Department of Planning, NSW Government.

Galvin, J. M. (1996). *Impact of Geology on Longwall Mining: A 20 Year Case Study*. Paper presented at the Symp. on Geology in Longwall Mining, pp. 21. Coalfield Geology Council of New South Wales.

Goldney, D., Mactaggart, B., & Merrick, N. M. (2010). Determining Whether or Not a Significant Impact has Occurred on Temperate Highland Peat Swamps on Sandstone within the Angus Place

Colliery Lease on the Newnes Plateau, prepared for Department of the Environment, Water, Heritage and the Arts. Cenwest Environmental Services, Bathurst.

Hebblewhite, B. K., Waddington, A. A., & Wood, J. (2000). Regional Horizontal Surface Displacements due to Mining Beneath Severe Surface Topography (pp. 149–157). Paper presented at the 19th international conference ground control in mining, Morgantown, WV, West Virginia University.

Holla L and Barkley E, 2000. Mine Subsidence in the Southern Coalfield, NSW, Australia, Mineral Resources of NSW, Sydney.

Islam, M.R. & Shinjo R. (2009). Mining-induced Fault Reactivation Associated with the Main Conveyor Belt Roadway and Safety of the Barapukuria Coal Mine in Bangladesh: Constraints from BEM simulations. *International Journal of Coal Geology* 79 (2009) 115–130. Jakobczyk-Karpierz S; Grabala D (eds.), *Groundwater Vulnerability- From Scientific concepts to practical applications*, Faculty of earth sciences, University of Silesia, presented at Groundwater vulnerability-From Scientific Concepts to Practical Applications, Ustron, Poland, 25 - 29 May 2015.

NSW CES. (2014). On Measuring the Cumulative Impacts of Activities which Impact Ground and Surface Water in the Sydney Water Catchment NSW, Chief Scientist & Engineer May 2014 [http://www.chiefscientist.nsw.gov.au/data/assets/pdf\\_file/0007/44485/140530\\_SCA-Report-Final-Combined.pdf](http://www.chiefscientist.nsw.gov.au/data/assets/pdf_file/0007/44485/140530_SCA-Report-Final-Combined.pdf)

NSW Government. (2015). *Draft Biodiversity Offsets Policy for Major Projects*. Framework for upland swamps impacted by longwall mining subsidence. Sydney: NSW Government.

Rančić A., Salas G., Kathuria A., Acworth I., Johnston W., Smithson A., & Beale, G. (2009). Climatic Influence on Shallow Fractured-rock Groundwater Systems in the Murray-Darling Basin. NSW Department of Environment and Climate Change. <http://www.environment.nsw.gov.au/resources/salinity/09108GroundwaterMDB.pdf>

Timbal, B. & Fawcett, R. (2013). A Historical Perspective on Southeastern Australian Rainfall since 1865 using the Instrumental Record. *J. Clim.* 26, 1112\_1129.

Tonkin C. & Timms W. (2015). Geological Structures and Fault-infill in the Southern Coalfields and Implications for Groundwater Flow, *Journal of Research Projects Review*, vol. 4, pp. 49 - 58, <https://www.researchgate.net/publication/281287677>