Maules Creek Community Council Inc
upthecreek2382@gmail.com

Steve Bradshaw	02 6794 4503
Phil Laird	0428 712 622
Fiona Morse	0408 656 808
Alistair Todd	0427 936 745
Peter Watson	0427 434 643

7 February 2011

Attn: Mr Colin Phillips
Mining & Extractive Industries
Major Development Assessment
Department of Planning
GPO Box 39
SYDNEY NSW 2001

Dear Mr Phillips

Re: Boggabri Coal Mine
Project Application Number: 09_0182

Please find enclosed a submission by the Maules Creek Community Council Inc (MCCC) regarding the Environmental Assessment by Boggabri Coal Pty Limited (Boggabri Coal) prepared as part of the abovementioned Project Application. Our submission addresses key aspects of the Environmental Assessment which impact the Maules Creek community and we have obtained advice from independently recognised experts where possible to support our objection to the Project Application.

The Environmental Assessment involves a substantial expansion of the existing mining activities in the Leard State Forest. The Maules Creek area is in the immediate vicinity of the Leard State Forest and Maules Creek residents are directly impacted by the mining activities in the Forest. In particular, the Maules Creek residents are very concerned about the proposed closure of the Leard Forest Road, which is an essential access route for emergency services in the event of flood or fire, and is used for commercial and personal purposes.

Furthermore, we understand Aston Resources will soon be submitting an Environmental Assessment to develop a separate large scale mining operation, which will also be located in the Leard State Forest and will be known as the Maules Creek Coal Project. We strongly urge you to consider both the individual and cumulative impacts of the Boggabri Coal Mine and the Maules Creek Coal Mine in determining whether approval is granted for either or both projects and, if approved, the conditions that will be placed upon these coal mining operations.

Should you wish to discuss our submission further, please contact any of the individuals listed above.

Yours sincerely
Maules Creek Community Council Inc

Disclosure Note: Upon application by MCCC, Boggabri Coal provided $10,000 to enable MCCC to engage expert consultants to assist in the preparation of this submission.

Boggabri Coal Mine

Project Application Number: 09_0182

Submission by: **Maules Creek Community Council Inc**

upthecreek2382@gmail.com

Steve Bradshaw	02 6794 4503
Phil Laird	0428 712 622
Fiona Morse	0408 656 808
Alistair Todd	0427 936 745
Peter Watson	0427 434 643

Contents

Appendix 6

Letter from Environmental Defender's Office Ltd regarding Continuation of Boggabri Cola Mine, Boggabri NSW, 1 February 2011

Appendix 7

Economists at Large review of the Continuation of Boggabri Coal Mine Economic Assessment, February 2011 provided by Economists at Large

Appendix 8

Map of remnant forest in the Liverpool Plains region provided by Carmel Flint, National Parks Association

Appendix 9

Copy of Supplementary General Manager's Report to Narrabri Shire Council, August 2010

Executive Summary

Boggabri Coal Pty Limited (Boggabri Coal) proposes to expand open cut mining in the Leard State Forest (the Forest), a significant piece of public land and diverse ecological habitat. The Maules Creek Community Council Inc (MCCC), which represents local landholders and residents, is a significant stakeholder in the immediate vicinity of the current and proposed mining operations.

The MCCC was formed after concerned local residents organised a meeting on 25 July 2010, following previous meetings regarding issues surrounding proposed closure of the Leard Forest Road. The lack of information and consultation regarding current and future mining projects from both the Narrabri Shire Council and the mining companies operating in the area has been a concern for some time amongst the local community. Six committee members were elected to represent local interests following the vote of sixty local residents who attended the meeting.[1]

Mining efficiencies and cost reductions are given as reasons to warrant the clearing of critically endangered woodland, fragmentation of the local community and environmental impacts to air and water quality. The value to the local community and the people of NSW of maintaining the Forest in its current state is omitted or undervalued. Furthermore, the consideration of other options has been inadequate, particularly regarding the feasibility of the underground mining option (Option 6).

Below is a summary of the issues of concern which are expected to result from Boggabri Coal's continuation/expansion plans using the open cut mining methodology, which are explained in further detail in the body of this submission. Due to these community and environmental impacts, the MCCC objects to the Project Application.

1. *Destruction of Leard State Forest*

The expected impacts on critically endangered White Box Grassy Woodland communities would seriously affect the endangered and threaten species that live in the Forest. It is expected there would be forced migration of displaced native animals to other land.

2. *Adequacy and appropriateness of proposed rehabilitation*

Expert advice received by the MCCC has questioned the rehabilitation methodology as to its ability to rehabilitate the Forest to its pre-mining condition. Furthermore, it is expected the 10 cm of topsoil spread over large heaps of "spoil" will have insufficient water holding capability, which will prevent permanent rehabilitation. The current ecosystem could not be re-instated if the rehabilitation were unsuccessful.

3. *Community fragmentation*

It is expected the purchase of offset land by Boggabri Coal could not establish "like" for "like" with regard to the ecosystem currently contained within the Forest. The main impact of the offset plan appears to permanently remove farmers from the landscape, decreasing the agricultural viability of the district and destroying the fabric of the local community.

[1] Since that time, one committee member has resigned for personal reasons.

4. Decreased air quality

Open cut mining has well-documented health, agricultural productivity and social impacts due to a general reduction in air quality. The MCCC has submitted a list of "principles" to guide the development of an extensive Air Quality Monitoring Network for the area if the Environmental Assessment is approved.

5. Reduction in groundwater quantity and quality

Due to dust suppression and coal washing requirements over the 21 year period of the open cut mining lease, it is expected significant quantities of groundwater would be diverted from environmental and food production purposes. Other losses of ground water associated with mining due to diversions of runoff and reductions in recharge are a major concern. Water supply in the Maules Creek area is highly dependent on seasonal rainfall and the increased demand on the aquifer by the mining operations will have significant impacts on the local community in periods of drought.

6. Impacts on the nearby Groundwater Dependent Ecosystems (GDE)

Stygofauna that have been documented in the Maules Creek and Back Creek aquifers are expected to be permanently affected due to the depressurization effect and permanent reduction in the water table as shown in the Environmental Assessment (Drawing A5 in Appendix O of the Environmental Assessment). Due to aquifer connectivity, there could be serious impacts on the stygofauna due to changes in water chemistry.

7. Impacts to irrigation due to a reduction in surface flows

Expert advice received by the MCCC has shown containment of onsite water within the 1,343 Ha mine site would have serious impacts on recharge and surface flows, and a potentially permanent reduction in water flows in the Namoi River reducing the water available for environmental and food production purposes. Zone 5 irrigators depend on inflows from the Maules Creek aquifer for the majority of irrigation water supplies.

The Namoi Catchment Water Study is designed to model all cumulative impacts to water within the catchment. Individual projects should not be considered in isolation and the Environmental Assessment should be subject to the Namoi Catchment Water Study model before a decision by the Minister is made.

8. Impacts to Aboriginal heritage sites

Cultural sites that are within the Forest and as yet undiscovered will be lost.

9. Proposed closure of Leard Forest Road is unfeasible and unacceptable

The Leard Forest Road is a vital emergency and trade route which should not be closed. The Maules Creek community has communicated many times to Boggabri Coal and the Narrabri Shire Council that access through the Forest is essential. An alternative route through the Forest should be provided during mining operations to maintain this crucial link between Maules Creek and the towns to the south and east.

10. Noise

It is expected there will be significant impacts on Forest fauna and birdlife, and neighbouring properties due to noise resulting from blasting and heavy equipment.

11. Negative impacts on property values

Due to the noise, dust and water impacts described above there is expected to be an impact on property valuations in areas immediately adjacent to the zone of acquisition/affectation. The number of potential buyers is expected to reduce significantly and a bargaining power imbalance exists between the mine and landholders. The timing of land disposal is out of the control of the existing land owner causing uncertainty and stress for those nearing retirement and those wishing to expand their operations.

12. Cumulative impact of mines in the Leard State Forest

Highly magnified cumulative effects due to other planned large scale open cut projects in the Leard State Forest will have unforeseen impacts on the Forest environment and on the local community. Detailed quantitative modelling of the cumulative projects has not been undertaken despite the same consultant being used for the two main projects.

13. Greenhouse gases (GHG)

The Boggabri Coal project is expected to make a significant contribution to the NSW GHG emissions impacting on the NSW Kyoto targets.

It is plain to see the impacts that the recently developed large scale, open cut mining has had on the Hunter Valley. It was not until the mining in the Hunter Valley moved from underground to open cut that the serious community and environmental issues with coal mining started to emerge. There is no need for a repeat of the same issues in a different location. The people of NSW should not have their environment, community and agricultural production put at risk for the benefit of a foreign company.

Accordingly, the MCCC strongly urges the Environmental Assessment is denied for the reasons set out in this submission. However, in the event the Environmental Assessment is approved, strict conditions should be placed on any approval that is granted to attempt to minimise or mitigate the impact of the issues of concern raised in this submission.

Summary of Recommendations

The MCCC strongly urges the Environmental Assessment is denied. However, in the event the Environmental Assessment is approved, we have set out conditions, the following is a summary of commitments Boggabri Coal should be required to make prior to continuing its mining operations. Further detail as to these commitments is included in the body of this submission at the respective page references set out below.

Project Justification

- The Department of Planning should reject the Environmental Assessment due to the inadequate nature of the assessment in considering all potential social-ecological consequences of an expanded open-cut mine operation within the Leard Forest.
- The Department of Planning should require the Environmental Assessment meet the objectives of the BNC Act 2005 and the EP&A Act before Determination of the Project Application can proceed under part 3A of the EA Process.

Air Quality and Greenhouse Gases

- Require Boggabri Coal to participate in establishing an air quality monitoring network as described above.
- The GHG emissions of the project should be considered in terms of its contributions to overall NSW emissions and Boggabri Coal should be required to offset these emissions in the voluntary emissions trading market.

Ecology and Biodiversity Offset Strategy

- The Boggabri Coal biodiversity offset strategy should replace removed vegetation communities with newly established like for like greenfield habitat areas. The purchase of the identified offset lands does not provide new habitat for displaced flora and fauna.
- A more intense survey (the habitat survey was a pilot study and used predictive modelling) there should be more on the ground surveys carried out during breeding season when the koalas are more active and audible. Furthermore, a full plan of management should be prepared to conserve the koala habitat in accordance with the Koala Habitat Protection Policy.

Groundwater

- All extractions from the Boggabri Coal pit be metered and a detailed accounting be made of water taken from alluvial, coal seam and surface flows.
- Revisit the Ground Water Model methodology in relation to the issues raised in the Peer Review.
- Await the findings of the Independent Namoi Catchment Water Study to understand catchment wide impacts of the Boggabri Coal mine. Use these findings to do an economic assessment on the impacts to irrigators in Zone 5.

- Undertake detailed study of Stygofauna and other Groundwater Dependent Ecosystems in the vicinity of Goonbri Creek, Back Creek and Maules Creek.
- Alienation of surface water run-off to the Namoi River catchment should be compensated for via the purchase of surface water diversion licenses.

Economic and Social Impact Assessment

- The economic impact assessment should be revised to properly address the issues raised by Economists at Large in Appendix 7. In particular, environmental costs and community costs should be quantified, costs and benefits should be identified by stakeholder and the alternate project options should be fully analysed.
- The social and emotional welfare of the Maules Creek community should be assessed, as opposed to the more general impact on the Narrabri and Gunnedah local government areas.
- The MCCC should be added to the list of stakeholders and be consulted at appropriate times.
- Prior negotiations with Boggabri Coal regarding alternate routes to the Manilla Road should be acknowledged by in the Environmental Assessment and further negotiations as to an alternative route be progressed. A condition as to the timing of the closure of the Leard Forest Road should be made once a suitable alternative to the community has been provided.
- An assessment should be done as to the cumulative impact that all existing, expanded and proposed mines will have upon liveability, amenity, saleability and value of properties outside the current proposed area of acquisition. This should include properties located beyond the northern boundary of the project which are likely to suffer the combined impact of Boggabri and proposed Aston Resources Maules Creek Project.
- Investigate the impact of changing use and value of rural land will have on the viability of agriculture within the area. This should consider interference to intergenerational change and the economic cost of declining farm productivity.
- Consideration of the loss in farm production as a result of environmental damage (water/dust) as a direct consequence of cumulative mining impacts.
- A more detailed study of housing access and affordability taking into consideration the cumulative impact of the additional mining operations yet to be developed and anticipated time required to develop additional residential accommodation.
- The Applicant is required to prepare detailed designs and subsequently construct improvements to
  - Boggabri Caravan Park
  - Boggabri Swimming Pool
  - Harparary Road (and Culverts replacing Causeways)
  - Harparary Road Bridge

  to the satisfaction of the Narrabri Shire Council and the MCCC, prior to the closure of the Leards Forest Road's current alignment through the mining lease site.
- Boggabri Coal is required to make a financial contribution to the Narrabri Shire Council based on detailed designs prepared by Boggabri Coal, sufficient to allow the Council to gravel and seal the unsealed section of road along the Harparary Road from the Leard Forest Road to the Kamilaroi Highway, prior to the closure of the Leard Forest Road's current alignment through the mining lease site.

Soils and Land Use

- A new soil survey should be completed that includes all available soil information in order to develop a rehabilitation strategy that will result in the regeneration and replacement of the critically endangered White Box Grassy Woodland community's that are currently being cleared by the project.
- Purchases of offset land should be restricted to that with soil types similar to Leard State Forest., i.e. undulating landscapes with native plant and animal assemblage habitats that are derived from Permian Coal measure derived soils. This land should provide a "like" for "like" offset.
- Once the new soil survey and associated modelling is complete the results should be investigated to ensure that impacts of changes to water runoff, recharge, water table levels and groundwater chemistry are considered in relation to the Stygofauna that has been identified in the aquifer, creeks and streams in the vicinity of the project.
- Alienation of surface water run off to the Namoi River catchment should be compensated for via the purchase of surface water diversion licenses.

Rehabilitation and Final Landform

- Boggabri Coal is required to prepare detailed Rehabilitation Strategy and Management Plan in consultation with the Narrabri Shire Council and the MCCC. The strategy is to be completed and approved by the Department of Planning prior to the closure of the Leard Forest Road's current alignment through the mining lease site.

Traffic and Transport

- Prior to the closure of the Leards Forest Road's current alignment through the mining lease site, Boggabri Coal must prepare a "Leards Forest Road Deviation Management Plan" in Consultation with, and to the satisfaction of the MCCC and the Narrabri Shire Council. The Leard Forest Road (on its current or deviated alignment) is to remain open at all times. As a minimum "The Plan" will cover the following;
  - Construction Drawings by a Chartered Professional Engineer, for the completion of the Harparary Road, Causeway and Bridge upgrade works. Where box culverts are to replace concrete causeways the causeways are to remain adjacent to the culverts and be available during construction and, as an alternative access should the culverts be damaged during flood events.
  - Box culverts are to be a minimum of 500mm above the approach roads finished surface level, measured 100m from the culvert.
  - The Harparary Road Bridge is to be a two lane bridge in accordance with the current Austroads bridge design code and capable of carrying as a minimum, Higher Mass Limit AB-Triples or similar. The new bridge is to be constructed on an alignment parallel to the current timber bridge alignment, thus allowing traffic to flow whilst construction occurs.
  - The proposed Leards Forest Road Deviation Route or Route(s), should more than one deviation be required during the Mines life, are to be funded and constructed by Boggabri Coal. The deviated route(s) is to be a gravel surface road with a minimum width of 7m to the satisfaction of Narrabri Shire Council, and constructed on an alignment to suits traffic speed of 70km/h as a minimum. <u>The Deviation</u> Management Plan will also show the proposed "Final Alignment" of the Leard Forest Road once mining has ceased and the mine site is

rehabilitated. Boggabri Coal will supply and deliver all gravel required to maintain the Leards Forest Road whilst the mine is operating.

- A proposed Construction Program that shows the proposed timeline for the upgrade of the Harparary Road, Causeways and Bridge, and the Leards Forest Road Deviation Route or Route(s) prior to the closure of the Leards Forest Road's current alignment through the mining lease site.
- A Consultation Strategy outlining how the proposed realignments of the "Leard Forest Road Deviation Management Plan" and Construction and Maintenance arrangements will be communicated to key stakeholders and regulators.

- Boggabri Coal will meet the reasonable costs of providing an independent inspector (to the satisfaction of Narrabri Shire Council and MCCC) to monitor any works Boggabri Coal (or its contractors) carries out on infrastructure for the ultimate benefit/ownership of the Narrabri Shire Council.
- At the completion of the proposed rail loop Boggabri Coal's existing private haul road will become the only heavy vehicle access route to the mine and controls at the intersections of the Leard Forest Road and Therribri Road will be changed to give priority to the public roads, with mining traffic not having right of way. Access to the Private Haul Road will be provided by Boggabri Coal at the Kamilaroi Highway to the satisfaction of the Roads and Traffic Authority.
- At the completion of the rail loop, the Manilla Road, from the Iron Bridge up to and including the Leard Forest Road intersection, will be rehabilitated to the satisfaction of the Narrabri Shire Council.

Underground Preliminary Plan

- The entire strategy for the development of the Boggabri Coal deposit including the lease A339 should be presented to the Department of Planning and the community so that a proper cumulative assessment of all (including future) environmental and community impacts within the project boundary and outside the project boundary can be made.
- The alternative underground mining report should provide an assessment of the benefits to the community and the environment of not disturbing the environment and fragmenting the community. These benefits have not been properly considered in underground mining report as an economic and social assessment has not been undertaken.
- An environmental assessment should be undertaken as to the impacts of Underground Mining on the Forest environment and the community.

Simultaneous Worst Case Cumulative Impact Scenario

- The MCCC does not accept the adequacy of the SWCCIS contained in the Environmental Assessment and believes a detailed verifiable quantitative assessment combining all proposed mining projects within the Leard State Forest should be submitted to the NSW Department of Planning (DoP) for appraisal before assessing individual Environmental Assessments. The precautionary principle should take precedence until all identified risks are satisfactorily investigated using scientific quantitative principles.
- The DoP should require Boggabri Coal to conduct a verifiable quantitative environmental assessment as described above.

- The DoP should refer all relevant environmental constraints of the projects such as White Box-Yellow Box- Blakely's Red Gum Grassy Woodland and Derived Native Grassland to the Federal Government for consideration under the EP&A Act.
- The DoP should require Boggabri Coal to appoint an independent autonomous organisation to assess the likely impact of alluvial groundwater depressurisation and chemical composition changes due to open cut coal mining upon the identified stygofauna/styobite groundwater dependent ecosystems located within the alluvial basin of the Maules Creek Catchment.

Project Justification

Introduction

The Environmental Assessment states the project approval is required to maximise the recovery of the additional coal reserves known to occur within Boggabri Coal's existing mining leases, whilst minimising environmental and social impacts resulting from the Project. Boggabri Coal has had no alternative but to enter into port contracts for the supply of coal to meet the forecast production for the project, and, project approval is required so that Boggabri Coal can meet this commitment. Furthermore, we understand Idemitsu Australia Resources has signed a five-year service agreement with Downer EDI for the provision of mining services at Boggabri open-cut mine worth an estimated A$900 million commencing December 2011.

The question needs to be asked whether any of the above signed contracts constitute an inherent need or incremental need for the justification of the Boggabri Coal Project in relation to immediate and broader economic community benefits, and whether it constitutes an incremental need for the continuation and extension of an existing project. Additionally, the Environmental Assessment states an increase in scale of operations associated with the mine will bring further efficiencies to the Boggabri Coal Mine (thus reducing, per tonne, the total environmental impact of coal recovered from the project area). This has been stated in the Environmental Assessment as justification for the project, purporting to demonstrate why it is needed.

The Environmental Assessment fails to fully consider community expectations and outcomes of a project of this size. The commercial obligations of a multinational corporation should not be used as justification for the project. The Environmental Assessment should be considered in isolation of any commercial agreements, both current and projected.

Site Suitability

The mine site is contained within an area of White Box Grassy Woodland. This ecological community is specifically identified by the EPBC Act as critically endangered. The Environmental Assessment states there will be significant loss of habitat and displacement of various threatened species. This would make the mine site unsuitable.

The proposed mining expansion is not a natural progression of the intended land use as described under Zone 4 of the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) (BNC Act). The objectives of the BNC Act are to be met by providing:

> (a) to reserve forested land in the Brigalow and Nandewar area to create a Community Conservation Area that provides for permanent conservation of land, protection of areas of natural and cultural heritage significance to Aboriginal people and sustainable forestry, mining and other appropriate uses, and
>
> (b) to give local communities a strong involvement in the management of that land.

The proposed open cut mine site is described as being located between two existing approved mine sites being Tarrawonga to the South and the Maules Creek Project to the North. This is both deceptive and incorrect because the Maules Creek open cut Project (CL375) is yet to be approved. Approval is in place for the Maules Creek (A346) underground project but it is non operational. The Environmental Assessment fails to mention the close proximity of the Maules Creek community, which includes Fairfax Public School, the Maules Creek Recreational Reserve Trust Hall and surrounding amenities, and surrounding Commercial Agricultural Businesses and associated Occupied Residential Dwellings.

Economic, Social and Environmental Impacts

The Environmental Assessment has failed to adequately assess all of the economic, social and environmental impacts associated with the project. The purported application of a stringent, contemporary environmental assessment process failed to identify any significant adverse economic, social or environmental impacts other than the inadequately identified impact on the current ecological value of the Leard State Forest. The shortfalls in the assessment of economic impact contained in the Environmental Assessment are described in detail in Appendix 7, which is a report provided to MCCC by Economists at Large for the purposes of this submission.

In an effort to remain abreast of the increased awareness of climate variability, policy directions and community expectations within the catchment, and to ensure that the Environmental Assessment is both contemporary and vigorous, it should be expected that Boggabri Coal adopt a 'Resilience Thinking' approach to the development of the Environmental Assessment.

Resilience is defined as the capacity of a system to absorb disturbance and still retain its basic function and structure (Walker and Salt 2006). Resilience Thinking has arisen because of current approaches to sustainable natural resource management are failing to deliver on environmental and socio-economic expectations.

They fail because they rely on modelling of average conditions and ignore the impacts of major disturbances. Sustainability and approaches that try to optimise systems fail to recognise secondary effects and feedback that impact on the bigger system. And finally, sustainability approaches fail to recognise that the world as a whole is changing and there is a need be in a position to work with change rather than being vulnerable to it.

Resilience Thinking identifies "Social-Ecological" systems. It assumes that we all live and operate in social systems that are acting on and underpinned by ecological systems. It assumes that people are dependent on ecosystems wherever they are. Social-Ecological systems are complex adaptive systems that do not stay the same, and do not change in linear or incremental ways. Social-Ecological systems can also change states in response to a shock or slow pattern of change. The point at which a system will change into a different state is called a threshold. The attribute of resilience is referring to a Social-Ecological system's capacity to absorb shocks and disturbances without crossing a threshold.

Social-Ecological systems are complex and controlled by multiple variables. However it is usually only a handful of variables that are the critical drivers of change in a system. Within each of these variables there could be a threshold that if crossed, means that the system will behave in a different way. Once a threshold has been crossed, it is usually very difficult to get back to the previous state. When managing for resilience, we are trying to manage to create or maintain distances between where the system is now and where the thresholds might be.

Resilience Thinking looks at two different 'parts' of the resilience of the system. The first part is 'Specified Resilience', which tries to understand the system's resilience to changes that are known about and can be measured. The second part is 'General Resilience', which looks at how resilient the system might be to changes, shocks and drivers that can't be known about or understood before they happen.

Attributes that contribute to General Resilience have been identified as diversity, ecological variability, modularity, an acknowledgment of slow variables, tight feedbacks, social capital, innovation, overlapping governance and an acknowledgment and appropriate pricing of ecosystem services.

The Environmental Assessment should identify potential thresholds of concern that will become immediate priorities for natural resource management intervention. This should provide intervention actions that, if successfully implemented, may ensure that identified critical thresholds are not crossed. The key assets of biodiversity, landscape, water and people need to be included within a conceptual model, to maximise future choices or options going forward. There is a significant link between a functioning natural resource base, economics and the key people functions/values of adaptive capacity and wellbeing.

The challenge for the future is allowing and supporting people to adapt, supporting current agricultural industry whilst providing opportunities for new industries to develop, and maintaining the natural resource base in a way that means decisions now don't limit the choices of options available to future generations. All of this needs to occur in the context of a dynamic system that we can expect to see change, driven by climate, moving policy paradigms and global uncertainty.

The Maules Creek economy underpins the Maules Creek community in that it provides the wherewithal for people to live in the community, but the relationship is a circular one, with the economy being equally as dependent on people. The local economy is also a driver of land use which can have both positive and negative effects on the other assets of water, soils and vegetation leading to its social, economic and biophysical stability.

Conclusion

The Environmental Assessment fails to adequately assess the relationship between economic, social and environmental impacts by failing to provide a conceptual model that utilises the "Resilience Thinking" to identify thresholds, shocks and drivers of change. The basic function and structure of the social-ecological system may be unable to absorb the disturbance of large scale coal extraction and still maintain its basic function and structure leading to a General Resilience threshold breakdown.

Objectives of the EP&A Act

The Environmental Assessment fails to address most objectives of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act). The objectives of the act are reproduced below followed by the MCCC response.

1: *"To encourage the proper management, development and conservation of natural resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment."*

The Boggabri Coal project clearly promotes the economic welfare of Idemitsu Australia Resources, a Japanese owned Australian subsidiary of Japanese Company Idemitsu Kosan Co Ltd.

The project fails to provide a better environment by clear felling 1384.6 Ha of Leard State Forest, which includes White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, a critically endangered ecological community as listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act).

The project fails proper management and conservation of water. The zone of affectation encroaches upon surrounding alluvial aquifers which contain Groundwater Dependent Ecosystems that provide a biological refuge for Stygofauna.

The project fails development and conservation of agricultural lands, by purchasing these lands for biodiversity offsets, removing a portion of these lands from Primary Agricultural Production.

The project fails the economic welfare of the community of Maules Creek by removing access to Leard Forest Road, a road used by local residents for commercial purposes on a day to day basis conducting commercial transport of agricultural produce and inputs. The proposed alternative access via Harparary Road adds considerable distance therefore cost of freight. The project fails the social welfare of the community by purchase of rural land for offsets, permanently removing farming families from the community, and generates fear of the unknown leading to isolation and depression.

2: "*To encourage the promotion and coordination of the orderly and economic use and development of land.*"

The project will result in the illogical progression of existing and future mining developments by failing to set an industry standard of quantitative assessment for cumulative impacts.

The failure to utilise Resilience Thinking to identify key assets, drivers of change and thresholds of key assets could severely impact upon the social-ecological system of the community.

If approved, the Project will encourage other developments within the Gunnedah Basin due to the generalist and inadequate nature of the Environmental Assessment.

3: "*To encourage the protection, provision and coordination of communication and utility services.*"

The closure of the Leard Forest Road (NSC SR-12) by the project expansion fails to provide the protection and provision of utility services. This road is the only access for Emergency Services and Maules Creek residents to and from Maules Creek during Namoi River Flood events. It also provides Emergency Access during bushfires within the Leard Forest.

4: "*To encourage the provision of public land for public purposes.*"

The Project Removes 1384.6 Ha of Crown land for public purposes.

The project provides 1384.6 Ha of Crown land for the private purposes of a Japanese owned corporation. The proposed method of rehabilitation after coal extraction is incapable of supporting native forest as is present, removing any future land use as prescribed under Zone 4 of the BNC Act.

5: *"To encourage the provision and coordination of community services and facilities."*

The Voluntary Planning Agreement (VPA) with Narrabri Shire Council (NSC) in regards to the Boggabri Caravan Park provides facilities for the influx of temporary workers associated with the mining boom within the Gunnedah Basin.

The VPA with NSC for the upgrade of Harparary Road (NSC SR-11) to offset the closure of SR-12 fails to provide a satisfactory provision of facilities due to the flood plains of the Namoi River. Harparary Road cannot be flood-proofed as it is a flood plain. The VPA contains no detail in regards to project costs or scope or when/how these projects shall be delivered and by whom. This leaves NSC and the Maules Creek Community in a vulnerable position.

6: "*To encourage the protection of the environment, including the the protection and conservation of native animals and plants, including Threatened species, populations and ecological communities, and their habitats.*"

The project fails to encourage the protection of the environment by the destruction of all ecosystems within the project disturbance area. The project's biodiversity offsets strategy provides protection and conservation in land title only. The offset areas already contain ecological communities and their habitats. This is why only carefully targeted properties are purchased for offset purposes as they already contain fragment remnant communities such as White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland as described and protected under the EPBC Act and the *Native Vegetation Act 2003* (NSW). The project's Environmental Assessment fails to identify threatened species, populations and ecological communities, and their habitats by the exclusion of stygofauna as found by the University of NSW connected waters team within the Maules Creek alluvial catchment. These alluvial groundwater dependent invertebrates occur within the zone of affectation of the project.

7: "*To encourage ecologically sustainable development.*"

The Boggabri Coal is by nature an "extractive industry" using a "non-renewable resource" (i.e. coal). This is not an ecologically sustainable development. The project is expected to produce 16.94 million tonnes of carbon dioxide equivalent emissions per annum. The Leard Forest as currently exists functions as a carbon sink and is currently ecologically sustainable.

8: "To encourage the provision and maintenance of affordable housing."

The employees at the Project to a large extent have not been engaged and housed in existing facilities. The Project Justification Section 10 at page 186 states: 'specifically the project will result in the economic benefits to the state economy of the following approximate values ~3,675 direct and indirect jobs' of which 1191 will occur at a regional level. We understand Boggabri Coal currently employes 238 permanent and contract employees.

9: *"To promote the sharing of the responsibility for environmental planning between the different levels of government in the state."*

The presence of a critically endangered ecological community within the project disturbance area ensures the Environmental Assessment is referred by the NSW Government to the Commonwealth Department of Sustainability, Environment, Water, Populations and Communities for determination under the EPBC Act.

10: "*To provide increased opportunity for public involvement and participation in environmental planning and assessment.*"

The MCCC was not identified as a stakeholder within the Environmental Assessment, which demonstrates a lack of commitment in regard to public involvement and participation. The Maules Creek Recreational Grounds and Fairfax Public School have continually been omitted from impact assessment maps by not centring the project area, or using adequate scale to include the district. This is deceptive for those unfamiliar with the geographic features of the area.

Conclusion

The Project encompasses the systematic progression of the exploitation of the open cut coal resources by a privately owned foreign company in the Leard State Forest, which is public land. There is an implied trust by the public that our government will conserve our publicly owned forests as functioning forests for their ecosystems and biodiversity for this generation and the generations to follow.

The Environmental Assessment fails to meet the objectives of the EP&A Act by providing misleading documentation, outdated ecological assessments, misleading and contradictory statements and omission of current research. The project described as Option 7 (Project Mine Plan) is unjustified due to the following reasons:

- Conflict with the objectives of the EPBC Act.
- Conflict with the objectives of the Brigalow and Nandewar Community Conservation Area Act 2005.
- Inadequate land rehabilitation post open cut mining.
- Inadequate groundwater modelling under the Murray Darling Basin guidelines checklist.
- Nonsensical biodiversity offsets strategy.
- Lack of quantitative assessment of all impacts including cumulative impacts.
- Lack of utilisation of Resilience Thinking to the issues of key resource management.
- Disregard for community concerns regarding the closure of the Leard Forest Road.
- Lack of information regarding connectivity between alluvial/bedrock aquifers.
- Inadequate workforce and housing assets to accommodate the planned expansion.
- No mention of groundwater dependent ecosystems.
- Effect of total greenhouse gas emissions from project not specified.
- Inadequate description of all future Boggabri Coal plans within the Leard Forest lease.

Alternatives to the Proposed Project

The MCCC believes serious consideration should be given to the other options mentioned in the Environmental Assessment. These other options have not been fully investigated in the Environmental Assessment.

The development of an underground longwall operation has been described as Option 6. Whilst this development also contains environmental risks, the underground option may alleviate some of the identified problems associated with an open cut operation. Option 6 uses the argument of coal sterilisation as a reason for Boggabri Coal preferring the open cut mining method to the longwall mining method. However this would seem flawed due to the higher efficiencies of longwall compared to open cut. The WDS Consulting report in the Environmental Assessment states (Volume 2 Section 3 page 19):

"While it is unlikely to recover anywhere near the reserves of the open cut, a longwall mine would produce with significantly less energy input. While outside the scope of this report, it would be an interesting further exercise to calculate the total energy balance between the two options. At the end of mining, the difference between the two in terms of nett energy produced may not be that different. The likely impost in forth coming years of an emissions tax (ETS) will add further beneficial weight to the underground option with significantly less energy input and overall production of greenhouse gases."

The MCCC would argue that this so-called 'interesting further exercise' should be mandatory for all open cut developments, and strongly recommends that this study should be completed before the Project Application is considered further.

It is our view that due to the long term and complex nature of the mining potential of the Boggabri Coal reserves and the relative short term nature of the lease period (21 years) there is incentive for Boggabri Coal to present a piecemeal group of projects without the overall strategy being considered by the Department of Planning. The 'cumulative effects' of the numerous staged projects within the Boggabri Coal reserves have not been properly explained and therefore cannot be properly assessed.

The preliminary underground mining report indicates that underground coal mining will be used by Boggabri Coal. The report states that once open cut operations are complete, Boggabri Coal intends to use underground mining to access the much deeper Templemore and Tarrawonga seams. In addition the undeveloped lease that the company holds in the Leard State Forest (A339) does not hold surface rights and underground mining will be required to access this reserve.

It is our view that a proper plan that considers all the reserves and the complete company strategy for the Boggabri Coal reserves is what should be submitted to the Department of Planning. Boggabri Coal's preferred Option 7 plan is about minimising extraction costs to the company and using low cost offsets to bolster this position. There is an element of cost shifting whereby the community picks up the tab for environmental and community impacts while mining costs are minimized.

Recommendations

- The Department of Planning should reject the Environmental Assessment due to the inadequate nature of the assessment in considering all potential social-ecological consequences of an expanded open-cut mine operation within the Leard Forest.
- The Department of Planning should require the Environmental Assessment meet the objectives of the BNC Act 2005 and the EP&A Act before Determination of the Project Application can proceed under part 3A of the EA Process.

Air Quality and Greenhouse Gases

Key Issues and Concerns – Green House Gases

Our GHG submission shows that the Boggabri Coal project mining operations make a significant contribution of an additional 1% of all NSW GHG emissions. If GHG emissions from the burning of coal produced at the Boggabri Coal mine where accounted for in the NSW emissions, these emissions would be the equivalent of 25% of the NSW Kyoto target. Increased GHG emissions have been shown to directly contribute to extreme weather events and changes in climate. The mining of coal in the Maules Creek area will directly contribute to the climate change problem that we are leaving to our children. As farmers our environment and our livelihood is directly impacted by severe weather and climate change. Our future generations will continue to pay the price long after mine closure and Idemitsu has moved on.

A full explanation of our GHG concerns are provided Appendix 4, which is a report prepared by Dr Ian Lowe.

Key Issues and Concerns – Impacts on Air Quality

Open cut mining has well documented health, agricultural productivity and social impacts due to a general reduction in air quality. The introduction of a drag line will exacerbate these concerns. It is essential for ongoing sophisticated real time air quality monitoring to reduce long term company - community conflict. To minimize this potential the MCCC has submitted a list of “principles” described below to guide the development of an extensive Air Quality Monitoring Network for the area. These “principles” have been passed on to Boggabri Coal and Aston Resources to outline the community’s position on the network. It is important that these detailed list of principles be included in any DOP consent for this project.

Proposed Air Quality Monitoring Network

An air quality monitoring network (the Network) should be established in the Maules Creek / Boggabri area.

Purpose of the Air Quality Monitoring Network

The Network should enable the various government agencies, local residents and other stakeholders to view the air quality of the Maules Creek area generally and in the immediate vicinity of the individual mines. The Network should be expandable to Gunnedah, Caroona and beyond as required.

The real time nature of the data should enable day to day tactical operational procedures (including temporary cessation of mining activities) to ensure air quality is maintained at or above minimum standards and help to identify mining practice change should it be deemed necessary. Clearly defined trigger levels should be set at various locations to help identify the need for remedial activities. These levels would be set by DECCW is conjunction with the mines and local community and be reviewed annually.

Minimum Requirements

Based on the purpose of the Network described above, the minimum requirements to ensure accurate, timely and independent date collection and analysis are as follows:

Data Collection and Ownership

- The air quality monitoring data should be gathered by automatic, electronic, wireless monitoring stations.
- The air quality monitoring data should be collected and displayed in real time.
- The information should be displayed over various cumulative periods (e.g. 1 hour, 1 day, 1 week).
- Data should be kept indefinitely so that historical comparisons are able to be made (e.g. year on year).
- The data should be owned by DECCW or an independent authority.
- The data should be shared to the public via a link on the DECCW website.
- Ambient weather data specific to key locations within the network should also be available.

Type and Location of Monitoring Equipment

- The equipment should be designed to capture a range of particulate material and noxious gases.
- There should be a mix of equipment (e.g. PM 10, PM 2.5, PM 1.0) and blast gas monitoring equipment.
- The equipment should be located around each mine so as to capture the source of the dust or gas before the dust or gas leaves the mine site.
- Additional equipment should be located around the district in order to capture air quality levels outside the Maules Creek mining precinct to enable comparison.

Cost

- The air quality monitoring equipment capital and operational costs should be paid for by the coal mines. This would include the costs of repairs and periodic calibration.
- The cost of development and ongoing maintenance of the air quality website should be paid for by the mines and outsourced to a specialist third party.
- The costs should contain a mix of fixed and tonnage based levies to allow for expansion of the Network should there be a increase in capacity of the mines or a necessary increase in the level of service.
- Co-ordination of the repairs and maintenance should be done by DECCW.
- Co-ordination of expansion of the network should be done by DECCW.
- Minimum service levels on equipment (e.g. 24 hour maximum downtime) should be specified.

Reporting

- Quarterly reporting by DECCW of summary air quality information including breaches and remedial activities.
- Equipment status should be available online at all times.

Recommendations

- Require Boggabri Coal to participate in establishing an air quality monitoring network as described above.
- The GHG emissions of the project should be considered in terms of its contributions to overall NSW emissions and Boggabri Coal should be required to offset these emissions in the voluntary emissions trading market.

Ecology and Biodiversity Offset Strategy

Key Issues and Concerns – Biodiversity Impact Assessment

A full review of the biodiversity impact assessment is contained in Appendix 1, which is a submission provided to MCCC by The EnviroFactor Pty Ltd. A brief summary of the concerns raised in the review are set out below:

- The existing Boggabri mining operations was exempt from the provisions of the Commonwealth EPBC Act and only the extension was referred. This was considered inappropriate as the entire project would impact on "Matters of National Significance".
- Threats to the importance of the Leard State Forest as large remnant in the Brigalow Bioregion.
- Simplistic and misleading analysis of existing remnant vegetative cover in the region.
- Offset strategy of linking highly fragmented small remnants in an extensively developed agricultural landscape is not an effective offset for clearing 1,384 Ha of a large contiguous remnant block.
- Significant impacts for a number of threatened species and ecological communities including:
  - Box –Gum Woodland – TSC and EPBC Act
  - Eight species of woodland bird – for which the area forms "core habitat" – *Threatened Species Conservation Act 1995* (NSW) (TSC Act)
  - Regent Honeyeater – TSC Act and EPBC Act
  - Three species of hollow-dependent microchiropteran bat – for which the area forms 'core habitat' - 3xTSC Act and 1x EPBC Act.
- A number of threatened species whose distribution matches the project area have been excluded from assessment based on a lack of suitable habitat present within the "study" area.
- Exclusion of all threatened species of fish on the basis of a lack of records and no preferred habitat within the study area is not consistent with DECCW Threatened Species Assessment Guidelines.
- An underestimation of the area of the aquatic Ecological Community of the Natural Drainage System of the Lower Darling.
- Loss of a significant area of habitat for hollow-nesting birds.
- Loss of a significant area of foraging habitat for cave dependent bats.
- Presence of an important population of the Superb Parrot.
- Loss of important habitat for migratory and/or nomadic species.
- Failure to consider the Pre-cautionary Principle.

No assessment has been undertaken of the potential impact of the proposal on a unique suite of stygofauna known to be associated with the groundwater in the Maules Creek catchment and potentially Leard State Forest.

Key Issues and Concerns – Biodiversity Offset Strategy

Community expectations have changed in recent years, leading to a renewed focus of how environmental impacts associated with open cut coal extraction should be managed. The Environmental Assessment outlines the strategy to offset the loss of ecological communities within the project disturbance area. The NSW Coal and Gas Strategy Scoping Paper (February 2011) (Scoping Paper) will be used as a format for this section of the submission.

*Emerging Community Conce*rns (page 4 of the Scoping Paper)

As a consequence of the buoyancy of the mining industry, concerns are emerging within the Maules Creek community about environmental and land use impacts associated with the growth of coal mining. This includes criticism of the environmental assessment of certain aspects of mining projects including cumulative impacts, biodiversity offset strategies and the adequacy of the policies, standards and guidance provided by Government. The Boggabri Coal offset strategy clearly fails sound environmental scrutiny in regard to providing genuine ecological community replacement for the areas of project disturbance.

Gunnedah Basin (page 7 of the Scoping Paper)

Development of the Gunnedah Basin is likely to be focused on three distinct areas. The Maules Creek community is focused on the area around and within the Leard State Forest, which could become a major open cut mining complex within the next 10 years.

The Scoping Paper states:

> "While this growth will represent an increase over current production rates, coal mining is expected to be a relative minor land use within the broader basin"

However 1384.6 Ha of the Leard Forest within the Boggabri Coal disturbance area, and 5450.8 Ha if the Maules Creek Project is included constitutes a major land use of the total 8136 ha Leard Forest area.

Key Issues (page 8 of the Scoping Paper)

- Management must include potential cumulative impacts of mining within the Leard State Forest.
- Biodiversity and ecological communities must be recognised and preserved.
- Rehabilitation must seek to be an 'improvement' of what is removed to gain any environmental benefit from the project.

Key Initiatives of the Strategy (page 9-10 of the Scoping Paper)

The NSW Coal and Gas Strategy and the Boggabri Coal Environmental Assessment should address

- World's best practice mine/land rehalilitation.
- An integrated regional approach to setting rehabilitation objectives.
- Strategic regional biodiversity planning.
- Recognition of unique bio-ecosystems and the positive functions that they contribute.

Conclusion

Both the Maules Creek community and the NSW government recognise the problems associated with large scale coal projects. The release of the Scoping Paper is a response to these community concerns.

The inadequacy of the Boggabri Coal biodiversity offset strategy has been described within this submission (refer the Project Justification section Appendix 1).

Key Issues and Concerns – Wildlife Corridor

1,384.6Ha of Leard State Forest will be impacted by Boggabri Mine: 624.9ha of this comes under the Threatened Ecological Communities. However, while the Boggabri Mine impacts the Leard State Forest, it should be noted that the cumulative impact of the mining projects in the area will impact 5,450.8ha of the possible 8,136ha of the vegetation within the Leard State Forest.

The offset strategy has not yet been completed and there is a reference to 'potential offsets' in the zone of affectation (ZOA) which have not been fully researched. For example, one of the 'Potential Offsets' in the ZOA (site 12) Vol 4 Appendix J page 44 BOS:

> "Provides a valuable link between large natural vegetated lands to east and west and the Namoi floodplain". At this stage is not owned by Boggabri Mine, and would be included in, and form part of the 'Wildlife Corridor" if purchased by the mine. This 'Potential Offset' still 'requires detailed field investigation to accurately determine biodiversity values' to offset habitat for Threatened owls and hollow dependent microchiropteran bats (table 3.4 Biodiversity Offset Strategy Vol 4 Appendix J page 44).

If the property remains privately owned it may leave a gap in the Wildlife Corridor, which may cause an increase of Wildlife activity across this property causing undue influx of animals, both native and feral, which could cost the landowner both in terms of time and money to control due to increased feral and native damage to cropping and grazing destruction.

Many of the properties in the ZOA have been targeted as potential offsets, and will be used to create a corridor for wildlife from the East to the West.

It is to be noted that part of the ZOA includes the proposed rail line and the proposed East-West Wildlife Corridor. If this is to be a genuine Wildlife Corridor then the real threat of injury as well as the noise aspect must be given consideration. The native wildlife safety must be taken into consideration.

With the expected increase in volume of coal extracted over the next 21 year period, including the cumulative effect of another possible rail line, the South-Eastern end of the Wildlife Corridor would be more of a congested interlinking of rail and road rather than a safe Wildlife Corridor. This Wildlife Corridor may be suitable for birds, but totally inappropriate for ground dwelling fauna that would have to cross the Newell Highway, if it is to link the East-West.

A detailed report that relates to impacts to the ecology of Leard State Forest and the wider region was provided by provided the EnviroFactor Pty Ltd is contained in Appendix 1.

Key Issues and Concerns – Koalas and Koala Habitat

The Environmental Assessment makes the following representations regarding koala numbers:

- "A single living koala was recorded in the Project boundary during field surveys." (Refer Conclusion – page E-143 App J)
- "Two koalas were observed during systematic searches for this species within the Boggabri Coal Project Boundary." (This was during a search for koala faecal pellets, refer page 32 Cumulative Impact Scenario for Biodiversity App. J)

The Environmental Assessment makes the following representations regarding koala habitat:

- "No records of koala habitat use occurred outside the Boggabri Coal Project Boundary (i.e. remaining Leard State Forest)" (refer page 32 CIS for Bio. App J)
- In respect of koala habitats within the Leard State Forest and its locality – "potential koala habitat survey was completed over 166 SPOT survey sites within the Leard State Forest (Parsons and Brinckerhoff 2010b). This study assessed a total of 2,858 trees, comprising nine species of Eucalyptus and one species of non-eucalyptus (figure 3-8)."
- Evidence of habitat use by koalas (i.e. presence of koala faecal pellets) was recorded in five of 166 survey sites (refer page 32 part 3.5 CIS for Bio. App J).
- Within Leard State Forest, only secondary food tree species for the western slopes and plains koala management area were recorded. However, E. camaldulensis, which is listed as a primary food tree, was recorded in a small section of the proposed rail corridor along the Namoi River (Vol 4 Appendix J page 33 CIS for Biodiversity).

The Environmental Assessment also states in respect of the koala breeding population:

> "Furthermore, if there is a breeding population present within the Project boundary, this population is not likely to be significant in light of area of habitat utilised and other more robust populations recorded in the Pilliga forests".

There may be robust populations in Pilliga and Gunnedah, but until a full survey and not just a pilot study on habitat with the aid of modelling is done, the actual koala population in Leard State Forest will not be revealed. A full study should include comprehensive surveys carried out during breeding season when the koalas are more active and audible.

Furthermore, it is not the number and size of existing koala communities that is necessarily conclusive as to whether the Environmental Assessment would impact on the ongoing viability of the koalas in and around the Leard State Forest. Communities of koalas, no matter how small should be protected to ensure biological diversity stated in Regulation 3 of the State Environmental Planning Policy No. 44 – Koala Habitat Protection (Koala Habitat Protection Policy):

> This Policy aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline:
>
>> (a) by requiring the preparation of plans of management before development consent can be granted in relation to areas of core koala habitat, and
>>
>> (b) by encouraging the identification of areas of core koala habitat, and

(c) by encouraging the inclusion of areas of core koala habitat in environment protection zones.

Recommendations

- The Boggabri Coal biodiversity offset strategy should replace removed vegetation communities with newly established like for like greenfield habitat areas. The purchase of the identified offset lands does not provide new habitat for displaced flora and fauna.
- A more intense survey (the habitat survey was a pilot study and used predictive modelling) there should be more on the ground surveys carried out during breeding season when the koalas are more active and audible. Furthermore, a full plan of management should be prepared to conserve the koala habitat in accordance with the Koala Habitat Protection Policy.

Groundwater

Key Issues and Concerns

One of the chief concerns of the Maules Creek community is impacts to groundwater. These concerns have been voiced long before the commencement of operations at the Boggabri Coal Mine. Ground water has been over allocated, (Sinclair et al 2005). These concerns have been heard by the relevant authorities and led to an increase in the number of groundwater monitoring bores in the district, the development of real time data logging, cease to pump triggers for downstream water users and a detailed study by the University of NSW Connected Waters Team funded by the Cotton CRC. The UNSW team has developed an entirely new way of looking at the mapping of underground flows based on the Maules Creek data. Members of the team have presented their research findings at ground water conferences all around the globe.

In particular the UNSW report notes a long term trend of reduced ground water levels, with falls of 3 to 4 meters over the past decade notwithstanding the seasonal variations. The report paints a picture of an over stretched aquifer that must be properly managed if levels are to stabilise. Management options such as cease to pump triggers were implemented and this caused conflict within the community that continues to this day.

It is expected Boggabri Coal will impact on the groundwater of the Maules Creek area by intercepting alluvial and coal seam aquifers and diverting ground water for use in dust suppression and coal washing. It is highly important that proper metering of all pumps used to extract ground water be installed and monitored.

In addition, page 144 of the Environmental Assessment states that there will be alluvial aquifer loss and a reduction in water levels due to reduced flow from the coal seams into the alluvial seams of up to 1 meter. Secondly there could be reductions in the ground water due to depressurization of up to 1 meter. Thirdly, the Ground Water Report the cumulative effect of Maules Creek Mine will cause a loss of water from the system in the long term, beyond 100 years, due to evaporation from the final void. Fourthly, as shown by our soils report, due to changes in the geological structure of the soil on the mine site, it is likely that recharge will go into different aquifers at different rates when compared with the natural rates and paths for recharge.

We note that our Soils Report (refer Appendix 3) shows that estimates of diversions in surface water flow are in the order of 721 ML per annum. This water is lost to the wider community for environmental and food production purposes.

It has been demonstrated in the Gins Leap Gap Report (KLC Environmental, 2010) Major Finding 6 that flows from Zone 4 into Zone 5 via the Gins Leap Gap no longer occur to any natural extent. The water that flows in the Zone 11 Maules Creek aquifer is the major source of water flowing into Zone 5 and thereby is of critical importance to the irrigators operating in Zone 5 from The Gap to Narrabri.

With the districts history of water issues and our current concerns as to a new demand placed on the Maules Creek aquifer by Boggabri Coal the MCCC commissioned Water Resource Australia to do a peer review of the ground water modeling contained in Appendix O in the Environmental Assessment. The conclusions are shown below and they indicate a number of issues that cast doubt on the validity of the modeled results.

> "Using the MDBC guidelines checklist, the modelling is found to be deficient and/or lacking in the areas of calibration, verification, sensitivity analyses and uncertainty analyses – each to varying degrees. The end result is no demonstration or basis, other than conservative assumptions by the modeler, by which to have any real confidence that what is being provided is the best estimate or even worst case. Therefore, the usefulness of this model is to

> a large extent unknown as the reader is left to accept a lot of what has been done on faith rather than demonstrated ability."

The recommendations for the peer review are;

- The cumulative impact assessment should consider the declining water levels within the alluvial systems along with the impacts of the surrounding mines as currently presented.
- A clear method for identifying mining related loss of well/bore yields from background yield losses should be defined up front to eliminate any confusion or difficulties after the fact.
- It is noted that a recommendation is provided for reviews of the monitoring data and model accuracy every 5 years. This is the fifth year of current operations and as such it would seem reasonable, based upon their own recommendation, for such a review to be conducted now as part of this submission.

Because of the concerns raised in the peer review, the MCCC has no confidence in Boggabri Coal's conclusions that alluvial aquifer loss would cause water levels to be "reduced by less than 1 m and this would not be detectable from seasonal variation". Further assertions as to the cumulative losses due to the depressurization effect of up to another meter are also open to question.

As further evidence of the lack of data we would note that Boggabri Coals own report contained in the Underground Study Appendix C on page 10-4 state that "details on the hydrology of the Boggabri Deposit are limited".

As Maules Creek residents rely so heavily on ground water for stock and domestic water, the MCCC believes that the findings of the Namoi Catchment Water Study should be included as evidence to substantiate the conclusions of the Boggabri Coal ground water and surface water impact assessments.

It is not sufficient in our view to infer that because the coal mining companies have, or will have purchased land in the zone of affectation these impacts are not important. Much has been made of the temporary nature of mining in our district and the MCCC is anxious that no permanent impacts to the community and the environment in the long term should occur. It is highly desirable that our community is able to be rehabilitated after the closure of the mines and ongoing water resources are fundamental to that rehabilitation.

Beyond community concerns of ground and surface water impacts, environmental concerns regarding water quality and quantity have not been fully considered in the Environmental Assessment. Due to the connectivity of the coal seam and alluvial aquifers, it may be expected that changes in water chemistry and water quantity will occur as the flows from the coal seam to the alluvium are reduced. These two impacts will have detrimental impacts on the stygofauna that have been identified (see Figure 1) by the UNSW Connected Waters Team in Maules Creek and Back Creek and their aquifers.

Figure 1. Stygofauna from the Region. Anderson M.S. 2008.

Recommendations

- All extractions from the Boggabri Coal pit be metered and a detailed accounting be made of water taken from alluvial, coal seam and surface flows.
- Revisit the Ground Water Model methodology in relation to the issues raised in the Peer Review.
- Await the findings of the Independent Namoi Catchment Water Study to understand catchment wide impacts of the Boggabri Coal mine. Use these findings to do an economic assessment on the impacts to irrigators in Zone 5.
- Undertake detailed study of Stygofauna and other Groundwater Dependent Ecosystems in the vicinity of Goonbri Creek, Back Creek and Maules Creek.
- Alienation of surface water run-off to the Namoi River catchment should be compensated for via the purchase of surface water diversion licenses.

Economic and Social Impact Assessment

Key Issues and Concerns – Economic Impact

The economic impact assessment included in the Environmental Assessment has failed to adequately assess all of the economic, social and environmental impacts associated with the project. The purported application of a stringent, contemporary environmental assessment process failed to identify any significant adverse economic, social or environmental impacts other than the inadequately identified impact on the current ecological value of the Leard State Forest.

The MCCC has engaged Economists at Large to provide an opinion on the economic impact assessment in respect of these concerns. Please refer to Appendix 7. The summary and conclusion of this report is contained below.

Economists at Large have found several issues that call into question aspects of the analysis presented by the Environmental Assessment. These issues are:

- No economic analysis of scenarios have been undertaken other than cessation of mining in 2011 and a 21 year, open cut extension despite seven alternative scenarios being mentioned in the Environmental Assessment.
- Mixing of private financial values and public economic values within the cost-benefit analysis.
- Miscalculation and/or omission of external costs and benefits.

The result of these issues is the Environmental Assessment (the cost-benefit analysis and then carried on into the economic impact assessment) present values that inflate public benefits and underestimate public costs. The Environmental Assessment seems to avoid discussion of distribution of benefits between stakeholders and fails to assess all alternative methods of expanding this mine.

In summary, the overstatement of benefits and understatement of costs of the project means the modelling results for the economic impact assessment are heavily compromised and should not be used for decision-making purposes.

Key Issues and Concerns – Social Impact

The local and regional population statistics in the Environmental Assessment makes no mention of the people that the proposed mining operations will impact the most – that is the farming community that have lived and worked on their properties in the district for generations; except to mention that there are private landowners near the Project Boundary and adjacent to the existing haul road and load out facility, and others at least 2 km from the active mining area. There is no consideration of the real ‘locals’ that live next to the mine and in the surrounding districts which includes and will impact the Maules Creek community.

The term ‘local community’ is used throughout the Environmental Assessment, and as stated on page 2:

> “due to the remote location of the site, the assessment of local social impacts associated with the project has focused on the ‘Narrabri’ and ‘Gunnedah’ LGAs.”

Both Narrabri and Gunnedah are in the local ‘district’ but the immediate impact of the mine will be on those who live and operate businesses in the immediate vicinity. This immediate impact has not been adequately addressed in terms of the social impacts resulting from the following areas of concern:

- air quality;
- acoustics impact (on stock and nearby residents);
- visual impact;
- surface and groundwater impact (possible loss or reduction of bore water on farms);
- traffic (increased road traffic and rail traffic that will increase over the life of the mine to accommodate the 20 plus Mt/pa from the cumulative effect of the 3 or possible 4 proposed mines); and
- ultimate change to the biodiversity (displacement of fauna especially kangaroos from the Leard State Forest impacting on crops and grazing land).

The Environmental Assessment overlooks the surrounding farming and grazing ‘stakeholders’ and appears to consider them as biodiversity offset prospects, or interconnecting wildlife corridors that will replace the fallen endangered communities impacted by the proposed mining operations. The social and emotional welfare of the Maules Creek community has not been taken into account or mentioned in the Environmental Assessment.

One of the core objectives of the National Strategy for Ecologically Sustainable Development (NSED) (described above) is

> “to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations.’”

Although the mining industry generates economic growth, it is the sustainability of our ecosystems, and ability of our future generations to have the resources to produce our agricultural products that will ensure our future.

Key Issues and Concerns – Stakeholder Engagement

Despite indications in the Environmental Assessment of exhaustive stakeholder identification and engagement the MCCC has not been recognised as a stakeholder in the Boggabri Coal Environmental Assessment. Community concerns raised in public meetings organised by the MCCC and in the media have also been omitted.

The MCCC has been proactive in seeking discussions with Boggabri Coal, the Narrabri Shire Council and Aston Resources (the proponent of the proposed Maules Creek Coal Mine). The MCCC has been vocal in the local media re our engagement with the various mining and gas companies.

The MCCC has met with Boggabri Coal on two separate occasions and has been involved in lengthy discussions concerning the alternative route to the Leards Forest Road and an agreed “in principle” solution was presented to a full Narrabri Shire Council meeting on the 17 August 2010. A resolution was passed by the Narrabri Shire Council for the Mayor and staff to meet with Boggabri Coal to “seek a commitment from Boggabri Coal that a deviation of SR 12 through or adjacent to Leard State Forest be constructed and maintained throughout the closure period”. Notwithstanding, the Environmental Assessment seeks approval to close the Leard Forest Road. This action by Boggabri Coal demonstrates a very limited commitment to stakeholder engagement.

As discussed above, it is very important for the MCCC and the residents and of the Maules Creek community to be identified as stakeholders due to their close proximity to the proposed mining operations. It is expected the proposed mining operations will seriously reduce the population of the

Maules Creek community, leading to further consequential impacts. Closure of roads, reduction in school student enrolments, fewer people to work in the community's organisations such as the CWA, Bush Fire Brigade etc, reduction in agricultural output, migration to overcrowded cities. It is a widely held belief that these zone of affectation and offset farm purchases will never be re-populated and that the mine workers will be based in larger towns such as Gunnedah and Tamworth or be fly in fly out. Any social benefits are limited to these towns and cities and are not shared with local people.

Key Issues and Concerns – Property Values, Farm Productivity and Housing Affordability

Under the Environmental Assessment preparation process, stakeholder engagement has been undertaken with near neighbours and the wider local community. As a result of this process property devaluation was identified as a key area of concern.

It is understood the Economic Impact Assessment prepared by Gillespie Economics as part of the Environmental Assessment has factored the cost of acquisition of 28 of the most severely affected properties as identified by the air quality and acoustic impact assessments. A further 58 properties have been identified as likely to receive minor to moderate levels of noise however the report assumed this would not negatively affect property values.

Decline in Rural Property Values

At a local level concern is held that remaining properties not identified for possible acquisition by the mine will suffer a loss in amenity and liveability as a result of the proposed expanded mining activities. This concern is well justified as these surrounding properties are likely to experience in varying degrees the many undesirable side effects of mining such as visual impacts, increases in airborne dust, noise pollution and possible interference and de pressurisation of aquifers. Any one or combination of the above affects is likely to adversely affect the saleability and value of the properties concerned. When the cumulative impacts of the proposed Aston Resources Maules Creek Coal Project and others are also considered it is not unreasonable to expect that properties located outside the proposed area of acquisition and beyond the 58 additional properties identified could suffer more severely from these affects than has been considered in the Environmental Assessment. These expected future impacts are a likely contributing factor in the depressed and uncertain property market currently being experienced.

Competing Land Use

As a result of mine activity and increased population concern is held that land traditionally used for the purpose of continuing agricultural production is instead purchased for alternative uses. Examples include mining biodiversity offsets, rural subdivisions, and small to medium properties purchased for the purpose of accommodation and lifestyle. The result is the emergence of a "multifunctional agricultural land market" with existing or prospective owners of rural enterprises having to compete against buyers who are not motivated by the underlying productive capacity of the land (Reed & Kleynams, 2010). Bona fide purchasers of agricultural or grazing land are in effect squeezed out of the market as these activities are no longer economic on a stand alone basis under higher land prices.

Farm Productivity

The unsaleability of properties directly affected by mining is likely to force an already aging farming population to work longer rather than the usual process of selling to a younger generation and retiring. In addition to the obvious health and safety implications it could also be expected productivity from these properties will decline as current owners struggle with workload. The next generation of younger farmers will find it difficult to purchase unaffected productive agricultural land as a direct result of competition for alternative land use. In effect mining is likely to seriously inhibit the process of intergenerational change of farming enterprises within the local area.

The loss of land to above mentioned competing land uses will also result in a decline in farm productivity. This is particularly evident where land is purchased for the purpose of lifestyle or biodiversity offsets. Under the planned offset strategy useful grazing land will be permanently removed from production in order to offset the destruction of forest at the mine site.

Of further concern is any loss in productivity as a direct result of environmental damage caused by mining. Interference and de pressurisation of water aquifers will have dire consequences to local water users who may be forced to permanently reduce livestock numbers or completely de stock during drier periods. Similarly the inundation of pasture or crop with airborne dust can lead to production losses. The Environmental Assessment has failed to consider the loss in agricultural production as an economic cost under the cost benefit analysis.

Shire Rate Increases

Disproportionate increases as a result of properties purchased for accommodation and lifestyle resulting in a cost burden to bona fide rural enterprises.

Housing Affordability

Failure of local government and mining companies to adequately plan for increased housing demand has resulted in the emergence of common theme across a number of mining towns and regions being the under supply and high cost of suitable housing (Haslem-McKenzie et. al, 2009). The Bowen Basin region located in Central Queensland is a relevant example of the impact mining operations have had on local housing affordability. It has been found that mining towns located in this region have had an insufficient supply of permanent accommodation which has resulted in median rental increases between 160% and 394% between 1998 and 2008. This is in comparison to the states capital of Brisbane which saw an increase of 100% for the same period (Petkova et. al, 2009).

The Environmental Assessment in its present form points to the significant potential supply of residential land as derived from the Narrabri Shire Draft Growth Management Strategy 2009. Whilst it is acknowledged land could be available concern is held whether suitable housing will be available in time to coincide with the increased production of the Boggabri mine and the development of the Aston mine and others at a similar time. The term housing is relevant for it is most unlikely workers will purchase land and build a residence prior to commencing employment at the mine. It is also a reasonable assumption that a significant proportion of workers will only ever require rental accommodation which may also include their families for which there is already a short supply in this area. The displacement of disadvantaged and lower income rental occupants to higher earning mine workers should accommodation shortages be realised is a major risk and requires further investigation.

Key Issues and Concerns – Voluntary Planning Agreement

In addition reference is made to the Voluntary Planning Agreement that has been mentioned in the Environmental Assessment. The Environmental Assessment makes general statements as to the commitments and Mr Keech's submission also recommends proper specification of these commitments.

The MCCC has obtained a submission from Paul Keech, former Director of Engineering Services at Narrabri Shire Council. Mr Keech's submission outlines the uncertainty and lack of specific details or plans around the Voluntary Planning Agreement in the community. Please refer to Appendix 5.

Recommendations

The Environmental Assessment in its present form has failed to adequately address the economic and social issues associated with the proposed mining operations. In particular the cumulative effect of all proposed mines needs to also be taken into consideration and included in the cost benefit analysis.

Further investigation and assessment should be undertaken in the following areas:

- The economic impact assessment should be revised to properly address the issues raised by Economists at Large in Appendix 7. In particular, environmental costs and community costs should be quantified, costs and benefits should be identified by stakeholder and the alternate project options should be fully analysed.
- The social and emotional welfare of the Maules Creek community should be assessed, as opposed to the more general impact on the Narrabri and Gunnedah local government areas.
- The MCCC should be added to the list of stakeholders and be consulted at appropriate times.
- Prior negotiations with Boggabri Coal regarding alternate routes to the Manilla Road should be acknowledged by in the Environmental Assessment and further negotiations as to an alternative route be progressed. A condition as to the timing of the closure of the Leard Forest Road should be made once a suitable alternative to the community has been provided.
- An assessment should be done as to the cumulative impact that all existing, expanded and proposed mines will have upon liveability, amenity, saleability and value of properties outside the current proposed area of acquisition. This should include properties located beyond the northern boundary of the project which are likely to suffer the combined impact of Boggabri and proposed Aston Resources Maules Creek Project.
- Investigate the impact of changing use and value of rural land will have on the viability of agriculture within the area. This should consider interference to intergenerational change and the economic cost of declining farm productivity.
- Consideration of the loss in farm production as a result of environmental damage (water/dust) as a direct consequence of cumulative mining impacts.
- A more detailed study of housing access and affordability taking into consideration the cumulative impact of the additional mining operations yet to be developed and anticipated time required to develop additional residential accommodation.
- The Applicant is required to prepare detailed designs and subsequently construct improvements to
    - Boggabri Caravan Park
    - Boggabri Swimming Pool
    - Harparary Road (and Culverts replacing Causeways)
    - Harparary Road Bridge

  to the satisfaction of the Narrabri Shire Council and the MCCC, prior to the closure of the Leards Forest Road's current alignment through the mining lease site.
- Boggabri Coal is required to make a financial contribution to the Narrabri Shire Council based on detailed designs prepared by Boggabri Coal, sufficient to allow the Council to gravel and seal the unsealed section of road along the Harparary Road from the Leard Forest Road to the Kamilaroi

Highway, prior to the closure of the Leard Forest Road's current alignment through the mining lease site.

Soils and Land Use

Key Issues and Concerns

The Environmental Assessment does not adequately address several important environmental issues relating to soils and land use. It appears existing published information has largely been ignored and to some degree the methodology and interpretations of soil information were not to Australian common standards. This information is critical in redesigning the rehabilitation program to return the White Box Grassy Woodland environment back to its pre mining condition.

The MCCC has engaged SoilFutures Consulting Pty Limited to provide an opinion on the Environmental Assessment in respect of these concerns. Please refer to Appendix 3.

Recommendations

- A new soil survey should be completed that includes all available soil information in order to develop a rehabilitation strategy that will result in the regeneration and replacement of the critically endangered White Box Grassy Woodland community's that are currently being cleared by the project.
- Purchases of offset land should be restricted to that with soil types similar to Leard State Forest., i.e. undulating landscapes with native plant and animal assemblage habitats that are derived from Permian Coal measure derived soils. This land should provide a "like" for "like" offset.
- Once the new soil survey and associated modelling is complete the results should be investigated to ensure that impacts of changes to water runoff, recharge, water table levels and groundwater chemistry are considered in relation to the Stygofauna that has been identified in the aquifer, creeks and streams in the vicinity of the project.
- Alienation of surface water run off to the Namoi River catchment should be compensated for via the purchase of surface water diversion licenses.

Rehabilitation and Final Landform

Key Issues and Concerns

The final land form is an opportunity to add value to recreational possibilities for the future residents of Maules Creek. The submission obtained from Paul Keech Maules Creek contains recommendations as to the rehabilitation and final landform. Please refer to Appendix 5.

Recommendations

The following recommendations are taken from the submission provided to MCCC by Paul Keech:

- Boggabri Coal is required to prepare detailed Rehabilitation Strategy and Management Plan in consultation with the Narrabri Shire Council and the MCCC. The strategy is to be completed and approved by the Department of Planning prior to the closure of the Leard Forest Road's current alignment through the mining lease site.

Traffic and Transport

Key Issues and Concerns

Boggabri Coal has applied to close Leard Forest Road. As shown in our submission this is a vital emergency and trade route. Alternate routes from Maules Creek to the Manilla Road, which "maintain road access at all times for the residents of Maules Creek" as required in the original Department of Planning consent have been omitted.

The submission obtained from Paul Keech clearly outlines the issues which will face Maules Creek residents if the road is closed. Please refer to Appendix 5.

Recommendations

The following recommendations are taken from the submission provided to MCCC by Paul Keech:

- Prior to the closure of the Leards Forest Road's current alignment through the mining lease site, Boggabri Coal must prepare a "Leards Forest Road Deviation Management Plan" in Consultation with, and to the satisfaction of the MCCC and the Narrabri Shire Council. The Leard Forest Road (on its current or deviated alignment) is to remain open at all times. As a minimum "The Plan" will cover the following;
  - Construction Drawings by a Chartered Professional Engineer, for the completion of the Harparary Road, Causeway and Bridge upgrade works. Where box culverts are to replace concrete causeways the causeways are to remain adjacent to the culverts and be available during construction and, as an alternative access should the culverts be damaged during flood events.
  - Box culverts are to be a minimum of 500mm above the approach roads finished surface level, measured 100m from the culvert.
  - The Harparary Road Bridge is to be a two lane bridge in accordance with the current Austroads bridge design code and capable of carrying as a minimum, Higher Mass Limit AB-Triples or similar. The new bridge is to be constructed on an alignment parallel to the current timber bridge alignment, thus allowing traffic to flow whilst construction occurs.
  - The proposed Leards Forest Road Deviation Route or Route(s), should more than one deviation be required during the Mines life, are to be funded and constructed by Boggabri Coal. The deviated route(s) is to be a gravel surface road with a minimum width of 7m to the satisfaction of Narrabri Shire Council, and constructed on an alignment to suits traffic speed of 70km/h as a minimum. <u>The Deviation</u> Management Plan will also show the proposed "Final Alignment" of the Leard Forest Road once mining has ceased and the mine site is rehabilitated. Boggabri Coal will supply and deliver all gravel required to maintain the Leards Forest Road whilst the mine is operating.
  - A proposed Construction Program that shows the proposed timeline for the upgrade of the Harparary Road, Causeways and Bridge, and the Leards Forest Road Deviation Route or Route(s) prior to the closure of the Leards Forest Road's current alignment through the mining lease site.

  - A Consultation Strategy outlining how the proposed realignments of the "Leard Forest Road Deviation Management Plan" and Construction and Maintenance arrangements will be communicated to key stakeholders and regulators.

- Boggabri Coal will meet the reasonable costs of providing an independent inspector (to the satisfaction of Narrabri Shire Council and MCCC) to monitor any works Boggabri Coal (or its contractors) carries out on infrastructure for the ultimate benefit/ownership of the Narrabri Shire Council.

- At the completion of the proposed rail loop Boggabri Coal's existing private haul road will become the only heavy vehicle access route to the mine and controls at the intersections of the Leard Forest Road and Therribri Road will be changed to give priority to the public roads, with mining traffic not having right of way. Access to the Private Haul Road will be provided by Boggabri Coal at the Kamilaroi Highway to the satisfaction of the Roads and Traffic Authority.

- At the completion of the rail loop, the Manilla Road, from the Iron Bridge up to and including the Leard Forest Road intersection, will be rehabilitated to the satisfaction of the Narrabri Shire Council.

Underground Preliminary Plan

Key Issues and Concerns

The alternative project plans that were required by the Director General, provide Option 6 - Underground Mining as an alternate to the preferred project plan (Option 7). However, the limitations put on the consultant, WDS, ensured that the actual long term development plans for the coal deposit as to a combination of open cut and underground mining are not specifically mentioned and therefore cannot be evaluated against the plan submitted for approval in the Environmental Assessment. That is, Option 6 is incomplete.

Project Plan Alternatives

The project plan as outlined in the Environmental Assessment is not the complete plan for the coal reserve contained within the Boggabri Coal Lease and a proper long term cumulative assessment of the costs and the benefits cannot be undertaken.

The purpose of the current Environmental Assessment report is mostly devoted to justifying the impacts to the environment and community that result from open cut mining than provide a serious plan as to the long term development of the deposit. Mining efficiencies and cost reductions are given as reason to warrant the clearing of critically endangered woodland, fragmentation of the local community and environmental impacts as to air and water quality. The costs to the community and the environment are omitted or minimised.

The underground mining alternative (Option 6) was not effectively considered in the Environmental Assessment as artificial restrictions placed on the consultant's report on the areas mined and the seams to be mined meant that the Option 6 as described would never actually be implemented. In addition benefits to the environment and the community of the reduced impact of underground mining were not included. The maintenance of critically endangered woodland, the maintenance of a healthy rural community, reductions in greenhouse gases, lower impacts to water quanlity and quantity, air quality etc are all omitted.

Nonetheless, underground mining is envisioned by Boggabri Coal to mine the deeper seams contained within the project boundary and in the adjacent lease areas that do not contain surface rights. The MCCC questions the desirability of clearing the forest and its ecosystem when the area will be underground mined anyway. In addition community impacts relating to farm land purchases associated with the zone of affectation and environmental offsets are greatly reduced.

Because Boggabri Coal is operating on public land, the MCCC believe that it is highly desirable for the complete Boggabri Coal plan for the entire reserve contained within all the Boggabri Coal lease boundaries to be on exhibition so that all environmental and community impacts and economic benefits can be properly considered. In effect the project can be considered for its long term contribution to the triple bottom line.

It is our view that due to the long term and complex nature of the mining potential of the Boggabri Coal reserves and the relatively short term nature of the lease period (21 years) there is incentive for Boggabri Coal to present over time a piecemeal group of projects without the overall strategy being considered by the Department of Planning. The cumulative effects of the numerous staged projects within the Boggabri Coal reserves have not been properly explained and therefore cannot be properly considered.

The preliminary underground mining report indicates that underground coal mining will be used by Boggabri Coal. The report says that once open cut operations are complete, Boggabri Coal intends to use underground mining to access the much deeper (400 to 500 meters) Templemore and Tarrawonga seams. In addition the undeveloped lease that the company holds in the Leard State Forest (A339) does not hold surface rights and underground mining will be required to mine that coal.

It appears Boggabri Coal fully intends to incur capital costs developing an underground mine, and it is incorrect for these costs to be used as a reason not to pursue the alternative Option 6 at the expense of the community and the environment. Option 6 or a more complete variant should be firmly on the table for consideration by the Department of Planning.

It is our view that a proper plan that considers all the reserves and the complete company strategy for the Boggabri Coal reserves is what should be submitted to the Department of Planning. Boggabri Coal's preferred Option 7 plan seems to be concerned with minimising extraction costs to the company and using low cost offsets to bolster this position. There is an element of cost shifting whereby the community picks up the tab for environmental and community impacts while mining costs are minimised.

Underground mining in the area is not without precedent. The nearby Narrabri mine operating in another State Forest, Pilliga, has limited surface disturbance and community impact.

Recommendations

- The entire strategy for the development of the Boggabri Coal deposit including the lease A339 should be presented to the Department of Planning and the community so that a proper cumulative assessment of all (including future) environmental and community impacts within the project boundary and outside the project boundary can be made.
- The alternative underground mining report should provide an assessment of the benefits to the community and the environment of not disturbing the environment and fragmenting the community. These benefits have not been properly considered in underground mining report as an economic and social assessment has not been undertaken.
- An environmental assessment should be undertaken as to the impacts of Underground Mining on the Forest environment and the community.

Simultaneous Worst Case Cumulative Impact Scenario

Key Issues and Concerns

The MCCC appreciates the efforts Boggabri Coal has undertaken in compiling the Simultaneous Worst Case Cumulative Impact Scenario (SWCCIS).

The SWCCIS compiled by Hansen Bailey and other consultants is by description “Qualitative” in nature and therefore cannot be accurately relied upon to provide a detailed scientific analysis of environmental project risks in combination with other pending Environmental Assessments including Aston Resources Maules Creek Coal Project.

As has been proven many times, cumulative effects can be different in nature (e.g. synergistic), larger in magnitude, greater in significance, more long-lasting, and/or greater in spatial extent than is the case with individual effects. Much uncertainty already exists with the identification and prediction of environmental effects using quantitative data on individual projects. This is only increased with cumulative effects, particularly as manipulative and synergistic effects are considered. An example of cumulative impacts would be the investigation instigated by Hon. Andrew McNamara into the Health of the Fitzroy River in Queensland which identified serious environmental problems of water quality downstream of several operational coal mines.

The exact nature and scope of the obligation to consider the SWCCIS must seek to understand the environmental connections between all proposed activities within a bio-region under the proposed development applications. This should also include “connected actions”, “segmentation”, and “secondary or indirect effects”.

Verifiable Quantitative Environmental Assessment

The MCCC requests that the relevant NSW Government Departments direct Boggabri Coal, Aston Resources and any other resources company associated with the Leard State Forest’s coal leases or exploration licences combine their consultants’ resources to provide a verifiable quantitative environmental assessment of the cumulative impacts of all proposed mining operations using scientific methodology to provide a defensible independent report, rather than the speculative SWCCIS as provided within Environmental Assessment.

The SWCCIS included in the Environmental Assessment reinforces community concerns by providing conflicting information in regard to air quality, noise impacts, ecological impacts, surface water impacts, groundwater impacts and traffic impacts. As the content of the SWCCIS fails to describe an accurate coordination of a quantitative assessment of the cumulative impacts of mining, this leads to doubt as to the conclusions reached therein.

Following are examples of conflicting statements within the SWCCIS in the Environmental Assessment.

1. Statements as to wind direction

The Environmental Assessment states (refer to Section 11 at page 193 of the Environmental Assessment):

> *Due to the **minimal winds from the East,** there is limited potential for significant cumulative impacts to properties to the west of Boggabri Coal Mine and Maules Creek Coal Project by the Goonbri Project.*

However, later in the Environmental Assessment it states (refer to Section 11 at page 193 of the Environmental Assessment):

> *The Maules Creek Coal Project, Tarrawonga Extension and/or the "Goonbri" Project could potentially result in cumulative impacts to properties to the North-West of Boggabri Coal. This is **due to predominant winds from the East** and South (most evident in summer and autumn).*

2. Statements as to impact on biodiversity

The Environmental Assessment states (refer to Section11 at page 193 of the Environmental Assessment):

> *The Leard State Forest has been intensively logged for its valuable timber resources on a regular basis up until the early 1980s.These activities **have affected the quality and diversity of habitats for locally occurring Threatened Species** and it is likely that in the absence of future mining projects, these activities would continue throughout the forest as productive timber develops.*

However, later in the Environmental Assessment it states (refer to the Cumulative Impact Scenario for Biodiversity at page 13 of the Environmental Assessment):

> *The majority of the Leard State Forest has been disturbed by previous landuse commonly associated with forest operations, including clearing, weed invasions, altered natural drainage and edge effects. **However these disturbances appear to have been relatively minor and have not significantly affected natural species diversity.***

3. Statements as to depressurisation effects

The Environmental Assessment states (refer to Section 11 at page 195 of the Environmental Assessment):

> *The modelling indicates **depressurisation would extend under the alluvial aquifers** to the north of the Maules Creek Coal Project and to the south of the Tarrawonga Mine outcrop area.*

However, later in the Environmental Assessment it states (refer to Section11 at page195 of the Environmental Assessment):

> *The zone of depressurisation will reach a maximum extent at the interface between the outcropping Permian bedrock aquifer and alluvial aquifer. **The higher recharge rate of the alluvial aquifer will prevent the further progression of the zone of depressurisation in the Permian bedrock aquifer.** depressurisation will reach a maximum extent at the interface*

4. *Statements as to biodiversity offset strategy*

The Environmental Assessment states (refer to the Cumulative Impact Scenario for Biodiversity at page 49 of the Environmental Assessment):

> *The cumulative impacts of the Boggabri Project and other projects within the locality of the Leard State forest are likely to have a substantial impact on the ecology of the local area. These projects may cumulatively remove approximately 5067ha of native vegetation, some of which is listed as Threatened under NSW and/or Commonwealth legislation. The development of a carefully designed and robust* ***biodiversity offset*** *package from all other projects (combined offset strategy) would aim to* ***compensate*** *for the identified impacts and in the medium to long term potentially improve ecological outcomes. Furthermore, the development of a combined offset strategy is likely to sufficiently ameliorate these impacts to the extent that no Threatened flora or fauna are likely to become extinct as a result of the other projects.*

However, later in the Environmental Assessment it states (refer to the Cumulative Impact Scenario for Biodiversity at page 52 of the Environmental Assessment):

> *Boggabri Coal has developed a Biodiversity Offset Strategy to further mitigate and* ***offset*** *the impacts arising from the Boggabri Project. This offset strategy* ***identifies large patches of Remnant vegetation*** *in the locality Leard State Forest and Cumulative Project Boundries.*

The purchase of remnant vegetation from private landholders for offset purposes does not increase the total area of remnant vegetation within the bioregion.

Additional identified issues to be included in a quantitative SWCCIS include, but are not limited to:

- Namoi Water Study (conducted by Schlumberger)
- Maules Creek /Back Creek Groundwater Dependent Ecosystems (GDE's). For example, stygofauna/stygobite as found by the University of NSW Connected Waters Study with their Investigation of Surface Water Groundwater Exchange in the Maules Creek Catchment
- Mine dust contamination of agricultural crops including cotton, horticulture and grazing pastures and the associated impacts upon livestock health/performance
- Mine dust contamination of native flora/fauna and associated welfare issues of native herbivores
- Noise impacts (explosives) on breeding fauna leading to nest abandonment, etc
- Realistic traffic assessments that include the impact of the proposed closure of the Leard Forest Road
- Greenhouse gas emissions including loss of natural sequestration within the Forest
- Socioeconomic impacts that include wage pressures, rental increases, cost of doing business for non-mine associated businesses

Conclusion and Recommendations

The MCCC does not accept the adequacy of the SWCCIS contained in the Environmental Assessment and believes a detailed verifiable quantitative assessment combining all proposed mining projects within the Leard State Forest should be submitted to the NSW Department of Planning (DoP) for appraisal before assessing individual Environmental Assessments. The precautionary principle should take precedence until all identified risks are satisfactorily investigated using scientific quantitative principles.

The following key recommendations should be considered prior to any decision on the Environmental Assessment:

- The DoP should require Boggabri Coal to conduct a verifiable quantitative environmental assessment as described above.
- The DoP should refer all relevant environmental constraints of the projects such as White Box-Yellow Box- Blakely's Red Gum Grassy Woodland and Derived Native Grassland to the Federal Government for consideration under the EP&A Act.
- The DoP should require Boggabri Coal to appoint an independent autonomous organisation to assess the likely impact of alluvial groundwater depressurisation and chemical composition changes due to open cut coal mining upon the identified stygofauna/styobite groundwater dependent ecosystems located within the alluvial basin of the Maules Creek Catchment.

References

Anderson, M.S. 2008. *Investigation of surface water groundwater exchange in Maules Creek Catchment.* Presentation to the IAH , 9 Sept, 2009. WRL UNSW Sydney.

Anderson, M. S. and Acworth, R. I 2007. *Chemical and Geophysical Sampling Campaign at Maules Creek. Data Report for 2006*. WRL Report 229, University of NSW.

Haslem-McKenzie, Phillips, Rowley, Brereton and Birdsall-Jones(2009)
Housing affordability and shortages in resource boom towns
Australian Housing and Urban Research Institute
AHURI Research & Policy Bulletin 120 September 2009

KLC Environmental (2010) *Gins Leap Gap Project (Final Report)*. Namoi Catchment Management Authority, Gunnedah and Tamworth

Petkova, Lockie, Rolfe and Ivanova (2009)
Mining Developments and Social Impacts on Communities:
Bowen Basin Case Studies
Rural Society 19 (3) (pp217-220)

Reed and Kleynhans (2010)
Highest and best use decision-making in a multifunctional agricultural land market.
Australia and New Zealand Property Journal, March 2010 (pp297-304)

Sinclair P, Barrett C and Williams RM, Impact of Groundwater Extraction on Maules Creek – Upper Namoi Valley, NSW Australia, Nov 2005

Walker B and Salt D, (2006) Resilience Thinking - Sustaining Ecosystems and People in a Changing World, Island Press, Washington DC

Appendix 1

Comments: Regarding Boggabri Coal Proposal in Regards to Flora and Fauna by The Envirofactor Pty Ltd, January 2011

Resume: Wendy Hawes, Director – The Envirofactor Pty Ltd

theenvirofactor
email. theenvirofactor@hotmail.com

THE ENVIROFACTOR PTY LTD
P O Box 626
Inverell NSW 2360
ABN. 96 108 633 325

p 267 224 997
m 0408 224 997

To: Phil Laird
From : Wendy Hawes, Terrestrial Ecologist

COMMENTS: REGARDING BOGGABRI COAL PROPOSAL IN REGARDS TO FLORA AND FAUNA

Hi Phil
I've looked at the various reports associated with the Biodiversity Impact Assessment (BIA) for the Continuation of the Boggarbri Coal Mine and following are my comments re this document.

Assessment under the EPBC Act

It is unclear why a full assessment of the environmental impacts of the existing and extension are not being considered under the EPBC Act given the large area of CEEC Box Gum Woodland and threatened species habitat being impacted. Only assessing the impacts associated with the extension of the mine in relation to the EPBC severely underestimates the impacts associated with the proposal on Matters of National Significance and substantially overestimates the value of potential offsets. For example the proposal will remove 624ha of Box Gum Woodland and 1, 385ha of habitat for the Regent Honeyeater but only 82ha and 650ha respectively will be assessed under the EBPC Act. I can only presume this anomaly is a result of the current approval that pre-dates the EPBC Act and which remains in force until November this year. However, to have any environmental credibility an impact assessment of the entire project should be carried out under the commonwealth legislation as the project clearly impacts on Matters of National Significance.

Vegetation Clearance and Landscape Context

As outlined in the document this project will remove 1,385ha of native vegetation in moderate to good condition including large areas of Threatened Ecological communities listed under State and Commonwealth legislation. The majority of this vegetation will be removed from Leard State Forest a large relatively intact remnant (approximately 8,136 ha) within the Brigalow Belt South Bioregion, which has since European settlement been extensively cleared for agriculture. Less than 40% of native vegetation remains within this bioregion, the majority of remnants occurring as small patches and linear remnants on private land and along roads within a highly developed agricultural matrix of exotic pastures, cropping and irrigation. As a result of their small size and the surrounding landuse many of these remnants are in poor condition as a consequence of ongoing degradation as a result of weed invasion, inappropriate grazing regimes, fertilizer and herbicide application, firewood collection and regrowth control. Therefore, although Leard State Forest has been historically been subject to forestry activities (which ceased some 20 years ago), its size and condition within this landscape make it a block of remnant vegetation of high conservation value and important for the maintenance of ecological function within the locality and region. This fact is not disputed by the BIA report.

Large relatively intact remnants support meta-populations of biota essential for the on-going maintenance of populations and the genetic diversity in small adjoining and/or remote remnants. Large intact remnants provide a buffer against the risk of local extinction in highly fragmented landscapes such as that within the Brigalow Belt South.

What the BIA fails to acknowledge is the importance of such large remnants in sustaining populations of flora and fauna in a changing climate. The size and diversity of habitat within large blocks are be important as they provide refuges and have the built in resilience to ensure the on-going survival of our native biodiversity. This is because small populations within highly fragmented remnants, such as that outside Leard State Forest, will be at escalating risk of extinction due to increasing frequency of extreme stochastic events (floods, bushfires, disease and increasing temperatures).

Remnant Vegetation Cover

The BIA depends heavily on an assessment of remnant vegetation cover within the 10km as evidence that viable populations of at least woodland birds will not be impacted by the project. The use of this device is misleading. The figures cited in the BIA are a 3% reduction from 51% to 48% within a 10km radius of the project area and tends to largely ignore the 49% reduction (94% down to 45%) in habitat within 100m of the Project. These figures are misleading in that the remnant cover within the 10km radius is made up of both woodland and derived grassland (which is generally not habitat for woodland birds). Further the woodland remnants which will remain exist predominantly as isolated patches too small to support viable breeding populations of many woodland birds which often require treed remnants (not derived grassland) of greater than 100ha for their long-term viability.

The 10% vegetation cover cited in the BIA for the maintenance of woodland birds and 30% for other organisms (Reid 2000[1]) as thresholds for maintain

[1] Reid JRW (2000) *Threatened and declining birds in the New South Wales Sheep-Wheat Belt: II Landscape relationships – modelling bird atlas data against vegetation cover.* Consultancy report to NSW National Parks and Wildlife Service. CSIRO Sustainable Ecosystems, Canberra.

biodiversity in the locality is also misleading. Reid (2000) clearly outlines that "cited vegetation targets of 10% and 30% cover translate to a predicted loss of 17 (19%) and 9 (10%) of woodland bird species from landscapes". In fact Reid (2000) proposes that in landscapes where broad scale vegetation clearance continues that;

- Defined vegetation communities should not be cleared below 30% of their original extent in that landscape. Note this is not an overall threshold for the maintenance of 30% vegetation cover within a landscape but a 30% threshold for each defined vegetation community and would require maintenance of much greater % areas of native vegetation cover.
- All broad-acre vegetation clearance should cease if 50% or more of the landscape is cleared.

The impact incremental loss of habitat and therefore connectivity in the landscape is complex. The simplistic and misleading thresholds provided in the BIA overlook this complexity. It has been demonstrated (Pearson et al 1996) that for species with poor movement ability (ie those that require contiguous habitat for movement) the loss of as little as than 30% of habitat will lead to a loss in connectivity and declines in populations. For those species with intermediate movement ability this threshold is 40% and for highly mobile species 70%. What this modeling indicates is that 70% of habitat must be retained within a landscape to ensure no loss of connectivity and maintain populations of flora and fauna (McIntyre *et al* 2002). Consequently it is highly likely the Boggabri Coal Project will lead to a significant loss of biodiversity both in the locality and in the region.

Proposed Biodiversity Offset Strategy

Since the proposed continuation of the Boggabri Coal Mine fails to meet any of the "maintain or improve' criteria outlined under the Native Vegetation Act 2003 it is proposed to offset the impacts using a biodiversity offset strategy. The document states that while the BioBanking tool has been used to assess and compare the biodiversity values it is not proposed to use the NSW BioBanking Scheme for this project. The reason outlined was due to uncertainty regarding the application of the tool and scheme at the time. However, I believe this uncertainty no longer exists and the BioBanking Scheme should apply to this project.

I'm not familiar with the requirements of BioBanking except in general terms, but it is unclear why BioBanking credits are only required for the Black-necked Stork and not other threatened species to be significantly impacted by the Project.

In summary the offset proposes to establish a Regional East-West Wildlife corridor from what remains of Leard State Forest east to the Nandewar Range and west to the Namoi River. A proposal which in the absence of the extensive clearing required for the Boggabri Coal Project would have significant biodiversity benefits to the locality and region. However, in the context of an offset for the loss of 1,384ha of habitat and 17% of a large remnant contiguous block it has significant shortfalls. These include:

- In the short to medium term there will be a significant net loss of native vegetation and habitat in the locality region, as in this time-frame no new and/or replacement habitat will be established but clearing for the current project will occur (ie large areas of habitat will be lost).
- The proposed offset vegetation is highly fragmented and generally comprises small patches in an extensively developed agricultural landscape, and at best will be marginal habitat for many of the species impacted by the proposal.
- There will be a suite of species which currently exist within Leard State Forest ie those that require large intact areas of habitat for survival for which the offset areas are unlikely to provide habitat except in the very long-term.
- Even if rehabilitation and replanting is successful important habitat features will be absent for long periods of time eg tree hollows (140 years). Some habitat features or aspects of biodiversity may never be retrieved eg soil biota, groundcover diversity, stygofauna. Consequently there will be long-term biodiversity losses.
- In the life of the proposal (21 years) it is unlikely there will be any significant gains in habitat, but there is a high likelihood of local species extinctions as a consequence of the time-lag between the clearing event and the establishment of suitable habitat to support displaced flora and fauna.
  - calculated from the BIAis that the project will remove more than 200,000 tree hollows - that's 200,000 animal homes which will be lost and not replaced for 140-400 years. It will also be impossible for them to replace this resource within their offset even using man-made boxes.
  - calculated from a Queensland study by Cogger et al (2003) for WWF as a rough average 223 mammals, birds and reptiles per hectare are killed by land clearing which means this project will potentially lead to the death and/or displacement of 308,632 mammals, birds and reptiles. Difficult to account for these numbers in the offset.

Threatened Species and Endangered Ecological Communities

The BIA itself indicates there will be significant impacts for a number of threatened species and ecological communities including:

- Box –Gum Woodland – TSC and EPBC Act
- Eight species of woodland bird – for which the area forms “core habitat” – TSC Act

- Regent Honeyeater – TSC and EPBC Act
- Three species of hollow-dependent microchiropteran bat – for which the area forms 'core habitat' - 3xTSC Act and 1x EPBC Act.

In the case of fauna it is the conclusion of the BIA that because a large area of Leard State Forest will remain, individual animals not killed by the immediate clearing operation will be able to move into this remaining habitat and utilize its resources eg tree hollows, foraging habitat etc. This very simplistic approach belies the fact that in nature ecological niches are rarely vacant. Any existing habitat will already be occupied. Displaced fauna cannot simply move. Displaced fauna will increase both intra and inter specific competition for the reduced food resources, mates and roosting/breeding sites. Increased competition will lead to increased stress within populations, potentially increasing disease factors and disrupting breeding cycles. In human terms consider the impact of leveling 17% of any town or city suburb including all houses, schools, supermarkets and food outlets. Then expecting the displaced families to move in with the neighbours and share their houses, schools and food resources.

In the case of Box-Gum Woodland the project will remove 624ha or 19% of this community within Leard State Forest. As identified in the BIA "*the area to be removed contains a high understorey diversity of native species, with minor disturbances from feral animals and past logging uses. Thus the area to be removed contains a valuable source of genetic diversity for this community, both in terms of flora and fauna that inhabit this ecosystem*". Given nationally the majority of remnants of this community are small and highly degraded, the large size and good condition of this remnant make it extremely important for the maintenance of genetic diversity both locally and regionally.

For both flora and fauna the large remnant that is Leard State Forest supports meta-populations which provide for the restocking of the small remote remnants within the more highly developed agricultural matrix.

While I agree with the assessment of significant impact for the species outlined above I believe there are substantial flaws in the impact assessment as regards a number of other threatened species.

A number of threatened species whose distribution matches the Project Area have been excluded from assessment based on a lack of suitable habitat present within the study area. However, given the vegetation communities and habitats described in the BIA it does appear habitat for these species exists within the project area and/or adjoining habitat including Leard State Forest. Therefore an assessment of the impact of the Boggabri Coal Project on these species should be undertaken. These species include:

Terrestrial Species

- *Bush Stone-curlew* - TSC Act – this species inhabits grasslands, grassy woodlands and grassy open forests including those with sparse grassy groundcover. According to the report these habitats are present within the project area and in the adjoining Leard State Forest.

- *Glossy Black Cockatoo* – TSC Act – this species is associated with woodland and open forest containing Casuarina/Allocasuarina. At least one vegetation community containing these species is present within the study area.
- *Black-breasted Buzzard* – TSC Act – this species is associated with a range of inland habitats including riparian woodland and grasslands. Habitat for this species is present within the study area.
- *Painted Snipe* – TSC – Is a species which inhabits temporary or permanent areas of shallow water. At least one soak within *E. camaldulensis* woodland occurs within the study area consequently there is habitat for this species.
- *Black-striped Wallaby* – TSC Act – inhabits vegetation types with dense understorey adjoining more open grassy systems. Habitat for this species appears to be present within the study area.
- *Eastern Freetail Bat* – TSC Act – inhabits open forest and woodland living under bark and in tree hollows. It was recorded in the locality and other records exist near Gunnedah and habitat for this species is present within the study area.
- *Stripe-faced Dunnart* – TSC Act – inhabits tussock grasslands on a range of soil types (including clay) often along drainage lines. Sheltering in soil cracks, under fallen logs and rocks. Habitat for this species exists within the study area.
- *Pale-headed Snake* – TSC Act – inhabits eucalypt and cypress open forests and woodlands. Habitat for this species exists within the study area.

Aquatic Species

Exclusion of all threatened species of fish on the basis of a lack of records and no preferred habitat within the study area is not consistent with DECCW Threatened Species Assessment Guidelines, with which this document purports to be consistent. Under these guidelines a local population of resident fauna "*comprises those individuals known or likely to occur in the study area, as well as individuals occurring in adjoining areas (contiguous or otherwise) that are known or likely to utilize habitats in the study area.*" The poor condition of the Namoi River within the study area is not an excuse that allows the exclusion of these species from assessment – indeed the condition of the Namoi River is consistent with, and representative of, the entire Murray Darling Basin and why these species are listed. Given a number of the threatened fish including, the Murray Cod, Eastern, Eel-tail Catfish and Silver Perch have been recorded within the Namoi River near Boggabri and these species are known to move up and down river reaches in response to changes in flow regimes it is likely these species would at various times (during moderate to high flows and floods) utilise the aquatic habitat within the study area. An assessment of the impact of the project therefore must include these species.

Other issues with the threatened species assessment within the BIA:

- **An underestimation of the area of the Aquatic Ecological Community of the Natural Drainage System of the Lower Darling**

  As described in the determination this community includes "*all native fish and aquatic invertebrates within all natural creeks, rivers, streams, and associated lagoons, billabongs, lakes, flow diversions to anabranches, and **the floodplains** of the Darling River*". Areas of floodplain of the Namoi River and its tributaries within the project area have been erroneously excluded from this community.

  One of the threats to this community is the alienation of floodplain areas which are important source of nutrients essential for ecosystem function within the aquatic environment. These nutrients becoming available to the riverine system as a result of overland flows during various flood events. Potentially the rail link to be constructed, presumably above known flood levels, will act as a levee bank alienating areas of floodplain from the river channel. The impact of this construction must therefore be assessed in regards to its impact on this TEC.

- **Loss of a significant area of habitat for hollow-nesting birds**

  The BIA suggests that there will not be a significant impact on two species of hollow-dependent birds – the Turquoise Parrot and Little Lorikeet despite the fact the project will removed 17% of their habitat including important breeding resources tree hollows. It is unclear in the BIA, why if the project is significant for other woodland birds and hollow-dependent micro-bats it is not significant for these two species. Especially given the sedentary nature of the Turquoise Parrot and the hollow fidelity displayed by the Little Lorikeet.

- **Loss of a significant area of foraging habitat for cave dependent bats**

  Although no known breeding habitat for these bats will be impacted by the Boggabri Coal Project it will significantly reduce (17%) the available foraging habitat. All these bat species are known to travel large distances for food and water. Whether the remaining habitat will be sufficient to maintain the existing breeding colonies of these bats is unknown. Therefore contrary to the BIA assessment it is likely the Project will disrupt the breeding cycle of these species.

Also contrary to the BIA the Large-eared Pied Bat population within the project area is an important population as the Project Area lies at the western edge of this species distribution.

- **Presence of an important population of the Superb Parrot**
- The BIA states that the Superb Parrot population for which the Project Area forms habitat is not an important population as no breeding habitat will be impacted (this species breeds in southern NSW). However, one of the EPBC Guideline criteria for identifying important populations is populations “at or near the limit of the species range”. Contrary to the BIA, NSW Wildlife Atlas records and species distribution information indicates the Project Area lies at the north-eastern extend of this species range and as such the population for which the Project Area potentially provides habitat is an ‘important population’. Further it is the on-going cumulative loss of foraging habitat which threatens migratory species – see Migratory Species below.
- **Loss of important habitat for migratory and/or nomadic species**

The BIA finds the habitat removal for the project not significant for these species due to their high mobility and the large area of Leard State Forest that will remain (6,750ha). However, migratory and nomadic species (including the Swift Parrot and Superb Parrot) have high energy needs and often require large areas of concentrated resources to sustain them in their extended movements across the landscape. It has been the incremental loss of habitat areas in particular foraging habitat which has significantly impacted on these species and lead to their decline. Consequently, it is likely that a 17% reduction in a large landscape remnant in good condition such as that proposed by Boggabri Coal will significantly impact on these species by reducing the available resources and therefore numbers of individuals the area can support at any given time.

- **Failure to consider the Pre-cautionary Principle**

In the case of *Digitaria porrecta* and the Spotted-tail Quoll the BIA uses the uncertainty of the occurrence of a resident population and/or the paucity of records within the project area to indicate the project will not have a significant impact on these species. Notwithstanding the project area supports potential habitat and/or populations of these species. This conclusion is contrary to the pre-cautionary principle on which economically sustainable development (ESD) is based, ie *where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (United Nations Conference on Environment and Development, Rio, 1992).*

Groundwater Dependent Fauna

No assessment has been undertaken of the potential impact of the proposal on a unique suite of stygofauna known to be associated with the groundwater in the Maules Creek catchment and potentially Leard State Forest. Currently the assessment within BIA relies on the fact that the proposal does not require water extraction from aquifers to indicate the proposal will have no or little impact on groundwater systems. This assessment is somewhat simplistic overlooking the fact the proposal will remove 1,384ha of native vegetation and is for an open cut mine which will create a pit up to 180m deep. Potentially there is a high likelihood the proposal will interrupt the recharge of and flows within of a number of sub-surface aquifers. This in turn may place this unique suite of stygofauna at risk of extinction.

R E S U M E

WENDY HAWES

21 Gordon Street
PO Box 626
INVERELL NSW 2360

Tel:	0267 224 997
Mob:	0408 224 997
Email:	w.hawes@bigpond.com theenvirofactor@hotmail.com

PERSONAL DETAILS

BORN:	24 February 1957
DRIVERS LICENCE:	Current Class C Gold

EDUCATIONAL RECORD

1969-1974:	WARILLA HIGH SCHOOL - Higher School Certificate
1975-1977:	UNIVERSITY OF NEW ENGLAND - Bachelor of Science (In zoology and ecology)
1978-1979:	UNIVERSITY OF NEW ENGLAND - Master of Science (Prelim)
1988:	INVERELL COLLEGE OF TAFE - Computer Studies 1
1989:	INVERELL COLLEGE OF TAFE - Text Editing
2008:	UNE PARTNERSHIPS – Certificate IV in Training and Assessment

CURRENT MEMBERSHIPS

The Envirofactor Pty Ltd - Director

Accredited Expert: Biodiversity and Threatened Species - NSW *Native Vegetation Regulation 2005*

Goonoowigall Conservation Area Consultative Group - DECCW

Border Rivers Community Consultative Advisory Committee (Scientific Rep) – DECCW

National Parks and Wildlife Northern Tablelands Region Advisory Committee (NCC/NPA Rep) - DECCW

Nature Conservation Council Rep – Inverell Bushfire Management Committee

Ecological Society of Australia

Australian Conservation Foundation

Birds Australia

Gould League

Australian Network for Plant Conservation

Australian Professional Engineers, Scientists and Managers Association

TECHNICAL REPORTS

Hawes W (1979) Preliminary Study of the Ecology and Behaviour of the Blue Bonnet Parrot (*Psephotus haematogaster haematorrhous*) Master of Science (Preliminary) Thesis. University of New England.

Hawes W (1992) *Rehabilitation of Degraded North West Croplands with Perennial Grasses*. Department of Conservation and Land Management.

Hawes W (1992) Flora and Fauna Survey In *Boobera Lagoon - Environmental Audit*. Department of Land and Water Conservation.

Hawes W (1994) Wildlife as a Natural Resource In *2000 and beyond.....Keeping the Land in Trust*. Macintyre Development Unit 2000. Nornews Ltd, NSW.

Hawes W, Boschma D and Rose A (1995) *Report on the Current Land Condition of the former "Moree Common"*. Department of Conservation and Land Management.

Hawes W, O'Keefe P and J Kewley (2000) Acacia *sp. "Myall Creek" (*Miller s.n. *25 May 2000). Site Inspection and Sample Collection*. Department of Land and Water Conservation.

SCIENTIFIC CONTRIBUTIONS

Blakers M, Davies S J J F and Reilly P N (1984) *The Atlas of Australian Birds*. Royal Australasian Ornithologists Union. Melbourne University Press.

Department of Land and Water Conservation (1999) *Interim Guidelines - for targeted and general flora and fauna surveys under the Native Vegetation Conservation Act 1997.* Centre for Natural Resources NSW Dept of Land and Water Conservation, Parramatta.

Department of Land and Water Conservation (2000) *Guidelines for Mapping Native Vegetation*. Centre for Natural Resources, Parramatta.

Department of Land and Water Conservation (undated) *Collecting field information for assessment of clearing applications under the NVC Act 1997.* Departmental document.

Ede AJ and W Hawes (1998) *Guidelines for Native Vegetation Assessment and Reporting – Barwon Region.* Dept of Land and Water Conservation. Departmental document.

Ede AJ and W Hawes (2004) *Draft Guidelines for the Environmental Assessment of Existing and New Structures/Developments under Part 8 of Water Act 1912 – Barwon Region.* Dept Infrastructure Planning and Natural Resources. Departmental document.

Gray E, Ede AJ and W Hawes (2000) *Assessment Notes and Short Reporting Guidelines – Barwon Region.* Department of Land and Water Conservation. Departmental document (Update of 1998 document).

Hawes W (2008) *Draft National Recovery Plan - White Box Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland*. Department of Environment and Climate Change *in press.*

Nadolny C *et al (*2003) *Grassy Vegetation in North-western NSW and Guidelines for its Management for Conservation*. Armidale Tree Group, Armidale, NSW.

Nadolny C, Hunter JT and W Hawes (2010) *Native Grassy Vegetation in the Border-Rivers-Gwydir Catchment: diversity, distribution, use and management.* A report to the Border Rivers-Gwydir Catchment Management Authority.

Oliver I and D Parkes (2003) *A Prototype Toolkit for Scoring the Biodiversity Benefits (and Disbenefits) of Land use change.* Vers 5.1. Centre for Natural Resources. Department of Sustainable Natural Resources, Parramatta.

Oliver I, Ede A, Hawes W and A Grieve (2005) The NSW Environmental Services Scheme: Results for the biodiversity benefits index, lessons learned, and the way forward. *Ecological Management. & Restoration*. **6** 197-205.

Turner K and PL Smith (1996) *Guidelines for assessing the significance of native vegetation removal on threatened species, populations, or ecological communities, or their habitats.* Dept of Land and Water Conservation publication.

FLORA AND FAUNA SURVEY EXPERIENCE

2010	Targetted Survey for Threatened Flora Species – Tuttle's Lane, Glen Innes – PowerServe Pty Ltd - TE
2009	Split Rock Dam Stage 1 Upgrade Flora and Fauna Survey – State Water - TE
2008	TSR Flora Survey for Identification of HCV sites – Lachlan CMA and Forbes/Young RLPBs – NWES & TE Copeton Dam Upgrade Flora and Fauna Survey – State Water -TE
2007	Border Rivers-Gwydir High Conservation Vegetation Mapping – Vegetation typing – DECC - TE
2006	Dept Environment and Climate Change - "5 Corners" Fauna Survey – NWES & TE
2005	Dept Environment and Conservation - Biodiversity Conservation in the NSW Sheep-Wheat Belt Project (Plant and Bird Surveys) – TE Bat Survey – Dept of Lands Hillgrove Derelict Mine Project – The Envirofactor (TE)
2004-2003	Habitat Manipulation in Grassy Woodlands Project (Reptile Survey) – CNR
2003-2002	Nandewar Regional Biodiversity Assessment Survey – NSW NPWS
2002	Threatened Flora Survey "Balaclava" Glen Innes - DLWC "Minbalup" Community Biodiversity Survey – NWES and Greening Australia
2001	Vegetation Condition Rating Project and Reptile Survey – Centre for Natural Resources (CNR) Flora and Fauna Survey, Peery National Park – Australian Museum, Australian Herpetological Society, Birds Australia
2001	Bat Survey – Ironbark Nature Reserve – NWES
2000	King Conrad Mine Fauna Survey – NWES and DLWC Fauna Survey, Sturt National Park – Australian Museum, Australian Herpetological Society, NWES
1998	Threatened Flora Survey "Fairview" Walgett– DLWC Threatened Flora Survey "Fairlands" Boggabilla - DLWC
1996	Pilliga Fauna Survey – DLWC Ecologists in conjunction with Harry Parnaby (Australian Museum) Gwydir Wetlands Fauna Survey – Northwest Ecological Services (NWES) and Dept Land and Water Conservation (DLWC)
1992	Environmental Audit Boobera Lagoon (Flora and Fauna Survey) – Dept Conservation and Land Management

RELEVANT TRAINING

Department of Natural Resources	Aboriginal Sites Identification Aerial Photo Interpretation Four Wheel Drive Training Introduction to Arcview Laboratory Techniques and Safety Risk Management Assessment Soil Data System Sponsorship Workshop Train the Trainer Vegetation Management Legal Enforcement Workshop Wetland Plant Identification
WorkCover	OHS General Induction for Construction Work in NSW
Farming For The Future	Facilitation Training
State Forests	Frog and Bat Identification and Survey Skills
University of New England	Identification of Western Grasses Tree and Shrub Identification

EMPLOYMENT HISTORY

THE ENVIROFACTOR PTY LTD

APR 2004 - PRESENT

DIRECTOR/TERRESTRIAL ECOLOGIST

Design & undertake flora/ fauna surveys and threatened species assessments for research, urban and rural infrastructure development to meet legislative requirements under planning state and federal planning legislation. Examples include:

- Identification of HCV vegetation within the Lachlan CMA area – GBW CMN

- Ecologist's Inspection of the Gwydir Highway Upgrade (Inverell) – Cut & Fill

- Flora and Fauna Impact Assessment – Proposed Boral Concrete Batching Plant (Tamworth)

- Flora and Fauna Impact assessment - Gwydir Highway Rehabilitation (Inverness), Spencer's Gully Bridge and Sawpit Gully Bridge Construction and Road Realignment, Guyra Road Realignment, Mackie Lane Widening (Inverell Shire Council)

- Flora and Fauna Reports for Rural Subdivisions at Sandy Hollow, Scone, Merriwa, Muswellbrook-

- Review of Environmental Factors for Copeton Dam and Split Rock Dam Security Upgrades – State Water

- Review of Environmental Factors – Boomi, Boronga, Welbondonga, Euraba & Dolgelly Artesian Water Supply Projects, Kensington Artesian Water Supply Project, Cryon Water Management Project, Tholloo Joint Water Supply Scheme, Wingadee Joint Water Supply Scheme (Office of Water)

- Statement of Environmental Effects for Rural Subdivisions at Inverell and Armidale

- Flora and Fauna Assessment for Telstra Cable Installation (Croppa Creek, Lowana and Copeton)

Critical expert review - *Flora Survey and Analysis Report of Box Gum Woodland at Muswellbrook (DEWHA)*

Expert advice for legislative compliance – *Assessment of the presence of the endangered ecological community, Myall Woodlands at Warren NSW (DEWHA)*

Develop National Recovery Plan for the Critically Endangered Ecological Community – *White Box Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland (DECCW)*

Develop and deliver environmental education packages:

-Staff field training for Multiple Ecological Communities Stewardship Program – Central West CMA

- Biodiversity and Threatened Species Training Workshop – Border Rivers-Gwydir CMA

- High Conservation Roadside Vegetation – Border Rivers-Gwydir CMA

Provide specialist ecological advice for the preparation and development of:

- Commonwealth and State Scientific Committees' – Threatened Ecological Community listings including: Box Gum Woodland, Myall Woodland Coolibah/Black Box Woodland, Inland Grey Box Woodland and Native Grasslands

- Commonwealth Environmental Stewardship Program

Project management, costing, OH&S risk assessments/safe work practices, equipment maintenance, data collection, analysis, interpretation and reporting. Client and government agency liaison.

DEPARTMENT OF NATURAL RESOURCES
Inverell Resource Centre (IRC)

OCT 1992 – JUNE 2006

TERRESTRIAL ECOLOGIST

Provide specialist ecological advice on vegetation management, biodiversity, habitat assessment and threatened species to:

- Departmental staff including Vegetation Management, Compliance and Water Licensing Officers administering State Environmental Planning Policy No 46 (SEPP 46), Native Vegetation Conservation Act 1997 (NVC Act), Water Act 1912 and Water Management Act 2000

- Local Government, Private Consultants, Community Groups and Landholders.

EMPLOYMENT HISTORY (continued)

Act as an expert witness in departmental compliance actions in respect to environmental harm and biodiversity issues, as well as, prepare remediation plans for areas illegally cleared.

Provide specialist ecological advice for the preparation and development of:

- *Commonwealth and State Scientific Committees' - Endangered Ecological Community listings*
- *Natural Resources Commission statewide biodiversity & vegetation targets*
- *DNR Director General's requirements for EIS, SEEs and REFs*
- *Catchment Management Authority (CMA) targets/plans- Vegetation Benchmarks for Property Vegetation Plan Developer (PVP Developer)*
- *Consultant Briefs for Flora and Fauna surveys*
- *Plans of Management for public and private land eg Boobera Lagoon Management Plan, Moree Common, Goonoowigall Bushland, Inverell Bushfire Management Plan*
- *Property Agreements.*

Critical review of flora, fauna and threatened species components of EIS', SEEs and REFs for departmental comment.

Assist in the development of:

- *Decision support systems - Biodiversity Benefits Index, Terrestrial & Aquatic Threatened Species database, PVP Developer*
- *Staff assessment guidelines – see Scientific Contributions*
- *Flora and fauna survey guidelines.*

Develop & deliver workshops, education material & presentations on native vegetation management and biodiversity for:

- *Departmental staff – Vegetation Management Officers, Water Licensing Staff, Compliance Staff*
- *NGOs – Grassy Box Woodland Conservation Management Network, Australian Network for Plant Conservation, UNE, "5 Corners" Voluntary Conservation Area*
- *Landholders*
- *Other agency staff – CMA Community Support Officers, Rural Fire Control Officers, Rural Lands Protection Board Rangers*

Design and conduct flora and fauna surveys, OH&S risk assessments, implementation of safe working practices, staff recruitment & management. Data collection, analysis and reporting.

MAR 1995 (6 Months)

ACTING PROPERTY MANAGEMENT PLANNER - MOREE

Responsible for the maintenance of the Farming for the Future program. Liaison with landcare groups. Organising & delivery of property planning workshops.

AUG 1990 - AUG 1995

EDUCATION OFFICER – BARWON

Liaison with educators and community groups regarding their environmental education needs. Develop and deliver specific education programs for schools, tertiary institutions and community groups. Organise functions focusing on the environment & education for specific events (*eg* Landcare Month, World Environment Day, Water Week). Responsible for the resources, operation & financial allocations associated with the IRC Environmental Education Centre. Team leader of the Northwest Schools Landcare Competition coordination committee. Organise outside sponsorship to fund specific events.

AUG 1989 - SEPT 1992

TECHNICAL ASSISTANT - BARWON

Assist with the implementation, maintenance, sampling and recording data of field trails. Collection and preparation of samples and undertaking laboratory (physical and chemical) soil tests for conservation earthworks and research programs. Assist in the operation and maintenance of equipment and stores for use in the laboratory and field. Assist in soil survey. Undertake data entry, analysis and interpretation. Report and submission writing.

EMPLOYMENT HISTORY (continued)

1988 - 1989	**INVERELL COLLEGE OF TAFE** TEACHER: (Casual) Design and deliver an outreach course, "Meeting Procedures", for community groups
1984-1987	**J.C. HAWKINS (BVSc)** **Inverell** VETERINARY ASSISTANT: Office administration, accounts, client liaison, surgical assistant, records maintenance and hospital/office cleaning.
1978-1983	**COMMUNITY YOUTH SUPPORT SCHEME** **Coonamble and Inverell** PROJECT OFFICER: Co-ordinating activities for young unemployed people (16-25 years). Liaison with employers and community organisations. Counselling and conflict resolution. Submission writing for government funding.

REFEREES

Dr Peter Smith

Manager – Climate Change Science

Department of Environment, Climate Change and Water

Phone: (02) 9895 6177
Fax: (02) 9895 7867
email: peter.smith@environment.nsw.gov.au

Julian Prior

Senior Lecturer

Ecosystem Management
University of New England

Phone: (02) 6773 3610
Fax: (02) 6773 2769
email: jprior@une.edu.au

Appendix 2

Review of Continuation of Boggabri Coal Mine Groundwater Assessment by Water Resource Australia Pty Limited, January 2011

Resume: Brian M. Rask, Director – Water Resource Australia Pty Ltd

Review of Continuation of Boggabri Coal Mine Groundwater Assessment

Prepared for: Maules Creek Community Council

January 2011

Water Resource Australia

Water Resource Australia Pty Limited
ABN 89 134 938 060

P.O Box 7275
Tathra NSW 2550

Phone: 02 6494 5030
Mobile: 04 0045 6452
Email: Wra1@bigpond.com

Revision	Details	Date	Amended By
00	Original	27/01/2011	Brian Rask

Author: Brian Rask ....

Signed: ....

Date: 28/01/2011 ....

Distribution: MCCC (electronic transfer) ....

Contents

List of tables

Appendices

Executive Summary

A groundwater model in the Boggabri area of the Namoi Catchment in New South Wales has been developed by Australasian Groundwater and Environmental Consultants Pty Ltd. (AGE) in support of the Environmental Assessment for the continuation of the Boggabri Coal Mine (Project). The objective of the groundwater study was to assess the impact of the Project on the hydrogeological regime and to meet the applicable Director Generals Requirements.

This report provides a review of the model development and reporting according to Australian modelling guidelines (MDBC, 2000) and the Project Director General Requirements.

Setup and development of the steady state model is in line with current industry practices – as indicated by the MDBC checklist (Table E-1, MDBC, 2000) – with conservative assumptions being made where possible. A thorough background literature research has been conducted and used as the foundation for the conceptual and numeric models.

The modelling report is overall of a high quality and provides sufficient figures and diagrams to provide illustrations of key features and results.

Using the MDBC guidelines checklist, the modelling is found to be deficient and/or lacking in the areas of calibration, verification, sensitivity analyses and uncertainty analyses – each to varying degrees. The end result is no demonstration or basis, other than conservative assumptions by the modeller, by which to have any real confidence that what is being provided is the best estimate or even worst case. Therefore, the usefulness of this model is to a large extent unknown as the reader is left to accept a lot of what has been done on faith rather than demonstrated ability.

The primary risks of impact being assessed are associated with the alluvial systems yet the connection between the alluvial and bedrock systems are not well explored either through field testing, literature research, vertical water level gradient analyses, and or model sensitivity assessments. Further work should be conducted, including field studies such as pumping tests to quantify this interaction as well as sensitivity assessments with the model to understand how sensitive the model results are to this characterisation.

Additional recommendations provided by the reviewer regarding the Boggabri groundwater modelling report are as follows:

- The cumulative impact assessment should consider the declining water levels within the alluvial systems along with the impacts of the surrounding mines as currently presented.
- A clear method for identifying mining related loss of well yields from background yield losses should be defined up front to eliminate any confusion or difficulties after the fact.
- It is noted that a recommendation is provided for reviews of the monitoring data and model accuracy every 5 years. This is the fifth year of current operations and as such it would seem reasonable, based upon their own recommendation, for such a review to be conducted now as part of this submission.

The overall impression left after the review is that the work done is competent and well presented, however it is the work not done that leaves cause for concern and uncertainty.

1. Introduction

The Boggabri Coal Mine was approved in 1990 for open cut coal mining of up to 5 Million tonnes per annum (Mtpa) for a period of 21 years and commenced mining operations in 2006. The development consent is due to expire on 15 November 2011and as such an application of continuation has been submitted.

The objective of the groundwater assessment is to assess the impact of the Project on the hydrogeological regime and to meet the applicable DGRs.

This report provides a peer review for Maules Creek Community Council (MCCC) of the Groundwater Assessment in support of the Environmental Assessment for the Continuation of the Boggabri Coal Mine (Project). The review is to be within the context of industry best practice and meeting the Director General Requirements (DGRs).

A glossary of technical terms is provided in Appendix A.

2. Background Information

2.1 Scope of Work

The key tasks requested by MCCC for the review of the groundwater assessment conducted in support of the Continuation of the Boggabri Coal submission were:

- A review of the groundwater assessment report by AGE (AGE, October 2010);
- A summary of AGE findings and how they relate to the DGRs as well as industry best practices, i.e. Murray Darling Basin Commission (MDBC) guidelines for modelling exercises (MDBC, 2000).
- An identification of limitations, if any, of the work conducted/presented and how they relate to fully satisfying the DGR requirements as well what work, analyses, reporting could be done to provide further assessment and confidence in findings, if any.
- Recommendations, if any, for further action/discussion.

2.2 Supplied Information

The application documentation on which this review is based are:

1. Australasian Groundwater and Environmental Consultants, Pty, Ltd. (AGE) (October 2010), *Continuation of Boggabri Coal Mine Groundwater Assessment*. Prepared for Boggabri Coal Pty Limited.
2. Hansen Bailey, (December 2010), *Continuation of Boggabri Coal Mine Environmental Assessment.* Prepared for Boggabri Coal Pty Limited.

The above references were downloaded from the NSW Government Planning website for major projects (http://majorprojects.planning.nsw.gov.au).

2.3 Review Criteria/Guidelines

The review has been designed to provide an assessment of the groundwater assessment based upon unbiased or subjective criteria. As such the MDBC guidelines process for review has been selected for the review along with the DGRs for the project available on the project planning website (http://majorprojects.planning.nsw.gov.au).

2.3.1 MDBC Guidelines

The 2-page review checklist (Table E-1, Appendix E, MDBC, 2000) provided in the guidelines has been selected for the model review. Not all questions in the checklist are relevant to the review - where possible these have been duly marked.

2.3.2 Director General Requirements

A copy of the DGRs was downloaded from the NSW planning website. The relevant section(s) that pertain to groundwater are summarised below.

- a detailed assessment of potential surface water and groundwater impacts;
- a detailed site water balance, including a description of the measures to be implemented to minimise water use on site;
- a detailed assessment of the potential impacts of the project on:
    - the quality and quantity of both surface water and ground water resources;
    - water users, both in the vicinity of and downstream of the project;
    - the riparian and ecological values of the watercourses both on site and downstream of the project; and
    - environmental flows; and
- a detailed description of the proposed water management system for the project and water monitoring program.

The above requirements were also to consider cumulative impacts of other activities within the surrounding area that could have a cumulative effect to the impacts solely attributable to the Boggabri Coal Mine.

2.4 Review Limitations

The level of effort and detail provided as part of a project submission is heavily dependent upon timing and budgetary constraints - details that are unknown by the reviewer. Hence any item(s) that may be commented as lacking or deficient are not necessarily an indication of unwillingness or inability to perform said task but instead a result of the prioritisation of tasks.

Given the above limitation by the reviewer, the following review has not made any assumptions regarding the cause for deficiencies, if any, but instead focuses upon what is and isn’t presented and what are the potential consequences.

3. Peer Review

3.1 MDBC Guidelines

A copy of the completed review checklist is provided in Appendix B. A discussion of findings is provided in the following sections corresponding with the sections of the review table.

3.1.1 The Report

The modelling and assessment report is a standalone document of high quality. Numerous cross-sections and "cartoon" diagrams are used to clearly present conceptualisations and subsurface structural understandings.

"The objective of the groundwater study was to assess the impact of the Project on the hydrogeological regime and to meet the applicable Director Generals Requirements." (AGE, 2010). These two objectives are essentially the same and as such will be commented further in Section 3.2.

3.1.2 Data Analysis

The assessment is founded upon a seemingly thorough literature review and the modelling is where possible based upon previous modelling and site investigations. Documentation of where information has been collected seems quite thorough.

The report is inconsistent in its description and presentation of exactly what water level data is and is not available. For example, Section 6.2.4 refers to "[a] network of groundwater bores monitored by the NSW government" within the alluvial aquifers that provides a long record of groundwater fluctuations. It is not presented how many bores records were made available, however it does present time series water levels for 10 locations. Figure 4 of the report however indicates there are 37 NOW monitoring bores within the study area. Of the 37 bores, were only 10 records available to the modeller?

Section 6.4.5 describes the water level monitoring "since commencement of mining." However no data has been presented in Figure 11 past December 2008 – thus missing the last 2.5 years of record with no explanation.

Recharge and discharge rates have not been assessed as part of this study. Initial recharge rates were assumed based upon previous modelling in the area and then allowed to change in the bedrock areas for calibration. As such no response to rainfall events were presented. However a cumulative rainfall deficit was provided on all water level graphs which is very useful.

3.1.3 Conceptualisation

The conceptual model is the most important part of any modelling exercise as it provides the framework and limitations for all analyses and assumptions. The report provides a good summary of the conceptual framework used to construct and constrain the model along with graphs and diagrams where applicable to further demonstrate the ideas.

Overall the conceptual model in combination with the data presentation provides an adequate description of the major hydrogeologic processes. Where the conceptualisation is found to be lacking is in the analyses and supporting data/testing of the vertical gradients and interconnectivity of the systems. The DGRs require an assessment of the impacts to groundwater users, riparian and ecological values of the water courses and environmental flows

– all of which are predicated within the model on how the bedrock aquifer(s) interact with the alluvial systems. The discussion regarding the interactions is limited to a one line comment that “Groundwater inflow to the alluvial aquifers from the surrounding bedrock is considered to be low as evident in previous government studies that have excluded bedrock from groundwater models.” No further comments are provided as to why this is believed to be the case. There are many different potential reasons for this comment to be true that could have variable outcomes to the modelling. For instance, the simplistic answer could be they are poorly connected, while another theory could be a reflection of the relative transmissivity and/or storage characteristics of each aquifer.

3.1.4 Model Design

Overall the documentation and design of the model seem reasonable and fit for purpose. One of the key factors in model development is the “[t]he model must not be configured or constrained such that it artificially produces a restricted range of prediction outcomes” (MDBC, 2000). The explicit boundary conditions at the edge of the model seem to be unrestrictive – with the noted interference of the no flow boundary during predictive simulations at the eastern boundary representing the bedrock aquifer extent.

The fixed parameterisation of the alluvium makes this in effect a prescribed internal boundary condition, like a General Head Boundary or fixed head/variable flux boundary, and the modelling results presented indicate that the alluvium is restricting any drawdown propagation past its boundaries. This relatively important role the alluvium is playing is not balanced by the presentation of field testing, data analysis, conceptualisation or sensitivity and uncertainty analyses. The motivation for choosing and not adjusting the parameterisation of the alluvium based upon previous works by the CSIRO and the state government are well understood and likely well founded. However these other models, as noted by the authors, did not include any interaction with the bedrock and hence the cause for concern regarding this model’s design for assessing impacts within the alluvial system based upon an activity in the bedrock.

3.1.5 Calibration

Calibration has been limited to steady state only. “Steady state simulations...are used to model equilibrium conditions (e.g. representing the long term “average” hydrological balance), and/or conditions where aquifer storage changes are not significant” and [t]ransient simulations are used to model time-dependent problems, and/or where significant volumes of water are released from or taken into aquifer storage” (MDBC, 2000). As such, the model is calibrated for long term average conditions, however it is being used to assess transient time and storage dependent problems - this is not an ideal situation.

The reasoning provided for this is that no alluvial abstraction data or pit inflow rate data is available to use as part of the transient calibration. While this is a limitation it is not necessarily a reason for not providing an effort at trying to match historic water level trends within the alluvium and changes within the bedrock since mining commenced. The level of confidence in transient calibration would be limited because of the unknown/uncalibrated flow rates, however this is still present for the steady state simulation as the natural flow rate to the river and creek systems is not known either.

The MDBC guidelines provide a table of model calibration performance measures (Table 3.2.1, MDBC, 2000). The steady state calibration conducted is compared and summarised using this table as its basis.

Table 3-1 Calibration Performance Measures

Performance Measure[1)]	***Criterion***[1)]	***Comment(s)***[2)]
Water balance Difference between total inflow and total outflow, including changes in storage, divided by total inflow or outflow, expressed as a percentage.	Less than 1% for each stress period and cumulatively for the entire simulation.	A water balance is provided for review with an error of <1%.
Iteration residual error The calculated error term is the maximum change in heads (for any node) between successive iterations of the model.	Iteration convergence criterion should be one to two orders of magnitude smaller than the level of accuracy desired in the model head results. Commonly set in the order of millimetres or centimetres.	Iteration convergence criteria is not documented.
Qualitative measures Patterns of groundwater flow (based on modelled contour plans of aquifer heads). Patterns of aquifer response to variations in hydrological stresses (hydrographs). Distributions of model aquifer properties adopted to achieve calibration.	Subjective assessment of the goodness of fit between modelled and measured groundwater level contour plans and hydrographs of bore water levels and surface flows. Justification for adopted model aquifer properties in relation to measured ranges of values and associated non-uniqueness issues.	A general review and discussion on goodness of fit is presented. A graph of predicted vs. observed heads is also provided. No obvious bias is present. No justification for surface flows is provided. Justification for adopted model parameters is provided to measured ranges. Non-uniqueness is not addressed.
Quantitative measures Statistical measures of the differences between modelled and measured head data. Mathematical and graphical comparisons between measured and simulated aquifer heads, and system flow components.	Residual head statistics criteria are detailed in Section 3.3. Consistency between modelled head values (in contour plans and scatter plots) and spot measurements from monitoring bores. Comparison of simulated and measured components of the water budget, notably surface water flows, groundwater abstractions and evapotranspiration estimates.	RMS error and Scaled RMS are provided for a selected set of the original data set with justification. It is noted that by far the greatest errors occur within the Boggabri monitoring datasets. No comparison of flows either conceptual or measured is presented. Justification for the rate of average baseflow to the ephemeral streams is not provided.

Notes: 1) MDBC, 2000
2) Reviewer's comments

The calibration conducted would at best have to be considered basic according to MDBC guidelines. The approach adopted by the modellers would seem to be more in line with the following description provided within the guidelines:

"where understanding or data are lacking, it is possible to design the associated model aspects to be conservative with respect to their intended use (eg. assuming an unknown aquifer parameter or stress is at the upper or lower limit of a realistic range)."

However the above philosophy is not an exemption from following standard calibration and sensitivity procedures to describe, assess and quantify non-uniqueness within the model. Non-uniqueness is the situation whereby many model input values and arrangements can produce the same or equally acceptable solutions. This situation arises because of the numerous variables available within the model setup. The recommended procedure for addressing non-uniqueness is described within the MDBC guidelines as follows:

> *The main methods that should be employed in conjunction to reduce the non-uniqueness problem comprise:*
>
> - *calibrating the model using hydraulic conductivity (and other) parameters that are consistent with measured values; and,*
> - *calibrating to multiple distinct hydrological conditions with that parameter set.*
>
> *The first method is designed to restrict the possible range of parameters to values that are consistent with the actual ("unique") values of the aquifer. The second method provides an indication of the predictive performance of a model by demonstrating that a given set of input model parameters (consistent with field measurements) are capable of reproducing system behaviour through a range of distinct hydrological conditions. The variation in hydrological conditions should not just relate to natural conditions, but also to induced stresses (e.g. pumping, river regulation, etc.).*
>
> *Similarly to the first method, a suggested third method of reducing the non-uniqueness problem involves the use of measured groundwater flow rates (eg. stream baseflow) as calibration targets, as this restricts the water budget to values that are consistent with actual aquifer conditions. However, it is often not practical or possible to directly measure groundwater flow rates, and where it is possible to estimate them, there is usually a large degree of uncertainty associated with the estimates, so this method is often not applicable.*
>
> *It is highly preferable that a model is calibrated to a range of distinct hydrological conditions (eg. prolonged or short term dry or wet periods, and ranges of induced stresses), and that calibration is achieved with hydraulic conductivity and other parameters that are consistent with measured values, as this helps address the non-uniqueness problem of model calibration.*

The model calibration presented in the report only addresses the first of three methods to be used conjunctively to address non-uniqueness. Simply put the model as reported is a non-unique solution with no evaluation as to the limits of possible solutions and the likely impact on this would have on predictive results.

3.1.6 Verification

"Verification (also called validation) is a test of whether the model can be used as a predictive tool, by demonstrating that the calibrated model is an adequate representation of the physical system. The common test for verification is to run the calibrated model in predictive mode to check whether the prediction reasonably matches the observations of a reserved data set, deliberately excluded from consideration during calibration" (MDBC, 2000).

Verification was not performed and/or presented in the model report. It is noted that the datasets presented in the Section 6 of the report would at face value seem to be reasonable datasets from which either a transient calibration or verification exercise could have been performed. The aim of the verification/calibration being to replicate the rate of drawdown associated with mining.

It is also noted in the predictive simulation setup description that the predictive model is intended to be simulating impacts/water levels from the commencement of mining in 2006 – yet a comparison of the predictive results for the first 5 years of mining with the monitoring dataset has not been provided.

3.1.7 Prediction

The setup of the predictive simulations is typical for an open pit mining and reclamation plan.

The assumed parameterisation of the backfill is reasonable.

It is not clearly described why the evapotranspiration extinction depth at the reclaimed site is set at the assumed pre-mining groundwater level and not a 2m depth from the reclaimed surface. It is also noted that on page 36 third bullet that no long term water level records are available prior to mining commencing to confirm the assumed historic average water levels. It is also not clearly reasoned what relevance this assumed water level has towards an assumed evapotranspiration extinction depth since the assumed pre-mining water level would have been far greater than 2m below the pre-mining surface elevation.

The presentation of results within the bedrock aquifers is adequate to understand predicted impacts.

Predictive model results that describe flow rates and/or changes to flow rates should have a caveat with them stating the model is not calibrated to any flow rates. This is not to say the reported values are wrong or even unreasonable – it just that is has not been demonstrated that the model provides reasonable estimates of flow rates.

3.1.8 Sensitivity Analyses

Minimal sensitivity analyses have been provided for predictive models. The underlying philosophy adopted was that the assumed parameters are conservative.

Sensitivity analyses for the recovery period to recharge rate is well demonstrated. However the sensitivity to alluvial connectivity is not, even though the drawdown propagation is being controlled by the alluvial system.

3.1.9 Uncertainty Analyses

No formal uncertainty analyses (i.e. Monte Carlo simulations, etc.) have been presented. This is not uncommon within the practice as computational, budgetary and time constraints often limit the ability to perform these analyses.

3.2 Director General Requirements

The DGRs list the following requirements that pertain to the groundwater assessments:

- a detailed assessment of potential surface water and groundwater impacts;
- a detailed site water balance, including a description of the measures to be implemented to minimise water use on site;
- a detailed assessment of the potential impacts of the project on:
    - the quality and quantity of both surface water and ground water resources;
    - water users, both in the vicinity of and downstream of the project;
    - the riparian and ecological values of the watercourses both on site and downstream of the project; and
    - environmental flows; and
- a detailed description of the proposed water management system for the project and water monitoring program.

The first and third bullets are reviewed together as they are essentially the same.

Figures are provided that depict the zone of impact or cone of depression estimated with the proposed mine plane. This zone of depression reaches the alluvial system within the first 5 years of the predictive simulation, which assumed to then be current impacts since the predictive simulation begins at year 2006. Subsequent years see an increase in radius of influence to the west, east and north of the site. The zone of impacts is constrained by the alluvial system in all predictive simulations, including the cumulative impact simulations.

The estimated drawdown within the alluvial system is reported to be up to <1m. A conclusion is drawn that a reduction of up to 1m in the alluvium would have minimal to no impact on groundwater users and ecosystems based upon the fact that season fluctuation of up to 3m in water levels occur. This dismissal of potential for impact is an over simplification of the well yield dynamics. Well yields are reliant upon available head/saturated thickness, well efficiencies, pump settings and efficiencies as well as a host of other factors. A reduction of up to 1m in water level/saturated thickness is not a simple linear extrapolation of reduction of yield.

The graphs provided in the report already show the alluvial system is experiencing declining water levels that are not correlated with climatic conditions. The graph provided indicates up to 3m of water level/saturated thickness has been lost over the last 10-20 years with no indication this trend is slowing. The system is not recovering from current extraction rates. The impact assessment does account for this in its cumulative impact assessment.

Pumps are rarely set any deeper than required due to extra electrical and capital costs. Given falling water level conditions within the alluvial aquifer, freeboard above many pumps are likely to already be minimal if non-existent. Mitigation measures for negotiating with land holders to lower pumps, replace bores, etc. to compensate for yield losses attributable to mining related impacts has been recommended but it is unclear how the cause of yield losses will be determined given the background conditions.

The assessment of impacts, including cumulative impacts, to alluvial water users is quite limited. In addition, in light of the previously mentioned lack of conceptualisation, documentation, testing, sensitivity analyses, etc of the interaction between the alluvium and the bedrock it is difficult to have much confidence in any results provided.

Water quality impacts from site activities are adequately covered with recommendations for mitigation and monitoring. Two notable exclusions are addressing any potential risk of salinity related impacts as well as the intermixing of aquifer waters.

Impacts to surface flow systems and environmental flows are not really addressed. The model is not calibrated for flow rates so this would not be particularly useful, although an estimate of X% reduction in flows could be reported given they were reported in the steady state water balance for ephemeral and streams and the Namoi River.

Water management measures, including measures to reduce water use, are not provided.

A description of the water level and quality monitoring systems has been provided and is relatively standard for this type of project. It is noted that a recommendation is provided for reviews of the monitoring data and model accuracy every 5 years. This is the fifth year of operation and as such it would seem reasonable, based upon their own recommendation, for such a review to be conducted now as part of this submission.

4. Conclusions and Recommendations

The modelling work conducted thus far is considered to be consistent with the fundamental guiding principle of best practice as defined by Hugh Middlemis (2004) in *Benchmarking Best Practice for Groundwater Flow Modelling*:

> *The fundamental guiding principle for best practice modelling is that model development is an ongoing process of refinement from an initially simple representation of the aquifer system to one with an appropriate degree of complexity. Thus, the model realisation at any stage is neither the best nor the last, but simply the latest representation of our developing understanding of the aquifer system.*

Based upon the current understanding of the work conducted presented in the AGE 2010 report, the following conclusions and recommendations are presented:

- Overall the work presented is in line with industry best practice, with the caveat above that modelling is an ongoing process of increased complexity often balanced by the practical limitations of budget and time.

- The report and presentation of the work conducted is of a high quality and is easily understood with good use of diagrams.

- A thorough background literature search has been completed and is well documented and used as a base for the conceptual and numeric model.

- Using the MDBC guidelines checklist, the modelling is found to be deficient and/or lacking in the areas of calibration, verification, sensitivity analyses and uncertainty analyses – each to varying degrees. The end result is no demonstration or basis, other than conservative assumptions by the modeller, by which to have any real confidence that what is being provided is the best estimate or even worst case. Water level hydrograph comparing the predicted and measured water levels for the first 5 years of the predictive simulation could go a long way to providing confidence the model actually replicates reality.

- The primary risks of impact being assessed are associated with the alluvial systems yet the connection between the alluvial and bedrock systems are not well explored either through field testing, literature research, vertical water level gradients, and or model sensitivity assessments. Further work should be conducted, including field studies such as pumping tests and model sensitivity assessments to quantify this interaction.

- The cumulative impact assessment should consider the declining water levels within the alluvial systems along with the impacts of the surrounding mines as currently presented.

- A clear method for identifying mining related loss of well yield from background yield losses should be defined up front to eliminate any confusion or difficulties after the fact.

In summary, the overall impression left after the review is that the work done is competent and well presented, however it is the work not done that leaves cause for concern and uncertainty.

.

.

5. References

Australasian Groundwater and Environmental Consultants, Pty, Ltd. (AGE) (October 2010) *Continuation of Boggabri Coal Mine Groundwater Assessment*. Prepared for Boggabri Coal Pty Limited, http://majorprojects.planning.nsw.gov.au.

Hansen Bailey (December 2010), *Continuation of Boggabri Coal Mine Environmental Assessment.* Prepared for Boggabri Coal Pty Limited. http://majorprojects.planning.nsw.gov.au.

Middlemis, H (2004), *Benchmarking Best Practice for Groundwater Flow Modelling*, prepared for The Winston Churchill Memorial Trust of Australia.

Murray Darling Basin Commission (MDBC) (2000), *Groundwater Flow Modelling Guideline*, prepared by Aquaterra.

NSW Department of Planning (2010), *Boggabri Coal Project (MP 09_0182) Director General Requirements,* http://majorprojects.planning.nsw.gov.au.

Appendix A

Glossary

Aquiclude	Low-***permeability*** unit that forms either the upper or lower boundary of a groundwater flow system.
Aquifer	Rock or sediment in a formation, group of formations or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water to bores, wells and springs.
Aquifer properties	Characteristics of an aquifer that determine its hydraulic behaviour and its response to abstraction.
Aquifer, confined	Aquifer that is overlain by a confining, low permeability strata. The ***hydraulic conductivity*** of the confining bed is significantly lower than that of the aquifer.
Aquifer, semi-confined	Aquifer confined by a low-***permeability*** layer that permits water to slowly flow through it. During pumping, recharge to the aquifer can occur across the confining layer; also known as a leaky artesian or leaky confined aquifer.
Aquifer, unconfined	Also known as a water table or phreatic aquifer. An aquifer in which there are no confining beds between the zone of saturation and the surface. The water table is the upper boundary of unconfined aquifers.
Aquitard	Low-permeability unit that can store groundwater and also transmit it slowly from one aquifer to another. Aquitards retard but do not prevent the movement of water to or from an adjacent aquifer.
Artesian water	Groundwater that is under pressure when tapped by a ***bore*** and is able to rise above the level at which it is first found. It may or may not flow out at ground level. The pressure in such an aquifer commonly is called artesian pressure, and the formation containing artesian water is an artesian aquifer or confined aquifer.
Australian Height Datum (AHD)	Reference point (very close to mean sea level) for all elevation measurements, and used for correlating depths of aquifers and water levels in bores.
Baseflow	Part of stream discharge that originates from groundwater seeping into the stream.
Bore	Structure drilled below the surface to obtain water from an aquifer system.
Boundary	Lateral discontinuity or change in the aquifer resulting in a significant change in ***hydraulic conductivity***, ***storativity*** or recharge.

Cone of depression	Depression of the ***potentiometric*** surface, which has the shape of an inverted cone, and develops around a production ***bore*** from which water is being drawn. It defines the area of influence of a bore.
Confining layer	Body of relatively impermeable material that is ***stratigraphically*** adjacent to one or more aquifers; it may lie above or below the aquifer.
Discharge	Volume of water flowing in a stream or through an ***aquifer*** past a specific point in a given period of time.
Discharge area	Area in which there are upward or sideways components of flow in an aquifer.
Drawdown	Lowering of the water table in an unconfined aquifer or the ***potentiometric*** surface of a confined aquifer.
Fissility	The property of rocks to split down planes of weakness.
Fracture	Breakage in a rock or mineral along a direction or directions that are not cleavage or ***fissility***.
Fractured rock aquifer	Occurs in sedimentary, igneous and metamorphosed rocks that have been disturbed, deformed, or weathered, and which allow water to move through joints, bedding plains and faults. Although fractured rock aquifers are found over a wide area, they generally contain much less groundwater than alluvial and porous sedimentary aquifers.
Groundwater	Water contained in interconnected pores located below the water table in an unconfined aquifer or located in a confined aquifer.
Groundwater flow	Movement of water through openings in sediment and rock; occurs in the zone of saturation.
Groundwater flow system	Regional aquifer or aquifers within the same geological unit that are likely to have similar recharge, flow, yield and water quality attributes.
Hydraulic conductivity	The rate with which water can move through pore spaces or fractures. It depends on the intrinsic ***permeability*** of the material and on the degree of saturation.
Hydraulic gradient	Change in total head (see below) with a change in distance in a given direction, which yields a maximum rate of decrease in head.

Hydraulic head	Specific measurement of water pressure or total energy per unit weight above a datum. It is usually measured as a water surface elevation, expressed in units of length. The hydraulic head can be used to determine a hydraulic gradient between two or more points.
Hydrogeology	Study of the interrelationships of geologic materials and processes with water, especially groundwater.
Hydrology	Study of the occurrence, distribution, and chemistry of all waters on the Earth.
Hydrostatic pressure	The pressure exerted by a fluid at equilibrium due to the force of gravity.
Infiltration	Flow of water downward from the land surface into and through the upper soil layers.
Parameterisation	The process of defining the parameters necessary for the specification of a model.
Perched water	Unconfined groundwater separated from an underlying body of groundwater by an unsaturated zone and supported by an ***aquitard*** or ***aquiclude***.
Permeability	Property or capacity of a porous rock, sediment, clay or soil to transmit a fluid. Measures the relative ease of fluid flow under unequal pressure. ***Hydraulic conductivity*** is a material's ***permeability*** to water at the prevailing temperature.
Permeable material	Material that permits water to move through it at perceptible rates under the hydraulic gradients normally present.
Piezometer (monitoring well)	Non-pumping monitoring well, generally of small diameter, which is used to measure the elevation of the water table and/or water quality. A piezometer generally has a short well screen through which water can enter.
Porosity	Proportion of interconnected open space within an aquifer, comprised of intergranular space, pores vesicles and fractures.
Porosity, primary	Porosity that represents the original pore openings when a rock or sediment formed.
Porosity, secondary	Porosity caused by fractures or weathering in a rock or sediment after it has been formed.

Potentiometric surface	Surface to which water in an aquifer would rise by ***hydrostatic pressure***.
Pumping test	Test made by pumping a bore for a period of time and observing the change in hydraulic head in the aquifer. It may be used to determine the capacity of the bore and the hydraulic characteristics of the aquifer.
Recharge	Process that replenishes groundwater, usually by rainfall infiltrating from the ground surface to the water table and by river water entering the water table or exposed aquifers; addition of water to an aquifer.
Recharge area	Area in which there are downward components of hydraulic head in the aquifer. Infiltration moves downward into the deeper parts of an aquifer in a recharge area.
Recovery	Difference between the observed water level during the recovery period after pumping stops and the water level measured immediately before pumping stopped.
Residence time	Time that a water source spends in storage before moving to a different part of the hydrological cycle (ie it could be argued it is a rate of replenishment).
Saturated zone	Zone in which the voids in the rock or soil are filled with water at a greater pressure than atmospheric. The water table is the top of the saturated zone in an unconfined aquifer.
Sedimentary aquifers	Occur in consolidated sediments, such as porous sandstones and conglomerates, in which water is stored in the intergranular pores, and limestone, in which water is stored in solution cavities and joints. They are generally located in sedimentary basins that are continuous over large areas, they may be tens or hundreds of metres thick, and they contain the largest groundwater resources.
Specific yield	Ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of the rock or soil. Gravity drainage may take many months to occur.
Spring	Location where groundwater emerges on to the ground surface. Water may be free flowing or slowly seeping.
Storativity	Volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. It is equal to the product of specific storage and aquifer thickness. In an unconfined aquifer, the storativity is equivalent to specific yield.

Stratigraphy	The study of stratified rocks (sediments and volcanics), including their sequence in time, the character of the rocks and the correlation of beds in different localities.
Surface water-groundwater interaction	Occurs in two ways: (1) Streams gain water from groundwater through the streambed when the elevation of the water table next to the streambed is greater than the water level in the stream. (2) Streams lose water to groundwater by outflow through streambeds when the elevation of the water table is lower than the water level in the stream.
Transmissivity	Rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient. It is a function of properties of the liquid, the porous media, and the thickness of the porous media.
Unconfined aquifer	Where the groundwater surface (water table) is at atmospheric pressure and the aquifer is recharged by direct rainfall infiltration from the ground surface.
Unsaturated zone	That part of an aquifer between the land surface and water table. It includes the root zone, intermediate zone and capillary fringe.
Water table	Surface in an unconfined aquifer or confining bed at which the pore water pressure is atmospheric. It can be measured by installing shallow wells extending a few feet into the zone of saturation and then measuring the water level in those wells.
Well	Any structure bored, drilled driven or dug into the ground, (which is deeper than it is wide), to reach groundwater.

Appendix B

MDBC Review Checklist

MODEL REVIEW: Continuation of Boggabri Coal Mine – Groundwater Assessment

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
1.0	**THE REPORT**								
1.1	Is there a clear statement of project objectives?		Missing	Deficient	Adequate	Very Good			
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes				The report does not explicitly describe a target or finished complexity in terms described by the MDBC guidelines.
1.32	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very Good			
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very Good			
1.5	Are the model results of any practical use?			No	Maybe	Yes			
2.0	**DATA ANALYSIS**								
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very Good			Water level data is inconsistent in its description and presentation thus the full extent of available data and its use is unknown.
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very Good			Conceptual descriptions and cross-sections. Data points are displayed on simulated heads plot Figure 9.
2.3	Have all potential recharge data been collected and analysed? (rainfall, streamflow, irrigation, floods, etc.)		Missing	Deficient	Adequate	Very Good			
2.4	Have all potential discharge data been collected and analysed? (abstraction, evapotranspiration, drainage, springflow, etc.)		Missing	Deficient	Adequate	Very Good			
2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very Good			
2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes			
2.7	Have consistent data units and standard geometrical datums been used?			No	Yes				

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
3.0	**CONCEPTUALISATION**								
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes			Data, testing, analysis and conceptualisation are lacking to fully characterise the vertical gradients/interactions between aquifers – specifically the interaction with the alluvial aquifers.
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very Good			
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very Good			
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No				With the exception of above notes.
4.0	**MODEL DESIGN**								
4.1	Is the spatial extent of the model appropriate?			No	Maybe	Yes			
4.2	Are the applied boundary conditions plausible and unrestrictive?		Missing	Deficient	Adequate	Very Good			The explicit boundary conditions input to the model seem to be unrestrictive. However the fixed parameterisation of the alluvium makes this in effect a prescribed boundary condition and the modelling results presented indicate that the alluvium is restricting any drawdown propagation. This relatively important role the alluvium is playing is not balanced by presentation of field testing, data analysis, or sensitivity and/or uncertainty analyses.
4.3	Is the software appropriate for the objectives of the study?			No	Maybe	Yes			

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
5.0	**CALIBRATION**								
5.1	Is there sufficient evidence provided for model calibration?		Missing	Deficient	Adequate	Very Good			The level of statistical calibration and presentation is adequate. However a spatial distribution of residual errors is not provided. It is also noted that the predictive simulation starts in 2006 when mining began – yet no comparisons are provided either as calibration or verification that the predicted water levels match those measured of the same time period (either in absolute head values or rate of decline).
5.2	Is the model sufficiently calibrated against spatial observations?		Missing	Deficient	Adequate	Very Good			
5.3	Is the model sufficiently calibrated against temporal observations?		Missing	Deficient	Adequate	Very Good			
5.4	Are calibrated parameter distributions and ranges plausible?			No	Maybe	Yes			
5.5	Does the calibration statistic satisfy agreed performance criteria?	Unknown	Missing	Deficient	Adequate	Very Good			None stated
5.6	Are there good reasons for not meeting agreed performance criteria?	Not Applicable	Missing	Deficient	Adequate	Very Good			
6.0	**VERIFICATION**								
6.1	Is there sufficient evidence provided for model verification?		Missing	Deficient	Adequate	Very Good			None provided even though datasets are said to exist and the predictive simulation included the previous 5 years of mining.
6.2	Does the reserved dataset include stresses consistent with the prediction scenarios?	Not Applicable	Unknown	No	Maybe	Yes			

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
6.3	Are there good reasons for an unsatisfactory verification?	Not Applicable	Missing	Deficient	Adequate	Very Good			
7.0	**PREDICTION**								
7.1	Have multiple scenarios been run for climate variability?		Missing	Deficient	Adequate	Very Good			
7.2	Have multiple scenarios been run for operational/management alternatives?	Unknown	Missing	Deficient	Adequate	Very Good			Multiple options have been listed as valuated in the EA but only the proposed option is assessed in the groundwater report. The scope of services is unknown but alternative assessments may be desirable considering the underground mining option.
7.3	Is the time horizon for prediction comparable with the length of the calibration / verification period?		Missing	No	Maybe	Yes			Calibration is steady state (i.e. no time period) and no verification is provided. Time series data provided does indicate a changing water table surfaces over the last 20+ years so the selection of an “average condition” based upon historic levels may not be applicable as a starting point for future predictions.
7.4	Are the model predictions plausible?			No	Maybe	Yes			
8.0	**SENSITIVITY ANALYSIS**								
8.1	Is the sensitivity analysis sufficiently intensive for key parameters?		Missing	Deficient	Adequate	Very Good			Minimal sensitivity analyses are performed. However it is noted that in most cases conservative assumptions are made where data is lacking.
8.2	Are sensitivity results used to qualify the reliability of model calibration?		Missing	Deficient	Adequate	Very Good			No sensitivity for model calibration is provided

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
8.3	Are sensitivity results used to qualify the accuracy of model prediction?		Missing	Deficient	Adequate	Very Good			Minimal sensitivity analyses are performed. Not enough for any assessment of the predictive accuracy – other than for recovery duration. However it is noted that in most cases conservative assumptions are made where data is lacking.
9.0	**UNCERTAINTY ANALYSIS**								
9.1	If required by the project brief, is uncertainty quantified in any way?	Unknown	Missing	No	Maybe	Yes			Unknown if required by project brief but quantification of uncertainty is not provided.
	TOTAL SCORE								**PERFORMANCE: %**

BRIAN M. RASK – PRINCIPAL HYDROGEOLOGIST/MODELLER

P.O. Box 7275, Tathra, NSW 2550 | (02) 6494 5030 | wra1@Bigpond.com

EDUCATION

Colorado State University, Fort Collins, Colorado, U.S.A

Bachelor of Science (Watershed Science) **1999**

University of Phoenix, Lone Tree, Colorado, U.S.A

Master Business Administration (Technology Management) **2003**

AWARDS

Winner of the 2008 NSW AWA Water Research Merit Award – **2007-2008**

Collaborative Research Program: Conceptualisation and Modeling of Surface Water – Groundwater Interaction in the Upper Nepean Fractured Aquifer System

KEY QUALIFICATIONS

Brian has provided numerous management and technical services throughout his career from senior hydrogeologist/modeler to Groundwater Team Manager and Water Resources Capability Executive for the PB water group in Sydney. As such Brian has been responsible for the leadership and coordination of over 30 staff in the Water Quality, Surface Water and Groundwater Teams. At the same time Brian was responsible for the continued technical development of the group through hands-on experience and appropriate educational training; Brian's success is best exemplified by one of Brian's projects in which he was the lead researcher evaluating and quantifying the surface and groundwater interaction within a fractured rock system – winner of the 2008 NSW AWA Water Research Merit Award.

Brian has extensive experience in hydrogeology in the US and Australia. Project experience includes surface and groundwater assessments; environmental impact statements; mine site water supply management; water supply, storage and operational management programs; contaminated site/surface and groundwater transport assessments/modeling; remedial action plans; project and financial management; drilling and well design/construction management. Brian is also experienced in the use of numerous surface and groundwater modeling programs including, but not limited to, MODFLOW (Visual and Groundwater Vistas), MODFLOW-SURFACT, FEFLOW, HEC-RAS, Quickflow, WinFlow, and WinTrans.

PROJECT EXPERIENCE – GROUNDWATER MODELLING

Middlemount Mine - Groundwater Impact Assessment, Middlemount Coal, QLD

Senior Hydrogeologist/Modeler **2010**

A groundwater model was created using the Groundwater Vistas MODFLOW pre-processor in conjunction with MODFLOW SURFACT. The model was calibrated with extensive calibration sensitivity assessments performed. One operational scenario was simulated with multiple predictive sensitivity simulations performed. Results of all modeling and a final report were provided within the aggressive 4-week project delivery schedule.

Cobbora Coal Mine Project - Groundwater Impact Assessment, Cobbora Management Company, NSW

Senior Hydrogeologist/Modeler **2009 - 2010**

A groundwater model was created using the Visual MODFLOW pre-processor in conjunction with MODFLOW SURFACT. The model was suitably calibrated for the project requirements. Two operational scenarios were simulated with respect to how the pit is dewatered, as well as numerous recovery simulations. An additional water balance model was developed to estimate the filling duration and long-term water level fluctuations within the final voids (2). Results of all modeling provided the quantitative basis for the groundwater impact assessment.

Airport Link – Eastern Connections, Thiess-John Holland, Brisbane, QLD

Senior Hydrogeologist/Modeler **2009**

A three dimension numerical model was developed in MODFLOW to simulate the inflow rates, drawdown and potential mitigation measures for the Eastern Connections area. Additional 2D models were used to provide pressure profiles on walled structures across the Eastern connections. Numerous sensitivity runs and adjustments to model and structural designs were done in order to provide a best for project, client, and environmental outcome.

Airport Link – Felix St Fate and Transport Groundwater Model, Thiess-John Holland, Brisbane, QLD

Senior Hydrogeologist/Modeler **2009**

A fate and transport model was developed for the Felix St, Lutwyche site, following identification of hydrocarbon contamination in groundwater at this location. The primary aims of the model were to evaluate the risk for the migration of contaminant into previously uncontaminated areas, the likelihood that contaminants would reach drained structures within the underground works, estimate concentrations of any contaminants for water treatment plant design purposes, and to estimate the duration treatment will be required. The results of the modeling provided the client with the appropriate information and risk assessment required for them to proceed with further design, construction and mitigation measures.

Oberon Timber Complex, Oberon, NSW

Senior Hydrogeologist/ Lead Modeler **2008**

A concept design was required to create “no discharge” from a waste heap. Analytical modeling followed by the creation of a MODFLOW model was used to estimate barrier wall and drainage trench (or extraction well) requirements.

South West Rocks, Caltex, NSW

Senior Hydrogeologist/ Modeler **2006**

A MODLFOW model was created and calibrated based upon steady state and transient flows as well as transiently calibrated for chemical transport, including natural attenuation processes. The geology of the area required the model to consist of three distinct aquifer layers with differing hydrogeologic and chemical transport properties. The model was used to estimate future plume migration and degradation due to natural attenuation processes. The end goal of the project was the delineation of a bore exclusion zones in all three layers. The modeling used MODLFOW along with the RT3D and MODPATH packages.

Greystanes Estate – Southern Employment Lands Groundwater Modeling, Boral Resources, Sydney, NSW

Senior Hydrogeologist /Modeler **2006**

A MODLFOW model was created and transiently calibrated for the quarry and surrounding areas. Future predictive simulations were then conducted to evaluate options for groundwater drainage for the post-quarry operations development of the land. A variety of drainage structures were modelled, including drains, artificially constructed high yielding aquifers, and wells. Model results were then prepared and presented to the client for selection of final drainage design concept.

Northern Hawkes Nest WWTP, Great Lakes Council, NSW

Senior Hydrogeologist /Modeler **2006**

A MODFLOW groundwater model was developed for the Hawks Nest Waste Water Treatment Plant to evaluate the suitability of expanding the existing dune exfiltration scheme to accommodate a proposed development to the north. The groundwater model was calibrated under steady state and transient conditions using historical effluent discharge rates, groundwater levels and rainfall. The model simulated increased effluent loadings for wet weather and peak effluent periods, predicting the likelihood of groundwater approaching the surface. The groundwater model water used to estimate area vulnerable to rises in groundwater table.

Groundwater Availability Assessment, Rancho Rosado, Colorado, USA

Hydrogeologist /Modeler **2004**

Provided oversight of the construction and testing of two artesian monitoring wells. Used results of the testing program to estimate groundwater availability using Quickflow. Provided preliminary well field design and cost to client.

Cherry Creek Alluvium/Stream Interaction Model for the Environmental Impact Statement for Rueter-Hess Reservoir, URS Corporation, Denver, Colorado, USA

Hydrogeologist /Modeler **2002 - 2004**

Conducted hydrologic and hydrogeologic assessment of the potential impacts associated with the construction and operation of an off-channel reservoir and associated facilities. The assessment included detailed site inspections, aquifer testing, flow measurements, collection of data from surrounding entities and extensive literature research. The data sets acquired were then used to create and model the stream, alluvium and deep aquifer under various reservoir operational scenarios using MODFLOW. Prepared a final report which was eventually included by the U.S. Army Corp of Engineers in the Final Environmental Impact Statement. The modeling was critical in the eventual permitting of the reservoir.

Future Groundwater Production Assessment, Parker Water and Sanitation District, Parker, Colorado, USA
Hydrogeologist /Modeler **2001 - 2003**
Conducted analytical and numerical modeling to estimate production rates from heavily pumped aquifers with layered sandstone and shale units. The assessment used simple analytical solutions as well as MODFLOW-SURFACT to estimate declining water levels and production rates within four separate aquifers, based upon historical water levels and pumping rate declines. The results of the study were used as part of a long-term water planning strategy which included the financial justification for the construction of a reservoir to store groundwater that is pumped year-round versus on demand-supply, thus reducing the number of wells required to meet peak demand.

Groundwater Availability Modelling, El Paso County, Colorado, USA
Hydrogeologist /Modeler **2002 - 2003**
Modified an existing MODFLOW model and simulated various pumping scenarios of various water entities. Based upon the results of the modeling, recommendations for well field placements and sustainability, as well as water development strategies, were provided to the client.

Analytical Modelling, Carlsbad, New Mexico, USA
Hydrologist/ Modeler **2000**
Conducted analytical modelling to estimate the increased runoff associated with a small development. The results of the modelling were used for detention pond design and site development approval.

Groundwater Modeling, Confidential Client, Nebraska, USA
Hydrologist/ Modeler **2000**
Characterized surface and ground water interaction, as well as ground water transport properties down-gradient of a hog farm. Modeled hypothetical spills and evaluated probabilities of water quality impacts to downstream water users.

PROJECT EXPERIENCE – GROUNDWATER TECHNICAL REVIEW

Ecomarkets, Victoria Department of Sustainability and Environment, Melbourne, VIC
Peer Reviewer **2009 - 2010**
Brian was the lead peer reviewer for the North Central and North East catchment models. Through a series of meetings at strategic model development stages (steady state and transient calibration) Brian was able to provide comments and recommendations throughout the process to assist DSE and their modeling contractor to deliver a groundwater model that met all project specifications. A final model review report was prepared by Brian that documented the model development, key assumptions, limitations and recommendations for model use and improvements.

Groundwater Fate and Transport Model, Stage 3 Remediation Powerhouse Fuel Spill Plume, Department of Defense, Garden Island, Western Australia.

Peer Reviewer **2010**

PB was commissioned to undertake Stage 3 works for environmental remedial works associated with the Powerhouse diesel fuel spill Part of the Stage 3 works includes undertaking groundwater modeling to simulate observed groundwater contamination; and scenario modeling to simulate options for aquifer remediation. Modeling undertaken included both flow and solute transport. Groundwater flow and transport modeling was undertaken using Visual MODFLOW Pro and MT3DMS software respectively. Brian provided technical peer review of the groundwater modeling and associated report.

Cape Lambert Magnetite Project: Hydrogeological Assessment, MCC Australia Sanjin Mining Pty Ltd, Western Australia.

Peer Reviewer **2010**

PB was commissioned to undertake hydrogeologic assessment for the Cape Lambert Magnetite Project. The hydrogeologic assessment included the development, calibration, and sensitivity assessment of a groundwater numeric model. The model was then used to assess the potential impacts associated with assumed mining conditions. Modeling was undertaken using the preprocessor Visual MODFLOW Pro in conjunction with MODLFOW-SURFACT software. Brian provided technical peer review of the groundwater modeling and associated report.

Melbourne Desalination Treatment Plant, AquaSure Joint Venture, VIC

Peer Reviewer **2009-2010**

As one of the Joint Venture’s associates, PB was commissioned to provide hydrogeologic assessments associated with the design and construction of a desalination plant in Victoria. These technical studies include the assessment of impacts during and after construction. Numerous models (3D MODFLOW and analytical models) were developed at various stages as part of the assessment. The assessments include estimated inflows to tunnels and excavations as well as the short and long term drawdown associated with the project. These results are then provided as part of an overall assessment of follow-on impacts such as acid-sulphate soils, subsidence, and ecological impacts. Brian was commissioned to provide technical peer review of the groundwater models being prepared as well as ongoing modeling/technical support.

Airport Link, Thiess-John Holland, Brisbane, QLD

Peer Reviewer **2008 - 2009**

A three dimension numerical model was developed in MODFLOW to simulate the inflow rates, drawdown and potential mitigation measures for the entire project area (global model). Numerous sensitivity runs and adjustments to model and structural designs were done in order to provide a best for project, client, and environmental outcome. Brian provided technical reviews of various versions as well as providing some strategic advice throughout the review and internal and external commenting processes.

Abbot Point State Development Area Infrastructure Corridor Study, Queensland Department of Infrastructure and Planning, QLD

Groundwater Technical Advisor **2008**

Brian conducted a review of the groundwater conditions in the area(s) proposed and provided a hydrogeologic constraints analysis and recommendations for work to be performed in order to further develop the preferred option(s) for the infrastructure corridor. Significant constraints were identified as the proposed area is a wetland and as such require significant risk mitigation.

Groundwater Due Diligence, Rio Tinto Hunter Valley, NSW

Groundwater Technical Advisor **2008**

A due diligence assessment was conducted for all operations in the Hunter Valley as it pertains to commitments made regarding groundwater investigations, monitoring, licensing, etc. The results of the investigation provided Rio Tinto with a roadmap of what further works need to be completed as well as a general prioritisation of tasks.

Jacinth Ambrosia Project, Iluka Resources Limited, South Australia

Peer Reviewer **2008**

Brian was responsible for the technical and fit-for-purpose peer review of all groundwater borefield construction design and tendering documents. Brian worked closely with the team to ensure that he understood the key demands and drivers to ensure the design and tender packages were appropriate for the intended purpose.

Old State Mine, Delta Electricity, Lithgow, NSW

Peer Reviewer **2007 - 2008**

PB was commissioned to conduct a groundwater model using FEFLOW to estimate potential water supply from the old State Mine at Lithgow. Brian provided peer review of the model and reporting through two rounds of model calibration and predictive simulations. The nature of the old workings for the longwall mining operation, known discharge points from the mine workings, outcropping and local groundwater users provided many challenges for the modeling and thus a significant modeling effort was required.

PROJECT EXPERIENCE – GROUNDWATER-SURFACE WATER INTERACTION

Collaborative Research Program: Conceptualisation and Modeling of Surface Water – Groundwater Interaction in the Upper Nepean Fractured Aquifer System, Sydney Catchment Authority, NSW

Project Manager/ Lead Researcher/Senior Hydrogeologist **2007 - 2008**

A Collaborative Research project to investigate the surface water and groundwater interaction in Doudles Folley Creek was undertaken near Bowral, NSW. The investigation comprised a comprehensive suite of hydrogeologic and hydrogeochemical tools, and tracers (environmental and applied) to quantify the natural interaction of the two systems and how it changes under a trial borefield simulation. Brian was the project manager and lead hydrogeologist for the project. The results of the eight month field program and later desk top analyses has provided the Sydney Catchment Authority with clear and quantifiable evidence of the background interaction and changes associated with localised pumping. The innovative approach, application of tools, and results on the project were recognised by Brian, his team, and the SCA being awarded the 2008 NSW AWA Water Research Merit Award.

Collaborative Research Program: Impacts of Longwall Mining in the Waratah Rivulet, Sydney Catchment Authority, NSW

Project Manager/ Lead Researcher/Senior Hydrogeologist **2007 - 2008**

A Collaborative Research project to investigate the changes to surface water and groundwater interaction in Waratah Rivulet as a result of longwall mining was undertaken near Helensburgh NSW. The investigation comprised a comprehensive suite of hydrogeologic and hydrogeochemical tools, and tracers (environmental and applied) to quantify the post-mining interaction of the two systems and how it might have changed as a result of longwall mining. Brian was only involved as the project manager and lead hydrogeologist for the project for the initial stages of the proejct. This project was a three year long project and as project manager Brian was responsible for the initial project reviews, such as literature review of longwall mining impacts and baseline dataset, and the development of the methodology for the field studies.

PROJECT EXPERIENCE – WATER RESOURCE MANAGEMENT/ENVIRONMENTAL ASSESSMENT

Environmental Impact Assessment for the Water for Bowen Project, SunWater, QLD

Water Resources Team Lead / Senior Hydrogeologist **2008 - 2009**

The Water for Bowen project proposed to deliver up to 60,000 mega litres (ML) of water per annum from SunWater's existing water allocation in the Burdekin Falls Dam. Brian was the technical lead for the water resources technical reports, as well as the lead hydrogeologist to assess the impacts to groundwater.

Environmental Impact Assessment for the Princess Highway Upgrade at Banora Point, RTA, NSW

Senior Hydrogeologist **2007**

Brian provided technical oversight and review of the hydrogeologic impact assessment. The assessment included the impacts associated with a large cut into the hillside which was expected to encounter local groundwater. The final report provided an assessment of the likely impacts to local springs and wetlands along with a water management strategy plan.

Cherry Creek Basin Water Quality Monitoring, Cherry Creek Basin Water Quality Authority, Colorado, USA

Project Manager/Senior Hydrologist/Hydrogeologist **1999 - 2006**

Managed and conducted basin-wide surface and groundwater sampling and monitoring of water quality and flow within a rapidly developing watershed that supplies water to a reservoir used for recreation in a State Park in Colorado, US. Sampling occurred on a variety of schedules ranging from fortnightly to annually, depending upon the water quality analysis required. Storm water sampling also was conducted to estimate peak flow concentrations and loading of phosphorus to the reservoir.

Review of Lower Guadalupe Water Supply Project, O'Connor Ranches, Houston, Texas, USA

Project Manager/Senior Hydrologist **2003 - 2006**

Managed staff and provided technical expertise for the review of a large-scale (>1,000 GL/yr) water supply transfer project. Reviewed the project in relation to permit requirements, storage requirements, environmental impacts and water yield analyses. Presented findings and answered questions/comments in a public forum.

Watershed Evaluation for an Environmental Contamination Lawsuit, Client Confidential, California, USA

Senior Hydrologist **2002 - 2004**

Assessed watershed characteristics to determine runoff volumes in a small watershed to assess the frequency and duration of flow in an ephemeral stream. These data were then used to evaluate transport mechanisms to move volatile organic compounds across a rocket test site, and potentially off-site.

Bear Creek Water Quality Monitoring Program, Evergreen Wastewater, Evergreen, Colorado, USA

Hydrologist **2002**

Provided a monitoring program for the characterization and assessment of wastewater discharge impacts to Bear Creek water quality. The study included site inspection of creek and discharge outfalls. The program was accepted and used as the dataset to settle a litigation case.

PROJECT EXPERIENCE – GROUNDWATER DEVELOPMENT/MANAGEMENT

Hydrogeological Assessment of Broke Gas Prospect, Sydney Gas, Broke, Hunter Valley, NSW

Project Manager/Senior Hydrogeologist **2006 - 2009**

Desktop assessment(s) of groundwater and surface water resources, groundwater quality and potential impacts from extraction of coal seam methane from Wittingham and Wollombi Coal Measures. Brian also provided strategic planning advice for throughout his 4 years of project involvement.

Emergency Drought Supply Evaluation: Pinedale Mine, Delta Electricity, Lithgow, NSW

Senior Hydrogeologist **2008**

Provided technical guidance and oversight of a desk-top investigation into the feasibility of extracting water for the mine void. The feasibility investigation included estimating volumes potentially available within the mine void, identification of permitting requirements, a conceptual model, and the conceptual design and placement of potential extraction bores.

Supervision and Hydrogeological Analysis of Drilling and Testing Program – Warragamba and Wallacia Investigation Sites, Sydney Catchment Authority, Wallacia, NSW

Project Manager/Senior Hydrogeologist **2006 - 2007**

Brian was project manager of the Drilling and Supervision project at the Warragamba and Wallacia Investigation Sites, which included the supervision of drilling two bores at the Warragamba site and three bores at the Wallacia site and the supervision of geophysical logging and pump testing of these test bores. Four bores were installed in the Hawkesbury Sandstone, with one bore (3A) drilled to 450m into the underlying Narrabeen Group sediments. 7-day pumping and recovery tests were conducted at each site with water levels monitored in all bores. A final report documenting all field work, water quality, pumping test results and estimated safe yields were provided at the completion of the project.

Supervision and Hydrogeological Analysis of Drilling and Testing Program – Illawarra Investigation Sites, Sydney Catchment Authority, Wollongong, NSW
Project Manager/Senior Hydrogeologist **2006 - 2007**
Brian was project manager of the Drilling and Supervision project at the Illawarra site. The primary objective of the investigation was to establish the potential groundwater yield and water quality, and to determine the potential for borefield construction. One bore was drilling on site, which had below average yields and water quality not ideal for borefield development. Further drilling and exploration was consequently canceled. A final report documenting all field work, water quality and yield measurements was provided at the completion of the project.

Emergency Drought Supply Evaluation: Lithgow Mine, Delta Electricity, Lithgow, NSW
Senior Hydrogeologist **2006 - 2007**
Evaluated and managed the project to identify potential water sources for drought supply. One site identified was the Lithgow Mine. Conducted numerous desk-top and field investigations into the feasibility of extracting water for the mine void. Feasibility investigations have ranged from estimating volumes potentially available within the mine void, identification of permitting requirements, a conceptual model, and the conceptual design and placement of potential extraction bores.

Greystanes Estate - Southern Employment Lands Groundwater Drainage Concept Design, Boral Resources (NSW) Pty Ltd, Sydney, NSW
Senior Hydrogeologist **2006**
Brian was coordinator for the groundwater design team; organizing a team of hydrogeologists, geochemists, civil engineers, waste water treatment engineers and draftsmen to provide a comprehensive concept design of the groundwater drainage network. The network was designed to maintain water levels below ground surface to a sufficient level to prevent, salinity and negative impacts to shallow piping networks, utilities, and other features associated with the 160 hectare development. Groundwater was then designed to be treated to a sufficient level for discharge to Prospect Creek.

Deep Aquifer Well Construction, Parker Water and Sanitation District, Parker, Colorado, USA
Senior Hydrogeologist/Hydrogeologist **1999 - 2006**
Provided contract documents and technical specifications for the drilling and construction of large diameter high production rate water supply wells. Solicited competitive bids on behalf of the client from drillers for the construction of the wells. Recommended to the client contractor selections and provided project oversight on behalf of the client over a six-year period.

Well Operations Efficiency Program, Parker Water and Sanitation District, Parker, Colorado, USA

Project Manager/Senior Hydrogeologist **2004-2005**

Designed and managed the creation of a groundwater use optimization program for the efficient operation of a well field of over 25 deep aquifer wells, which is expected to expand to over 40 wells in the next 20 years. The software operates the wells through an existing SCADA system based upon water levels in multiple storage tanks, and uses previous historical data, such as demand and climate records, to predict demand. The system also adjusts production rates based upon water levels in the wells; the intent being to distribute pumping aerially across the aquifer as much as possible to reduce localized drawdown and air intrusion. As a result of implementing the system, operational electrical costs alone are expected to decrease by 15% the first year, resulting in an estimated net savings in 2006 of over $250,000 (US). Once the system is fully operational and the well field is completed, electrical cost savings are expected to exceed US$500,000 annually.

Passive Injection and Recovery Well, Parker Water and Sanitation District, Parker, Colorado, USA

Project Manager/Senior Hydrogeologist **2004 - 2005**

Designed, managed, and obtained State and Federal permits for the construction and testing of a new well construction design, intended to allow water to be extracted from and recharged to multiple aquifers within a single well. The well design allows for water to be extracted from one or more aquifers and injected and\or brought to the surface without the need of redundant infrastructure for each aquifer, such as wells, pumps, meters, piping, etc. The design included multiple options for the measurement of flow to and from each aquifer, which was required for groundwater production reporting to the State and injection reporting to USEPA.

Characterized a UAN spill and plume migration, CF Industries – Fremont, Fremont, Nebraska, USA

Hydrogeologist **2000 - 2003**

Characterization included onsite inspection, monitoring well construction, water quality sampling, and analytical modeling of plume migration. Based upon the study results an assessment of risk to surrounding shallow groundwater users was provided to the State as well as a monitoring and remediation plan. Subsequently, annual reports were supplied to the client and the State.

Alluvial Aquifer Characterization Program, Parker Water and Sanitation District, Parker, Colorado, USA

Hydrogeologist **2000 - 2001**

Conducted and managed a drilling program to characterize an alluvial aquifer determined to be a critical factor in the supply of water and reuse of treated water. The program included discreet split spoon sampling every 1.5 meters during borehole drilling and monitoring well construction. Results of the drilling program were used to characterize the aquifer within the project area and recommendations were provided to the client for the placement of large diameter, high rate production wells (12 in total).

Preliminary Groundwater Availability Assessment, Cheyenne Board of Public Utilities, Cheyenne, Wyoming, USA

Hydrogeologist **2001**

Conducted field visits and literature research on local aquifers. Literature reviewed included geophysical logs of boreholes completed in the surrounding area as well as seismic refraction tests conducted onsite. Based upon the findings, a drilling and testing program was recommended to the client for aquifer testing and production well construction. An assessment of potential impacts to surrounding groundwater users and surface water flows was also provided, as well as a monitoring plan to assess impacts.

Large Lot Residential Well Permitting, Newmont Mining, Ouray, Colorado, USA

Hydrogeologist **2001**

Assisted Newmont Mining in the permitting of residential wells for the housing development being constructed at a reclaimed mine site. In addition, provided contract documents and technical specifications for the solicitation of bids to drill and construct the wells.

PROJECT EXPERIENCE – SURFACE WATER DEVELOPMENT/MANAGEMENT

Rueter-Hess Reservoir Operational Studies, Parker Water and Sanitation District, Parker, Colorado, USA

Senior Hydrologist/Hydrogeologist **1999- 2006**

Over the period of 6 years, conducted and managed numerous studies for the design and operation of an off-channel reservoir to be used as an integral part of a water supply distribution system, as well as a water reuse program. Assessments included sizing the reservoir and intake structures based upon various potential water sources available, as well as modeling of chemical mixing expected to take place within the reservoir from the various source waters. Over the period of 2004-2006, the planned reservoir size increased over 400% due to the partnership with other water supply entities, resulting development of complex operational rules and accounting.

Upper South Platte River Water Supply Feasibility Assessment, Parker Water and Sanitation District, South Platte River, Colorado, USA

Senior Hydrologist/Hydrogeologist **2004 - 2005**

Conducted a preliminary evaluation of water availability and reservoir site location in the upper regions of the South Platte River, Colorado. The study included reservoir sizing and cost estimation. The results of the study were presented in a long-term water supply planning conference held by the client.

Lower South Platte River Water Supply Feasibility Assessment, Parker Water and Sanitation District, South Platte River, Colorado, USA

Senior Hydrologist/Hydrogeologist **2004 - 2005**

Conducted a preliminary evaluation of water availability and reservoir site location in the lower regions of the South Platte River, Colorado. The study included reservoir sizing and cost estimation. The results of the study were presented in a long-term water supply planning conference held by the client.

Parker Farms Management Strategy, Parker Water and Sanitation District, Logan County, Colorado, USA

Senior Hydrologist/Hydrogeologist **2003 - 2005**

After the purchase of numerous farms and associated water rights a study was conducted to assess water availability from the new assets. A detailed review was conducted to estimate historical land and water use, with the intention of providing recommendations for more efficient water use; the point being if water is used more efficiently, more water would be available for municipal use. The study resulted in a water management and land management plan designed to maximize the efficiency of water used in irrigation, making available more water to be supplied for municipal purposes.

Cactus Park Reservoir and Hydroelectric Generation Project, Grand Mesa Water Task Force, Cedaredge, Colorado, USA

Senior Hydrologist/Hydrogeologist **2005**

The project included the preliminary feasibility study of using a network of reservoirs to store water and generate hydroelectric revenue to pay for the project construction and maintenance. The study included historic flow characterisations, water rights availability assessment, as well as the operational simulations of up to three hydroelectric stations and two reservoirs working in series over a 30 year period. Results of the operational simulations were provided for reservoir and hydroelectric generator sizing and cost estimates. A final report was prepared and presentation given to the task force, as well as recommendations for future actions and potential fatal flaws.

Annual Operational Review and Water Supply Assessment, Parker Water and Sanitation District, Parker, Colorado, USA

Senior Hydrologist/Hydrogeologist **1999 - 2005**

Managed, conducted and presented to the client annually a review of their water supply and operations, as well as provided recommendations for system improvements and advice regarding potential short fall in supply. The water supply system included both surface and ground water components requiring planning to meet short-term and long-term objectives.

Cherry Creek Water Availability Assessment, Parker Water and Sanitation District, Parker, Colorado, USA

Hydrologist/Hydrogeologist **2002- 2004**

Conducted a water availability assessment for the sizing of an in-take structure and forebay, as well as the terminal off-channel reservoir. Fifty years worth of hydrologic records were used in the estimate of water availability. Flow records needed to be adjusted for increased drainage area from the point of recorded flow to the intake structure and decreased due to water diversions from other entities in the same reach. Flow estimates were then verified with downstream flow measurements.

PROJECT EXPERIENCE – MINING RELATED HYDROLOGIC/HYDROGEOLOGIC STUDIES

Preliminary Water Availability Assessment for a Proposed Mine, U.S. Energy, Mt. Emmons, Colorado, USA
Senior Hydrologist/Hydrogeologist **2005**
The water availability assessment included the use of multiple reservoirs and water diversions and transportation from multiple catchments.

Tailings Seepage Analyses, Smith Williams Consulting, Rock Creek, Alaska, USA
Senior Hydrologist/Hydrogeologist **2005**
Conducted tailings seepage analyses for the design of tailings facilities using a variety of potential hydraulic conductivities resulting from processing as well as potential tailings structure lining.

Preliminary site Hydrologic/Hydrogeologic Characterization for Mine Feasibility Report, Smith Williams Consulting, Mt. Hope, Nevada, USA
Senior Hydrologist/Hydrogeologist **2004 - 2005**
Installed monitoring network for the measurement of discharge from the mine pits to the local alluvial aquifer and associated stream. Numerous pumping tests were conducted and analyzed.

Monitoring of Tailings Facility, Battle Mountain Resources, San Luis Mine, Colorado, USA
Hydrologist/Hydrogeologist **2001**
Installed monitoring network downstream of the tailings facility to demonstrate no discharge to the local water supply.

Discharge Monitoring Network, Battle Mountain Resources, San Luis Mine, Colorado, USA
Hydrologist/Hydrogeologist **2000 - 2001**
Installed monitoring network for the measurement of discharge from the mine pits to the local alluvial aquifer and associated stream. Numerous pumping tests were conducted and analyzed.

Analytical Modeling, AMAX-Gold, Fort Knox, Alaska, USA
Engineer Technician **1993**
Conducted literature research for watershed characterization. Conducted analytical modeling for mine dewatering as well as tailings seepage estimates.

PUBLICATIONS AND PAPERS

"Interpreting Pumping Tests for a Basalt-Interbed Hydrostratigraphic Unit," Co-authored with C.E. Divine, Proceedings of the Twenty Second Annual American Geophysical Union Hydrology Days, Fort Collins, Colorado, USA. April 1-4, 2002

"Results of Rueter-Hess Reservoir Project EIS Modeling,"
Paper presented at the AWRA Summer Specialty Conference: Ground Water/Surface Water Interactions*, Keystone, Colorado, USA. July 1-3, 200*

LANGUAGES

English – native language

PROFESSIONAL HISTORY

March 2009 – present	Water Resource Australia Pty Ltd
February 2006 – March 2009	Parsons Brinckerhoff Australia Pty Ltd
May 1999–- January 2006	John C. Halepaska and Associates, Inc. (USA)
Oct 1991 – January 1993	John C. Halepaska and Associates, Inc. (USA)

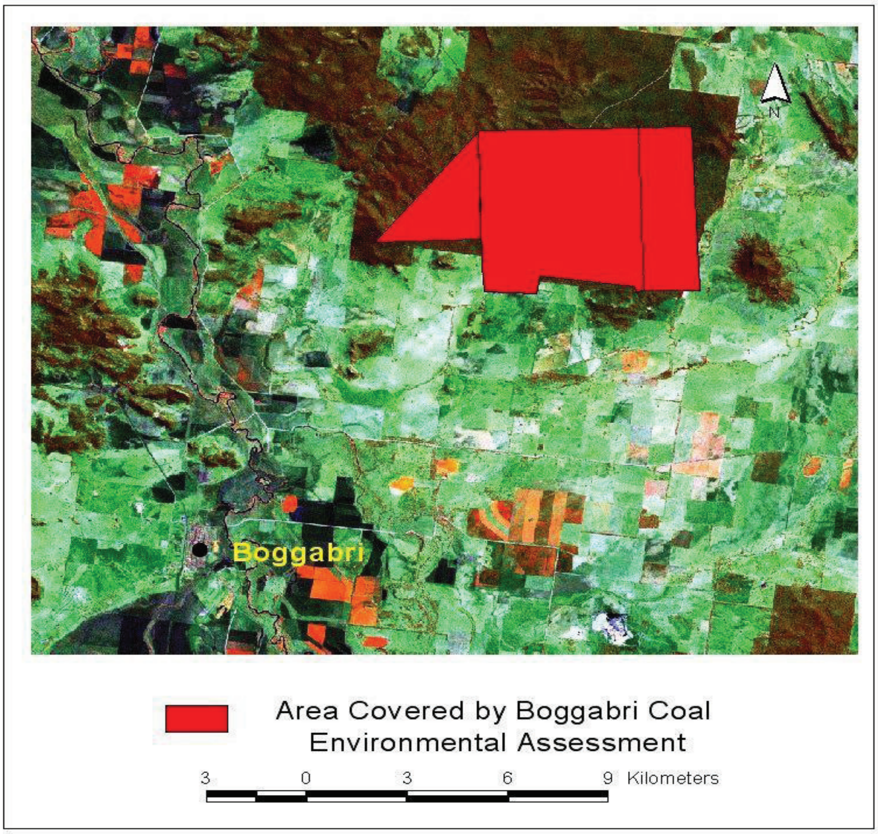
Appendix 3

Review of Environmental Assessment: Boggabri Coal Mine by SoilFutures Consulting Pty Limited, January 2011

SoilFutures Consulting Pty Ltd

REVIEW OF ENVIRONMENTAL ASSESSMENT

BOGGABRI COAL MINE



Prepared for

MAULES CREEK COMMUNITY COUNCIL

January 2011

Copyright

Table of Contents

1. Introduction

1.1 Background

This report has been prepared in response to a request from Mr Philip Laird of the Maules Creek Community Council. He requested that a review be made of the Environmental Assessment (EA) presented to the Maules Creek Community Council by Boggabri Coal in December 2010.

This review covers an assessment of the validity of the information given in the EA, and supplies supplemental information and science to aid in assessing some of the claims made by Boggabri Coal about their project.

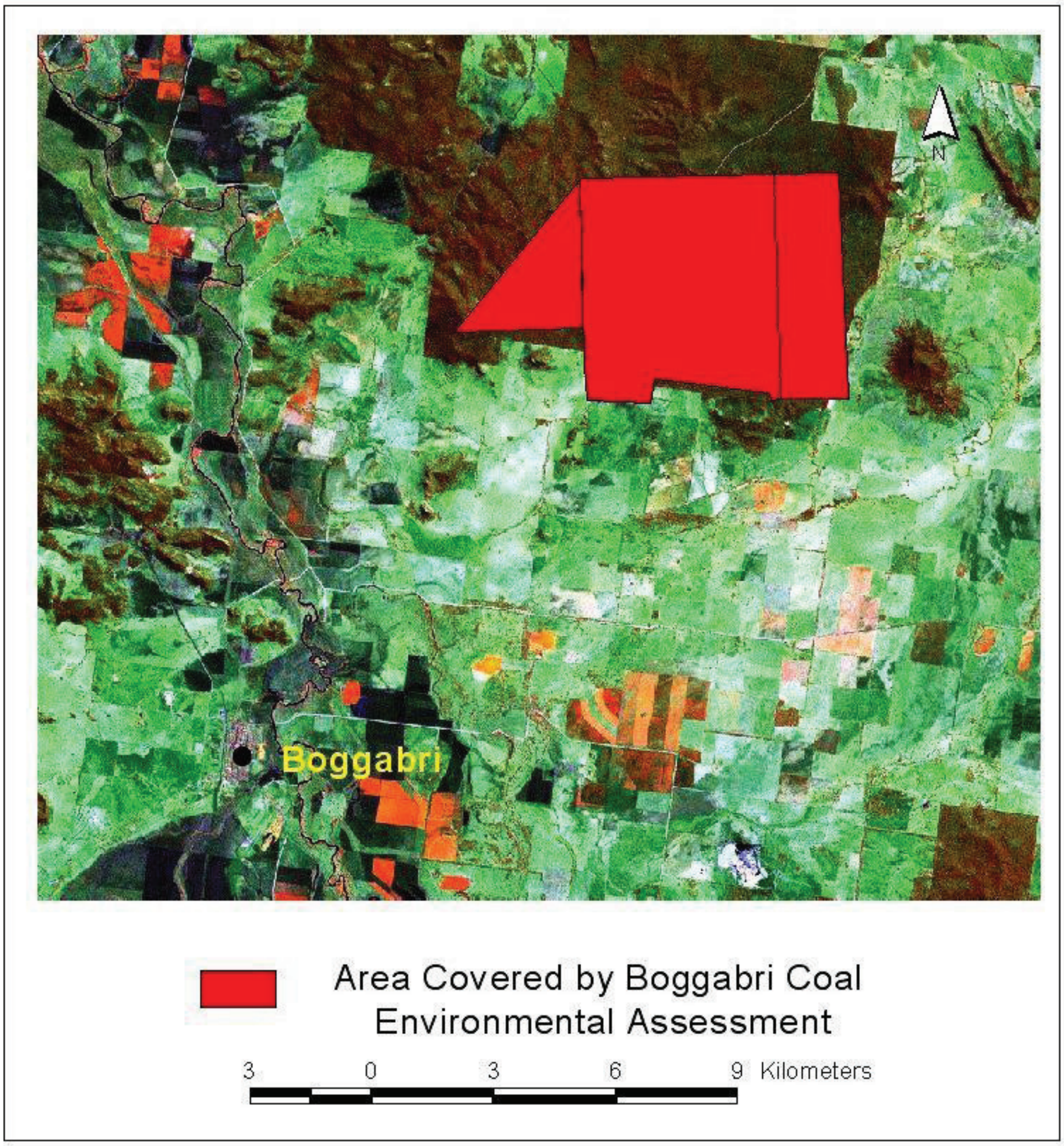


Figure 1: Location of Boggabri Coal Enviornmental Assessment area

This report is not as comprehensive as it might have been due to the limited time frame given by the proponent to comment on their EA.

1.2 Report Objectives

The main objectives of this review are to:

1. Critically review the Environmental Assessment commissioned by Boggabri Coal, specifically with respect to soils, and aspects of vegetation and water.

2. Provide some basic modeling to show that there are important issues which Boggabri Coal have clearly failed either to address, or to address adequately in their Environmental Assessment.

3. Summarise the issues that remain to be addressed with respect to soil, vegetation, and water by Boggabri Coal.

2. Review of Environmental Assessment with respect to selected groundwater issues.

2.1 Stygofauna in vicinity of mine proposal and address offsite impacts.

Anderson (2008) and Serov (Pers Comm) report Stygofauna in the adjacent Maules Creek Catchment. Stygofauna in this case are interstitial invertebrates (similar to prawns and other aquatic invertebrates) which are living in the gaps between the gravels in the alluvial groundwater to the north of the proposed mining site. Most Stygofauna are completely unique assemblages of animals which are endemic only to small and isolated groundwater pockets. Although Appendix J (pages 136, Paragraph 5) mentions these fauna and describe them as "obligate groundwater inhabitants", its findings (Appendix J, Page 139 Paragraph 1) show that there were no Stygofauna found within the project boundary. Offsite consideration to Stygofauna and potential mining activity impacts on Stygofauna are not considered in the EA.

Stygofauna are thought to play a major role in keeping coarse gravel aquifers open and clean by consuming organic growth which grows on the gravels and would otherwise partially clog or contaminate the aquifer (Neil Forster, pers. comm.)

Anderson and Acworth (2007) report that some of the alluvial aquifer systems in the vicinity of Maules Creek and Back Creek to the north of the proposed mine are characterised by a mixture of fresher groundwater coming from Mt Kaputar and coal aquifer waters coming from the Permian Triassic sequences which are proposed to be mined in this EA. The rock in which the coal lays dips to the north east, thus creating a vector for groundwater to cross into the Maules Creek catchment from the EA area.

It is generally acknowledged that Stygofauna are only found in stable hydrogeological conditions, and as such, any change in the condition of the Stygofauna habitat (ie the alluvial aquifer in which they live) generally results in the death of the Stygofauna community (Ecologia, nd).

Stygofauna is generally protected by the Federal Environmental Protection and Biodiversity Conservation Act 1999.

In view of Stygofauna being present in the vicinity of the proposed mine, the proponent should ensure that:

1. Water tables are not lowered or artificially changed

2. Groundwater chemistry is not changed as a result of increased salinity or nutrient levels or other pollutants.

These issues have not been addressed in the EA. Although groundwater depressurization has been addressed (Figure 33) no comment has been made on the potential impacts on groundwater fauna. The projected cumulative impact of the proposed Boggabri mine and the adjacent Maules Creek mine (Appendix O, Drawing No. 5) indicates significant changes to groundwater at 100 years extending well into the Maules Creek and Back Creek catchments. This is indicative of a significant threat to Stygofauna in these catchments.

3. Soil

3.1 Introductory Remarks

Appendix S, of the EA is very poorly worded and fails to deliver an understanding of the soils, which is accurate for mining and rehabilitation of mined areas. It appears that the author has failed both to understand the information available to them and did not interpret soil information for the purpose of mine rehabilitation adequately. This section of the review will proceed with a stepwise analysis of both the EA, and Appendix S, the soils section. Following this, a series of calculations based on soil data will be made, to test the assumptions made regarding rehabilitation and offsite effects which have not been addressed adequately in the EA

3.2 Stepwise Critique of soils sections of Volume 1 EA and Appendix S of the

EA Page 109 – Note – although this is not in the soil section of the EA, it is important to note that Biodiversity Offsets to be purchased by Boggabri Coal are not on undulating, coal bearing Permian Sandstones. Therefore no specific habitat or plant communities which rely on soils derived from this parent material are being preserved by the company in purchasing these offsets.

EA Page 158 – No mention of background or existing soil information has been made. No mention of the Soil Surveyors Accreditation to do soil survey (should be a Certified Professional Soil Scientist (CPSS) as listed on the Australian Soil Science Society Website).

EA Page 159 – Soil types mentioned are not soil types. They are loose names which do not describe the soils at all. The Australian Standard for soil classification is the Australian Soil Classification or (ASC) by Isbell (2002). The ASC should be used in every soil survey in Australia to communicate the full nature of the soils described.

Soil test results are referred to in this section of the document; however, there are no soil tests in Appendix S relating to Sodicity. It appears that the author has forgotten to include these in Appendix S.

EA Page 161. This section shows a clear misunderstanding of Land Capability as defined by Emery (1985). State Forest is not a Land Capability and if the author were to refer properly to the soil survey information provided to them by the Namoi CMA they would have realised that there is full and published Land Capability Mapping available for the EA Area (SoilFutures 2008, Namoi CMA 2009). Land Capability is determined not just on slope but on soil type as well. Given the proposed *Mitigation and Management* suggestions put forward in the EA, all land within the state forest would be then considered class 7 or 8 (post mining), as there would be almost no soil on the rehabilitated lands. This concept will further discussed in this document.

Given that one of the concepts of the mine is to restore native vegetation which is destroyed in the mining process, the large change in both soil type and land capability pre and post mining has not been considered. See Figures 3 and 4 below for more detail.

Appendix S, Page 2. The use of Land Management Units is interesting. These units are based on the detailed Soil Landscape Mapping which already exists for the site (SoilFutures 2008, NCMA 2009). There is no necessity for this broad information in the EA.
Appendix S, Page 4. There is no mention of mapping scale in this section. Map scale is determined by the intensity of a development and should be stated (Gunn et al, 1988).

No mention of previous surveys as stated above and shown in Figure 2

Soil Profiling – should be called *soil profile description*, and should be to the Australian Standards for soil survey as mentioned above. Soil profile classification should be according to Isbell (2002)

Appendix S, Page 5. Soil Profiles were assessed "generally" according to McDonald et al, 1998). If the author has deviated from this standard, they need to specify where.

Laboratory testing for Cation Exchange Capacity and Exchangeable Sodium is mentioned here, but there are no laboratory results for these tests later in the EA.

Appendix S, Page 6. Published Land Capability maps for the area Zoned as State Forest already exist and are mentioned above. "State Forest" is not a Land Capability, it is a land Zoning over which the former Soil Conservation Service had no jurisdiction. This was changed in the 1990's when The Soil Conservation Service had to have input into the management of State Forests. As such, Land Capability maps for all of the Namoi catchment including State Forests and National Parks were published by SoilFutures Consulting (2008) and the Namoi Catchment Management Authority in 2009.

Appendix S, Page 8. As mentioned above, these are not recognized soil types and the Australian Soil Classification (Isbell, 2002) should be used to classify these soils.

Appendix S, Pages 9-12. Salinity in soil is not assessed using Electrical Conductivity (EC) of the soil alone. It must be assessed in terms of its impact on the osmotic gradient of plants which varies according to the texture of the soil (as per Hazelton and Murphy 2007). These salinity statements are wrong. This will be explained below.

It should also be noted that any naturally occurring primary salinity, sodicity and alkalinity in the soils described, are what the local vegetation is adapted to. Whilst they may constitute a problem for handling and storage or for inappropriate plants in the soil, they are natural soils which the vegetation communities depend upon.

Appendix S, Page 13. The topdressing and stripping suitability recommendations here are inadequate if the plan is to reestablish the State Forest to its former Land Capability. If the rehabilitated lands are to support similar communities to those destroyed during mining, the soil depths and water holding potentials of soils should be maintained.

Appendix S, Page 14. As stated above, State Forest is a **Land Zoning**, relating to historical jurisdiction between NSW State Government Departments. State Forest is not a Land Capability. There is no problem with using Land Capability within the bounds of a State Forest.

Appendix S, Page 16. No account has been taken of the loss of recharge to aquifers through soil or to the amount of runoff which will be lost to the catchment through the open cut mining. This needs to be a logical outcome of soil landscape mapping or soil survey for mining.

Appendix S, Appendix 3 – Soil Test Results. Clearly the salinity comments made in the soil profile section of the EA (mentioned above) are incorrect. These soil data clearly show for example that the sample for Site 11, horizon 3 is **Slightly Saline** and that sample for Site 12, horizon 3 is Moderately Saline, when the EC data are converted to ECe (using Hazelton and Murphy, 2007, or Salt Action, 2001, or QDNR 1997). The correct interpretations of this data should be included in Appendix S. It is also interesting to note that Cation Exchange Capacity and Exchangeable Sodium percentage have not been supplied in this document. There is no way of assessing soils fertility or whether it is sodic or otherwise as a result.

3.3 Background information and previous soil survey results.

It appears that the author preparing Appendix S of the EA has not read the documentation for the Namoi CMA data for the area. The published data is in SoilFutures (2008) and NCMA (2009) and is based on Banks and King (in Press) for the Boggabri 1:100 000 Sheet. This is one area of the Namoi Catchment which does have existing detailed soil landscape maps. These maps were done to a national standard, are published at 1:100 000 Scale and are accurate to a scale of 1:25 000.

The available soil landscape mapping details soil distributions and limitations. Soil landscapes for the area controlled by Boggabri Coal are given in Figure 1 below, with detailed soil landscape descriptions given in Appendix 1.

The author could have used this information as a much more detailed basis for their survey. In addition, the consultant has failed to use SALIS, the NSW Soil and Land Information System, which already has detailed soil profile descriptions with laboratory data for the EA area and surrounds.

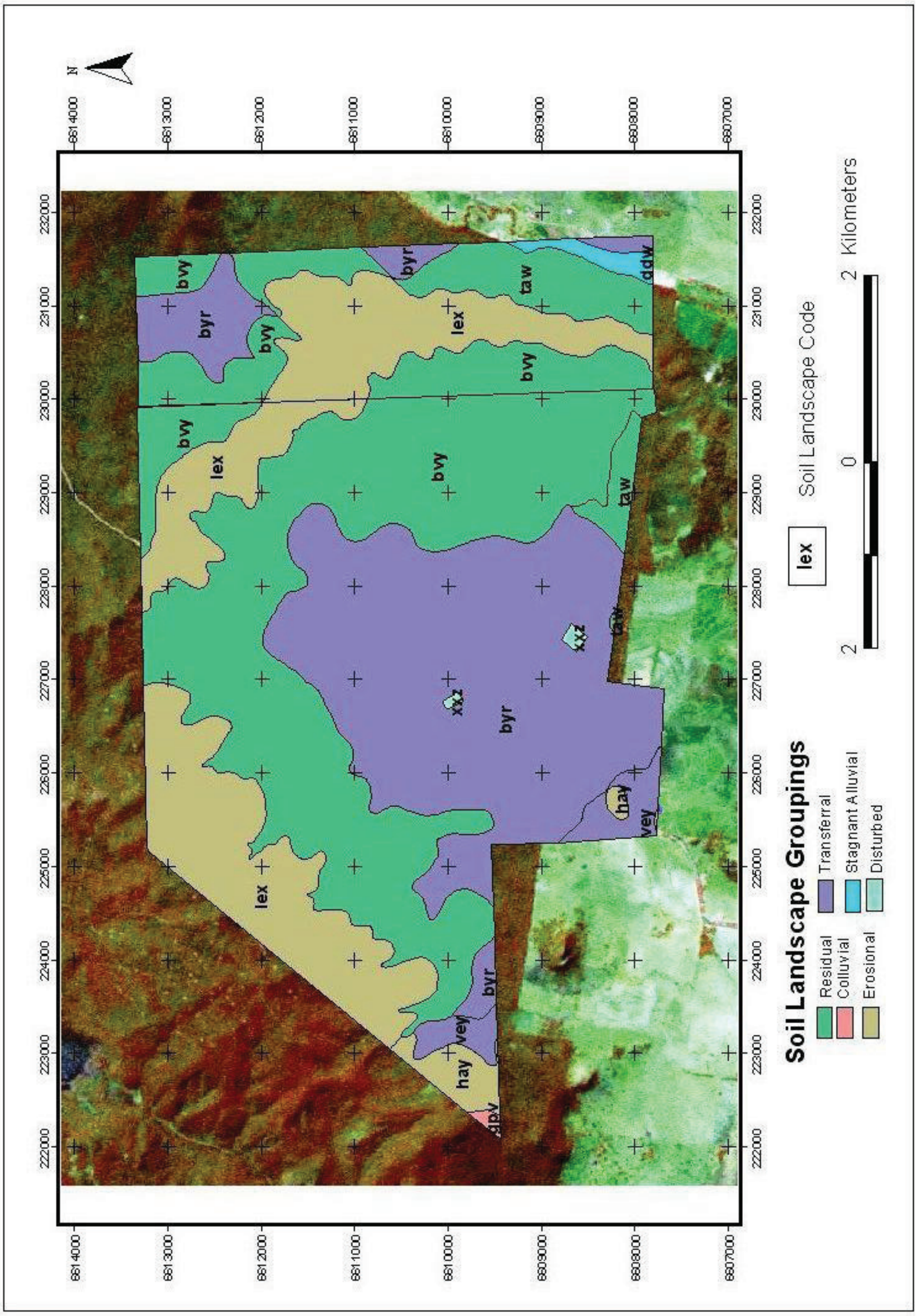


Figure 2: Soil Landscapes of Boggabri Coal Enviornmental Assessment area (SoilFutures, 2008; Banks and King, In Press)

3.4 Standard Land Capability assessment.

Existing Rural Land Capability mapping is available for the site – it is accurate to 1:25 000 scale and derived from Banks and King (In Press) and available in SoilFutures (2008) through the Namoi Catchment Management Authority (NCMA. 2009) (see Figure 3 below). It is suggested that the author be requested to use this information or consider obtaining the Access Based Data Utility Land and Soil Capability Assessment tool (ABDUL) from DECCW to run the Land Capability based on soil and landscape attributes for the site.

3.5 Using soil data to predict hydrological impacts.

Given concerns expressed re Stygofauna above, it is important to estimate the physical amounts of change to run off and recharge coming from the site, should it be developed for open cut mining. Figure 4 has been prepared using Ringrose-Voase et al (2003), and further refined in SoilFutures (2009) and KLC Environmental (2010). Each soil landscape unit has been ranked in terms of its saturated hydraulic conductivity, and runoff potential, using real data and modeled data from Ringrose-Voase et al (2003). Figure 4 shows the potential loss of runoff to the wider Namoi catchment through the disturbed land created by area of proposed open cut mining. This is of concern to the wider community as most runoff within the rehabilitation area will be contained and lost to the community.

Figure 4 shows clearly that the estimated runoff losses to the wider Namoi catchment are to the order of 721 ML. This is 721ML of water that will no longer enter adjacent streams and rivers as it will be largely contained on site following mining.

Figure 5 shows the estimated annual recharge rates for the land within the area proposed to be open cut mined through the life of the project. It should be noted that whilst recharge will continue to occur post mining, it is likely to go into different aquifers at different rates when compared with the natural rates and paths for recharge simply because of the change in the structure of the geological material onsite. Estimates for recharge pre mining are to the order of 246 ML. What will happen following mining in this regard is largely unknown.

These hydrological changes to the Namoi catchment will be permanent, and need to be seriously considered in both in terms of the future generations within the agricultural community, the environmental flow effects, and any cumulative effects with other exisitng or proposed mines.

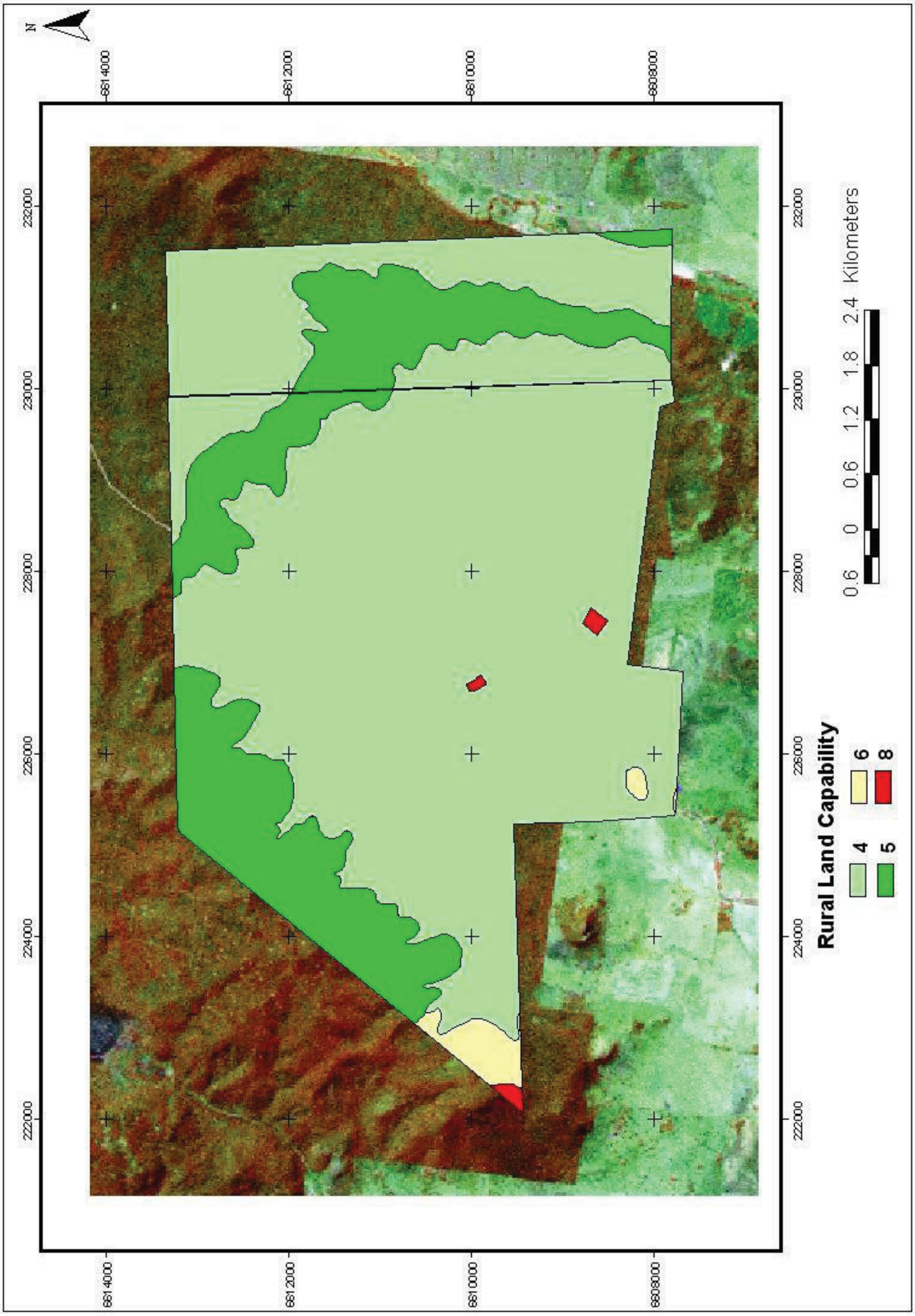


Figure 3: Rural Land Capability of Boggabri Coal Enviornmental Assessment area (SoilFutures, 2008.; Namoi CMA 2009)

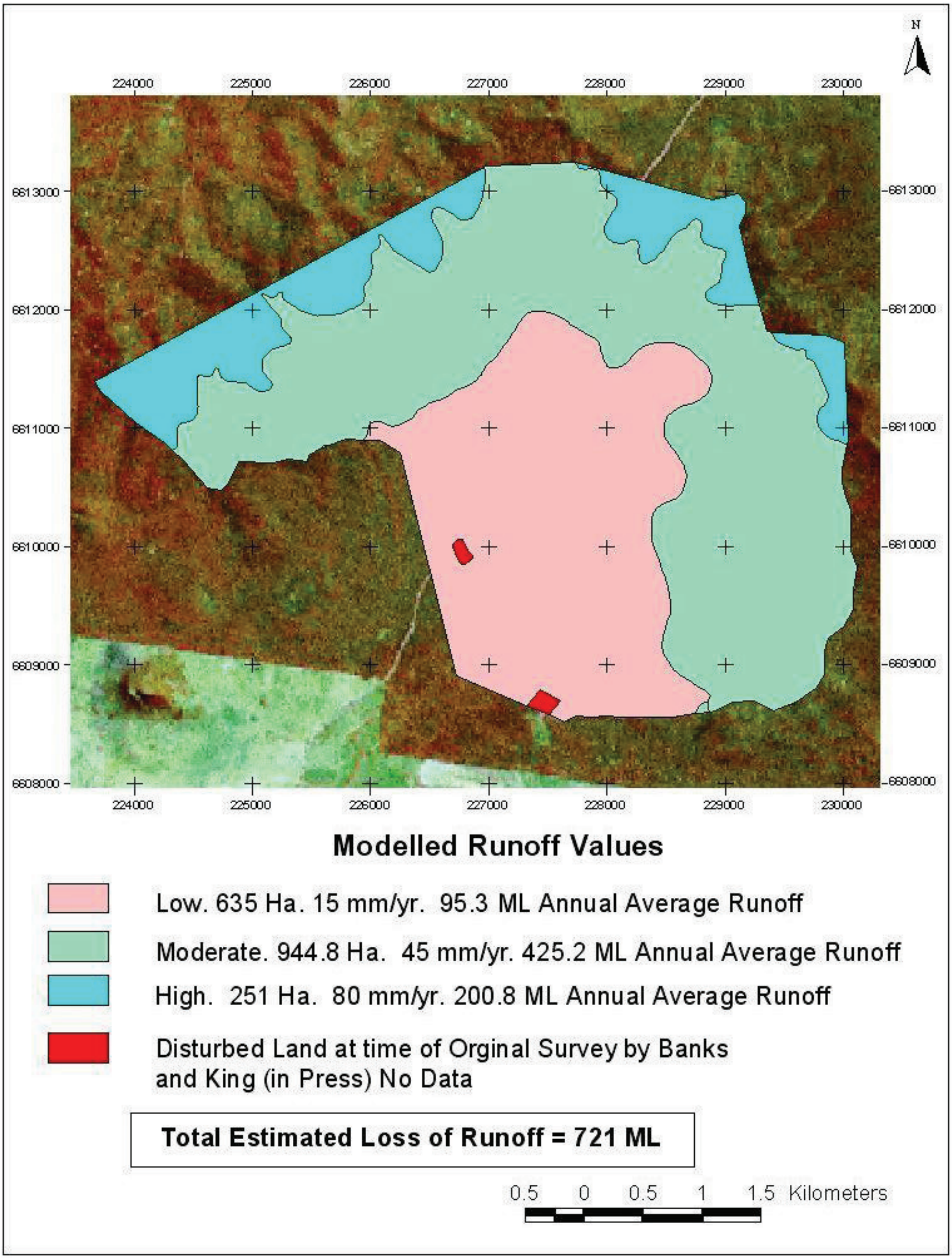


Figure 4: Predicted Runoff Losses Thorugh Open Cut mining (Extracted from KLC 2011)

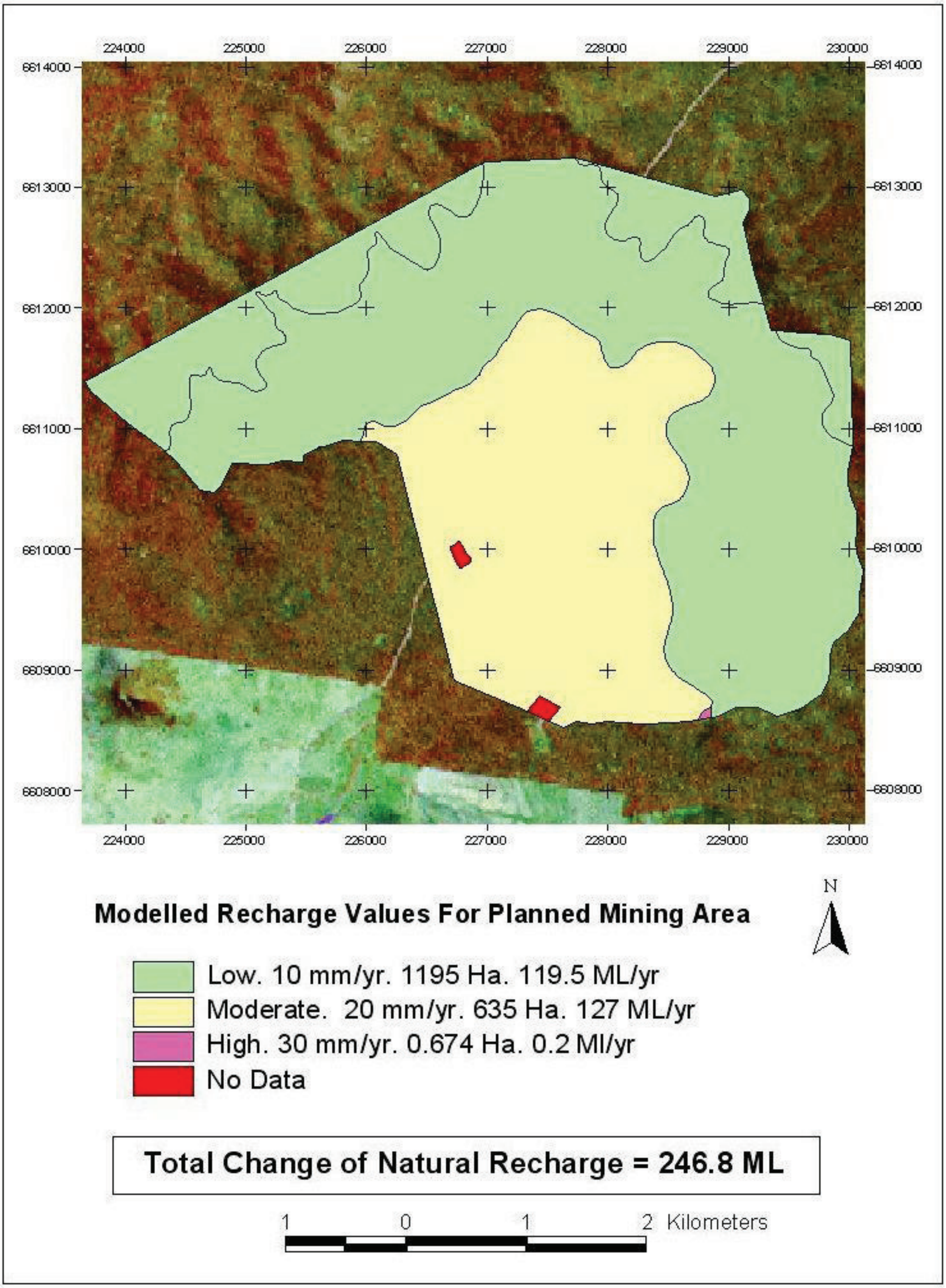


Figure 5: Predicted Deep Drainage (disturbance to natural groundwater recharge) Losses Thorugh Open Cut mining (Extracted from KLC 2011)

3.5 Using soil data to predict effectiveness of rehabilitation and revegetation

The proposed *rehabilitation* of mine spoil includes land shaping, and then covering with 10 cm of topsoil obtained from suitable areas within the area to be mined. Also noted above is the attempt to re plant the "box-gum" communities which the mine plans to destroy through clearing of land. This would be through a process of replanting as well as natural regeneration from seed banks stored in the topsoil.

The plant community referred mostly as "box-gum" throughout the EA, is actually classified as *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* and is *critically endangered* as given in the Threatened Ecological Communities List under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

It should be noted, that the natural soil depths in the EA area are much greater than 10 cm, and would average at least 1 m, except for some upper slope areas (see Appendix 1 for full soil distribution details in each soil landscape).

Whilst the proposal sounds amenable to restoring land to its previous land capability, it is clearly not. The native vegetation communities within the area proposed to be mined and the areas already mined and in part "rehabilitated" are adapted to certain soil types, depths and soil profile moisture storage, known as Available Water Holding Capacity (or AWC). Using published soil landscape information, with AWC data for profiles mostly within the proposed and current open cut mining areas, it was possible to build up a pre and post mining soil moisture storage map for the areas included in open cut mining in the Environmental Assessment. Soil profiles used for these calculations are given in Appendix 2 and were retrieved from the NSW Soil and Land Information System (SALIS), a database run by NSW DECCW.

The difference in moisture storage can be represented on a map to illustrate that it is effectively not possible to replace the vegetation cleared, and it is doubtful, in the long term as to whether any long term tree or simulated vegetation community is possible. Figure 6 shows clearly that the estimated AWC of the area to be mined by Boggabri Coal is to the order of 6400 ML. Were this area to be entirely mined and covered with 10 cm of sandy loam material as stated in Appendix S, the landscape AWC for the newly formed rehabilitation areas with only be 366 ML (AWC estimate from Hazelton and Murphy, 2007). **This represents a soil available water holding capacity deficit of 6041 ML,** so it is very difficult to see how anything like the original native vegetation can be replaced on the "rehabilitated" areas.

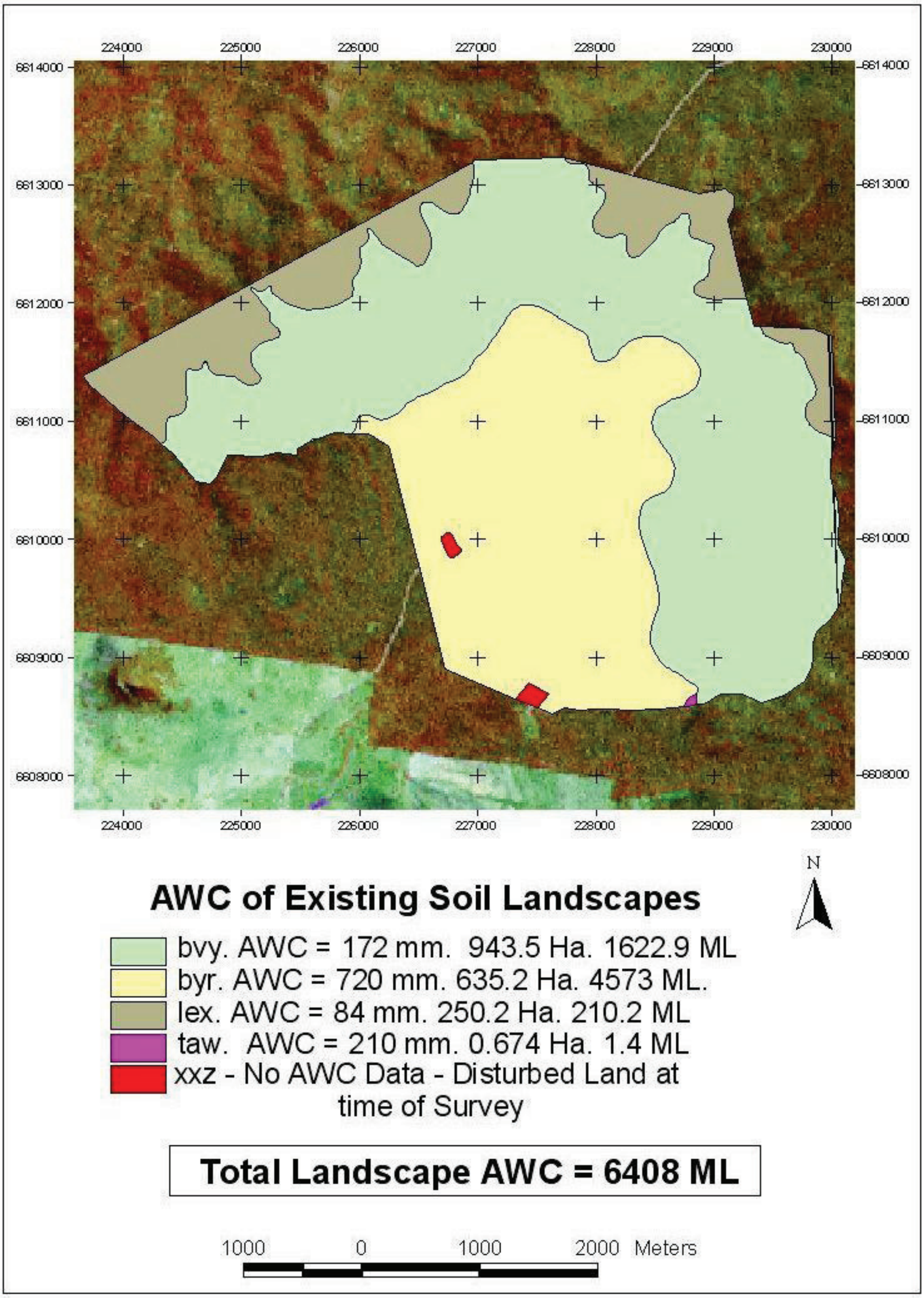


Figure 6: AWC of Soil Landscapes using SoilFutures (2008) and Banks and King (In Press)

4. Short comment on Surface Water Assessments.

A brief overview of the comments on natural streamlines in the area covered by and outside the Environmental Assessment, shows that little has been made with published information. Page 102 of the EA refers to the Namoi River as being *Severely Polluted* based on the assemblage of invertebrates sampled in the river.

The NSW Department of Infrastructure, Planning and Natural Resources (DIPNR) published the River Styles report and maps of the entire Namoi Catchment, detailing river and stream condition of all of the major 2nd order and above streams in the Namoi Catchment (Lampert and Short, 2004). The spatial data for the area including and surrounding the Gunnedah Coal Environmental Assessment is given in Figure 7 below. It is strongly suggested that this information be more seriously considered in the EA.

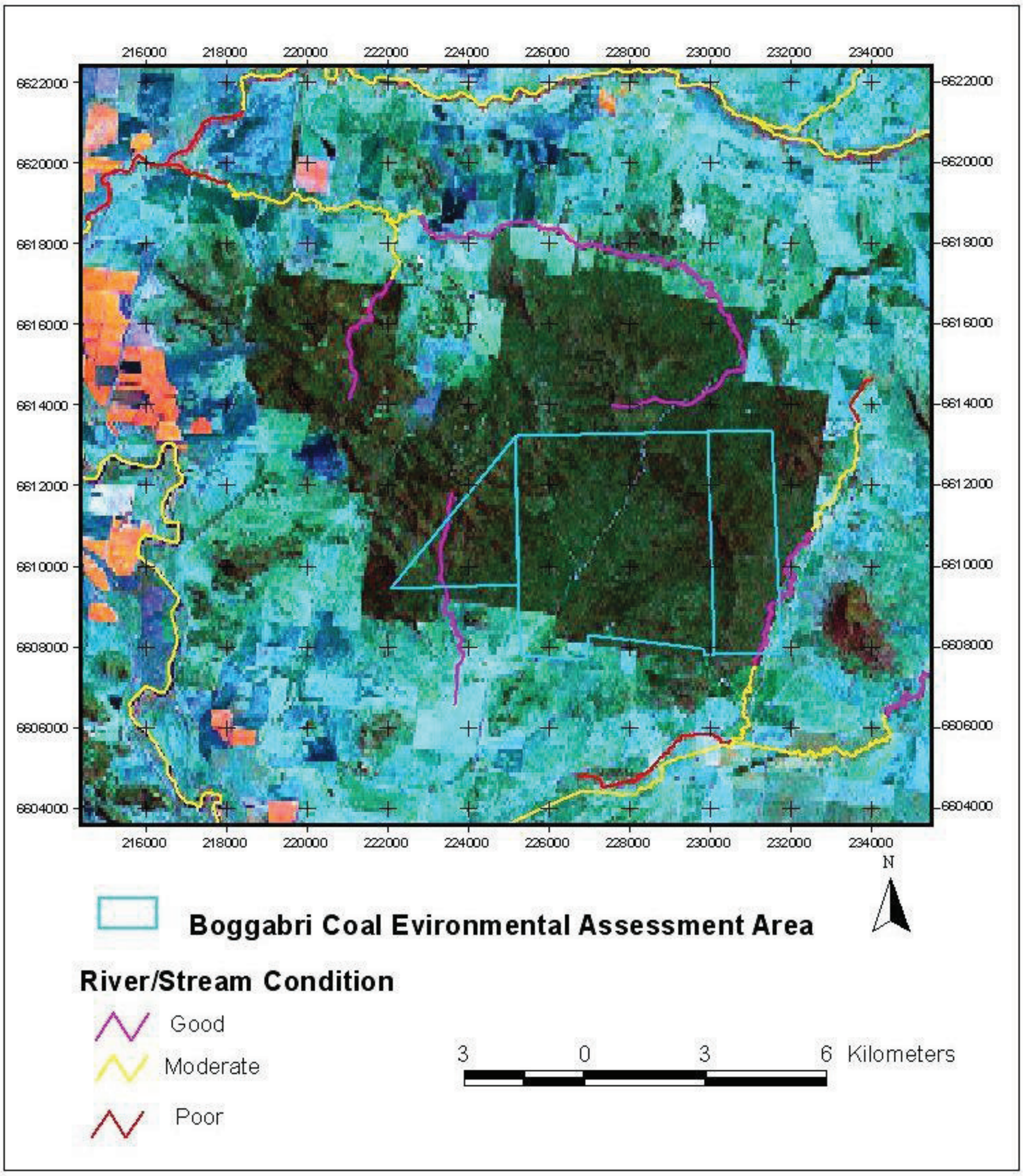


Figure 7: River Condition Layer from Lampert and Short (2004)

Lampert and Short (2004) provide a multitude of information and stream health, stream bank vegetation status, stream bank stability and geomorphic condition. This allows for a stratified approach to sampling and detailing water and river quality to be undertaken by the consultants for this EA.

5. Conclusions and Recommendations

This brief review demonstrates that the Boggabri Coal Environmental Assessment (2010) does not adequately address several important environmental issues. Existing published information has largely been ignored and to some degree the methodology and interpretations of soil information were not to Australian common standards. It is suggested that Boggabri Coal needs to adequately address the issues arising from this review as listed below.

5.1 Stygofauna

- The EA does not mention the presence of Stygofauna, unique and currently undescribed aquifer fauna (Serov, Pers. Comm.; Anderson, 2008).
- Stygofauna is present in areas to the north of the Boggabri Coal EA in the Maules Creek Catchment.
- Stygofauna is generally protected by the Federal EPBC Act 1999.
- Stygofauna are dependent on a stable groundwater ecosystem requiring consistent water quality and stable water tables.
- Currently the predicted cumulative impacts on groundwater extend well into the Maules Creek Catchment where Stygofauna are known and reported.

These issues need to be urgently and adequately addressed in the EA.

5.2 Biodiversity Offsets

- The purchasing of biodiversity offsets by Boggabri Coal, do not in any way replace or preserve the soil and native plant and animal assemblage habitats that are specific to undulating Permian Coal measure derived soils.

Attention needs to be given to including the type of land to be mined rather than lands on other soil and geological types to ensure continuation of local biological assemblages.

5.3 Soil

- The soil sections of the EA have not attempted to use the Australian Soil Classification (ASC) (Isbell 2002).
- The soils sections of the EA have errors in the interpretation of soil laboratory data and fail to provide soil laboratory data for Cation Exchange

Capacity and Exchangeable Sodium Percentage.

- The soil section of the report confuses Land Capability with Land Zoning and states that State Forest is a Land Capability. The result of this is that a correct Land Capability assessment of the area to be mined has not been carried out, resulting in poor outcomes for rehabilitation.
- Post mining lands should be restored to the previous land capability which is derived from slope, terrain and soil attributes.
- The omission of published soil information on the EA area indicates that the author is not familiar with the local area or the range of data available for the area. Soil Landscape maps are widely used for this purpose, are available for the area, and have not been used.
- It is critical that all available information be used in calculating hydrological changes to the Namoi catchment through changes runoff and recharge to the broader catchment. Examples of how to do this have been provided.
- It is critical that soil information be used to develop a realistic rehabilitation plan with respect to the intention to restore "box-gum" woodlands destroyed by the mining process. This plant need to be referred to properly as defined in the Threatened Ecological Communities List under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).
- Modeled outcomes in this review show that the planned mining would result in a permanent removal of to the order of 720ML runoff which would otherwise have entered the wider Namoi catchment.
- Modeled outcomes in this review indicate that the planned mining would disrupt 240ML of natural recharge to groundwaters. The end result of this change is unknown.
- Published soil landscapes and soil data indicate that the rehabilitation proposal for mine spoil is inadequate to restore native vegetation at the site. The soil available water holding capacity of the site pre-mining estimated to be 6408 ML, and only 240ML post mining, creating a 6041 ML soil Available Water Holding Capacity deficit

5.4 Surface Water

- The sections on existing surface water in the area surrounding the EA area make poor or no use of published information. It is strongly suggested that Lampert and Short (2004) be heavily used in these sections of the report.

6. References

Anderson, M.S. 2008. *Investigation of surface water groundwater exchange in Maules Creek Catchment.* Presentation to the IAH , 9 Seet, 2009. WRL UNSW Sydney.

Anderson, M. S. and Acworth, R. I 2007. *Chemical and Geophysical Sampling Campaign at Maules Creek. Data Report for 2006*. WRL Report 229, University of NSW.

Banks RG and King D (In Press*) Soil Landscapes of the Boggrabri 100 000 sheet*. Map and Report. NSW Department of Environment Climate Change and Water, Sydney.

CSIRO (2009). *Australian Soil and Land Survey Field Handbook*. 3rd Edition, CSIRO Publishing, Collingwood, Vic.

Banks, R.G. and King, D.P. In Press *Soil Landscapes of the Tamworth 1:100 000 Sheet.* Map and Report. NSW Department of Infrastructure Planning and Natural Resources. Sydney.

Ecologia (no date). *Environmental Management. Stygofauna.* Ecologia Environment. Perth.

Emery, K.A. 1985, Rural Land Capability Mapping, Soil Conservation Service of NSW, Sydney.

Gates, G.W.B. 1980, *The hydrology of the unconsolidated sediments in the Mooki River Valley, New South Wales*, MSc thesis, University of New South Wales, Sydney.

RH Gunn, JA Beattie, RE Reid and RHM Van de Graff (Eds) 1988. *Australian Soil and Land Survey Handbook – Guidelines for Conducting Surveys.* Inkata Press. Melbourne and Sydney

Hazelton, P.A. and Murphy, B.M. (2007). *What Do All the Numbers Mean? A Guide for the Interpretation of Soil Test Results*. CSIRO Publishing, Collingwood, Vic.

Isbell RF (2002) *The Australian Soil Classification. CSIRO Publishing. Sydney and Melbourne.*

KLC Environmental (2010) *Gins Leap Gap Project (Final Report)*. Namoi Catchment Management Authority, Gunnedah and Tamworth.

Lampert, G. and Short, A (2004) *River styles, indicative geomorphic condition and geomorphic priorities for river conservation and rehabilitation in the Namoi catchment, North-West, NSW* DIPNR, Sydney.

NCMA (2009). *Reconnaissance Soil Landscapes of the Namoi Catchment.* Namoi Catchment Management Authority, Tamworth. (Available online or as a self extracting DVD ROM)

QDNR (1997). *Salinity Management Handbook*. Queensland Department of Natural Resources. Scientific Publishing, Resource Sciences Centre. Brisbane.

A.J. Ringrose-Voase, R.R. Young, Z. Paydar, N.I. Huth, A.L. Bernardi, H.P. Cresswell, B.A. Keating, J.F. Scott, M. Stauffacher, R.G. Banks, J.F. Holland, R.M. Johnston, T.W. Green, L.J. Gregory, I. Daniells, R. Farquharson, R.J. Drinkwater, S. Heidenreich, S.G. Donaldson, C.L. Alston (2003) *Deep Drainage under Different Land Uses in the Liverpool Plains*. NSW Agriculture Technical Bulletin, CSIRO Land and Water Technical Report.

Salt Action (2001) *Soil and Water Salinity Calculator*. Salt Action NSW. Dubbo.

SoilFutures Consulting Pty Ltd. 2008. *Reconnaissance Soil Landscapes of the Namoi Catchment.* SoilFutures Consulting, Gunnedah.

SoilFutures Consulting Pty Ltd 2009. *Deep Drainage and Runoff Estimates for Coal Exploration Leases EL 6505 and EL 7223.* Presented to Senate Committee hearing for food security, 2009.

.

7. Appendices

Appendix 7.1 Soil Landscapes from Banks and King (In Press)

Landscape-- 84.8 km^2; Undulating low hills and hills on Permian sandstones and conglomerates of the Curlewis Hills. Local relief 70 m; elevation 250 - 420 m; slopes 1 – 10%. Woodland and grassland, in State Forests or cleared for grazing.

Soils— Soils vary little across the landscape. Brown Chromosols (Non-calcic Brown Soils) and Brown Sodosols (Solonetz) are dominant, with Bleached Brown Chromosols (Non-calcic Brown Soils) occasionally present.

Qualities and Limitations-- known saline aquifer recharge area; inherent erosion risk; sheet erosion risk; rill and gully erosion risk; wind erosion risk; low moisture availability; *Callitris spp. (cypress pines)* regrowth potential.

LOCATION AND SIGNIFICANCE

Undulating low hills and hills on Permian sandstones and conglomerates of the Curlewis Hills. Type location is south of Willowtree Range in Leard State Forest . Grid Reference 2 27900E, 66 11000N.

LANDSCAPE

Geology and Regolith

Quartz and lithic sandstones, conglomerates, mudstones, and associated coal seams of the Permian Black Jack group Geological map code Pbx) and the Maules Creek Formations (Geological map code Pmx). Some sandstones within this group are highly acidic. Depth to unweathered rock is generally less than 2 m.

Terrain

Simple and convex sideslopes with generally broad crests on undulating to hills and hills of the Curlewis Hills. . Local relief to 70 m; elevation 250 - 420 m; slopes 1 – 10%. Drainage is predominantly by sheetflow.

Climate and Hydrology

The Permian sandstones form an important saline fractured rock aquifer system that is hydraulically connected to the deep Gunnedah Formation aquifers on the alluvial plains (Broughton, 1994).

Average annual rainfall range 570 – 655 mm, increasing towards the Melville Range.
Vegetation

Open and closed woodland communities, 90% cleared for grazing. Dominant tree species include *Eucalyptus albens* (white box), *E. sideroxylon* (mugga ironbark), *E. melanophloia* (silver-leaved ironbark) , *Eucalyptus crebra* (narrow-leaved ironbark), *Eucalyptus populnea* (bimble box), *Eucalyptus pilligaensis* (pilliga grey box), *Eucalyptus dealbata* (tumbledown gum), *Allocasuarina distyla* (scrub she-oak*), Notelaea microcarpa* (native olive), *Beyeria viscosa* (sticky wallaby-bush), *Olearia elliptica* (sticky daisy bush), *Ehretia membranifolia* (peach bush), *Geijera parviflora* (wilga), *Alectryon oleifolius* (rosewood), *Callitris glaucophylla* (white cypress pine), and *Callitris endlicheri* (black cypress pine).

Groundcover species include *Bothriochloa macra* (red grass), *Austrostipa verticillata* (slender bamboo grass), *Chloris truncata* (windmill grass), *Aristida vagans* (three-awned spear grass), and *Austrostipa setacea* (corkscrew grass*),* *Austrostipa scabra* (spear grass), *Desmodium brachypodium* (large tick-trefoil), *Cymbopogon refractus* (barbed-wire grass) and *Aristida ramosa* (wire grass).

Land Use

Much of this landscape is in State Forests or cleared and used for grazing on native or improved pastures. The landscape has a history of cropping in some locations, but now is predominantly used for grazing. Owing to the underlying geology, this landscape is a favoured area for open cut coal mining.

Land Degradation

Most soils in cleared areas show moderate to severe sheet erosion. This is most evident in areas previously cultivated, where topsoils are thin and gravelly. Overgrazed pastures providing inadequate groundcover are also affected. Rill erosion and gully head formation is also evident in some areas.

LANDSCAPE QUALITIES AND LIMITATIONS

Known saline aquifer recharge area; inherent erosion risk; sheet erosion risk; rill and gully erosion risk; wind erosion risk; poor moisture availability; *Callitris spp. (cypress pines)* regrowth potential. Known saline discharge sites at landscape margins and in adjacent flanking landscapes.

SOILS

Variation and Distribution

As this landscape crosses the western map boundary into the Baan Baa sheet, it was studied as one unit crossing the map boundary into the Baan Baa Sheet. Some soil profiles are described by Pengelly (In Press) with type locations occurring on the Baan Baa sheet to the west of the Boggabri sheet.

This landscape is dominated by Chromosols (Red-brown Earths and Non-Calcic brown soils. Crests on sandstone generally have Vertic Red Chromosols (Red-brown Earths) whereas crests conglomerate tend to have Bleached Red Chromosols (Non-Calcic Brown Soils), sideslopes are generally dominated by Vertic Brown Chromosols (Red-brown Earths) with Brown Sodosols (Solodic Soils) occurring on lower slopes.

Position in landscape	**Soil Type**	**Dominance**
Crests on sandstone	Red Chromosols	25%
Crests on conglomerate	Bleached Red Chromosols	15%
Hillslopes	Bleached Brown Chromosols	50%
Lower slopes	Brown Sodosols	10%

Dominant Soil Materials

bv1 – Dark brown clay loam, sandy (A1 Horizons). Dark reddish brown to dark brown (5YR 3/3 – 10YR 4/3) clay loam, sandy to clay loam; massive; earthy (dry); porous; field pH 6.5 – 7.0. Quartz and conglomerate coarse fragments absent to few (0 – 10%). Surface is hardsetting, occasionally loose.

bv2 – Dark brown sandy loam (A1 Horizons). Dark brown (7.5YR 3/3) loamy sand to sandy loam; massive to weak pedality; earthy (dry); sub-angular blocky (5 – 10 mm) where pedal; field pH 6.0. Few (2 – 10%) quartz sandstone coarse fragments often present. Surface is loose to hardsetting.

bv3– Bleached sandy loam (A2e Horizons). Brown (7.5YR 4/4) (dry colours almost white) sandy loam; massive; earthy (dry); porous; field pH 6.0. Conglomerate coarse fragments few (2 – 10%).

bv4 – Reddish brown clayey subsoils (B2 Horizons). Red to reddish brown (2.5YR 4/8 – 5YR 4/4) sandy clay loam to medium heavy clay; weak to strong pedality; peds smooth-faced (dry); angular blocky (20 – 50 mm); field pH 6.0 – 8.5. Slickensides many (>50%) in clays; calcareous segregations very few (<2%) when pH ≥ 8.5.

bv5 – Yellowish brown clayey subsoils (B2, B21, B22k Horizons). Strong brown to brownish yellow (7.5YR 4/6 – 10YR 6/6) and dark yellowish brown (10YR 4/4) light clay with fine sand to heavy clay; moderate to strong pedality; peds smooth-faced (dry); angular blocky (20 – 50 mm) to prismatic (20 – 100 mm); field pH 7.5 – 9.5. Calcareous segregations common (10 – 20%) and fine calcium carbonate evident with HCl where pH ≥ 8.5; slight salting occasionally evident with AgNO3 at depth; few quartz sandstone and quartz coarse fragments occasionally evident.

Type Profiles

Type profile 1: Hillcrest	
Soil classification: moderately well drained Bleached Eutrophic Red Chromosol, thick, slightly gravelly, loamy, clay loamy, very deep, (Non-calcic Brown Soil); few (2-10%) surface gravels; surface condition is gravelly, hard set, expected to be hardsetting when dry	
Depth of observation: 70 cm.	
Location: Boggabri 1:25 000 topographic map - 500m South East of "Thuin" (Map reference: 228036 E, 6605363 N). Profile 96. Timber/scrub/unused.	
Layer 1, A1, 0 - 0.2 m, bv2	dark brown sandy loam with massive structure, earthy; few (2-10%), as parent material coarse fragments; common roots; field pH is 6; clear (20-50 mm) smooth boundary to-
Layer 2, A2, 0.2 - 0.55 m, bv3	brown sandy loam with massive structure, earthy; few (2-10%), as parent material coarse fragments; common roots; field pH is 6; gradual (50-100 mm) smooth boundary to-
Layer 3, B2, 0.55 - 0.7 m, bv4	red sandy clay loam with weak pedality (angular blocky), smooth-faced peds; as parent material coarse fragments; common roots; field pH is 6; gradual (50-100 mm) smooth boundary to weathered conglomerate.

Type profile 2: Hillcrest	
Soil classification: mod. well drained Vertic Mesotrophic Red Chromosol, medium, non gravelly, clay loamy, clayey, moderate, 3 (Non-calcic Brown Soil);	
Depth of observation: 55 cm.	
Location: Gulligal 1:25 000 topographic map - NR Trig on " Emerald Plains" (Map reference: 222278 E, 6582458 N). Profile 45. Improved Pasture.	
Layer 1, A1, 0 - 0.15 m, bv1	dark reddish brown clay loam sandy with massive structure, earthy; common roots; field pH is 6.5; clear (20-50 mm) smooth boundary to-
Layer 2, B2, 0.15 - 0.55 m, bv4	reddish brown medium heavy clay with strong pedality (angular blocky, 20-50 mm), smooth-faced peds; very few (< 2%) calcareous segregations; no roots; field pH is 8.5; directly overlies bedrock

Type profile 3: hillslope	
Soil classification: mod. well drained Bleached-Vertic Mesotrophic Brown Chromosol, medium, non gravelly, clay loamy, clayey, moderate, 2;	
Depth of observation: 90 cm.	
Location: Gulligal 1:25 000 topographic map – hillock on "Emerald Plains" (Map reference: 222424 E, 6582638 N). Profile 46. Improved Pasture.	
Layer 1, A1, 0 - 0.05 m, bv1	dark brown clay loam sandy with massive structure, earthy; common roots; field pH is 7; sharp (<5 mm) smooth boundary to-
Layer 2, B2, 0.05 - 0.45 m, bv5	no colour recorded, heavy clay with strong pedality (angular blocky, 20-50 mm), smooth-faced peds; no roots; field pH is 8.5; gradual (50-100 mm) smooth boundary to-
Layer 3, B22, 0.45 - 0.9 m, bv5	brownish yellow heavy clay with strong pedality (prismatic, 50-100 mm), smooth-faced peds; common (10% - 20%) calcareous segregations; no roots; field pH is 9.5; directly overlies bedrock

****

Type profile 4: Lower slope	
Soil classification: Brown Sodosol, medium, non gravelly, sandy, clayey, moderate, 2 (Red-brown Earth);	
Depth of observation: 90 cm.	
Location: BORAH 1:50 000 topographic Map (from Baan Baa Survey - 200m ENE of Kanangra Ridge (Map reference: 783596 E, 6592890 N). Profile 164. Voluntary native Pasture.	
Layer 1, A1, 0 - 0.15 m, bv2	dark brown loamy sand with weak pedality (sub-angular blocky, 5-10 mm), earthy; few (2-10%), gravel (6-20 mm), quartz, coarse fragments; few roots; field pH is 6; sharp (<5 mm) boundary to-
Layer 2, A2, 0.15 - 0.3 m, bv3	strong brown loamy sand with single grained, sandy; few (2-10%), gravel (6-20 mm), as parent material, coarse fragments; no roots; field pH is 7; sharp (<5 mm) boundary to-
Layer 3, B2, 0.3 - 0.53 m, bv5	strong brown fine light clay with moderate pedality (angular blocky, 20-50 mm), smooth-faced peds; few (2-10%), gravel (6-20 mm), as parent material, coarse fragments; no roots; field pH is 7.5; gradual (50-100 mm) boundary to-
Layer 4, C, 0.53 - 0.9 m, Associated soil material.	strong brown sandy clay loam with moderate pedality (sub-angular blocky, 10-20 mm), smooth-faced peds; common (10-20%), gravel (6-20 mm), as parent material, coarse fragments; field pH is 8.5; layer continues...

Erodibility

	Non-concentrated flows	**Concentrated flows**	**Wind**
bv1	**moderate**	**high**	**moderate**
bv2	**high**	**high**	**high**
bv3	**high**	**high**	**high**
bv4	low - moderate	moderate	low
bv5	moderate	high	low

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
Cropping	**High**	**High**	**High**
Pasture	**low - Moderate**	**Low**	**Low**

Rural Capability and Sustainable Land Management Recommendations

This landscape has been classified as LMU C – Sedimentary Footslopes (URS 2001). Some crest and bench elements of this landscape should be managed for a much higher limitations than are implied by this classification, with higher tree cover levels and possible exclusion of stock where appropriate.

Generally, soils should remain under perennial native or improved pasture as part of a rotational grazing system. Contour banks should be incorporated on slopes above 2% to minimise sheet and gully erosion. Groundcover levels should remain above 70%, with at least 25% tree cover planted throughout the landscape, particularly as shelterbelts or interception plantings and along drainage lines (Pengelly, In Press).

Regrowth of species such as *Callitris* spp. (cypress pines) should be managed to reduce soil erosion.
Low to moderate limitations for grazing, high limitations for cropping.

Urban Capability
Low to moderate limitations for urban development due to relatively stable soils. Some areas have bedrock very close to the surface which may cause some footing problems. Care should be taken with water supply, drainage and septic systems in this area to not aggravate local salinity problems.

Liverpool Plains Land Management Unit/s

LMU B – Sedimentary Slopes.
LMU C – Sedimentary Footslopes.

by BRENTRY **Transferral**

Landscape—99.3 km^2**.** Drainage plains and fans formed on Quaternary alluvium from Permian quartz sandstones and conglomerates of the Curlewis Hills. Local relief is less than 40 m, elevation 240 - 410 m. Slopes range from 0 – 2%. Mostly cleared open woodland, with isolated patches remaining in upper catchment areas and where the landscape meets the Cox's Creek Floodplain.

Landscape Variant—bya—gilgai variant with giant melonhole gilgai and Vertosols dominating the area. The soils and characteristics of this variant are quite different from by in that they have very poor (often internal) drainage, and riparian-like vegetation, with distinct zonation of vegetation according to position on gilgai and the associated degree of cracking/self-mulching.

Soils—Footslopes are dominated by very deep gravelly imperfectly drained loamy Grey Chromosols (Solodic Soils), or by giant moderately well drained loamy Brown Sodosols (Red-brown Earths/Solodic Soils). Gilgai variant **bya** is dominated by very poorly drained giant Grey or Brown Vertosols (Grey and Brown Clays). Plain elements of the landscape are dominated by giant very poorly drained Brown Vertosols (Brown Clays) and imperfectly to poorly drained deep to giant loamy Brown Sodosols (Solodic Soils and Solodized Solonetz).

Some locations near rhyolite have Silpanic Sodosols (Solodic soils with hard silica pans).

Qualities and Limitations— Localised poor drainage; high run-on, complex soils/complex terrain (bya), localised flood hazard near alluvial plains; localised seasonal waterlogging; localised dryland salinity; known saline discharge area; known recharge area; inherent erosion risk; high sheet erosion risk; high rill and gully erosion risk; high wind erosion risk; *Callitris spp. (cypress pines)* regrowth potential. Soil materials with high plasticity, localised low wet bearing strength, localised high shrink-swell potential, high organic matter (some topsoils), sodicity/dispersion, localised high erodibility, hardsetting surfaces, low permeability, localised high permeability, strong alkalinity, localised salinity and low fertility.

LOCATION AND SIGNIFICANCE

Drainage plains, lower footslopes and fans at the base of Permian sedimentary hills of the Curlewis Hills. Type locations is on the northern end of the Boggabri Stock Route. Grid Reference 213200E, 65 96 600N.

LANDSCAPE

Geology and Regolith

Quaternary alluvium from Permian quartz sandstones, conglomerates and coal seams of the Black Jack Group and Maules Creek Formations. Alluvium and colluvium is generally derived from Top Rock (to), Blue Vale (bv) and Leard (le) soil landscapes. Regolith depth is generally greater than 3 m.

Climate and Hydrology

The Permian sandstones underlie much of the Triassic sedimentary material in the Liverpool Plains, and together form an important saline fractured rock aquifer system that is hydraulically connected to the deep Gunnedah Formation aquifers on the alluvial plains (Broughton, 1994). Flood heights of adjacent floodplain landscapes are such that water often reaches the lower parts of this landscape, influencing soils, land use and vegetation types.

Soils are generally have impeded drainage and much of this landscape is dominated by runoff and interflow (water running downhill in the A2e horizon), which can cause waterlogging and salinity at the break of slope with adjacent (lower) landscapes.

Estimated average annual rainfall range 575 – 630 mm.

Terrain

Level to very gently inclined drainage plains, lower footslopes and fans, and occasional sheet flood fans, of the Curlewis Hills, with slopes from 0 – 2%. Elevation ranges from 240 - 380 m, local relief to 40 m, usually less than 10 m on drainage plains, with closely to very widely spaced (250 – 1585 m) unidirectional to divergent shallow drainage lines, which tend to terminate in fans rather than connecting with other surface drainage.

Vegetation

Open woodland with grass understorey, 80% cleared for grazing and cropping. Major tree and shrub species are *Eucalyptus populnea* (bimble box), *E. sideroxylon* (mugga ironbark), *E. microcarpa* (western grey box), E. *pilligaensis* (pilliga grey box), *E. crebra* (narrow-leaved ironbark), *E. melanophloia* (silver-leaved ironbark), localised E. albens (white box), *E. dealbata* (tumbledown gum), *Eucalyptus blakelyi* (blakely's red gum), *Eucalyptus conica* (fuzzy box), *Allocasuarina leuhmannii* (bull oak) *Callitris glaucophylla* (white cypress pine), *Notelaea microcarpa* (native olive), *Beyeria viscosa* (sticky wallaby-bush), and *Olearia elliptica* (sticky daisy bush).

Groundcover species include *Austrostipa verticillata* (slender bamboo grass), *Chloris truncata* (windmill grass), *Austrostipa setacea* (corkscrew grass), *Austrostipa scabra* (spear grass), *Austrodanthonia* spp. (wallaby grass), *Panicum* spp. (panics), *Chloris ventricosa* (tall windmill grass), *Cymbopogon refractus* (barbed-wire grass), *Aristida ramosa* (wire grass)and *Bothriochloa macra* (red grass).

Land Use

Mostly used for native and occasional improved pasture grazing. Some areas were previously cultivated but this was restricted by high soil erodibility, and structure and fertility decline.

Land Degradation

There is moderate to severe sheet and wind erosion on fans where overgrazing or cropping has occurred. Entire surface horizons have been removed in some areas, leaving hardsetting clay soil surfaces, often with ferromanganiferous nodules or quartz and jasper gravels on the surface. Minor to moderate rill and gully erosion is common in some areas, creating a network of rapidly migrating, very shallow channels, which are mostly relatively stable and revegetated. Some dryland salinity occurs in this landscape, particularly at the lower end of the footslope.

Landscape Variants

Landscape variant **bya** is a giant gilgai variant dominated by very heavy and dispersive Vertosols. This part of the landscape has unique vegetation patterns related to micro-topography of the gilgai with tussock grasses on mounds, sod grasses on the sides of depressions, and wetland type vegetation in the centre of the hollows. This pattern is thought to be related to the abundance of available calcium and waterlogging events. Many of the hollows remain full of water for several months following rain events.

LANDSCAPE QUALITIES AND LIMITATIONS

Localised poor drainage; high run-on, complex soils/complex terrain (bya), localised flood hazard near alluvial plains; localised seasonal waterlogging; localised dryland salinity; known saline discharge area; known recharge area; inherent erosion risk; high sheet erosion risk; high rill and gully erosion risk; high wind erosion risk; *Callitris spp. (cypress pines)* regrowth potential.

SOILS

Variation and Distribution

Brentry is a complex outwash unit from a sedimentary complex of materials which includes a full range of sand to swelling clay minerals. As the landscape appears to be very old, distribution patterns are hard to discern as the landscape becomes flatter.

Soils on footslope positions in this landscape vary according to local sediment source. Some footslopes are dominated by very deep gravelly imperfectly drained loamy Grey Chromosols (Solodic Soils), with others by giant moderately well drained loamy Brown Sodosols (Red-brown Earths/Solodic Soils). Gilgai variant **bya** is dominated by very poorly drained giant Grey or Brown Vertosols (Grey and Brown Clays). The plain elements of the landscape are dominated by giant very poorly drained Brown Vertosols (Brown Clays) and imperfectly to poorly drained deep to giant loamy Brown Sodosols (Solodic Soils and Solodized Solonetz).

Some locations near rhyolite have Vertic Red Chromosols with a silica hardpan. Although these are limited in distribution, they are significant because they topsoils are cemented together by silica and these locations tend to be of limited productivity as ploughing only makes the pan break into hard, cemented lumps.

As this landscape crosses the western map boundary into the Baan Baa sheet, it was studied as one unit crossing the map boundary into the Baan Baa Sheet. Some soil profiles are described by Pengelly (In Press) with type locations occurring on the Baan Baa sheet to the west of the Boggabri sheet.

Position in landscape	**Soil Type**	**Dominance**
Footslope	Brown Sodosols Grey Chromosols	25% 15%
Gilgai var. **bya**	Grey Vertosols Brown Vertosols	<5% (80% of variant) <2% (20% of variant)
Plain	Brown Vertosols Brown Sodosols	25% 25%
Plains near a source of Silica (eg Rhyolite)	Vertic Red Chromosols with hardpan	<1%

Dominant Soil Materials

by1 – Dark sandy topsoils (A1 Horizons). Dark brown to brown (7.5YR 3/3 – 10YR 4/3) loamy sand and sandy loam; massive; earthy (dry); porous; field pH 5.0 – 5.5. Surface loose, occasionally hardsetting.

by2—Dark clay loamy topsoils (A1, Ap Horizons). Dark reddish brown to dark reddish grey to dark brown (5YR 3/2 – 4/2 – 7.5YR 3/2) clay loam, sandy to silty clay loam; generally earthy and massive but can have moderate pedality with smooth faced angular blocky (10 – 20 mm) peds with heavier textures; field pH 5.5 – 7.0; surface is hardsetting and can be gravelly in some locations.

by3—Brownish clay topsoils (A1 Horizons) generally in association with giant gilgai of bya. Dark brown to dark greyish brown (7.5YR 3/2 – 10YR 4/2) light to heavy clay; strong pedality, peds smooth faced and polyhedral (2 – 5 mm); field pH 5.5 – 7.5; some locations have chloride salts as measured by silver nitrate field test; some areas covered with gibber like gravel lag but generally not gravelly; surface is cracking to self-mulching and can appear scalded and hardset in some locations with a long history of heavy grazing scalded looking.

by4 – Bleached sandy loams (A2e, A2en Horizons). Very dark brown (7.5YR 2.5/2)(dry colours often almost white) clayey sand; massive; earthy (dry); field pH 5.0. Ferromanganiferous nodules commonly present. Extremely hardset and often very eroded where exposed.

by5 – Hardsetting dark clayey topsoils (A1 Horizons). Dark brown (7.5YR 3/2) sandy clay; moderate pedality; smooth-faced peds (dry); sub-angular blocky (10 – 20 mm); field pH 7.5. Very few

(<2% orange mottles; few (2 – 10%) quartz fragments. Surface is hardsetting. This material occurs predominantly on the adjacent Baan Baa 1:100 000 Sheet.

by6 – Brownish clay subsoils (B21, B21k, B22, B23 Horizons). Brown to dark brown (7.5YR 5/6 – 10YR 3/3), occasionally to yellowish red (5YR 4/6) sandy clay loam to medium heavy sandy clay; moderate to strong pedality; peds smooth-faced (dry); sub-angular blocky (10 – 50 mm) to angular blocky (20 – 50 mm) and prismatic (50 – 100 mm); field pH 8 – 10. Very few to few (<2 – 10%) orange, yellow, and red mottles; occasionally mangan ped coatings common (10 – 50%); calcareous segregations absent to common (0 – 20%); slight to conspicuous salt evident with $AgNO_3$; quartz and lithic sandstone, conglomerate, and jasper coarse fragments generally very few to common (<2 – 20%). Hardsetting when exposed.

by7 – Greyish blocky clay subsoils (B22k, B23 Horizons). Brown to greyish brown (7.5YR 4/2 – 10YR 5/2) medium sandy clay to heavy clay with coarse sand; moderate to strong pedality; peds smooth-faced (dry); sub-angular blocky (10 – 50 mm), occasionally polyhedral; field pH 6.5 – 10. Slickensides absent to common (0 – 50%); dark, orange, and red mottles very few to many (<2 -50%); mangan ped coatings many (20 – 50%) at depth; calcareous segregations few to common (2 – 20%) in upper subsoil horizons; gypseous crystals absent to few (0 – 10%); lithic sandstone, quartz, and jasper coarse fragments few to common (2 – 20%) in upper subsoil horizons.

by8—Grey gilgai clayey subsoils (B2, B2g, B22, B22k Horizons). Dark grey to grey to light yellowish brown (2.5Y4/1 – 5/1 – 10YR or Y 6/3) medium to heavy clays; various mottle colours may occur at depth; strong pedality with smooth faced prismatic to lenticular (5 – 50 mm) peds; slickenside coatings generally evident; field pH 7.0 – 9.0; slight to conspicuous salt evident with $AgNO_3$; quartz and lithic sandstone, conglomerate, and jasper coarse fragments generally very few to common (<2 – 20%); segregations few to common (2 – 20%) where pH >8.5.

by9—Reddish clay subsoils (B2 Horizons). Yellowish red (5YR 5/6 – 5/8) heavy clay; strong pedality with smooth-faced prismatic (50 – 100 mm) peds; slickenside coatings often present, field pH 6.0 – 8.0

Associated Soil Materials

Soils on drainage plains are occasionally underlain by C horizon material of yellowish red (5YR 5/6) sandy clay loam with fine sand and many (20 – 50% orange and red mottles; field pH 8.5. Conspicuous salt evident with $AgNO_3$; slight fine calcium carbonate evident with HCl. Not encountered exposed.

TYPE PROFILES

Type profile 1: Footslope	
Soil classification: Grey Chromosol, very thick, moderately gravelly, loamy, clayey, deep, (Solodic Soil); common (10-20%) surface gravels; surface condition is gravelly, hard set, expected to be hardsetting when dry	
Depth of observation: 120 cm.	
Location: Gully on Main Road - Leard State Forest. (Map reference: 226711 E, 6609902 N). Profile 98. Timber	
Layer 1, A1, 0 - 0.1 m, by1,	very dark grey sandy loam with massive structure, earthy; common (10-20%), coarse gravel (20-60 mm),cobbles (60-200 mm),stones (200-600 mm), as parent material, coarse fragments; no roots; field pH is 7; abrupt (5-20 mm) smooth boundary to...
Layer 2, A2, 0.1 - 0.18 m, by4,	dark grey sandy loam with massive structure, earthy; common (10-20%), coarse gravel (20-60 mm),cobbles (60-200 mm),stones (200-600 mm), as parent material, coarse fragments; no roots; field pH is 6; clear (20-50 mm) smooth boundary to...

Layer 3, A31, 0.18 - 0.28 m, by4,	dark greyish brown clayey sand with massive structure, earthy; many (20-50%), coarse gravel (20-60 mm),cobbles (60-200 mm),stones (200-600 mm), as parent material, coarse fragments; no roots; field pH is 6; gradual (50-100 mm) smooth boundary to...
Layer 4, 2A3, 0.28 - 0.8 m, by4,	greyish brown coarse clayey sand with massive structure, earthy; very abundant (> 90%), coarse gravel (20-60 mm),cobbles (60-200 mm),stones (200-600 mm), as parent material, coarse fragments; no roots; field pH is 6; AgNO3 result is light precipitate; clear (20-50 mm) smooth boundary to...
Layer 5, B2, 0.8 - 1.2 m, by7	dark grey mottled light sandy clay with weak pedality (angular blocky); smooth-faced peds, abundant (50-90%), coarse gravel (20-60 mm),cobbles (60-200 mm),stones (200-600 mm), as parent material, coarse fragments; no roots; field pH is 6; directly overlies bedrock

Type profile 2: footslope	
Soil classification: Hypocalcic Subnatric Brown Sodosol, medium, non gravelly, clay loamy, clayey, moderate (Solodic Soil)	
Depth of observation: 160 cm.	
Location: Boggabri 1:25 000 Topographic Map - Boggabri-Mullaley Stock route (Map reference: 213165 E, 6596563 N). Profile 71. Voluntary/native Pasture.	
Layer 1, A1, 0 - 0.2 m, by2	dark reddish brown silty clay loam with strong pedality (angular blocky, 10-20 mm), smooth-faced peds; ; common roots; field pH is 6.5; AgNO3 result is light precipitate; clear (20-50 mm) boundary to...
Layer 2, B2, 0.2 - 0.6 m, by2	brown medium clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; ; few (2% - 10%) calcareous segregations; few roots; field pH is 8.5; AgNO3 result is light precipitate; clear (20-50 mm) smooth boundary to...
Layer 3, D, 0.6 - 1.6 m, by8	strong brown sandy clay loam with massive structure, earthy; ; no roots; field pH is 8; AgNO3 result is conspicuous white precipitate; layer continues...

Type profile 3: Gilgai variant bya	
Soil classification: very poorly drained Epicalcareous-Epihypersodic Epipedal Grey Vertosol, non gravelly, very fine, very fine, giant, 2 (Grey Clay);	
Depth of observation: 120 cm.	
Location: Boggabri 1:25 000 Topographic Map – westernmost gilgai on "Merton" (Map reference: 230187 E, 6596559 N). Profile 57. Voluntary/native Pasture.	
Layer 1, A1, 0 - 0.15 m, by3,	dark greyish brown medium heavy clay with strong pedality (polyhedral, 2-5 mm), smooth-faced peds; ; many roots; field pH is 7; diffuse (>100 mm) smooth boundary to...
Layer 2, B2, 0.15 - 0.55 m, by8,	light yellowish brown medium heavy clay with strong pedality (prismatic, 10-20 mm), smooth-faced peds; ; many (20% - 50%) calcareous segregations; common roots; field pH is 9; AgNO3 result is conspicuous white precipitate; diffuse (>100 mm) smooth boundary to...
Layer 3, B22, 0.55 - 1.2 m, by8,	light greyish brown heavy clay with strong pedality (prismatic, 10-20 mm), smooth-faced peds; ; few roots; field pH is 8.5; diffuse (>100 mm) smooth boundary to...

Type profile 4: Plain	
Soil classification: very poorly drained Episodic Epipedal Brown Vertosol, non gravelly, very fine, very fine, very deep, (Brown Clay);	
Depth of observation: 160 cm.	
Location: Boggabri 1:25 000 Topographic Map - front paddock "Merton" (Map reference: 231152 E, 6597608 N). Profile 77. Voluntary/native Pasture.	
Layer 1, A1, 0 - 0.1 m, by3,	dark brown medium clay with strong pedality (polyhedral, 2-5 mm), smooth-faced peds; ; few roots; field pH is 7.5; gradual (50-100 mm) smooth boundary to...
Layer 2, B1, 0.1 - 0.45 m, by6,	brown medium heavy clay with strong pedality (polyhedral, 5-10 mm), smooth-faced peds; ; few (2% - 10%) calcareous segregations; no roots; field pH is 9.5; AgNO3 result is light precipitate; gradual (50-100 mm) smooth boundary to...
Layer 3, B2, 0.45 - 1 m, by6,	brown heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; ; few (2% - 10%) calcareous segregations; no roots; field pH is 9.5; AgNO3 result is conspicuous white precipitate; gradual (50-100 mm) smooth boundary to...
Layer 4, B22, 1 - 1.6 m, by6,	brown heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; ; few (2% - 10%) gypseous segregations; field pH is 8.5; AgNO3 result is conspicuous white precipitate; gradual (50-100 mm) smooth boundary to...

****

Type profile 5: Plain	
Soil classification: very poorly drained Vertic Eutrophic Red Chromosol, medium, non gravelly, clay loamy, clayey, very deep, 3 (Solodic Soil with a silica pan);	
Depth of observation: 70 cm.	
Location: Emerald Hill 1:25 000 Topographic Map – Paddock north of entrance road to “Gunnible” (Map reference: 236750 E, 6574975 N). Profile 10. Cropping.	
Layer 1, A1, 0 - 0.15 m, by2,	dark reddish grey fine clay loam sandy with massive structure, earthy; ; cultivated pan; few roots; field pH is 5.5; clear (20-50 mm) boundary to...
Layer 2, A2, 0.15 - 0.3 m, by4,	reddish brown fine clay loam sandy with massive structure, earthy; ; cultivated pan; no roots; field pH is 5.5; abrupt (5-20 mm) boundary to...
Layer 3, B2, 0.3 - 0.7 m, by9,	yellowish red heavy clay with strong pedality (prismatic, 50-100 mm), smooth-faced peds; ; field pH is 7; soil continues...

Type profile 6: Plain	
Dominance: Approximately 15% of soil landscape.	
Soil classification: Brown Sodosol, medium, non gravelly, loamy, clayey, deep, (Solodized Solonetz);	
Depth of observation: 140 cm.	
Location: Borah 1:50 000 topographic map (from Baan Baa Survey) 50 m north of Road intersection (Map reference: 783054 E, 6591733 N). Profile 17. Timber.	
Layer 1, A1, 0 - 0.12 m, by1	dark brown fine sandy loam with massive structure, earthy; few roots; field pH is 5; gradual (50-100 mm) boundary to-
Layer 2, A2, 0.12 - 0.3 m, by4,	7.5YR 2.5/2 fine clayey sand with massive structure, earthy; no roots; field pH is 5; sharp (<5 mm) boundary to-
Layer 3, B21, 0.3 - 0.7 m, by6,	brown fine sandy clay with strong pedality (prismatic, 50-100 mm), smooth-faced peds; no roots; field pH is 9; gradual (50-100 mm) boundary to-

Layer 4, B22, 0.7 - 1.25 m, by6	strong brown fine light medium clay with strong pedality (prismatic, 50-100 mm), smooth-faced peds; no roots; field pH is 10; gradual (50-100 mm) boundary to-
Layer 5, D, 1.25 - 1.4 m, Associated soil material	yellowish red fine light medium clay ; no roots; field pH is 8.5; layer continues...

Notes on Soil Test Results

The soil test results for soil profile 57, layer 2, (**by8**) has extremely high calcium content owing to its gypsum store. Laboratory sample preparation for particle size analysis and cation exchange capacity (CEC) measurement could not adequately remove the large amounts of gypsum in the sample. Tis resulted in false readings for calcium in the cation exchange capacity measurements and a zero clay content in the particle size analyses (the gypsum made the clay aggregate). Despite these results, the material is a heavy clay.

Erodibility

	Non-concentrated flows	**Concentrated flows**	**Wind**
by1	moderate	high	moderate
by2	moderate	high	moderate
by3	moderate	high	low
by4	high	high	high
by5	moderate	high	low
by6	low	moderate	low
by7	low	moderate	low
by8	moderate	moderate	low
by9	low	moderate	low

Erosion Hazard

	Non-concentrated flows	**Concentrated flows**	**Wind**
Cropping	*moderate*	high	high
Grazing	Low	Moderate	low

Soil Conservation Earthworks (Small Farm Dams)

All topsoils for all soil types in this landscape are generally unsuitable for dam construction. Most subsoils generally have extreme shrink swell as well as high variability in other engineering characteristics and site specific soil testing is recommended. The Red Sodosols subsoils (by4 and by9) tend be suitable for waterholding in normal small farm dams, although care should be taken to keep batter grades relatively low and that the core is very well compacted..

Rural Capability and Sustainable Land Management Recommendations

The dominant soils in this landscape have low to moderate fertility and are prone to structural severe decline under cultivation or heavy grazing. Native or improved pasture grazing is recommended, ensuring that 70% groundcover is present throughout the year, with 15% tree cover planted as shade and shelter belts, and along drainage lines. Areas of topsoil degradation have shown strong improvement with controlled grazing and attention to soil nutrient status.
Regrowth of species such as *Callitris spp. (cypress pines)* and *Cassinia* spp. (cough bush/siffon bush) should be managed to reduce soil erosion.

Generally low limitations for grazing, moderate to high limitations for cropping.

Urban Capability
Generally low to moderate limitations for urban development. The dispersiveness and high erodibility of the soils should be taken into consideration. Flood prone areas should be avoided. Areas such as

bya which have very high foundation hazard are not generally suited for normal structures.

Liverpool Plains Land Management Unit/s

LMU F – Mixed Alluvial Plains. Slopes <2% with a mosaic of soils, often including Vertosols other than Black Earths (dark Vertosols).

Landscape-- 240 km^2; Extensive stagnant alluvial plains, alluvial fans and sheet-flood fans on Quaternary and older alluvium which form westward draining plains from the Melville Range. Local relief <9 m; slopes <1%; elevation range 240 – 260 m. Complex mosaic of grassland and woodland approximately 70% cleared for mixed cropping and grazing.
Landscape Variant—dda—Stagnant alluvial plain and fan system confined by low hills in the Maules creek district. This variant may tend to have more pronounced run-on from adjacent landscapes and because of its confined nature may have more potential for high groundwater.

Soils— Soil distribution is complex and related to ancient alluvial processes which are no longer evident. Soil types include poorly drained giant clay loamy Grey Chromosols (Solodic Soils), poorly drained giant silty Brown Sodosols (imperfectly drained giant Gypsic Brown Vertosols (Brown Clays), poorly drained giant Brown Vertosols (Brown Clays), and very poorly drained giant Grey Vertosols (Grey Clays). The Vertosols tend to dominate the landscape. Some low rise areas have Brown Dermosols (Brown Clays).

Qualities and Limitations—Complex soils, localised dieback, localised poor drainage, engineering hazard, localised low fertility, localised flood hazard, localised permanently high watertables, localised poor moisture availability, known discharge area, recharge area, high run-on, dryland salinity, irrigated salinity, localised seasonal waterlogging and localised wind erosion risk. Soil materials with localised high plasticity, localised low wet bearing strength, localised high shrink-swell potential, localised high organic matter (topsoils), widespread sodicity/dispersion, localised high erodibility, hardsetting topsoils, low permeability, localised strong alkalinity, localised saline subsoils.

LOCATION AND SIGNIFICANCE

Extensive stagnant alluvial plains, alluvial fans and sheet-flood fans on Quaternary and older alluvium which form westward draining plains from the Melville Range. This landscape is differentiated from Dead Horse (**dh**) soil landscape, which occurs further to the south and the adjacent Burburgate (**bu**) soil landscape, by its generally older and poorer soils. Type location is on where Bollol Creek crosses the Boggabri – Manilla Road east of Barber's Lagoon (Grid Reference 2 23600E, 66 02650N.)

LANDSCAPE

Geology and Regolith

Deep Quaternary and Tertiary alluvium derived from the mixed geologies of the Melville Range. In some areas, Permian bedrock highs underlay the alluvium at depths of less than 30 m, and it is possible that the alluvium in these areas could be much older than Tertiary. Some of the more competent upper streams have gravel beds which extend for up to half way across the landscape, with water disappearing and re-emerging from them along the stream course. It appears that some older areas of alluvium have been uplifted through block faulting or warping of the Permian bedrock substrate which underlays the landscape. This occurs near Wean Racecourse where there is a sudden 5 – 8 m rise in the plain over approximately 100 m.

Generally, the sediments which for the alluvium are extremely old and weathered, giving rise to poorer soils than most of the other alluvial landscapes on the Boggabri Sheet. Regolith depth is 20 - > 40 m.

Terrain

Extensive stagnant alluvial plains, alluvial fans and sheet-flood fans on Quaternary and older alluvium which form very low relief, slightly undulating plains with local relief <3 m; slopes <1%; elevation range 240 – 360 m. Drainage is generally by sheetflow with few, barely incised channels (open-depressions <50 cm deep) which are only active from end to end during extremely wet periods. Main drainage lines are discontinuous and unidirectional to deranged, forming gullies in some places where flow is concentrated by culverts. Drainage is more constrained to channels at the upper ends of the landscape where streams have some competence and energy as they leave the steeper elements of the Melville Range.

Climate and Hydrology

As this landscape forms a complex mosaic of soils over a very complex and mostly ancient alluvium, its hydrology is difficult to describe simply. Generally at the head (upper reaches) of the landscape, streams are relatively competent and have gravel beds. As the streams lose competence, much of their water appears to go into the gravel beds which underlie the plains. Some of these gravel beds continue to rise to the surface across the plain, forming well watered open depressions which are characterised by isolated closed-forest (dry rainforest) occurrences.

There is potential for deep drainage from fallow agriculture and poor grazing practice over much of the landscape. Salt stores in subsoils are very large (due to the extreme age of the landscape) and it is possible that deep drainage could contribute to salinisation of otherwise fresh shallow aquifers in the district. Estimated average annual rainfall range 570 – 670 mm.
Vegetation

as this landscape is a broad and complex mosaic of soils, it has a correspondingly broad group vegetation types. Generally the landscape is dominated by various types of woodland. Species found vary in dominance possibly dependant on waterlogging conditions of soils and flood regimes. Tree species include *Eucalyptus albens* (white box, *Eucalyptus trachyphloia* (silver leaved ironbark) *Eucalyptus melliodora* (yellow box), *Eucalyptus pilligaensis* (pilliga box), *Eucalyptus microcarpa* (western grey box), *Eucalyptus camaldulensis* (river red gum), *Eucalyptus dealbata* (tumbledown red gum). Other species include: *Brachychiton populneus* (kurrajong), *Callitris glaucophylla* (white cypress pine), *Notelaea microcarpa* (native olive), *Geijera parviflora* (wilga), *Alectryon oleifolius* (western rosewood), *Angophora floribunda* (rough-barked apple), *Acacia decora* (western golden wattle), *Acacia salicina* (cooba), *Acacia homalophylla* (yarran), occasional *Acacia harpophylla* (brigalow), *Casuarina cristata* (belah), *Casuarina cunninghamiana* (river oak (creek lines)) and *Allocasuarina luehmannii* (bull oak).

Small pockets of closed forest (dry rainforest) occur on the plain where groundwater bearing gravel seams are very close to the surface. These areas tend to be dominated by *Melaleuca bracteata* (white cloud tree), and *Angophora floribunda* (rough barked apple) with *Geijera parviflora* (wilga) generally found on the flanks of the closed forest.

Ground cover species include Austrostipa spp (spear grasses), *Bothriochloa macra*,(red grass), *Dicanthium sericeum* (Queensland blue grass), *Aristida sp* (wire grasses), with *Juncus* spp. (rushes) found in some low lying areas. There are many introduced grass species in this landscape.

Land Use

Previously widely cultivated. Owing to the wide variety of soil types in this landscape, it has a mosaic of agricultural land capability, and this is reflected in the land use patterns. Much of the landscape is used for grazing, with dryland and some irrigated agriculture being primarily located on higher quality soils.

Land Degradation

Sheet erosion and soil structure decline are a common feature of this landscape which is largely an artefact of previous, more widespread cultivation, and heavy stocking. During dry periods, some of the lighter (silty) topsoil areas are extremely prone to wind erosion. Dryland salinity is apparent in some areas, as is scalding with sodic and often saline subsoils exposed. Some gully and streambank erosion occurs in areas where flow is concentrated by road culverts.

Landscape Variant—dda—Stagnant alluvial plain and fan system confined by low hills in the Maules creek district. This variant may tend to have more pronounced run-on from adjacent landscapes and because of its confined nature may have more potential for high groundwater.

Landscape Qualities and Limitations

Complex soils, localised dieback, localised poor drainage, engineering hazard, localised low fertility, localised flood hazard, localised permanently high watertables, localised poor moisture availability, known discharge area, recharge area, high run-on, dryland salinity, irrigated salinity, localised seasonal waterlogging and localised wind erosion risk.

SOILS

Variation and Distribution

Soil distribution is complex and related in many cases to ancient alluvial processes which are no longer evident. There is little in the way of landform elements to indicate soil patterns.

Soil types include poorly drained giant clay loamy Grey Chromosols (Solodic Soils), poorly drained giant silty Brown Sodosols (Solodic Soils), imperfectly drained giant Gypsic Brown Vertosols (Brown Clays), poorly drained giant Brown Vertosols (Brown Clays), and very poorly drained giant Grey Vertosols (Grey Clays). The Vertosols tend to dominate the landscape. Some low rises with ancient abandoned fluvial features on them have imperfectly drained Eutrophic Brown Dermosols (Brown Clays

Position in landscape	**Soil Type**	**Dominance**
Plain	Grey Chromosols Brown Sodosols Gypsic Brown Vertosols Brown Vertosols Grey Vertosols	15% 15% 10% 25% 25%
Very low rises	Brown Dermosols	<10%

Soil Materials

dd1—Light sandy hardsetting topsoils (A1 horizons). Dark greyish brown (10YR 4/2) sandy loam to sandy clay loam; earthy, massive; field pH 6.0 – 7.5; surface is hardsetting, becoming easily compacted and bare under traffic or heavy grazing/cultivation.

dd2—Hardsetting loamy topsoils (A1 Horizons). Dark reddish brown to dark brown (5YR 3/3 – 7.5YR 3/3) silty clay loam, earthy, massive; field pH 6.0 – 7.0, occasionally more acid in degraded condition. Surface is hardsetting.

dd3—Brown structured clayey topsoils (A1 Horizons). Very dark brown to brown (7.5YR 2.5/2 – 7.5 YR 4/4) silty clay to medium clay; moderate to strong pedality, peds smooth faced polyhedral to angular blocky (1 – 50 mm) (often dependant on management), pH 6.0 – 8.5; occasionally has low level salinity with a slight reaction with silver nitrate. Surface is generally cracked, occasionally self-mulching, and often appears hardsetting in heavily grazed or cultivated areas.

dd4—Grey Clay topsoils (A1, Ap Horizons). Dark grey (10YR 4/1) medium to heavy clay; strong pedality with smooth-faced polyhedral (2-5 mm) peds; pH 6.5 – 7.5; surface is seasonally cracking, occasionally self-mulching.

dd5—Reddish clay topsoils (A1 horizons). Reddish brown (5YR 4/4) medium to heavy clay; strong pedality with smooth-faced, angular blocky peds (20 – 50 mm); pH 6.5 – 8.0, surface is hardsetting. This material was not sampled for laboratory analyses, however is significant in that it should have much higher permeability that most of the topsoils in this landscape.

dd6—Bleached topsoils horizons (A2e Horizons). Greyish brown (10YR 5/2) (dry colour almost white silty loam to silty clay loam, earthy, massive; pH 6.0 – 7.0; occasionally has few (2 – 10%) managniferous nodules; surface is generally very hardsetting where exposed by erosion or cultivation.

dd7—Brown clayey subsoils (B2, B22, 2B22 horizons). Dark brown to strong brown (7.5YR 3 /4 – 7.5YR 5/8) sandy clay to heavy clay; strong pedality with peds tanging angular blocky to prismatic and lenticular (10 – 100 mm) generally becoming courser and more prismatic with depth, slickenside ped coatings become common with depth; pH 7.0 – 9.5; calcium carbonate nodules and soft segregations become more common with depth, gypsum crystals can often be found as a discreet layer in this material. Chloride salts are generally evident, often increasing with depth, as indicated by silver nitrate field tests.

dd8—Grey and yellowish clayey subsoils (B1, B2, B22 horizons). Dark grey (2.5Y 4/1) to greyish yellow (2.5Y 5/2) or dark greyish brown to dark yellowish brown (10YR 4/2 – 4/4) medium to heavy clays; strong pedality, with peds lenticular to prismatic (10 – 100 mm) generally becoming coarser with depth; slickenside ped coatings become common with depth; pH 6.5 – 9.0, increasing with depth, calcium carbonate nodules and soft segregations become more common with depth, chloride salts are generally evident, often increasing with depth, as indicated by silver nitrate field tests.

dd9 Dark silty clay subsoils (B2 horizons). Very Dark Brown (7.5YR 2.5/3) silty clay, strong pedality with smooth faced, angular blocky peds (10 – 20 mm), pH (6.0 – 7.0), few (2 – 10%) calcareous nodules present, and chloride salts are generally strongly evident as indicated by silver nitrate field tests.

Type Profiles

Type profile 1: Plain	
Soil classification: Haplic Eutrophic Grey Chromosol, medium, slightly gravelly, clay loamy, clayey, very deep, (Solodic Soil);	
Depth of observation: 60 cm.	
Location: Boggabri 1:25 000 Topographic Map (Map reference: 223887 E, 6600958 N). Profile 72. Voluntary/native Pasture.	
Layer 1, A1, 0 - 0.2 m, dd1	dark greyish brown sandy clay loam with massive structure, earthy; ; few roots; field pH is 7; abrupt (5-20 mm) smooth boundary to...
Layer 2, A2, 0.2 - 0.4 m, dd6	greyish brown silty loam with massive structure, earthy; few (2-10%), gravel (6-20 mm),coarse gravel (20-60 mm), as parent material, coarse fragments; few (2% - 10%) manganiferous segregations; no roots; field pH is 7; abrupt (5-20 mm) smooth boundary to...
Layer 3, B1, 0.4 - 0.6 m, dd8	dark greyish brown medium clay with strong pedality (prismatic, 50-100 mm), smooth-faced peds; ; no roots; field pH is 6.5; soil continues

Type profile 2: Plain	
Soil classification: imperfectly drained Gypsic Epipedal Brown Vertosol, non gravelly, very fine, very fine, giant, (Brown Clay);	
Depth of observation: 140 cm.	
Location: Kelvin 1:25 000 Topographic Map - TSR between Rosebury & Surrey (Map reference: 239255 E, 6589636 N). Profile 231. Voluntary/native Pasture.	
Layer 1, A1, 0 - 0.08 m, dd3	dark brown medium clay with strong pedality (polyhedral, 5-10 mm), smooth-faced peds; ; common roots; field pH is 6.5; AgNO3 result is light precipitate; gradual (50-100 mm) broken boundary to...
Layer 2, B2, 0.08 - 0.8 m, dd7	brown medium clay with strong pedality (lenticular, 10-20 mm), smooth-faced peds; ; common (10% - 20%) gypseous segregations; few roots; field pH is 7; AgNO3 result is light precipitate; diffuse (>100 mm) broken boundary to...
Layer 3, 2B2, 0.8 - 1.4 m, dd7	strong brown light medium clay with moderate pedality (lenticular, 10-20 mm), smooth-faced peds; ; few (2% - 10%) gypseous segregations; field pH is 9; AgNO3 result is conspicuous white precipitate; soil continues

Type profile 3: Plain	
Soil classification: poorly drained Epicalcareous-Endohypersodic Epipedal Brown Vertosol, non gravelly, fine, very fine, giant, (Brown Clay);	
Depth of observation: 110. cm.	
Location: Gulligal 1:25 000 Topographic Map - Blue Vale Rd nr "Coulston" (Map reference: 232655 E, 6584829 N). Profile 228. Voluntary/native Pasture.	
Layer 1, A1, 0 - 0.1 m, dd3	brown silty clay with strong pedality (polyhedral, 5-10 mm), smooth-faced peds; ; few roots; field pH is 6.5; gradual (50-100 mm) boundary to...
Layer 2, B2, 0.1 - 0.65 m, dd7	strong brown heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; ; few (2% - 10%) calcareous segregations; no roots; field pH is 9; AgNO3 result is light precipitate; diffuse (>100 mm) broken boundary to...
Layer 3, B22, 0.65 - 1.1 m, dd7	brown heavy clay with strong pedality (lenticular, 20-50 mm), smooth-faced peds; ; few (2% - 10%) calcareous segregations; field pH is 9; AgNO3 result is conspicuous white precipitate; soil continues….

Type profile 4: Plain	
Soil classification: Hypocalcic Mesonatric Brown Sodosol, thin, non gravelly, silty, clayey, very deep, (Solodic Soil);	
Depth of observation: 140 cm.	
Location: Kelvin 1:25 000 Topographic Map TSR between Rosebury + Surrey (Map reference: 239132 E, 6589643 N). Profile 230. Voluntary/native Pasture.	
Layer 1, A1, 0 - 0.05 m, dd2	dark reddish brown silty clay loam with massive structure, earthy; ; common roots; field pH is 6.5; sharp (<5 mm) boundary to...
Layer 2, B2, 0.05 - 0.35 m, dd9	7.5YR 2.5/3 silty clay with strong pedality (angular blocky, 10-20 mm), smooth-faced peds; ; few (2% - 10%) calcareous segregations; few roots; field pH is 6.5; AgNO3 result is conspicuous white precipitate; gradual (50-100 mm) boundary to...
Layer 3, 2B2, 0.35 - 1.4 m, dd7	strong brown light medium clay with moderate pedality (prismatic, 20-50 mm), smooth-faced peds; ; common (10% - 20%) calcareous segregations; field pH is 9; AgNO3 result is conspicuous white precipitate; soil continues….

Type profile 5: Plain	
Soil classification: very poorly drained Episodic-Endohypersodic Epipedal Grey Vertosol, non gravelly, very fine, very fine, giant, ;	
Depth of observation: 140 cm.	
Location: Gulligal 1:25 000 Topographic Map - N Blue Vale Rd (Map reference: 232117 E, 6588601 N). Profile 226. Voluntary/native Pasture.	
Layer 1, A1, 0 - 0.1 m, dd4	dark grey mottled medium clay with strong pedality (polyhedral, 2-5 mm), smooth-faced peds; ; common roots; field pH is 7; diffuse (>100 mm) boundary to...
Layer 2, B2, 0.1 - 1.1 m, dd8	dark grey heavy clay with strong pedality (lenticular, 10-20 mm), smooth-faced peds; ; very few (< 2%) calcareous segregations; few roots; field pH is 9; gradual (50-100 mm) boundary to...

Layer 3, B22, 1.1 - 1.4 m, dd8	greyish yellow medium clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; ; very few (< 2%) calcareous segregations; field pH is 9; AgNO3 result is conspicuous white precipitate; soil continues…

Type profile 6: Very low rise	
Soil classification: imperfectly drained Eutrophic Brown Dermosol, medium, non gravelly, clayey, clayey, very deep, (Brown Clay);	
Depth of observation: 140 cm.	
Location: Kelvin - Low red rise - Wean Rd (Map reference: 238220 E, 6587666 N). Profile 229. Voluntary Native Pasture.	
Layer 1, A1, 0 - 0.2 m, dd5	reddish brown medium clay with strong pedality (angular blocky, 20-50 mm), smooth-faced peds; very few (< 2%), fine gravel (2-6 mm),gravel (6-20 mm), as parent material, coarse fragments; common roots; field pH is 7.5; AgNO3 result is no precipitate; gradual (50-100 mm) broken boundary to...
Layer 2, B2, 0 - 1 m, dd7	strong brown coarse sandy clay with moderate pedality (prismatic, 10-20 mm), smooth-faced peds; abundant (50-90%), fine gravel (2-6 mm),gravel (6-20 mm), as parent material, coarse fragments; few roots; field pH is 9; AgNO3 result is no precipitate; gradual (50-100 mm) boundary to...
Layer 3, B22, 1 - 1.4 m, dd7	strong brown medium clay with strong pedality (angular blocky, 20-50 mm), smooth-faced peds; very few (< 2%), fine gravel (2-6 mm),gravel (6-20 mm), as parent material, coarse fragments; few (2% - 10%) gypseous segregations; no roots; field pH is 8.5; AgNO3 result is conspicuous white precipitate; gradual (50-100 mm) broken boundary to...

QUALITIES AND LIMITATIONS

Erodibility

Soil Material	Non-concentrated flows	Concentrated flows	Wind
dd1	moderate	high	moderate – high
dd2	moderate	high	low
dd3	low	moderate	low
dd4	moderate	high	low
dd5	low	moderate	low
dd6	high	high	moderate – high
dd7	moderate	high	low
dd8	moderate	high	low
dd9	low	high	low

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
Cropping	Low - Moderate	Moderate - high	Low – Moderate
Pasture	Low	Low - moderate	Low

Soil Conservation Earthworks (Small Farm Dams)

The subsoils in this landscape generally have extreme shrink swell as well as high variability in other engineering characteristics and site specific soil testing is recommended before dam construction in this landscape.

Rural Capability and Sustainable Land Management Recommendations

Although the soil type in this landscape area also found in other, younger landscapes on the Boggabri

Sheet, they are much older and more weathered versions of the same soils. They tend to be low in naturally available nutrients, have very sodic subsoils and high in salts in many locations. This landscape is classified by URS (2001) as LMU F – Mixed Alluvial Plains – which has a high capability for cropping. The age of this landscape generally precludes continuous cropping and permanent pasture is recommended as the sustainable landuse for this landscape, with occasional cropping for pasture re-establishment purposes.

Moderate to high limitations for cropping. Low to moderate limitations for grazing.

Urban Capability

Generally low capability for urban development due to sporadic flood hazard, drainage and salinity problems in the landscape. Some higher rises in the landscape have moderate suitability and may be effected by high foundation hazard and low septic absorption potential.

Liverpool Plains Land Management Unit/s

LMU F – Mixed Alluvial Plains.

Landscape—20.5 km^2; Steep to precipitous hills and scarps on Permian Rhyolite and other acid to intermediate volcanics of the Boggabri Hills. Local relief to 180 m, slopes generally greater than 30% with some areas >70%, elevation range 240 – 440 m. Landscapes forms cliffs, cliff footslopes, scree slopes and hillslopes. Woodland, open forest mostly occurring in state forests or unused.

Soils— Upper slopes are dominated by rapidly drained shallow Lithic Leptic Tenosols (Lithosols). Mid to lower slopes are dominated by rock scree and exposed saprolite or well drained shallow to moderately deep Red Vertosols (Red Clays).

Qualities and Limitations— Localised engineering hazard, gully erosion risk, sheet erosion risk, mass movement hazard, poor moisture availability, potential recharge area, rockfall hazard, rock outcrop, high run-on (lower slopes), shallow soils, steep slopes and woody weeds.

LOCATION AND SIGNIFICANCE

Steep to precipitous hills and scarps on Permian Rhyolite and other acid volcanics of the Boggabri Hills. Type location is on the slopes of Gins Leap (Grid Reference 2 16200E, 66 04500N).

LANDSCAPE

Geology and Regolith

Colluvium derived from acid to intermediate volcanics of the Boggabri Volcanics. Includes rhyolitic, to dacitic lavas, ashflow tuffs with occasional trachyte and andesite outcrop. Regolith is generally deeply weathered and fractured colluvium underlain generally by a deep saprolite. Soil depths generally <50 cm.

Terrain

Steep to precipitous hills and scarps. Slopes are typically < 1000 m long. Local relief to 180 m, slopes generally greater than 20% with some areas >70%, elevation range 240 – 440 m. Rock outcrop <20%. Typical landform elements include narrow crests, steep to precipitous simple to waxing hillslopes, scarps, cliff footslopes with minor scree slopes and gullies. Drainage is generally by widely spaced, deeply incised drainage lines and sheetflow.

Climate and Hydrology

It is likely that the deeply weathered saprolites and colluvium on lower slopes of this landscape are a recharge area for small fractured rock aquifers which may feed into shallow saline groundwater on adjoining lower landscapes.

Estimated average annual rainfall range 575 – 630 mm.

Vegetation

Generally mixed open woodland and woodland, with some small areas of closed forest in sheltered locations such as at the base of cliff lines.

Woodland areas include *Callitris glaucophylla* (white cypress pine), *Eucalyptus crebra* (narrow-leaved ironbark), *E. melanophloia* (silver-leaved ironbark), *E. dealbata* (tumbledown gum), *Callitris endlicheri* (black cypress pine), localised *E. alb*ens (white box), *Notelaea microcarpa* (native olive), *Beyeria viscosa* (sticky wallaby-bush), *Dodonaea viscosa* (giant hopbush), *Olearia elliptica* (sticky daisy bush), occasional *Acacia cheelii*, *Kunzea sp*. 'Mt Kaputar', *Calytrix tetragonia* (common fringe-myrtle), *Ozothamnus obcordatus*, *Acacia triptera* (spur-wing wattle), *Micormyrtus sessi*lis (heath myrtle) and *Homoranthus flavescens*.

Groundcover species include *Austrostipa scabra* (spear grass), *Desmodium brachypodium* (large tick-trefoil), *Cymbopogon refractus* (barbed-wire grass), *Bothriochloa decipens* (red grass), *Cymbopogon refractus* (barbed wire grass), *Cheilanthes sieberi* (rock fern) and Aristida ramosa (wire grass).

Small closed forest areas tend to be dominated by *Alphitonia excelsa* (red ash), *Geijera parviflora* (wilga), and *Ficus rubiginosa* (rusty fig).

Small areas of spinifex grassland dominated by *Triodia irritans* (spinifex), occur in some locations on particularly exposed and rocky colluvium.

Land Use

Generally unused land or lands in State Forests with some lower sloping areas used for occasional light grazing. Gins Leap is used for recreation as a look out.

Land Degradation

Areas with a long history of grazing, either by domestic stock or feral goats exhibit severe sheet and rill erosion.

Landscape Qualities and Limitations

Localised engineering hazard, gully erosion risk, sheet erosion risk, mass movement hazard, poor moisture availability, potential recharge area, rockfall hazard, rock outcrop, high run-on (lower slopes), shallow soils, steep slopes and woody weeds.

SOILS

Variation and Distribution

Upper slopes are dominated by rapidly drained shallow Lithic Leptic Tenosols (Lithosols). Mid to lower slopes are dominated by rock scree and exposed saprolite or well drained shallow to moderately deep Red Vertosols (Red Clays).

Position in landscape	**Soil Type**	**Dominance**
Upper slopes	Tenosols	25%
Mid to Lower slopes	Red Vertosols Loose rock scree/exposed weathered rock	40% 25%

Dominant Soil Materials

gp1—Black Sandy Loam (A1 Horizons). Black (7.5YR 2.5/1) light sandy loam; single grained structure, sandy fabric; field pH is 5.5; Coarse fragments absent to abundant (0 -90%). Surface condition ranges from loose to hardsetting.

gp2—Yellowish Brown Sandy Subsoils (BC Horizons). Dark yellowish brown (10YR 3/ 4) whole-coloured coarse sandy loam with single grained structure, sandy fabric; field pH is 5.5; Coarse fragments absent to abundant (0 -90%).

gp3—Red Clayey Topsoils (A1 Horizons). Dusky red (2.5YR 3/2) coarse light medium sandy clay with moderate pedality (granular, 1-2 mm), smooth-faced peds; field pH is 7; Coarse fragments absent to few (0-10%); Surface condition is generally gravelly and self-mulched.

gp4—Reddish Brown Clay subsoils (B2 Horizons). Dark reddish brown (2.5YR 3/ 4) mottled heavy clay with strong pedality (angular blocky, 20-50 mm), smooth-faced peds; field pH is 7; ; Coarse fragments absent to few (0-10%).

Type Profiles

Type profile 1: Upper slope	
Soil classification: rapidly drained Basic Lithic Leptic Tenosol, medium, very gravelly, loamy, loamy, shallow, 2 (Lithosol); many (20-50%) surface gravels; surface condition is gravelly, loose, expected to be loose when dry	
Depth of observation: 30 cm.	
Location: Boggabri 1:25 000 topographic map - Gins Leap track (Map reference: 216126 E, 6604482 N). Profile 328. Timber/scrub/unused.	
Layer 1, A1, 0 - 0.2 m, gp1	7.5YR 2.5/1 whole-coloured coarse light sandy loam with single grained, sandy; abundant (50-90%), fine gravel (2-6 mm),gravel (6-20 mm),coarse gravel (20-60 mm), as substrate, coarse fragments; field pH is 5.5; clear (20-50 mm) boundary to...
Layer 2, BC2, 0.2 - 0.3 m, gp2	dark yellowish brown whole-coloured coarse sandy loam with single grained, sandy; abundant (50-90%), fine gravel (2-6 mm),gravel (6-20 mm),coarse gravel (20-60 mm), as substrate, coarse fragments; field pH is 5.5; directly overlies bedrock

Type profile 2: Lower Slope	
Soil classification: well drained Self-Mulching Red Vertosol (Red Clay); many (20-50%) surface gravels; surface condition is gravelly, self mulched, expected to be self mulching when dry	
Depth of observation: 70 cm.	
Location: Boggabri 1:25 000 topographic map - between rest stop and Gins Leap. (Map reference: 216178 E, 6604527 N). Profile 329. Timber/scrub/unused.	
Layer 1, A1, 0 - 0.15 m, gp3	dusky red whole-coloured coarse light medium sandy clay with moderate pedality (granular, 1-2 mm), smooth-faced peds; few (2-10%), gravel (6-20 mm), as substrate, coarse fragments; field pH is 7; clear (20-50 mm) boundary to...
Layer 2, B2, 0.15 - 0.7 m, gp4	dark reddish brown mottled fine heavy clay with strong pedality (angular blocky, 20-50 mm), smooth-faced peds; few (2-10%), gravel (6-20 mm), as substrate, coarse fragments; field pH is 7; directly overlies bedrock

Associated Soil Materials

QUALITIES AND LIMITATIONS

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
Pasture	Moderate	High	Low

Rural Capability and Sustainable Land Management Recommendations
This landscape has very limited production value and should generally be excluded from agricultural activities. High to severe limitations for grazing, severe limitations for cropping.

Urban Capability

Generally high limitations for urban development due to steep slopes and high levels of hard rock outcrop.

Liverpool Plains Land Management Unit/s
LMU A - Sedimentary Hilltops and steep slopes. This landscape is definitely not sedimentary in origin, but has the same capabilities as those described for LMU A.

Landscape—26.2 km^2. Rolling to undulating low hills on Permian-Carboniferous rhyolites, rhyolite tuffs and andesites of the Gunnedah and Boggabri Volcanics. Local relief to 50 m, slope range 8 - 20% with rounded to relatively flat crests, elevation range 240 - 450 m. Rock outcrop approximately 40%. Partially cleared open-woodland with a grass or shrub understorey.

Soils—Hillcrests dominated by very shallow Lithic Leptic Tenosols (Lithosols) with hillslopes on rhyolite dominated by Chernic Tenosols (Lithosols). Hillslopes on dacite and andesite tend to have heavier soils such as Grey or Black Vertosols (Grey Clays and Black Earths).

Limitations-- Localised engineering hazard, low fertility, flood hazard, gully erosion risk, sheet erosion risk, poor moisture availability, potential recharge area, rock outcrop, high internal run-on, shallow soils, and woody weeds.

LOCATION

Rolling low hills on Permian-Carboniferous rhyolite and rhyodacite/andesite. Type location is west of Leard State Forest, north of (Grid reference 2 20000E, 66 15000N).

Geology

Permian/Carboniferous rhyolite, rhyolite tuff and rhyodacite/andesite of the Permian Boggabri and Gunnedah Volcanics. Depth to unweathered rock is generally < 1 m but can exceed this in some deeply weathered andesite locations.

Terrain

Rolling to undulating low hills with local relief 30 - 50 m between 240 and 450 m. Slopes range from 8 - 20%, waxing gently to moderately inclined long (>300 m) sideslopes with rounded to flat, moderately broad (100 - 300 m) crests. Rock outcrop often forms low, rounded scarps and covers approximately 40% of the land surface. Few incised drainage lines.

Climate and Hydrology

Generally a runoff dominated but some areas of andesite may function as intensively fractured rock aquifers. Generally, the rhyolite in this landscape has only limited fracturing and is more runoff dominated. Estimated annual rainfall range 580 – 635 mm.

Vegetation

Partially cleared mixed open-woodland with grass understorey. Dominant tree species include *Alphitonia excelsa* (red ash), *Eucalyptus dealbata* (tumbledown gum), *E. crebra* (narrow-leaved ironbark), *E. melanophloia* (silver-leaved ironbark), *Eucalyptus populnea* (bimble box), *Geijera parviflora* (wilga), *Notelaea microcarpa* (native olive), *Brachychiton populneus* (kurrajong), *Dodonaea viscosa* (giant hopbush), *Callitris glaucophylla* (white cypress pine) and *Acacia cheelii* (motherumbah).

Ground cover plants include *Aristida* spp. (wire grasses), *Austrostipa scabra* (spear grass), *Austrostipa verticillata* (slender bamboo grass), *Desmodium brachypodium* (large tick-trefoil), *Cymbopogon refractus* (barbed-wire grass) and *Aristida ramosa* (wire grass).

Land Use

Trees have been thinned for native pasture in some locations. Mainly used for light sheep and cattle grazing.

Existing Land Degradation

Moderate to severe sheet erosion has occurred throughout the landscape. There is some minor gully erosion <1.5 m deep where deeper soils occur. Gully erosion usually continues to bedrock. Skeletal soils directly overlying bedrock have been eroded to bare rock especially on crests. Areas of recently exposed rock are difficult to distinguish from natural outcrop. Areas where stock have concentrated tend to exhibit structural decline, especially on shallower soils. Most cleared areas are dominated by *Callitris glaucophylla* regrowth.

Landscape Qualities and Limitations

Localised engineering hazard, low fertility, flood hazard, gully erosion risk, sheet erosion risk, poor moisture availability, potential recharge area, rock outcrop, high internal run-on, shallow soils, and woody weeds.

SOILS

Variation and Distribution

Hillcrests are generally dominated by very shallow Lithic Leptic Tenosols (Lithosols) with hillslopes on rhyolite dominated by Chernic Tenosols (Lithosols). Hillslopes on dacite and andesite tend to have heavier soils such as Grey or Black Vertosols (Grey Clays and Black Earths).

Position in landscape	**Soil Type**	**Dominance**
Hillcrests	Lithic Leptic Tenosols	20%
Hillslopes on rhyolite	Chernic Tenosols	15%
Hillslopes on dacite/ andesite	Grey/Black Vertosols	15%

Dominant Soil Materials

Soil materials ha2 and ha3 occur more extensively on the adjacent Soil landscapes of the Curlewis 1:100 000 Sheet (Banks 1995). These materials were not encountered during this survey, however there may be limited occurrences in the southern portion of the map.

ha1--Hardsetting dark reddish brown fine sandy clay loam (A_1 horizons). Black (7.5YR 2.5/1)to dull reddish brown (5YR 4/4) to dark reddish brown (2.5YR 3/3) sandy clay loam to clay loam sandy; massive, earthy, dense, field pH 6.0 - 7.0, often very stony throughout; surface is hardsetting.

ha4—Greyish clay topsoils (A1 horizons). Very dark brown to dark grey (7.5YR 3/1 - 3/2) light to medium clay; strong pedality with polyhedral (2 – 10 mm) peds; field pH 7.0 – 8.5, lime occasionally evident in small amounts and generally only detectable with HCl field test. Surface is self-mulching to self-mulching and cracking.

ha5—Grey clay subsoils (B horizons). Dark grey (10YR 4/1) medium to heavy clay, strong pedality with smooth-faced prismatic (20 – 50 mm) peds, field pH 7.0 – 8.0. Surface is generally self-mulching and seasonal cracking.

ha6—Brown clay subsoils (B22 Horizons). Brown (10 YR 5/3) medium to heavy clay, strong pedality with smooth faced (10 – 20 mm) prismatic peds, slickenside ped coatings usually present, field pH 7.0 – 8.0.

Type Profiles

Type profile 1: Hillcrest
Soil classification: rapidly drained Basic Lithic Leptic Rudosol, very gravelly, clay loamy, very shallow, (Lithosol); abundant (50-90%) surface gravels; surface condition is hard set, expected to be hardsetting when dry
Depth of observation: 12 cm.
Location: Therribri 1:25 000 topographic map - Rhyolite hill "Riverway" (Map reference: 217694 E, 6615056 N). Profile 276. Voluntary native Pasture.

Layer 1, A1, 0 - 0.12 m, ha1	7.5YR 2.5/1 coarse clay loam sandy with massive structure, earthy; abundant (50-90%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; common roots; field pH is 6; directly overlies bedrock

Type profile 2: Hillslope	
Soil classification: Chernic Tenosol, medium, gravelly, clayey, clayey, very shallow, (Lithosol); many (20-50%) surface gravels; surface condition is self mulched, expected to be self mulching when dry	
Depth of observation: 50 cm.	
Location: Therribri 1:25 000 topographic map - Leard SF W TSR (Map reference: 218989 E, 6615659 N). Profile 178. Logged Native Forest.	
Layer 1, A, 0 - 0.25 m, ha4	dark brown light clay with strong pedality (polyhedral, 5-10 mm), smooth-faced peds; common (10-20%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; common roots; field pH is 7; clear (20-50 mm) boundary to...
Layer 2, C, 0.25 - 0.5 m, Assoc	clear (20-50 mm) boundary to...bedrock

Type profile 3: Hillslope on andesite/dacite	
Soil classification: mod. well drained Self-Mulching Grey Vertosol (Grey Clay); few (2-10%) surface gravels; surface condition is self mulched, expected to be seasonal cracking when dry	
Depth of observation: 70 cm.	
Location: Therribri 1:25 000 topographic map - Leard SF (Map reference: 221945 E, 6612330 N). Profile 176. Timber/scrub/unused.	
Layer 1, A, 0 - 0.05 m, ha4	very dark grey light clay with strong pedality (polyhedral, 2-5 mm), smooth-faced peds; few (2-10%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; common roots; field pH is 8.5; sharp (<5 mm) smooth boundary to...
Layer 2, B2, 0 - 0.38 m, ha5	dark grey light medium clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; few (2-10%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; common roots; field pH is 7.5; clear (20-50 mm) irregular boundary to...
Layer 3, 2B2, 0 - 0.7 m, ha6	brown medium clay with strong pedality (prismatic, 10-20 mm), smooth-faced peds; few (2-10%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; no roots; field pH is 7.5; layer continues...

QUALITIES AND LIMITATIONS

Erodibility

	Non-concentrated flows	Concentrated flows	Wind
ha1	high	high	low
ha4	moderate	high	low
ha5	moderate	high	low
ha6	moderate	high	low

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
Pasture	moderate - high	Severe	Low

Soil Conservation Earthworks (Small Farm Dams)

Generally high to extreme limitations for earthworks as suitable sites are rare, and soils are generally very shallow.

Rural Capability and Sustainable Land Management Recommendations

Best managed as uncleared timber or for light grazing under timber in areas of heavier soil. Maintain and monitor 70% permanent pasture cover to reduce overland flow and prevent sheet erosion. Areas of very dense cypress pines (*Callitris* spp.) regrowth should be thinned to avoid associated soil erosion problems.

Severe limitations for cultivation. Moderate to high limitations for grazing.

Urban Capability

Low to moderate limitations for urban development.

Liverpool Plains Land Management Unit/s

LMU A - Sedimentary Hilltops and steep slopes.
LMU B – Sedimentary Slopes.

Comment: Although this unit is not on sedimentary material, the predominant acid volcanics, shallow soils and slopes give it the same land capability listed for the sedimentary Land Management Units.

Landscape—47.7 km^2; Rolling to steep and low hills on Permian Sandstones and conglomerates of the Curlewis Hills in the Central portion of the Boggabri sheet. Local relief to 150 m, slopes 10 – 35% but generally around 15%, rock outcrop 10%, elevation range 290 – 500 m. Woodland and open forest partially cleared for grazing or managed as State Forest.

Landscape Variant—lea—small areas of steeper land with >32% slope with higher erosion hazard.

Soils— Hillcrests and benches are dominated by well drained Rudosols and Tenosols (Lithosols), with Brown Kurosols (Brown Podzollic Soils) and minor Red and Brown Chromosols (Non-calcic Brown Soils and Podzollic Soils) occurring on acid shales/mudstones. Grey Sodosols are reported for some locations in the nearby Baan Baa 1:100 000 Sheet (Pengelly, In Press).

Qualities and Limitations— Low fertility, localised gully erosion risk, sheet erosion risk, poor moisture availability, recharge area, rock outcrop, run-on, shallow soils, localised steep slopes (**lea**), and woody weeds.

LOCATION AND SIGNIFICANCE

Rolling to steep and low hills on Permian Sandstones and conglomerates of the Curlewis Hills in the Central portion of the Boggabri sheet. Type Location is at Willowtree Range in Leard State Forest (Grid Reference 2 28300E, 66 12500N).

LANDSCAPE

Geology and Regolith

Permian sediments of the Black Jack Group and Maules Creek Formation (Geological map codes Pbx and Pmx). Lithologies include siltstones, quartz and lithic sandstones, claystones, minor tuff beds, with some conglomerates forming higher hillcrests. Bedding is usually near horizontal.

Regolith depth is usually <2 m.

Terrain

Rolling to steep and low hills with local relief to 150 m, slopes 10 – 35% but generally around 15%, rock outcrop 10%, elevation range 290 – 500 m. Crests are generally broad and rounded with occasional outcrop, sideslopes being long and occasionally benched. Drainage is by sheetflow with moderately spaced, ephemeral erosional streams draining the landscape.

Climate and Hydrology

This landscape is characterised by a mixture of runoff and deep drainage through shallow, stony soils into a fractured rock aquifer. Estimated average annual rainfall range 600 – 645 mm.

Vegetation

Predominantly woodland, much of which is maintained in State Forests. Some locations cleared for grazing. Dominant tree and shrub species include *Callitris glaucophylla* (white cypress pine), *Callitris endlicheri* (black cypress pine), *Eucalyptus crebra* (narrow-leaved ironbark), *E. melanophloia* (silver-leaved ironbark), *E. sideroxylon* (mugga ironbark) localised *E. albens* (white box), *Acacia cheelii* (motherumbah), *Notelaea microcarpa* (native olive), *Beyeria viscosa* (sticky wallaby-bush), *Olearia elliptica* (sticky daisy bush). Groundcover species include *Austrostipa scabra* (spear grass), *Austrostipa verticillata* (slender bamboo grass), *Desmodium brachypodium* (large tick-trefoil), *Cymbopogon refractus* (barbed-wire grass) and *Aristida ramosa* (wire grass).

Land Use

Predominantly used for light grazing or forestry activities. Some areas in the north of Leard State forest are still cultivated for winter cereals.

Land Degradation

Minor to severe sheet erosion is evident on cleared crests, and sideslopes where animal tracks are present. Rill and gully erosion are evident in areas with current or historical cultivation. Most areas remain protected by either adequate vegetation or leaf litter cover.

Landscape Variant

lea—small areas of steeper land with >32% slope with higher erosion hazard.

Landscape Qualities and Limitations

Low fertility, localised gully erosion risk, sheet erosion risk, poor moisture availability, recharge area, rock outcrop, run-on, shallow soils, localised steep slopes (**lea**), and woody weeds.

SOILS

Variation and Distribution

Hillcrests and benches are dominated by well drained Rudosols and Tenosols (Lithosols), with Brown Kurosols (Brown Podzollic Soils) and minor Red and Brown Chromosols (Non-calcic Brown Soils and Podzollic Soils) occurring on acid shales/mudstones. Grey Sodosols are reported for some locations in the nearby Baan Baa 1:100 000 Sheet (Pengelly, In Press).

Position in landscape	**Soil Type**	**Dominance**
Upper slopes/Crests	Rudosols/Tenosols	40%
Acid Shale Hillslopes	Brown Kurosols/Chromosols	15%
Lower slopes	Grey Sodosols	15%

Dominant Soil Materials

Joint field work was carried out for Leard soil landscape across the boundary of the Boggabri and Baan Baa Sheets to ensure precision of mapping. Some of the type profiles and soil materials described here have type locations on the adjacent Baan Baa 1:100 000 Sheet (Pengelly, In Press).

le1 – Dark sandy to clay loam topsoils (A1, A11, A12, AC Horizons). Dark reddish brown to dark brown (5YR 3/3 – 7.5YR 4/3) and dark yellowish brown (10YR 3/4) loamy sand to clay loam; massive to weak pedality; earthy to smooth-faced peds in clay loams (dry); sub-angular blocky (2 – 5 mm) where pedal; porous; field pH 5.5 – 7.0. Quartz and lithic sandstone, quartz, and jasper fragments few to abundant (2 – >90%). Surface loose, occasionally hardsetting.

le2—Bleached near surface layers (A2e Horizons). Brown (7.5YR 4/3 – 4/4) sandy loam to sandy clay loam (dry colours **le1—Loamy topsoils (A1 Horizons).** almost white), earthy, massive; field pH 5.5 – 7.0. Quartz and lithic sandstone, quartz, and jasper fragments few to abundant (2 – >90%). Hardsetting and highly erodible where exposed.

le3 – Reddish clayey subsoils (B21, B22 Horizons). Red to reddish brown (2.5YR 4/6 – 5YR 4/4) light medium clay to medium silty clay; moderate pedality; peds smooth-faced (dry); dense; sub-angular (10 – 20 mm) to angular blocky (10 – 20 mm); field pH 6.5. Red mottles absent to few (0 – 10%), hardsetting when exposed.

le4 – Greyish clayey subsoils (B21, B22k Horizons). Pale brown (10YR 6/3) medium to medium heavy clay; moderate pedality; peds smooth-faced dry); dense; sub-angular blocky (5 – 20 mm); field pH 8.0 – 9.0. Yellow mottles absent to few (0 – 10%); calcareous segregations common (0 – 20%) and strong fine earth calcium carbonate detectable with HCl field test where pH ≥ 8.5. Not encountered exposed.

le5 – Dark brown weakly structured loam subsoils (B2t Horizons). Dark brown (7.5YR 3/3) loam; weak pedality; peds smooth-faced (dry); sub-angular blocky (2 – 5 mm); porous; field pH 6.0. Conglomerate and quartz coarse fragments common (10 – 20%). Not encountered exposed.

Type Profiles

Type profile 1: Crest	
Soil classification: well drained Basic Lithic Leptic Rudosol, slightly gravelly, loamy, shallow, (Lithosol); few (2-10%) surface gravels; surface condition is loose, expected to be loose when dry	
Depth of observation: 30 cm.	
Location: BAAN BAA 1:50 000 topographic Map - Crest of most southern ridge at Booroomin (Map reference: 785702 E, 6597023 N). Profile 92. Timber/scrub/unused.	
Layer 1, A11, 0 - 0.07 m, le1	dark reddish brown loam with massive structure, earthy; few (2-10%), coarse gravel (20-60 mm), quartz, coarse fragments; common roots; field pH is 6.5; abrupt (5-20 mm) boundary to-
Layer 2, A12, 0.07 - 0.3 m, le1	dark reddish brown loam with massive structure, earthy; many (20-50%), coarse gravel (20-60 mm), quartz, coarse fragments; few roots; field pH is 6.5; directly overlies bedrock

Type profile 2: Upper Slope	
Soil classification: mod. well drained Basic Bleached-Leptic Tenosol, medium, moderately gravelly, loamy, shallow, (Lithosol);	
Depth of observation: 45 cm.	
Location: Therribri 1:25 000 Topographic Map - Road cut Willow Tree Range (Map reference: 228225 E, 6612345 N). Profile 94. Timber/scrub/unused.	
Layer 1, A1, 0 - 0.15 m, le1	dark greyish brown sandy loam with massive structure, earthy; many (20-50%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; common roots; field pH is 7.5; abrupt (5-20 mm) smooth boundary to-
Layer 2, A2, 0.15 - 0.45 m, le2	brown sandy loam with massive structure, earthy; abundant (50-90%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; few roots; field pH is 6; directly overlies bedrock

Type profile 3: Upper Slope	
Soil classification: well drained Basic Lithic Orthic Tenosol, thin, gravelly, sandy, loamy, shallow, 3 (Earthy Sand); few (2-10%) surface gravels; surface condition is loose, expected to be loose when dry	
Depth of observation: 30 cm.	
Location: BAAN BAA 1:50 000 topographic map - upper slope of southern most ridge at Booroomia (Map reference: 785555 E, 6596716 N). Profile 93. Timber/scrub/unused.	
Layer 1, A1, 0 - 0.05 m, le1	dark brown loamy sand with massive structure, earthy; few (2-10%), coarse gravel (20-60 mm), quartz, coarse fragments; common roots; field pH is 6; abrupt (5-20 mm) boundary to-
Layer 2, B2, 0.05 - 0.3 m, le5	dark brown loam with weak pedality (sub-angular blocky, 2-5 mm), smooth-faced peds; common (10-20%), coarse gravel (20-60 mm), quartz, coarse fragments; few roots; field pH is 6; directly overlies bedrock

Type profile 4: Midslope

Soil classification: Eutrophic Haplic Brown Kurosol, thin, gravelly, clay loamy, clayey, moderate, (Brown Podzollic Soil); many (20-50%) surface gravels; surface condition is gravelly, hard set, expected to be hardsetting when dry	
Depth of observation: 45 cm.	
Location: Gulligal 1:25 000 Topographic Map - Vickery SF (Map reference: 235766 E, 6592726 N). Profile 181. Logged Native Forest.	
Layer 1, A1, 0 - 0.1 m, le2	brown sandy clay loam with massive structure, earthy; common (10-20%), as parent material coarse fragments; common roots; field pH is 5.5; clear (20-50 mm) broken boundary to-
Layer 2, B2, 0.1 - 0.45 m, le4	strong brown light clay ; common (10-20%), as parent material coarse fragments; no roots; field pH is 7.5; directly overlies shale bedrock

Type profile 5: Midslope	
Soil classification: imperfectly drained Calcic Subnatric Grey Sodosol, medium, moderately gravelly, clay loamy, clayey, shallow, 3 (Solonetz); very few (< 2%) surface gravels; surface condition is gravelly, loose, expected to be loose when dry	
Depth of observation: 30 cm.	
Location: Baan Baa 1:100 000 Topographic Map. East slope of hill south of Curracabah trig. (Map reference: 786600 E, 6598100 N). Profile 7. Timber/scrub/unused.	
Layer 1, A1, 0 - 0.1 m, le1	dark yellowish brown fine light clay loam with weak pedality (sub-angular blocky, 2-5 mm), smooth-faced peds; few (2-10%), gravel (6-20 mm), as parent material, coarse fragments; few roots; field pH is 7; sharp (<5 mm) boundary to-
Layer 2, B21, 0.1 - 0.18 m, le4	pale brown medium heavy clay with moderate pedality (sub-angular blocky, 10-20 mm), smooth-faced peds; no roots; field pH is 8; gradual (50-100 mm) boundary to-
Layer 3, B22, 0.18 - 0.3 m, le4	pale brown medium clay with moderate pedality (sub-angular blocky, 5-10 mm), smooth-faced peds; common (10% - 20%) calcareous segregations; field pH is 9; layer continues...

QUALITIES AND LIMITATIONS

Erodibility

	Non-concentrated flows	Concentrated flows	Wind
le1	moderate	high	moderate
le2	high	severe	moderate
le3	low	moderate	low
le4	moderate	high	low
le5	moderate	high	low

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
Cropping	High	High	High
Native/improved pasture	Low	Moderate	Low

Soil Conservation Earthworks (Small Farm Dams)

Farm dam construction limited by site availability and shallow soils, however, the Red Chromosol subsoil le4 is generally suitable for dam construction with no special limitations.

Rural Capability and Sustainable Land Management Recommendations
This landscape can be categorised as LMU B, Sedimentary Slopes (URS, 2001) and is limited by low soil fertility, including topsoil acidification and high aluminium toxicity potential. High timber cover levels are recommended with grazing on native or improved pastures. Steeper areas such as lea should be excluded from stock.

Severe limitations for cropping. Moderate – high limitations for grazing.

Urban Capability

Generally low limitations for urban development.

Liverpool Plains Land Management Unit/s

LMU A - Sedimentary Hilltops and steep slopes.
LMU B – Sedimentary Slopes.

Landscape—10.3 km2, undulating broad hillcrests, and plateaux, on Jurassic basalts, and dolerites of the Mullaley Hills, Curlewis Hills and Liverpool Plains. Local relief to 50 m, slopes 1 - 5% (occasionally to 10%), elevation range 260 - 430 m, rock outcrop <20%. Open-woodland and closed-grassland mostly cleared for grazing.

Soils-- Soil types vary with parent material and level of weathering. Very shallow, well drained Leptic Rudosols (Lithosols) occur on some rocky crests with well drained shallow to very deep Red Ferrosols and Dermosols (Euchrozems) dominating the landscape. Deep, moderately well drained Red, Brown, and Black Vertosols (Red and Brown Clays and Black Earths) are occasionally present on broad crests and plateaux.

Limitations-- Groundwater pollution hazard, sheet erosion risk, poor moisture availability, known recharge area, localised rock outcrop, high run-on, shallow soils, localised woody weeds.

LOCATION

Undulating hills generally on plateaux on Jurassic volcanics in the Mullaley and Curlewis Hills, and often occurring as "islands" in the wider Liverpool Plains area, extending on to the adjacent Tambar Springs Curlewis and Baan Baa 1:100 000 Map Sheets (Pengelly, *In Press*; Banks 1995; Pengelly and Townsend, In Press). This landscape was originally described in *Soil Landscapes of the Curlewis 1:100 000 Map Sheet* (Banks, 1995). Type location is at "Collygra" property (Area reference 2 20600E, 65 69500N).

LANDSCAPE

Geology

Jurassic basalts, dolerites, and tuffs of the Garrawilla Volcanics (Geology map Code Jgv), with some tuffaceous lithic sandstone and unconsolidated ash. Quartz rich sandstone cobbles are often present on the soil surface, suggesting that there has been some mixing through tree fall where soils and bedrock are shallow and underlain by sandstones. Bedrock weathering varies from hard weathered rock to deep calcareous saprolite. Some locations appear to have nor remaining fractured basalts. Depth to relatively fresh bedrock varies greatly from 1 – >20 m.

Terrain

Undulating rises and hills with narrow to broad (>300 m) crests, broad to very broad (300 - >1000 m) plateaux, and associated sills. Local relief to 50 m, slopes 1 -5% (occasionally to 10%), rock outcrop <20%, elevation range 260 - 430 m. Drainage is dominated by sheetflow, with some widely spaced (600 – 1000 m), shallow stream channels on plateaux and upper slopes.

Climate and Hydrology

This landscape is characterised by strongly fractured and weathered basaltic substrate, with generally shallow and well aggregated soils. This landscape is an area of high deep drainage through soil profiles into fractured rock aquifers.

Estimated average annual rainfall range 580 – 595 mm.

Vegetation

Open-woodland and closed-grassland communities mostly cleared for agriculture and grazing. Dominant woodland species include *Eucalyptus albens* (white box), *Eucalyptus blakelyi* (blakely's red gum), *Eucalyptus dealbata* (tumbledown gum), *Eucalyptus populnea* (bimble box), *Eucalyptus microcarpa* (western grey box), *Callitris glaucophylla* (white cypress pine), *Acacia pendula* (weeping myall), *Geijera parviflora* (wilga), *Heterodendron oleifolium* (rosewood), *Alphitonia excelsa* (red ash), *Schinus* sp. (pepper tree), *Brachychiton populneus* (kurrajong), *Dodonea viscosa* (sticky hopbush), and

Callitris endlicheri (black cypress pine). Isolated pockets of *Eucalyptus melliodora* (yellow box) also occur, often below rock outcrops.

The dominant ground cover species in grassland areas is *Austrostipa aristiglumis* (plains grass). Common ground cover species which occur in the woodland communities and as minor species in grassland areas include *Panicum* spp. (panics), *Dicanthium sericeum* (Queensland blue grass), *Chloris* spp. (windmill grasses), *Austrostipa verticillata* (slender bamboo grass), *Austrostipa* spp. (spear grasses), *Aristida vagans* (three-awn spear grass), *Austrodanthonia* spp. (wallaby grasses), *Austrostipa setacea* (corkscrew grass), and *Craspedia pleiocephala* (soft billy-buttons).

Land Use

Predominantly native and improved pastures, with occasional isolated hilltops and sills remaining in woodland and open forest vegetation. Cropping has been attempted in some locations on the sheet but was not successful, usually due to soil depth and poor access to landscape.

Existing Land Degradation

Minor to moderate sheet erosion, particularly in heavily stocked areas and moderate gully erosion is also present along some drainage lines.

Landscape Qualities and Limitations

Groundwater pollution hazard, sheet erosion risk, poor moisture availability, known recharge area, localised rock outcrop, run-on, shallow soils, localised woody weeds.

Included Soil Landscapes

Some areas of Mount Milbulla (mm) soil landscape may occur on hilltops and plateaux where they are too small to be mapped at 1:100 000 scale.
SOILS

Variation and Distribution

Unlike the adjacent Baan Baa Sheet (Pengelly, In Press), there is little variation in soil type in this landscape on the Boggabri Sheet. This is because the parent material does not vary greatly over its occurrence. Soil types vary with parent material and level of weathering. Very shallow, well drained Leptic Rudosols (Lithosols) occur on some rocky crests with well drained shallow to very deep Red Ferrosols and Dermosols (Euchrozems) dominating the landscape. Deep, moderately well drained Red, Brown, and Black Vertosols (Red and Brown Clays and Black Earths) are occasionally present on broad crests and plateaux.

Position in landscape	**Soil Type**	**Dominance**
Near rock outcrop and steeper crests	Leptic Rudosols	10%
Remainder of landscape	Red Ferrosols and Dermosols Red, Brown and Black Vertosols	80% <10%

Dominant Soil Materials

Soil materials **ta2** to **ta3** and **ta5** to **ta6** were originally described in (Banks, 1995). **ta7** – **ta9** are described in Pengelly (In Press). Owing to the limited distribution of this landscape on the Boggabri sheet, and the uniformity of the soils within its occurrence , only two materials are relatively prominent.

ta1 – Reddish clay loamy topsoils (A1 Horizons). Dusky red to dark reddish brown (2.5YR 3/2 – 2.5YR 4/4) sandy clay loam to clay loam; moderate to strong pedality; smooth or rough -faced Polyhedral to sub-angular blocky (1 – 50 mm) peds; field pH 6 – 7.0; Hardsetting to self-mulching when exposed (often dependant on local management).

ta4 – Reddish clay subsoils (B21, B21k, B22 Horizons). Dark Red to Red (2.5YR 3/6 – 10R 4/6) medium to heavy clay; strong pedality; with smooth-faced polyhedral, prismatic to angular-blocky peds (10 – 50 mm); field pH 6.0 – 8. Slickensides absent to many (0 – >50%), increasing with depth; basalt and occasional sandstone coarse fragments absent to abundant (0 – >90%).

Type Profiles

Type profile 1: Crest	
Soil classification: rapidly drained Haplic Mesotrophic Red Dermosol, medium, slightly gravelly, clay loamy, clayey, very deep, (Euchrozem); few (2-10%) surface gravels; surface condition is hard set, expected to be hardsetting when dry	
Depth of observation: 100 cm.	
Location: Emerald Hill 1:25 000 topographic map - Oxley Hwy (Map reference: 231084 E, 6568786 N). Profile 188. Timber/scrub/unused.	
Layer 1, A1, 0 - 0.25 m, ta1	reddish brown sandy clay loam with weak pedality (polyhedral), rough-faced peds; few (2-10%), gravel (6-20 mm), as parent material, coarse fragments; no roots; field pH is 6; diffuse (>100 mm) broken boundary to-
Layer 2, B2, 0.25 - 1 m, ta4	red medium clay with strong pedality (polyhedral), rough-faced peds; few (2-10%), fine gravel (2-6 mm), as parent material, coarse fragments; field pH is 6; diffuse (>100 mm) Layer continues…

Type profile 2: Plateaux	
Soil classification: Eutrophic Haplic Red Ferrosol, medium, slightly gravelly, clay loamy, clayey, moderate, (Euchrozem); abundant (50-90%) surface gravels; surface condition is surface crust, expected to be surface crusting when dry	
Depth of observation: 80 cm.	
Location: Emerald Hill 1:25 000 topographic map - Collygra - root ball on ridge (Map reference: 220088 E, 6568895 N). Profile 193. Timber/scrub/unused.	
Layer 1, A1, 0 - 0.1 m, ta1	dusky red clay loam with strong pedality (polyhedral, 2-5 mm), smooth-faced peds; few (2-10%), coarse gravel (20-60 mm), as parent material, coarse fragments; no roots; field pH is 6; gradual (50-100 mm) broken boundary to-
Layer 2, B2, 0.1 - 0.8 m, ta4	dark red heavy clay with strong pedality (angular blocky, 10-20 mm), smooth-faced peds; few (2-10%), coarse gravel (20-60 mm), as parent material, coarse fragments; no roots; field pH is 6; directly overlies basalt bedrock

Erodibility

	Non-concentrated flows	Concentrated flows	Wind
ta1	Moderate	Moderate	Moderate
ta4	Low	Low	Low

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
Cropping	Moderate	Moderate	Low – Moderate
Grazing	Low	Moderate	Low

Soil Conservation Earthworks (Small Farm Dams)

Moderate to high landscape limitations for earthworks with low run-on and localised shallow and stony soils. All soil materials have high to very high limitations for earthworks. Subsoils are generally aggregated and or highly expansive and have low to moderate dispersion. Soil testing should be carried out at individual sites, and care should be taken with construction, usually incorporating a dispersant and ensuring that a sheepsfoot roller is used to obtain optimum compaction.

Rural Capability and Sustainable Land Management Recommendations

Generally low to moderate limitations for grazing. Generally moderate to high limitations for cropping.

Rudosols (Lithosols) and Ferrosols (Euchrozems) on hillcrests and sills are commonly of low fertility, shallow (<50 cm) and erodible, and have up to 30% rock outcrop. It is recommended that these areas remain under native pasture in a rotational grazing system. Ground cover should remain at 70%, with up to 40% tree cover. Regrowth of species such as *Callitris* spp. (cypress pines) on well drained soils should be managed to reduce soil erosion.

Urban Capability

Generally moderate limitations to urban development. Small crests commonly have poor access, shallow soils, and up to 20% rock outcrop. Broad crests and plateaux have a high shrink-swell capacity, and bedrock within 1 m of the surface. Installation of drainage and septic works should consider the high groundwater pollution hazard in this landscape.

Liverpool Plains Land Management Unit/s

LMU H – Basalt Slopes.

to Top Rock **Transferral**

Landscape—67.1 **km2**, Broad, long (1000 – 1500m) gently inclined footslopes on colluvium derived from Permian sandstones and conglomerates of the Curlewis Hills. Local relief 30 – 70 m; slopes 2 – 8%; elevation range 250 – 280m. 95% cleared for native and improved pasture grazing.

Soils- This landscape is relatively simple and dominated by hard duplex soils with highly variable gravel content and degrees of sodicity. Upper slopes are generally dominated by moderately well drained very deep Red Sodosols and some Bleached Red Chromosols (Red-brown Earths), whilst mid to lower footslopes are dominated by imperfectly to poorly drained deep to very deep Brown Sodosols (Solodic Soils).

Qualities and Limitations--Localised dieback, localised poor drainage, localised engineering hazard, gully erosion risk, sheet erosion risk, known discharge area, known recharge area, high run-on, dryland salinity, seepage scalds, wind erosion risk (under cultivation), woody weeds (*Callitris spp. (cypress pines)* regrowth potential).

LOCATION AND SIGNIFICANCE

Footslopes and alluvial fans on colluvium derived from Permian sandstones and conglomerates of the Curlewis Hills, extending onto the Baan Baa 1:100 000 Map Sheet. Type location is at Broadwater Reserve near the Vickery Mine Site (Grid Reference 2 26500E, 65 92 600N).

LANDSCAPE

Geology and Regolith

Fans and footslopes of colluvium derived from Permian quartz sandstones and conglomerates of the Black Jack Group and Maules Creek Formation. Soil depths range from 1.4 m to greater than 2.5 m, with highly weathered sediments encountered below this.. In some areas, the sandstone bedrock has very low pH and high salinity levels.

Terrain

Long (1000 – 1500m), broad, very gently to moderately inclined footslopes and alluvial fans of colluvium derived from Permian sediments of the Curlewis Hills, with slopes varying from 2 – 8%, occasionally up to 10%. Elevation ranges from 250 – 450 m; local relief 30 – 70 m.

Drainage is predominantly by sheetflow, with some closely to widely spaced (250 – 1000m), divergent to unidirectional shallow stream channels, although on lower footslopes drainage becomes similar to that of Sheet Flood Fans, with numerous, shallow, rapidly migrating, integrated to interrupted stream flow.

Climate and Hydrology

The Permian sandstones underlie much of the Triassic sedimentary material in the Liverpool Plains, and together form an important fractured rock aquifer system that is hydraulically connected to the deep Gunnedah Formation aquifers on the alluvial plains (Broughton, 1994). Estimated average annual rainfall range is 575 – 650 mm.

Vegetation

Open and closed woodland communities, 90% being cleared for grazing. Dominant tree species include *Eucalyptus albens* (white box), *Eucalyptus populnea* (bimble box), *Eucalyptus pilligaensis* (pilliga grey box), *Eucalyptus dealbata* (tumbledown/ hill red gum), *Allocasuarina distyla* (scrub she-oak), *Ehretia membranifolia* (peach bush), *Geijera parviflora* (wilga), *Alectryon oleifolius* (rosewood), *Callitris glaucophylla* (white cypress pine), and *Callitris endlicheri* (black cypress pine).

Groundcover species include *Bothriochloa macra* (red grass), *Austrostipa verticillata* (slender bamboo grass), *Chloris truncata* (windmill grass), *Aristida vagans* (three-awned spear grass), and *Austrostipa setacea* (corkscrew grass).

Land Use

The majority of the landscape is utilised for native and improved pasture grazing. Winter cereal cropping was the dominant land use since the early 1900's due to the lightly textured topsoils, with native pasture grazing before this. Cropping is still practiced in some areas, although is limited by poor fertility and structure.

Land Degradation

Areas with current or previously inadequate groundcover exhibit moderate to severe fertility and structural decline, as well as moderate to severe sheet, rill, wind and gully erosion. The entire surface horizon has been removed in some areas. Salinisation of dams is evident in association with saline bedrock. Saline discharge areas often occur at junctions with plains and the lower Brentry (**by**) Soil Landscape .

Landscape Qualities and Limitations

Localised dieback, localised poor drainage, localised engineering hazard, gully erosion risk, sheet erosion risk, known discharge area, known recharge area, high run-on, dryland salinity, seepage scalds, wind erosion risk (under cultivation), woody weeds (*Callitris spp. (cypress pines)* regrowth potential).

Included Soil Landscape

Small areas of Blue Vale **(bv)** soil landscape which occur on upper footslopes and fans (Brentry (br) soil landscape) have been included where they are too small to map accurately at 1:25 000 scale.

SOILS

Variation and Distribution

This landscape is relatively simple and dominated by hard duplex soils with highly variable gravel content and degrees of sodicity. Upper slopes are generally dominated by moderately well drained very deep Red Sodosols and some Bleached Red Chromosols (Red-brown Earths), whilst mid to lower footslopes are dominated by imperfectly to poorly drained deep to very deep Brown Sodosols (Solodic Soils).

Position in landscape	**Soil Type**	**Dominance**
Upper footslope	Red Sodosols/Chromosols	40%
Mid-Lower footslope	Brown Sodosols	60%

Dominant Soil Materials

Soil materials **to5**, **to6** and **to7** are described in detail in *Soil Landscapes of the Baan Baa 1:100 000 Sheet* (Pengelly, *in press*).

to1 – Dark silty loam and clay loam topsoils **(A1 Horizons).** Very dark grey to dark greyish brown (10YR 3/1 – 4/2) clay loam, sandy top sandy clay loam; massive; earthy (dry); porous; field pH 6.0 – 7.0. Surface hardsetting, can be gravelly in some areas.

to2—Bleached near surface layers (A2e Horizons). Brown (7.5YR 4/3 – 10 YR 4/3) sandy clay loam to light clay (dry colours almost white); earthy, massive; field pH 6.0 – 7.0; gravels absent to abundant (0 - >90%). Hardsetting when exposed.

to3—Reddish clayey topsoils (A1 Horizons). Dark reddish brown (5YR 3/6) medium to heavy clay; strong pedality with smooth-faced angular-blocky (20 – 50 mm) peds; field pH6.0 – 7.0; Surface hardsetting, can be gravelly in some areas.

to4 –Yellowish brown mottled clay subsoils with segregations (B22k, B23k, B23y, Ck Horizons). Dark brown to pale brown (7.5YR 3/2 - 10YR 6/3) light to heavy clay, occasionally with fine sand; moderate to strong pedality, with smooth-faced angular blocky (10 – 50 mm) to prismatic (20 – 50 mm) peds; field pH 7.5 – 9.0. Slickensides absent to common (0 – 50%), increasing with depth; with very few to few (<2 – 10%) dark, orange and red mottle; calcareous segregations very few to common (<2 – 20%); occasional gypseous crystals at depth; absent to strong fine calcium carbonate evident with HCl at depth; absent to conspicuous salt evident with silver nitrate field test; lithic and quartz sandstone, jasper and ironstone gravel fragments absent to few (0 – 10%). Not encountered exposed.

TYPE PROFILES

Type profile 1: Upper footslope	
Soil classification: mod. well drained Subnatric Eutrophic Red Sodosol, thick, moderately gravelly, clay loamy, clayey, very deep, (Red-brown Earth); many (20-50%) surface gravels; surface condition is gravelly, hard set, expected to be hardsetting when dry	
Depth of observation: 160 cm.	
Location: Boggabri 1:25 000 Topographic Map - new road cutting. Whitehaven Mine (Map reference: 230680 E, 6595615 N). Profile 79. Voluntary/native Pasture.	
Layer 1, , 0 - 0.3 m, to1	dark brown clay loam sandy with massive structure, earthy; many (20-50%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; common roots; field pH is 6.5; clear (20-50 mm) smooth boundary to-
Layer 2, A2, 0.3 - 0.6 m, to2	brown sandy clay loam with massive structure, earthy; many (20-50%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; common roots; field pH is 7; clear (20-50 mm) smooth boundary to-
Layer 3, B2, 0.6 - 1.1 m, to3	dark reddish brown heavy clay with strong pedality (angular blocky, 20-50 mm), smooth-faced peds; many (20-50%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; no roots; field pH is 7; gradual (50-100 mm) smooth boundary to-
Layer 4, B22, 1.1 - 1.6 m, to4	strong brown medium heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; many (20-50%), gravel (6-20 mm),coarse gravel (20-60 mm),cobbles (60-200 mm), as parent material, coarse fragments; very few (< 2%) manganiferous segregations; no roots; field pH is 7; AgNO3 result is light precipitate; gradual (50-100 mm); Soil continues…

****

Type profile 2: Mid footslope	
Soil classification: Hypernatric Eutrophic Brown Sodosol, medium, non gravelly, clay loamy, clayey, very deep, (Solodic Soil); few (2-10%) surface gravels; surface condition is hard set, expected to be hardsetting when dry	
Depth of observation: 200 cm.	
Location: Gulligal 1:25 000 Topographic Map – Gully on Broadwater Reserve (Map reference: 227188 E, 6592588 N). Profile 225. Voluntary/native Pasture.	
Layer 1, A1, 0 - 0.1 m, to1	dark greyish brown sandy clay loam with massive structure, earthy; very few (< 2%), gravel (6-20 mm), as parent material, coarse fragments; many roots; field pH is 6.5; clear (20-50 mm) boundary to-
Layer 2, A2, 0.1 - 0.25 m, to2	brown light clay with massive structure, earthy; very few (< 2%), gravel (6-20 mm), as parent material, coarse fragments; common roots; field pH is 7; abrupt (5-20 mm) boundary to-
Layer 3, B2, 0.25 - 0.68 m, to4	strong brown light medium clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; very few (< 2%), gravel (6-20 mm), as parent material, coarse fragments; no roots; field pH is 8.5; diffuse (>100 mm) boundary to-

Layer 4, 2B2, 0.68 - 2 m, to4	dark brown medium clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; many (20-50%), gravel (6-20 mm), as parent material, coarse fragments; few (2% - 10%) calcareous segregations; no roots; field pH is 8.5; AgNO3 result is light precipitate; soil continues

Type profile 3	
Soil classification: poorly drained Mesonatric Vertic Effervescent Brown Sodosol, medium, non gravelly, silty, clayey, giant, 2 (Solodic Soil);	
Depth of observation: 120 cm.	
Location: Gulligal 1:25 000 Topographic Map - slope plain junction "Emerald Plains" (Map reference: 222830 E, 6582722 N). Profile 48. Improved Pasture.	
Layer 1, A, 0 - 0.15 m, to2	no colour recorded, light sandy clay with massive structure, earthy; field pH is 7; clear (20-50 mm) boundary to-
Layer 2, B2, 0.15 - 0.75 m, to4	brown heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; ; few (2% - 10%) calcareous segregations; field pH is 9; AgNO3 result is conspicuous white precipitate; gradual (50-100 mm) smooth boundary to...
Layer 3, B22, 0.75 - 1.2 m, to4	strong brown heavy clay with strong pedality (prismatic, 50-100 mm), smooth-faced peds; ; common (10% - 20%) calcareous segregations; field pH is 9; AgNO3 result is conspicuous white precipitate; gradual (50-100 mm); Soil continues…

Notes on Soil Test Results

QUALITIES AND LIMITATIONS

Erodibility

	Non-concentrated flows	Concentrated flows	Wind
to1	moderate	high	moderate
to2	high	severe	moderate
to3	moderate	high	low
to4	moderate	high	low

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
Cropping	Moderate- High	High	High
Grazing	Low-Moderate	Moderate	Low

Soil Conservation Earthworks (Small Farm Dams)
Subsoil materials in this landscape are highly variable in character and range within a soil material from having low to high limitations for construction of earthworks. Individual site testing is recommended before commencing construction.
Rural Capability and Sustainable Land Management Recommendations

Soils should be managed under permanent improved or native pasture due to their high erodibility and low to moderate fertility. Contour banks should be incorporated, even on very gently inclined slopes. Ground cover should remain above 70% throughout the year, with 25% tree cover in stands or shelter belts.

Short grazing and long rest periods should be used to encourage an increase in soil organic matter levels where topsoil is absent.

Regrowth of species such as *Callitris* spp. (cypress pines) should be managed to reduce soil erosion and improve pasture production.

Generally low to moderate limitations for grazing. Generally high limitations for cropping.
Urban Capability
Low limitations for urban development. Salinity hazard and soil erosivity should be considered before construction.

Liverpool Plains Land Management Unit/s

LMU C – Sedimentary Footslopes.

Landscape—74.4 km^2; Very gently inclined to moderately inclined long footslopes of hills on Permian-Carboniferous rhyolites, rhyolite tuffs, andesite and rhyodacite of the Boggabri Volcanics in the Boggabri and Curlewis Hills. Local relief to 60 m, slope range 1 – 8%, elevation 240 – 330 m. Mostly cleared open-woodland with a grass or shrub understorey or grassland.

Soils— Slopes derived from more course grained parent materials dominated by moderately well drained to imperfectly drained deep to very deep Brown Sodosols (Solodic Soils and Solodized Solonetz). Slopes which contain a mixture of clayey and coarse grained parent materials generally have some component of poorly drained very deep to giant Brown Vertosols (Brown Clays) with some Grey Vertosols (Grey Clays). Slopes dominated by clayey materials tend to be dominated by moderately well drained deep to giant Black Vertosols (Black Earths). Poorly drained deep to giant Grey Vertosols (Grey Clays) frequently occur at the terminal end of the landscape.

Qualities and Limitations— Complex soils distributions, localised tree dieback, poor drainage on duplex soils, high engineering hazard (Vertosols), low fertility (duplex soils), localised flood hazard, high gully erosion risk, sheet erosion risk, poor moisture availability on duplex soils, saline discharge area, recharge area, high run-on, dryland salinity, irrigated salinity, localised seasonal waterlogging, and localised seepage scalds.

LOCATION AND SIGNIFICANCE

Very gently inclined to moderately inclined long footslopes of hills on Permian-Carboniferous rhyolites, rhyolite tuffs and rhyodacite of the Boggabri Volcanics in the Boggabri and Curlewis Hills. Type location is at “Riverway” north of Boggabri (Grid Reference 2 17 000, 66 15000N).

LANDSCAPE

Geology and Regolith

Alluvium and colluvium from both acid and intermediate volcanic of the Boggabri Volcanics (geological map code Pbr). This landscape is defined by a mixture of both heavy clay alluvia from andesites and dacites, and the more light texture alluvia from rhyolitic material. Depth to unweathered rock was not determined for this landscape although some bores in the district penetrate more than 20 m in clay alluvium without encountering rock.

Terrain

Elevation range 240 – 330 m.

Climate and Hydrology

Estimated annual rainfall range 575 – 625 mm
Vegetation

As this landscape is characterised by two virtually opposite soil types in terms of fertility, there are quite marked differences between the dominant woodland and grassland species present.

Woodlands species on duplex soils include *Callitris glaucophylla* (white cypress pine), *Allocasuarina leuhmannii* (bull oak), *Eucalyptus melliodora* (yellow box), *E. albens* (white box), *E. pilligaensis* (pilliga box), *E. populnea* (bimble box), *Geijera parviflora* (wilga), *Notelaea microcarpa* (native olive), *Beyeria viscosa* (sticky wallaby-bush), *Carissa ovata* (currant bush) and *Cassine australis* (red olive plum). Groundcover species include *Austrostipa verticillata* (slender bamboo grass), *Dicanthium sericeum* (Queensland bluegrass), *Cymbopogon refractus* (barbed wire grass) and *Aristida ramosa* (wire grass).

Heavy soils tend to be dominated by *Casuarina cristata* (belah), *Eucalyptus microcarpa* (western grey box), *Alectryon oleifolius* (rosewood), *Eremophila mitchellii* (budda), *Acacia pendula* (myall), and *Geijera parviflora* (wilga) separated by grasslands. Grassland species include *Dicanthium sericeum* (Queensland bluegrass), *Austrostipa aristiglumis* (plains grass), *Aristida leptopoda* (white wiregrass), *Oxalis perennans* (sorrel), *Chloris truncata* (windmill grass) and *Sclerolaena muricata* (copper burr).

Land Use

Due to the large difference in the two main soil groups of this landscape, it is split between grazing on lighter soils and cropping on heavier soils

Land Degradation

Historical and some current sheet, rill and gully erosion are evident throughout this landscape. Saline outbreaks are common at slope breaks, and soil structure decline is common in cropping areas.

Landscape Qualities and Limitations

Complex soils distributions, localised tree dieback, poor drainage on duplex soils, high engineering hazard (Vertosols), low fertility (duplex soils), localised flood hazard, high gully erosion risk, sheet erosion risk, poor moisture availability on duplex soils, saline discharge area, recharge area, high run-on, dryland salinity, irrigated salinity, localised seasonal waterlogging, and localised seepage scalds,

SOILS

Variation and Distribution

Soil distribution is highly complex and related to colluvial and alluvial processes as well as proximity to differing parent materials. Some locations have similar soil types from top to bottom of an individual footslope, whereas others have a complex and highly variable Mosaic of duplex soils and Vertosols.

Slopes predominantly derived from more acid and course grained parent materials are dominated by moderately well drained to imperfectly drained deep to very deep Brown Sodosols (Solodic Soils and Solodized Solonetz). Slopes which contain a mixture of clayey and coarse grained parent materials generally have some component of poorly drained very deep to giant Brown Vertosols (Brown Clays) with some Grey Vertosols (Grey Clays). Slopes dominated by clayey materials tend to be dominated by moderately well drained deep to giant Black Vertosols (Black Earths). Poorly drained deep to giant Grey Vertosols (Grey Clays) frequently occurring at the terminal end of the landscape.

Position in landscape	**Soil Type**	**Dominance**
Footslopes on coarse parent materials	Brown Sodosols	35%
Footslopes with mixed parent materials	Brown Vertosols	15%
Footslopes on Clayey parent materials	Black Vertosols	40%
Terminal end of footslopes	Grey Vertosols	10%

Dominant Soil Materials

ve1—Hardsetting brown sandy loam (A1 horizons). Dark yellowish brown to brown (10YR 3 /4 - 4/3) sandy loam,; earthy, massive; field pH 5.5 – 6.0, surface is hardsetting.

ve2—Dark clay loamy topsoils (A1 Horizons). Very dark grey to dark greyish brown (10YR 3/1 - 3/2) silty clay loam to clay loam, sandy; earthy, massive; field pH 6.0 – 7.0; surface is hardsetting.

ve3—Dark cracking clay topsoils (A1, Ap horizons). Black (5YR 3/2) to very dark grey (10YR 3/2) medium to heavy clay; strong pedality with smooth faced polyhedral (2- 10 mm) , occasionally angular blocky (10 – 20 mm) peds; field pH 5.5 – 8.5; occasional presence of lime where pH> 8.0. Surface is seasonally cracking to self-mulching and cracking.

ve4—Grey clay topsoils (A1, Ap horizons). Dark grey to brown (10YR 4/1 – 7.5YR 4/2) light to medium clay; strong pedality with smooth faced polyhedral to angular blocky (2 – 10 mm) peds; field pH 6.0 – 7.0; surface is seasonal cracking and often self-mulching.

ve5—Bleached silty horizons (A2e horizons). Light brown to light grey (10YR 6/2 – 7/2) sandy loam to silty loam; earthy, massive; field pH 5.5 – 6.5; manganiferous nodules found in some locations, hardsetting and highly erodible when exposed.

ve6—Grey clay subsoils (B horizons). Dark greyish brown to dark grey (2.5Y4/1, 10YR 4/1) to dark greyish brown (10 YR 4/2) sandy clay to heavy clay; strong pedality with smooth-faced prismatic to lenticular (20 – 200 mm) peds; slickenside coatings often present; field pH range 6.0 – 9.0 (increasing generally with depth); lime segregations occur where pH> 8.0; chloride salts occur in some locations as indicated by silver nitrate field tests.

ve7—Darker brown clay subsoils (B Horizons). Dark brown to brown, occasionally reddish brown 7.5YR 3/3 – 10YR 4/4, 5YR 4/3) medium to heavy clay; strong pedality with smooth faced prismatic to lenticular (20 – 50 mm) peds, slickenside coatings generally present; field pH 6.5 – 9.5; soft lime segregations present where pH> 8.0; chloride salts are very common as indicated by silver nitrate field tests.

ve8—Black clay subsoils (B horizons). Black to very dark grey (5YR 2.5/1 – 7.5YR 3/1) medium to heavy clay; strong pedality with prismatic, occasionally columnar peds, slickenside ped coatings generally present; field pH 6.0 – 9.0 (generally increasing with depth), lime segregations occur where pH> 8.0; chloride salts occur in some locations as indicated by silver nitrate field tests.

ve9—Light brown to yellowish clay subsoils (B horizons). Brown to light yellow 10YR 5/4 – 2.5Y 6/3) medium to heavy clay; strong pedality with prismatic (20 – 100 mm) peds, slickenside peds coatings occasionally present; field pH 6.0 – 9.5; lime segregations occur where pH> 8.0; chloride salts occur in some locations as indicated by silver nitrate field tests.

Type Profiles

Type profile 1: mid footslope	
Soil classification: Brown Sodosol, medium, non gravelly, loamy, clayey, deep, (Solodic Soil);	
Depth of observation: 130 cm.	
Location: Boggabri 1:25 000 topographic map - "Kilmarnock" mid footslope (Map reference: 221321 E, 6598237 N). Profile 202. Voluntary native Pasture.	
Layer 1, , 0 - 0.2 m, ve1	dark yellowish brown sandy loam with massive structure, earthy; common roots; field pH is 6; clear (20-50 mm) boundary to...
Layer 2, A2, 0 - 0.6 m, ve5	light grey sandy loam with massive structure, earthy; few (2% - 10%) manganiferous segregations; few roots; field pH is 6; clear (20-50 mm) boundary to...
Layer 3, B2, 0.6 - 1.3 m, ve9	dark yellowish brown medium clay with moderate pedality (prismatic, 20-50 mm), smooth-faced peds; field pH is 9; soil continues...

Type profile 2: Lower footslope
Soil classification: Brown Sodosol, medium, gravelly, clay loamy, clayey, very deep, (Solodic Soil); common (10-20%) surface gravels; surface condition is hard set, expected to be hardsetting when dry
Depth of observation: 130 cm.
Location: Therribri 1:25 000 topographic map - nr gate to "Velyama" (Map reference: 217766 E, 6611138 N). Profile 293. Voluntary native Pasture.

Layer 1, A1, 0 - 0.11 m, ve2	very dark grey whole-coloured silty clay loam with massive structure, earthy; common (10-20%), fine gravel (2-6 mm),gravel (6-20 mm),coarse gravel (20-60 mm), as parent material, coarse fragments; common roots; field pH is 6; abrupt (5-20 mm) boundary to...
Layer 2, A2, 0 - 0.19 m, ve5	light brownish grey whole-coloured silty loam with massive structure, earthy; common (10-20%), fine gravel (2-6 mm),gravel (6-20 mm),coarse gravel (20-60 mm), as parent material, coarse fragments; few roots; field pH is 6; abrupt (5-20 mm) boundary to...
Layer 3, B1, 0.19 - 0.5 m, ve9	brown whole-coloured medium clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; no roots; field pH is 8; AgNO3 result is light precipitate; clear (20-50 mm) boundary to...
Layer 4, B2, 0.5 - 1 m, ve7	brown whole-coloured medium heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; very few (< 2%) calcareous segregations; field pH is 8.5; AgNO3 result is conspicuous white precipitate; gradual (50-100 mm) boundary to...
Layer 5, BC, 1 - 1.3 m, ve9	yellowish brown medium clay with weak pedality (prismatic, 20-50 mm), smooth-faced peds; common (10-20%), fine gravel (2-6 mm),gravel (6-20 mm),coarse gravel (20-60 mm), as parent material, coarse fragments; very few (< 2%) calcareous segregations; field pH is 9.5; AgNO3 result is light precipitate; soil continues...

Type profile 3: Lower footslope	
Soil classification: poorly drained Gypsic Self-Mulching Brown Vertosol (Brown Clay);	
Location: Boggabri "Kilmarnock" L. Footslope (Map reference: 221150 E, 6598175 N). Profile 134. Voluntary native Pasture.	
Layer 1, A1, 0 - 0.2 m, ve3	very dark greyish brown heavy clay with strong pedality (polyhedral, 2-5 mm), smooth-faced peds; few roots; field pH is 6; diffuse (>100 mm) boundary to...
Layer 2, B2, 0 - 0.8 m, ve7	brown heavy clay with strong pedality (lenticular, 20-50 mm), smooth-faced peds; no roots; field pH is 9.5; AgNO3 result is light precipitate; diffuse (>100 mm) boundary to...
Layer 3, B22, 0 - 1.3 m, ve7	dark yellowish brown heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; very few (< 2%) calcareous segregations; field pH is 9; AgNO3 result is conspicuous white precipitate; soil continues...

Type profile 4: Lower footslope	
Soil classification: mod. well drained Epicalcareous Self-Mulching Black Vertosol (Black Earth);	
Depth of observation: 120 cm.	
Location: Therribri 1:25 000 topographic map - Lower footslope "Riverway" (Map reference: 216766 E, 6614575 N). Profile 278. Cropping.	
Layer 1, A1, 0 - 0.1 m, ve3	dark reddish brown heavy clay with strong pedality (polyhedral, 2-5 mm), smooth-faced peds; very few (< 2%) calcareous segregations; no roots; field pH is 8.5; gradual (50-100 mm) boundary to...

Layer 2, B2, 0 - 0.8 m, ve8	dark reddish brown heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; very few (< 2%) calcareous segregations; no roots; field pH is 9; AgNO3 result is light precipitate; gradual (50-100 mm) boundary to...
Layer 3, 2B2, 0 - 1.2 m, ve7	reddish brown heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; few (2% - 10%) calcareous segregations; field pH is 9; AgNO3 result is conspicuous white precipitate; soil continues...

Type profile 5: Lower footslope	
Soil classification: poorly drained Endocalcareous Epipedal Grey Vertosol (Grey Clay);	
Depth of observation: 130 cm.	
Location: Therribri 1:25 000 topographic map - 500m NNE "Velyama" gate (Map reference: 217928 E, 6611460 N). Profile 279. Voluntary native Pasture.	
Layer 1, A1, 0 - 0.08 m, ve4	dark grey medium clay with moderate pedality (angular blocky, 5-10 mm), smooth-faced peds; common roots; field pH is 6; clear (20-50 mm) boundary to...
Layer 2, B2, 0 - 0.5 m, ve6	dark grey heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; very few (< 2%) calcareous segregations; few roots; field pH is 8.5; diffuse (>100 mm) boundary to...
Layer 3, B22, 0 - 1.3 m, ve9	yellowish brown heavy clay with strong pedality (prismatic, 20-50 mm), smooth-faced peds; few (2% - 10%) calcareous segregations; field pH is 9; AgNO3 result is light precipitate; soil continues...

Associated Soil Materials

QUALITIES AND LIMITATIONS

Erodibility

	Non-concentrated flows	Concentrated flows	Wind
ve1	moderate	high	moderate
ve2	moderate	high	low
ve3	moderate	high	low
ve4	high	severe	low
ve5	severe	severe	moderate
ve6	high	severe	low
ve7	moderate	high	low
ve8	moderate	high	low
ve9	moderate	high	low

Erosion Hazard

	Non-concentrated flows	Concentrated flows	Wind
Cropping	Low – Moderate	Moderate - High	Low - moderate
Pasture	Low	Low - Moderate	Low

Rural Capability and Sustainable Land Management Recommendations
Low to moderate limitations for grazing. Low to high limitations for cropping due to the extremes of soil type in the landscape with low limitations on the Vertosols (cracking clays) and high limitations on the other lighter soils.
Urban Capability

Low to moderate limitations for urban development. Areas with Vertosols have very high foundation hazard. Salt loads are high in this landscape and septic or drainage placements should be located so as not to exacerbate any potential salinity problems.

Liverpool Plains Land Management Unit/s

LMU C – Sedimentary Footslopes

LMU G – Colluvial Basalt Footslopes.

12.1 km^2, Occurs in other landscapes and is mapped as xx. The topography generally varies from level to undulating plains to undulating low hills and hills, and has been disturbed by human activity to a depth of at least 100 cm. The original soil has been removed, greatly disturbed or buried. Land fill includes soil, rock, building and waste material. Original vegetation has been largely cleared, although many areas of disturbed terrain are sites of extensive regrowth across the Boggabri sheet.

Limitations are dependent on nature of fill material and include subsidence resulting in a mass movement hazard (subsidence), groundwater pollution hazard soil impermeability leading to poor drainage, low fertility and toxic materials. Care must be taken when these sites are developed. A survey at a suitable scale as well as geotechnical analyses should be undertaken because of variability of materials throughout the sites. Advice from local councils and the NSW Department of Mineral Resources should be sought concerning localised areas of disturbed terrain.

Landscape Variant—xxv—extensive area of the former Vickery Open Cut Mine. Land has been re-shaped and rehabilitated and has generally a higher capability than other types of disturbed terrain on the map. Open cut mining in this part of the Boggabri is ongoing and this map may not accurately depict disturbed mining areas shortly after publication.

LOCATION

Large areas of disturbed terrain are found at the mostly rehabilitated Vickery Mine Site, and the current Gunnedah Shire landfill. Small areas of disturbed terrain occur across the Boggabri sheet and are generally in the form of small rubbish pits near Gunnedah and Boggabri, with smaller small road base quarries, gravel quarries and landfills found across the sheet.

Geology

Underlying geology of the larger Disturbed sites on the Boggabri sheet generally sandstone or other sedimentary rocks, which behave as fractured rock aquifers. Landfills in these situations need to consider drainage through the landfill mass as a serious potential source of groundwater contamination.

Land Use

Little rehabilitation work has been undertaken with many small gravel pits in the area, although their effect is mostly very localised, providing stock watering points in the disused pits.

Filled in rubbish pits such as at Emerald Hill seem to eventually be colonised by local species after a period of weed invasion. Native species diversity on these sites is always depauperate compared with undisturbed conditions.

Larger gravel quarries are frequently left bare of cover, but local councils have been trying to contain sediment on site with appropriate banking and dam structures.

The larger, rehabilitated open-cut mine sites have been re-filled and topsoiled and an attempt has been made to restore these sites to their former land capabilities.

Existing Land Degradation

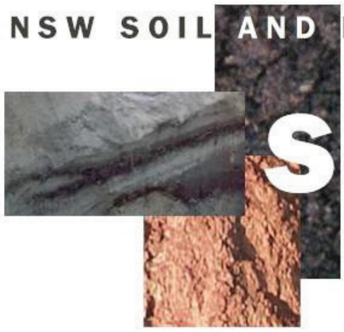
Most of the larger disturbed terrain areas on the Boggabri sheet are relatively stable or have erosion control structures in place and vary in on site degree of land degradation. Groundwater monitoring is taking place around the Gunnedah Council Landfill to ensure that groundwater contamination is minimised.

Landscape Variant—xxv—extensive area of the former Vickery Open Cut Mine. Land has been re-shaped and rehabilitated and has generally a higher capability than other types of disturbed terrain on the map.

LIMITATIONS TO DEVELOPMENT

Limitations for development are extremely variable and intensive soil and geotechnical advice should be sought when considering development of these areas particularly in the case of old rubbish pit sites.

Appendix 7.2 Soil Profile Descriptions from SALIS.



NSW SOIL AND LAND INFORMATION SYSTEM

Soil Profile Report

Site location

EM HIll - Collygra Plain - "Merralong"

Profile details

Soil Landscapes of the Boggabri 1:100 000 Sheet (1000935), Profile 43, recorded by Robert Banks on 14 Sep 1999

Map reference

AMG grid reference 218890E, 6573395N, AMG Zone 56; MGA grid reference 218994E, 6573584N, MGA Zone 56; GDA Latitude -30.93778, GDA Longitude 150.05901; Boggabri (8936) 1:100,000 map sheet

Terrain

alluvial flat; part of plain; local relief is extremely low (< 9m), slope is 0% (measured), elevation is 280 m

Geology

alluvium substrate (Qa) and parent material

Vegetation

vegetation community is woodland grass u'storey, species recorded include Austrostipa aristiglumis (plains grass)

Hydrology

profile is mod. well drained, run-on is low, runoff is low

Land use

occasional cultivation, used for volun./native pasture, with volun./native pasture,improved pasture in general area

Erosion

slight erosion hazard, minor stable sheet erosion

Site condition

cracked when described, expected to be seasonal cracking when dry, ground cover is 100%

Soil type

Epicalcareous Epipedal Red Vertosol, non gravelly, very fine, very fine, giant, all required data available (ASC)

Profile Notes

Plains grass patch with some other tussocks.

Profile Addendum

none recorded

Soil description

<u>Surface</u>

no coarse fragments recorded

Layer 1, A1 horizon, 0 - 0.15 m

dark reddish brown (5YR 3/3) light clay with strong pedality (polyhedral, 5 - 10 mm), smooth-faced peds; coarse fragments not recorded; field pH is 6.5; AgNO3 result is no precipitate; no layer notes recorded; gradual (50-100 mm) smooth boundary to...

Soil sample information

Sample code WEL/03/9/44(1), 0 - 0.15 m

Volume expansion	14%	Linear shrinkage	n.t.
PSA Clay	27%	PSA Clay (mech. disp.)	n.t.
PSA Silt	19%	PSA Silt (mech. disp.)	n.t.
PSA Fine sand	45%	PSA fine sand (mech. disp.)	n.t.
PSA Coarse sand	8%	PSA C. sand (mech. disp.)	n.t.
PSA Gravel	1%	PSA Gravel (mech. disp.)	n.t.
Dispersion Percentage	18%	USCS	n.t.
Emerson Aggregate Test	3(2)	Non wind erodible %	21%
Permanent wilt point	10.3%	Field capacity	35.8%
Field water repellence	1	pH 1:5 soil:water	6.3
pH 1:5 soil:CaCl2 dS/m	5.5	EC	0.09
CEC meq/100g	13.3 meq/100g	Exchangeable Al	0
Exchangeable Ca meq/100g	6.3 meq/100g	Exchangeable K	1.7
Exchangeable Mg meq/100g	3.9 meq/100g	Exchangeable Na	0.2
ESP	1.5%	Organic Carbon	n.t.
Available P	8 mg/kg	Available P (Lactate)	n.t.
P sorption	240 mg/kg	Extractable Fe	n.t.

Layer 2, B2 horizon, 0.15 - 0.75 m

reddish brown (dull reddish brown) (5YR 4/4) medium heavy clay with strong pedality (prismatic, 50 - 100 mm), smooth-faced peds; coarse fragments not recorded; field pH is 8.5; AgNO3 result is no precipitate; no layer notes recorded; diffuse (>100 mm) smooth boundary to...

Soil sample information

Sample code WEL/03/9/45(1), 0.15 - 0.75 m

Volume expansion	34%	Linear shrinkage	n.t.
PSA Clay	58%	PSA Clay (mech. disp.)	3%
PSA Silt	14%	PSA Silt (mech. disp.)	39%
PSA Fine sand	21%	PSA fine sand (mech. disp.)	50%
PSA Coarse sand	7%	PSA C. sand (mech. disp.)	8%
PSA Gravel	0%	PSA Gravel (mech. disp.)	0%
Dispersion Percentage	10%	USCS	n.t.
Emerson Aggregate Test	5	Non wind erodible %	18%
Permanent wilt point	18.3%	Field capacity	44.1%
Field water repellence	0	pH 1:5 soil:water	7.5
pH 1:5 soil:CaCl2 dS/m	7.0	EC	0.10
CEC	24.3 meq/100g	Exchangeable Al	0

meq/100g

Exchangeable Ca meq/100g	10.7 meq/100g	Exchangeable K	0.9
Exchangeable Mg meq/100g	9.5 meq/100g	Exchangeable Na	0.2
ESP	0.8%	Organic Carbon	n.t.
Available P	1 mg/kg	Available P (Lactate)	1 mg/kg
P sorption	432 mg/kg	Extractable Fe	n.t.

<u>Layer 3, B22 horizon, 0.75 - 1.45 m</u>

yellowish red (reddish brown) (5YR 4/6) heavy clay with strong pedality (prismatic, 50 - 100 mm), smooth-faced peds; very few (< 2%) manganiferous ; coarse fragments not recorded; field pH is 9; AgNO3 result is light precipitate; no layer notes recorded; diffuse (>100 mm) smooth boundary to...

Soil sample information

Sample code WEL/03/9/46(1), 0.75 - 1.45 m

Volume expansion	31%	Linear shrinkage	n.t.
PSA Clay	51%	PSA Clay (mech. disp.)	n.t.
PSA Silt	11%	PSA Silt (mech. disp.)	n.t.
PSA Fine sand	22%	PSA fine sand (mech. disp.)	n.t.
PSA Coarse sand	9%	PSA C. sand (mech. disp.)	n.t.
PSA Gravel	7%	PSA Gravel (mech. disp.)	n.t.
Dispersion Percentage	17%	USCS	n.t.
Emerson Aggregate Test	2(1)	Non wind erodible %	12%
Permanent wilt point	17.7%	Field capacity	43.8%
Field water repellence	0	pH 1:5 soil:water	8.7
pH 1:5 soil:CaCl2 dS/m	7.8	EC	0.17
CEC meq/100g	19.9 meq/100g	Exchangeable Al	0
Exchangeable Ca meq/100g	5.2 meq/100g	Exchangeable K	0.6
Exchangeable Mg meq/100g	14.0 meq/100g	Exchangeable Na	0.8
ESP	4%	Organic Carbon	n.t.
Available P mg/kg	9 mg/kg	Available P (Lactate)	11
P sorption	315 mg/kg	Extractable Fe	n.t.

<u>Substrate</u>

alluvium substrate (Qa)

SALIS Soil Profile Report v1.51 with LabTable Tue Jan 18 13:19:03 2011

NSW SOIL AND LAND INFORMATION SYSTEM

Soil Profile Report

Site location

Boggabri - Bog-Mull Stock route

Profile details

Soil Landscapes of the Boggabri 1:100 000 Sheet (1000935), Profile 71, recorded by Robert Banks on 08 Feb 2000

Map reference

AMG grid reference 213166E, 6596563N, AMG Zone 56; MGA grid reference 213270E, 6596752N, MGA Zone 56; GDA Latitude -30.72763, GDA Longitude 150.00566; Boggabri (8936) 1:100,000 map sheet

Terrain

alluvial waning lower slope; part of footslope; local relief is low (30-90 m), slope is 1% (measured)

Geology

sandstone-lithic,conglomerate,alluvium substrate (Qx), with alluvium parent material

Vegetation

vegetation community is woodland grass u'storey

Hydrology

profile is poorly drained, run-on is moderate, runoff is low

Land use

limited clearing, used for volun./native pasture, with volun./native pasture in general area

Erosion

moderate erosion hazard, moderate stable sheet erosion

Site condition

hard set when described, expected to be hardsetting when dry, ground cover is 100%

Soil type

Brown Chromosol; medium, non gravelly, clay loamy, clayey, moderate, (ASC)

Profile Notes

none recorded

Profile Addendum

none recorded

Soil description

Surface

no coarse fragments recorded

Layer 1, A1 horizon, 0 - 0.2 m

dark reddish brown (5YR 3/2) silty clay loam with strong pedality (angular blocky, 10 - 20 mm), smooth-faced peds; coarse fragments not recorded; field pH is 6.5; AgNO3 result is light precipitate; no layer notes recorded; clear (20-50 mm) boundary to...

Soil sample information

Sample code WEL/03/9/70(1), 0 - 0.2 m

Volume expansion	12%	Linear shrinkage	n.t.
PSA Clay	21%	PSA Clay (mech. disp.)	n.t.
PSA Silt	17%	PSA Silt (mech. disp.)	n.t.
PSA Fine sand	27%	PSA fine sand (mech. disp.)	n.t.
PSA Coarse sand	14%	PSA C. sand (mech. disp.)	n.t.
PSA Gravel	21%	PSA Gravel (mech. disp.)	n.t.
Dispersion Percentage	16%	USCS	n.t.
Emerson Aggregate Test	3(2)	Non wind erodible %	13%
Permanent wilt point	11.7%	Field capacity	33%
Field water repellence	2	pH 1:5 soil:water	6.4
pH 1:5 soil:CaCl2 dS/m	5.6	EC	0.08
CEC meq/100g	19.5 meq/100g	Exchangeable Al	0
Exchangeable Ca meq/100g	9.2 meq/100g	Exchangeable K	1.3
Exchangeable Mg meq/100g	4.5 meq/100g	Exchangeable Na	0.6
ESP	3.1%	Organic Carbon	n.t.
Available P	5 mg/kg	Available P (Lactate)	n.t.
P sorption	118 mg/kg	Extractable Fe	n.t.

Layer 2, B2 horizon, 0.2 - 0.6 m

brown (greyish brown) (7.5YR 4/2) medium clay with strong pedality (prismatic, 20 - 50 mm), smooth-faced peds; few (2% - 10%) calcareous ; coarse fragments not recorded; field pH is 8.5; AgNO3 result is light precipitate; no layer notes recorded; clear (20-50 mm) smooth boundary to...

Soil sample information

Sample code WEL/03/9/71(1), 0.2 - 0.6 m

Volume expansion	23%	Linear shrinkage	n.t.
PSA Clay	47%	PSA Clay (mech. disp.)	n.t.
PSA Silt	21%	PSA Silt (mech. disp.)	n.t.
PSA Fine sand	13%	PSA fine sand (mech. disp.)	n.t.
PSA Coarse sand	11%	PSA C. sand (mech. disp.)	n.t.
PSA Gravel	8%	PSA Gravel (mech. disp.)	n.t.
Dispersion Percentage	17%	USCS	n.t.
Emerson Aggregate Test	2(1)	Non wind erodible %	21%
Permanent wilt point	18.2%	Field capacity	45.5%
Field water repellence	0	pH 1:5 soil:water	7.2
pH 1:5 soil:CaCl2 dS/m	6.8	EC	0.54
CEC meq/100g	30.4 meq/100g	Exchangeable Al	0
Exchangeable Ca	17.6 meq/100g	Exchangeable K	0.6

meq/100g

Exchangeable Mg meq/100g	9.5 meq/100g	Exchangeable Na	2.7
ESP	8.9%	Organic Carbon	n.t.
Available P	4 mg/kg	Available P (Lactate)	n.t.
P sorption	200 mg/kg	Extractable Fe	n.t.

Layer 3, Dz horizon, 0 - 1.6 m

strong brown (bright brown) (7.5YR 5/6) sandy clay loam with massive structure, earthy fabric; coarse fragments not recorded; field pH is 8; AgNO3 result is conspicuous white precipitate; no layer notes recorded; layer continues...

Soil sample information

Sample code WEL/03/9/72(1), 0.6 - 1.6 m

Volume expansion	25%	Linear shrinkage	n.t.
PSA Clay	31%	PSA Clay (mech. disp.)	n.t.
PSA Silt	8%	PSA Silt (mech. disp.)	n.t.
PSA Fine sand	20%	PSA fine sand (mech. disp.)	n.t.
PSA Coarse sand	38%	PSA C. sand (mech. disp.)	n.t.
PSA Gravel	3%	PSA Gravel (mech. disp.)	n.t.
Dispersion Percentage	21%	USCS	n.t.
Emerson Aggregate Test	2(1)	Non wind erodible %	45%
Permanent wilt point	11.3%	Field capacity	29.6%
Field water repellence	0	pH 1:5 soil:water	8.4
pH 1:5 soil:CaCl2 dS/m	7.6	EC	0.61
CEC meq/100g	10.3 meq/100g	Exchangeable Al	0
Exchangeable Ca meq/100g	8.0 meq/100g	Exchangeable K	0.3
Exchangeable Mg meq/100g	4.1 meq/100g	Exchangeable Na	1.0
ESP	9.7%	Organic Carbon	n.t.
Available P mg/kg	90 mg/kg	Available P (Lactate)	74
P sorption	93 mg/kg	Extractable Fe	n.t.

Substrate

sandstone-lithic,conglomerate,alluvium substrate (Qx)

SALIS Soil Profile Report v1.51 with LabTable Tue Jan 18 13:19:20 2011

NSW SOIL AND LAND INFORMATION SYSTEM

Soil Profile Report

Site location

Gulligal - crop paddock NE of Binnalong

Profile details

Soil Landscapes of the Boggabri 1:100 000 Sheet (1000935), Profile 93, recorded by Robert Banks on 17 Feb 2000

Map reference

AMG grid reference 215016E, 6590912N, AMG Zone 56; MGA grid reference 215120E, 6591101N, MGA Zone 56; GDA Latitude -30.779, GDA Longitude 150.02339; Boggabri (8936) 1:100,000 map sheet

Terrain

alluvial flat; part of plain; local relief is extremely low (< 9m), slope is 0% (measured)

Geology

alluvium substrate (Qx) and parent material

Vegetation

vegetation community is grassland/herbland

Hydrology

profile is poorly drained, run-on is low, runoff is low

Land use

rainfed cultivation, used for cropping, with cropping in general area

Erosion

slight erosion hazard, no erosion recorded

Site condition

recently cultivated,cracked,self mulched when described, expected to be seasonal cracking when dry, ground cover is 05%

Soil type

Endocalcareous Self-mulching Black Vertosol, non gravelly, very fine, very fine, giant, all required data available (ASC); Black Earth (GSG)

Profile Notes

none recorded

Profile Addendum

none recorded

Soil description

<u>Surface</u>

no coarse fragments recorded

<u>Layer 1, Ap horizon, 0 - 0.15 m</u>

dark brown (brownish black) (7.5YR 3/2) medium clay with strong pedality (polyhedral, 5 - 10 mm), smooth-faced peds; coarse fragments not recorded; field pH is 7.5; AgNO3 result is no precipitate; no layer notes recorded; gradual (50-100 mm) boundary to...

<u>Layer 2, B2 horizon, 0.15 - 0.7 m</u>

dark brown (brownish black) (7.5YR 3/2) heavy clay with strong pedality (prismatic, 20 - 50 mm), smooth-faced peds; coarse fragments not recorded; field pH is 8.5; AgNO3 result is no precipitate; no layer notes recorded; gradual (50-100 mm) boundary to...

<u>Layer 3, B22 horizon, 0.7 - 1.4 m</u>

brown (7.5YR 4/3) heavy clay with strong pedality (lenticular, 20 - 50 mm), smooth-faced peds; very few (< 2%) calcareous ; coarse fragments not recorded; field pH is 9.5; AgNO3 result is light precipitate; no layer notes recorded; layer continues...

<u>Substrate</u>

alluvium substrate (Qx)

SALIS Soil Profile Report v1.51 with LabTable Tue Jan 18 13:19:29 2011

NSW SOIL AND LAND INFORMATION SYSTEM

Soil Profile Report

Site location

Emerald Hill - Oxley Hwy

Profile details

Soil Landscapes of the Boggabri 1:100 000 Sheet (1000935), Profile 188, recorded by Robert Banks on 16 May 2002

Map reference

AMG grid reference 231085E, 6568786N, AMG Zone 56; MGA grid reference 231190E, 6568975N, MGA Zone 56; GDA Latitude -30.98216, GDA Longitude 150.18529; Boggabri (8936) 1:100,000 map sheet

Terrain

residual waxing mid-slope; part of hillslope within low hills; local relief is very low (9-30 m), slope is 4% (measured), elevation is 340 m

Geology

sandstone-lithic,basalt,colluvium substrate (Jgr) and parent material

Vegetation

vegetation community is woodland grass u'storey

Hydrology

profile is rapidly drained, run-on is low, runoff is moderate

Land use

limited clearing, used for timber/scrub/unused, with timber/scrub/unused in general area

Erosion

slight erosion hazard, minor stable sheet erosion

Site condition

hard set when described, expected to be hardsetting when dry, ground cover is 100%

Soil type

Haplic Mesotrophic Red Ferrosol; medium, slightly gravelly, clay loamy, clayey, very deep, (ASC); Euchrozem (GSG)

Profile Notes

none recorded

Profile Addendum

none recorded

Soil description

<u>Surface</u>

few (2-10%) surface gravels, hard set when described, expected to be hardsetting when dry, ground cover is 100%

Layer 1, A1 horizon, 0 - 0.25 m

reddish brown (dull reddish brown) (2.5YR 4/4) sandy clay loam with weak pedality (polyhedral), rough-faced peds; coarse fragments are few (2-10%), gravel (6-20 mm), as parent material; field pH is 6; AgNO3 result is no precipitate; no layer notes recorded; diffuse (>100 mm) boundary to...

Soil sample information

Sample code WEL/03/9/186(1), 0 - 0.25 m

Volume expansion	9%	Linear shrinkage	n.t.
PSA Clay	13%	PSA Clay (mech. disp.)	6%
PSA Silt	7%	PSA Silt (mech. disp.)	11%
PSA Fine sand	26%	PSA fine sand (mech. disp.)	27%
PSA Coarse sand	8%	PSA C. sand (mech. disp.)	10%
PSA Gravel	46%	PSA Gravel (mech. disp.)	46%
Dispersion Percentage	10%	USCS	n.t.
Emerson Aggregate Test	3(2)	Non wind erodible %	24%
Permanent wilt point	11.5%	Field capacity	33.1%
Field water repellence	0	pH 1:5 soil:water	6.5
pH 1:5 soil:CaCl2 dS/m	5.8	EC	0.05
CEC meq/100g	10.2 meq/100g	Exchangeable Al	0.1
Exchangeable Ca meq/100g	8.3 meq/100g	Exchangeable K	1.4
Exchangeable Mg meq/100g	2.0 meq/100g	Exchangeable Na	0.2
ESP	2%	Organic Carbon	n.t.
Available P	8 mg/kg	Available P (Lactate)	n.t.
P sorption	142 mg/kg	Extractable Fe	n.t.

Layer 2, B2 horizon, 0.25 - 1 m

red (10R 4/6) medium clay with strong pedality (polyhedral), rough-faced peds; coarse fragments are few (2-10%), fine gravel (2-6 mm), as parent material; field pH is 6; AgNO3 result is no precipitate; no layer notes recorded; layer continues...

Soil sample information

Sample code WEL/03/9/187(1), 0.25 - 1 m

Volume expansion	17%	Linear shrinkage	n.t.
PSA Clay	74%	PSA Clay (mech. disp.)	22%
PSA Silt	6%	PSA Silt (mech. disp.)	23%
PSA Fine sand	10%	PSA fine sand (mech. disp.)	43%
PSA Coarse sand	6%	PSA C. sand (mech. disp.)	8%
PSA Gravel	4%	PSA Gravel (mech. disp.)	4%
Dispersion Percentage	5%	USCS	n.t.
Emerson Aggregate Test	6	Non wind erodible %	25%
Permanent wilt point	21.7%	Field capacity	39.2%
Field water repellence	0	pH 1:5 soil:water	6.8
pH 1:5 soil:CaCl2 dS/m	6.3	EC	0.06
CEC	14.4 meq/100g	Exchangeable Al	0

meq/100g

Exchangeable Ca meq/100g	9.3 meq/100g	Exchangeable K	1.3
Exchangeable Mg meq/100g	4.9 meq/100g	Exchangeable Na	0.2
ESP	1.4%	Organic Carbon	n.t.
Available P	1 mg/kg	Available P (Lactate)	n.t.
P sorption	553 mg/kg	Extractable Fe	n.t.

<u>Substrate</u>

sandstone-lithic,basalt,colluvium substrate (Jgr)

SALIS Soil Profile Report v1.51 with LabTable Tue Jan 18 13:19:43 2011

Appendix 4

Boggabri proposed coal mine: greenhouse gas emissions by Dr Ian Lowe

Resume: Dr Ian Lowe

Boggabri proposed coal mine: greenhouse gas emissions
By Dr Ian Lowe

1. The carbon dioxide emissions of New South Wales (**NSW)** are currently about 163 million tonnes per year.[1] For the reasons given below, this means that NSW is close to the present allowable limit of its share of Australia's obligations under the United Nations Framework Convention on Climate Change (**FCCC**) and the Kyoto Protocol. The FCCC was adopted at the 1992 United Nations Earth Summit in Rio de Janeiro, and entered into force in March 1994. Australia supported the adoption of the FCCC, and was one of the original parties to it.

2. Following the entry into force of the FCCC, its translation into legally binding emissions targets was considered at a succession of Conferences of the Parties to the treaty. The first Conference of the Parties (**COP**), held in Berlin from 28 March to 3 April 1995, (**COP1**) set indicative targets only. COP2, held in Geneva from 8 to 19 July 1996, and which I attended as a member of the formal Australian delegation, outlined a basis for legally binding targets. COP3, held in Kyoto from 1 to 10 December 1997, which I also attended, developed the Kyoto Protocol, which was formally adopted on 11 December 1997. The Kyoto Protocol provided emissions limits for each party for the commitment period 2008-2012.

3. These emissions limits were set as a percentage of each country's baseline, that is, the country's recorded emissions in 1990. Australia agreed at the Kyoto COP to limit our emissions for the 2008-2012 period to 108 per cent of our 1990 baseline. There was, however, a very significant qualification to the Kyoto agreement, requested by the Australian delegation on the last morning of the COP and conceded as part of the Protocol. Australia proposed that the Kyoto figures, both the 1990 baseline and the 2008-2012 targets, include changes to land use, as well as emissions from burning fossil fuels. The case for this proposal was that the clearing of native vegetation releases carbon dioxide into the air, while planting new forest areas removes carbon dioxide. Australia argued that a comprehensive treaty should include land use change, as well as the emissions from burning fossil fuels. The proposal made no significant difference to the other States parties who accepted emission reduction targets in the Kyoto Protocol, because no other party was significantly changing its land use. However, Australia cleared about 500,000 hectares of land in 1990, mainly in Queensland and NSW, so the inclusion of "*land use change*" in the Kyoto Protocol added about 30 per cent to our carbon dioxide emissions in that baseline year. This constituted an extremely generous inflation of our 1990 baseline, making it significantly easier for Australia to meet its emission target for the 2008-2012 period. The concession is, for this reason, known internationally as "*the Australia clause*".

4. The national commitment is to limit Australia's emissions for the Kyoto period of 2008 to 2012 to no more than 8 per cent above the inflated 1990 baseline. Since the Kyoto Protocol was formally ratified by Australia in December 2007, this is now a legal obligation. The 1990 figure for NSW was 161 million tonnes.[2] Reducing land-clearing brought emissions down to about 150 million tonnes in 2000. However, that one-off cut has now been erased by growth in energy-related carbon dioxide production. NSW is now back above the 1990 baseline.[3]

5. There are not yet legally binding obligations for greenhouse gas reductions beyond the Kyoto commitment period. However, international discussions to set post-2012 targets began at the thirteenth COP (Bali, December 2007). A broad basis was agreed at COP13 and was subsequently enshrined in the Copenhagen Accord, which was the outcome of COP15 in Copenhagen (7-18 December, 2009). I also attended that meeting. The Copenhagen Accord is a statement of principles rather than a legally binding protocol to the FCCC.

6. However, the agreement at Copenhagen included a commitment to work toward a binding legal agreement. The COP16 in Cancun last year took another step toward that goal. The Accord will, if translated into a legally binding agreement, require Australia to achieve emissions reductions in the range of 25 to 40 per cent of the 1990 baseline by 2020. If that obligation is shared between the States, NSW will be expected to reduce its carbon dioxide emissions significantly by 2020. The State target will be about 115 million tonnes per year for a 25 per cent reduction, or 90 million tonnes per year if the national goal is a 40 per cent reduction.

7. The proposed Boggabri mine would produce up to 7 million tonnes of coal per year. Using the National Greenhouse Assessment workbook factors, this mining operation would release 0.87 million tones of CO_2 equivalent each year. That represents about 1 per cent addition to the State's total production, assuming the NSW target is in the range agreed at Cancun.

8. It would, however, be dishonest to claim that the emissions produced by mining would be the total impact of the proposed mine. The coal would be burned and release much more carbon dioxide. This would only count against the NSW greenhouse gas target if the coal were burned within the State, but the global impact is the same, wherever the burning happens. Depending on the ash content, burning 7 million tonnes of coal would release between 20 and 25 million tonnes of carbon dioxide. So this mine would, if approved, add to the global greenhouse burden an amount equivalent to about 25 per cent of the State's overall target.

9. For 25 years, climate science has been warning that the consequences of global warming would include more frequent extreme events: droughts, heatwaves, severe bushfires and floods. Recent extreme weather events are consistent with this prediction. The changes we are now seeing are associated with the increase in average global temperature of 0.8 degrees. The most optimistic outlook is that a concerted international effort might hold the increase in average global temperature this century to two degrees; the present trajectory is on target for three or four degrees increase in average temperature. So the science is saying that we are inevitably producing more extreme weather events like the 2009 Victorian bushfires and the 2011 floods, that such events will become more intense and more frequent, but the scale of the problem will be determined by the level of commitment to curbing release of greenhouse gases. The short-term economic benefits of a new coal mine do not justify the burden it will place on the entire community by contributing to more frequent extreme weather events.

References:

1. Director-General's Environmental Assessment Report – Bayswater B – page 33 (2010).
2. Ibid.
3. Ibid.

Curriculum vitae

NAME	IAN LOWE
HONOURS	Officer of the Order of Australia, Centenary Medal
ACADEMIC QUALIFICATIONS	B.Sc. [University of New South Wales, 1967] D.Phil. [University of York, 1974] D.Univ. [Griffith University, 2006]

PROFESSIONAL ELECTIONS

- Fellow of the Australian Academy of Technological Sciences and Engineering
- Fellow of the Queensland Academy of Arts & Sciences
- Fellow of the World Federation of Futures Studies

NATIONALITY	Australian
CURRENT POSITION	Emeritus Professor of Science, Technology & Society Griffith University
PREVIOUS POSITIONS	Professor of Science, Technology & Society 1996-2000 Associate Professor, 1987-96, Senior Lecturer 1980-87 [also Director of the Science Policy Research Centre, 1980-92] Sub-Dean, Faculty of Technology, UK Open University 1978-80 [Senior Lecturer 1977-80, Lecturer 1971-77]

PROFESSIONAL ADDRESS

School of Science
Griffith University
Nathan 4111
AUSTRALIA

PRIVATE ADDRESS

5/2 Tamarindus Street
Marcoola 4564
AUSTRALIA

E-mail i.lowe@griffith.edu.au

Appendix 5

Letter from Paul Keech & Associates Pty Ltd, February 2011

Resume: Paul Keech, Paul Keech & Associates Pty Ltd

PAUL KEECH & ASSOCIATES Pty Ltd
Professional Engineering Services ABN 71 147 471 109

3 February 2011

Maules Creek Community Council
c/- Middle Creek
Boggabri NSW 2382

Attention: Phil Laird

Dear Phil

Re: Continuation of Boggabri Coal Mine

Further to my email dated 31 December 2010 and our recent discussions, the following comments and suggested approval conditions, are provided for the Maules Creek Community Council to consider including in its submission to the NSW Department of Planning in relation to the application for Continuation of the Boggabri Coal Mine.

Traffic and Transport

Key Issues and Concerns

Harparary Road and Bridge upgrade

The Environmental Assessment - Hansen Bailey December 2010 suggests that the Harparary Road, Causeways and Bridge upgrade proposed in the "Voluntary Planning Agreement" (VPA) for the proposed expansion, is compensation for the closure of the Leards Forest Road.

The Environmental Assessment (Appendix T pg 40 to 42) also suggests that the section of the Kamilaroi Highway from Baan Baa to Boggabri has an accident and crash history and infers that the Therribri Road would be "safer" alternative route for Leards Forest Road traffic. The study however fails to assess the flood prone nature of the Therribri Road nor does it look at the actual impact of more traffic on this road.

The Harparary Road will need to be upgraded to accommodate future heavy vehicle usage and this is likely to include Road Trains, B-Triples and AB-Triples. At present the road is only rated as a B-Double route however it is reasonable to assume that longer combinations will be encouraged along this highly productive route.

pjkeech@hotmail.com | 0447 349 399 | 02 6792 5691 | 9 Hillam Ave Narrabri 2390 NSW

The Harparary Road Bridge is currently a single lane timber bridge. The replacement bridge will need to be a two lane bridge capable of supporting Higher Mass Limits of B-Triples and AB-Triples and any other likely future combination.

pjkeech@hotmail.com
0447 349 399
02 6792 5691
9 Hillam Ave
Narrabri 2390 NSW

The Harparary Road currently crosses a number of watercourses via concrete causeways which become impassable at times of heavy rain with fast flowing, debris filled water. The VPA indicates that these causeways will be replaced by box culverts. To be effective for a reasonable storm recurrence interval, the culverts will need to be designed such that their underside is higher than the finished surface level of the approaches thus allowing as much debris as possible to pass under the road. Despite the best intentions and construction standards the proposed culverts are likely to be overtopped or blocked and thus suffer regular damage. To mitigate this, each culvert will need to be constructed adjacent to the existing concrete causeways which is to remain serviceable, thus providing a reliable backup when the inevitable flood damage repairs to the culverts are being affected.

The Harparary Road, Causeways and Bridge upgrade is proposed due to the Mine expansion and will provide a benefit to the Maules Creek Community (particularly those to the West of the Leards Forest Road). This should not however be considered a permanent alternative to the Leards Forest Road, and not a substitute to the original Development Approval condition.

Importance of the Leards Forest Road

In 1988 – The Development Application for Boggabri Coal Mining in Leards Forest was considered. At the time Narrabri Shire Council made comment to the Department of Planning as follows;

> "x In the event of Shire Road No. 12 (Boggabri – Maules Creek) being closed as a result of the development, a deviation via Shire Roads No. 26 (Boggabri – Goonbri) and 167 (Goonbri – Stewarts) shall be constructed and maintained at the Applicant's cost and to the satisfaction of the Narrabri Shire Council."
> (Extract from Letter to Department of Planning 27/7/1988):

After considering Narrabri Shire Council's submission the Department of Planning set the following condition in the Development Consent;

> "9. (a) The applicant shall maintain road access at all times for residents of Maules Creek and meet the requirements of the Council in the selection and construction and maintenance of alternative road access and meet the cost of such road works;"

The Economic Assessment of the Project (Appendix Q pg 10) seems to have made an assumption that the Leards Forest Road (or a reasonable deviation of it through the mining lease) will remain open. It refers to the Harparary Road upgrade as being a "wet weather" improvement. There is no discussion of the Economic impacts of a permanent closure of the alignment, on the Maules Creek economy.

Additionally Economic Assessment of the Project (Appendix T pg 36 to 38) identifies the additional travel time and distance that the closure will create and then proceeds to trivialise this as being a minor impact due to small traffic loads based on the consultant's traffic sampling. The additional travel time and distance represents real cost and time burdens to the residents of Maules Creek and the Environmental Assessment does not adequately address this.

The requirement of Narrabri Shire Council in 1988 recognised the vital link that the Leards Forest Road provides to the Maules Creek Community and the cost and inconvenience that a permanent closure would create. Whilst it may not be a heavily trafficked route it is valuable and essential to Maules Creek because it provides;

1. an alternative route connecting Maules Creek to the State Road network when other routes become impassable as a result of floodwaters originating in various catchments.
2. a direct link to Maules Creek for the emergency services stationed at Boggabri (ie Police, Ambulance, SES and RFS).
3. direct access to the facilities in Boggabri that are essential support services such as a medical general practitioner, chemist, HACC as well as leisure and recreation facilities.
4. access to services not provided directly within the Narrabri Local Government Area. Sheep sales at the Gunnedah Saleyards and specialist medical services in Tamworth are obvious and real examples.
5. access for residents of Upper Maules Creek to the local schools in Boggabri. Some parents drive this road twice a day to deliver and pick up their children.
6. an access to the Leards State Forest and
7. a firebreak through the Forest.

A deviation via SR26 and SR167 may be problematic and expensive in the context of present day land acquisition, clearing and construction standards, however a deviation through or around the mining lease is feasible and likely to be very cost effective if considered at the planning phase of the Mines development.

The bottom line for the Maules Creek Community is that the Leards Forest Road, in its current alignment or a reasonable deviation from it, <u>must remain open</u> and development approval must clearly require this.

Heavy Vehicle Access to the Mine Site

The heavy vehicle traffic to the Mine Site under current operational capacity is already stressing the local road infrastructure leading to the Mine Site. The Iron Bridge (Manilla Road over Namoi River) has buckled plates and has had various load limits imposed over recent years. Additionally the newly sealed Manilla Road is showing signs of heavy vehicle fatigue at the Leards Forest Road intersection, as identified in the Environmental Assessment.

Suggested Approval Conditions

1. *Prior to the closure of the Leards Forest Road's current alignment through the mining lease site, the Applicant must prepare a "Leards Forest Road Deviation Management Plan" in Consultation with, and to the satisfaction of the Maules Creek Community Council and the Narrabri Shire Council.* ***The Leards Forest Road (on its current or deviated alignment) is to remain open at all times****. As a minimum "The Plan" will cover the following;*
    a. *Construction Drawings by a Chartered Professional Engineer, for the completion of the Harparary Road, Causeway and Bridge upgrade works. Where box culverts are to replace concrete causeways the causeways are to remain adjacent to the culverts and be available during construction and, as an alternative access should the culverts be damaged during flood events.*
    b. *The underside of the Box culverts are to be a minimum of 500mm above the approach roads finished surface level, measured 100m from the culvert, to reduce the impact of debris build up*
    c. *The Harparary Road Bridge is to be a two lane bridge in accordance with the current Austroads bridge design code and capable of carrying as a minimum, Higher Mass Limit AB-Triples or similar. The new bridge is to be constructed on an alignment parallel to the current timber bridge alignment, thus allowing traffic to flow whilst construction occurs.*
    d. *The proposed Leards Forest Road Deviation Route or Route(s), should more than one deviation be required during the Mines life, are to be funded and constructed by the Applicant. The deviated route(s) is to be a gravel surface road with a minimum width of 7m to the satisfaction of Narrabri Shire Council, and constructed on an alignment to suits traffic speed of 70km/h as a minimum. The Deviation Management Plan will also show the proposed "****Final Alignment" of the Leards Forest Road once mining has ceased and the mine site is rehabilitated****. The Applicant will supply and deliver all gravel required to maintain the Leards Forest Road whilst the mine is operating.*
    e. *A proposed Construction Program that shows the proposed timeline for the upgrade of the Harparary Road, Causeways and Bridge, and the Leards Forest Road Deviation Route or Route(s) prior to the closure of the Leards*

Forest Road's current alignment through the mining lease site.

f. *A Consultation Strategy outlining how the proposed realignments of the "Leards Forest Road* <u>*Deviation*</u> *Management Plan" and Construction and Maintenance arrangements will be communicated to key stakeholders and regulators.*

2. *The Applicant will meet the reasonable costs of providing an independent inspector (to the satisfaction of Narrabri Shire Council and Maules Creek Community Council) to monitor any works the Applicant (or its contractors) carries out on infrastructure for the ultimate benefit/ownership of the Narrabri Shire Council.*

3. *At the completion of the proposed rail loop the Applicant's existing private haul road will become the only heavy vehicle access route to the mine and controls at the intersections of the Leards Forest Road and Therribri Road will be changed to give priority to the public roads, with mining traffic not having right of way. Access to the Private Haul Road will be provided by the Applicant at the Kamilaroi Highway to the satisfaction of the Roads and Traffic Authority.*

4. *At the completion of the rail loop, the Manilla Road, from the Iron Bridge up to and including the Leards Forest Road intersection, will be rehabilitated to the satisfaction of the Narrabri Shire Council.*

<u>Social</u>

Key Issues and Concerns

Voluntary Planning Agreement Uncertainty

The Environmental Assessment refers to a "Voluntary Planning Agreement" to the value of $9.67 million (2010) with major projects being;

- Boggabri Caravan Park and Swimming Pool and
- Harparary Road and Bridge over Namoi River

The Environmental Assessment provides no details of these projects, nor how these projects are to be delivered or by whom. Without and detailed information it seems reasonable to assume that $9.67 million is a ballpark cost estimate based on similar types of projects in the area, provided to aid preliminary "Voluntary Planning Agreement" negotiations. If this is the case there is a real possibility that actual project costs, once detailed designs have been completed, could be well in excess of the preliminary ballpark estimates and Narrabri Shire Council may not be able to fund the difference thus the projects may stall. Additionally if the projects are not commenced immediately inflation could eat away at the value of the works as construction indices can be very volatile.

In the case of the Boggabri Caravan Park and Swimming Pool and, the Harparary Road Bridge and Culverts (replacing Causeways) the Narrabri Shire Council should define the scope and requirements of these projects (ie minimum culvert size etc) with the Applicant delivering detailed designs and construction. This properly protects the community from the risk associated with potential budget overruns.

In the case of the Harparary Road roadworks the Narrabri Shire Council should do this work for an agreed price once detailed designs are completed. Again this properly protects the long-term interests of the community by reducing the risk of early failures due to poor/ inexperienced workmanship.

Suggested Approval Conditions

5. *The Applicant is required to prepare detailed designs and subsequently construct improvements to*
    a. *Boggabri Caravan Park*
    b. *Boggabri Swimming Pool*
    c. *Harparary Road (and Culverts replacing Causeways)*
    d. *Harparary Road Bridge*

    to the satisfaction of the Narrabri Shire Council and the Maules Creek Community Council, prior to the closure of the Leards Forest Road's current alignment through the mining lease site.

6. *The Applicant is required to make a financial contribution to the Narrabri Shire Council based on detailed designs prepared by the Applicant, sufficient to allow the Council to gravel and seal the unsealed section of road along the Harparary Road from the Leards Forest Road to the Kamilaroi Highway, prior to the closure of the Leards Forest Road's current alignment through the mining lease site.*

Rehabilitation and Final Landform

Key Issues and Concerns

Recreational Opportunities

The Environmental Assessment; Section 8.16.3 Final Landform and Domain Specific Rehabilitation (p164) states;

> "Boggabri Coal will maximise opportunities for a diverse post-mining landscape and land-use where possible. It is proposed that the final land-use of the rehabilitated site will include those similar to pre-mining land-use including biodiversity, pastoral, forestry and recreational opportunities."

The Environmental Assessment; Intergenerational Equity (p125) states;

> "The Leards State Forest has been identified as Zone 4 in accordance with the BNC Act and dedicated for forestry, recreational and mineral extraction"

The Environmental Assessment however is silent on any detailed commitment to the recreational opportunities that will be provided.

Initiatives such as a historic horse/walking trail through the forest with various pioneer/ historical information displays and campsites along the route could be developed. The trail could operate as a tourist route during the hunting off season.

Suggested Approval Conditions

7. *The Applicant is required to prepare detailed Rehabilitation Strategy and Management Plan in consultation with the Narrabri Shire Council and the Maules Creek Community Council. The strategy is to be completed by the Applicant (and approved by the NSW Department of Planning) prior to the closure of the Leards Forest Road's current alignment through the mining lease site.*

Consultation Strategy

Key Issues and Concerns

Ongoing Operational Consultation

The current good will and commitment to cooperation displayed by the Applicant and the Maules Creek Community should continue. The management at Boggabri Coal seems to have recognized the existence and importance of the Maules Creek Community Council by meeting with the Maules Creek Community Council representatives on a regular basis.

For effective consultation to continue a properly constituted Community Consultation Committee should formed within three months of development consent for the Proposed Project being granted.

It is important for the Maules Creek Community Council to make sure that a Community Consultation Committee is a requirement of operation and not a Committee formed in good faith by the current Management of the Applicant. The reason being that if the relationship strains in the future the Committee must operate and not fold due to lack of interest on the part of the Applicant.

Suggested Approval Conditions

8. A Community Consultation Committee is to be formed within three months of development consent for the Proposed Project being granted.

   The minimum scope of the Community Consultation *Committee is to monitor and comment on the degree of conformance to the development conditions (and subsequent Management Plans) by the Applicant.*

   The Community Consultation *Committee would be chaired by a Narrabri Shire Councillor with membership being;*

   One Chairperson (Narrabri Shire Councillor)

   Four Applicant appointees

Four Community Representatives (two positions reserved for the Maules Creek Community Council and other two positions determined by the Narrabri Shire Council after a public expression of interest process)

The Applicant will be required to provide a budget to the committee so that the committee can provide training to representatives and engage independent experts on an as needs basis. The value of the budget is to be determined by the committee but set at a minimum of $10,000 (annually adjusted in line with CPI from the date of Development Consent being granted).

Disputes that cannot be resolved by 2/3 majority of the committee are to be referred to the Director General of Planning for resolution.

The governing Constitution and rules of the committee are to be developed by the Committee at its first meeting with the Department of Planning Facilitating the process.

I trust this information is to your satisfaction and invite you to contact me via the phone or email, if you would like to discuss further.

Yours sincerely

Paul Keech BE (Civil) MBA

Director
MIEAust CPEng

Paul Keech is the sole Director of Paul Keech & Associates Pty Ltd.

Qualifications, Experience and Expertise

Chartered Professional Engineer, Member of the Institute of Engineers Australia

Bachelor of Engineering (CIVIL)
University of Technology N.S.W. 1991
Second Class Honours

Master of Business Administration (Technology Management)
Deakin University APESMA 2001

Twenty (20) years' experience, in designing, constructing and maintaining infrastructure such as roads, bridges, stormwater, water supply, sewerage systems and treatment, waste management, community facilities and quarries.

Six (6) years as the Director of Engineering Services at Narrabri Shire Council (NSW), managing a workforce of approximately 200 staff and subcontractors.

Areas of expertise include;

- Project and Contract Management
- Development and implementation of Management Systems such as Safety AS4804, Quality ISO9000 and Environmental ISO14001
- Development and implementation of Asset Management Systems
- Risk Assessment
- Traffic Management (inc Route & HML assessments)
- State and Local Government Liaison (ie RTA & Councils)
- Development Applications (inc Subdivisions)
- Strategic Management
- Emergency Management
- Road Works Design and Construction Supervision
- Site Supervision of Bulk Earthworks Projects
- Fleet Management
- Project Tendering and Estimating

pjkeech@hotmail.com
0447 349 399
02 6792 5691
9 Hillam Ave
Narrabri 2390 NSW

Appendix 6

Letter from Environmental Defender's Office Ltd regarding Continuation of Boggabri Cola Mine, Boggabri NSW, 1 February 2011

ABN: 72 002 880 864

Environmental Defender's Office Ltd

10 Club Lane
PO Box 212
Lismore NSW 2480
Tel: 1300 369 791
Fax: (61 2) 6622 6404

1/89 York Street
Sydney NSW 2000
Tel: (61 2) 9262 6989
Fax: (61 2) 9262 6998

email: edonsw@edo.org.au
web: www.edo.org.au/edonsw

Our Ref: 1115772

1 February 2011

The Hon Tony Burke MP
Minister for Sustainability, Environment, Water, Population and Communities
PO Box 6022
Parliament House
CANBERRA ACT 2600

Dear Mr Burke

RE: Continuation of Boggabri Coal Mine, Boggabri NSW
EXTENSION TO EXISTING OPERATIONS

We act for the Maules Creek Community Council in relation to the above proposal which has been recently referred to under the *Environment Protection Biodiversity Conservation Act 1999* ("the EPBC Act").

You may be aware that only the extension of this project has been referred to you. The proponent has only referred the part of the project that relates to the extension of the mine on the basis of the fact that the original Environmental Impact Statement for the Boggabri mine complied with the provisions of the *Environment Protection (Impact of Proposals) Act 1974* and therefore did not need to be assessed under the EPBC Act.

We are requesting under s.78A of the EPBC Act that you reconsider the matter pursuant to your powers under s.78 of the EPBC Act and ask that the whole Boggabri mine be referred to you for assessment. Under s.78 of the EPBC Act you are able to reconsider your decision if you are satisfied that there is substantial new information about the impacts of the action on matters protected under the EPBC Act or a substantial change in circumstances not foreseen at the time of the first decision.

There are broadly two reasons we say that there is new information or a substantial change in circumstances:

(i) Firstly, there is new information or a substantial change in circumstances about the impacts of this project since its original assessment; and
(ii) Secondly there is a complete change in the cumulative impacts of the project.

New information/Substantial change

The original EIS was lodged in 1987, and was largely based on scientific surveys undertaken in 1978, over 30 years ago.

Since this time, substantially new scientific information has come to light. The original EIS showed some vegetation communities in the area including white box and red gum communities, but located no endangered plants. In comparison the current referral lists eight threatened plants in the area and the impact on the now critically endangered white box, yellow box, blakely's red gum grassy woodland and derived native grassland ("the endangered EEC"). The original EIS also did not locate many endangered species of fauna. It did not locate the regent honeyeater or any endangered bat species that are discussed in the referral of the extension. It did mention but did not identify nomadic or migratory bird species in the area. The current referral notes that eleven migratory birds were located in the study area.

One other recent discovery is of groundwater fauna, or stygofauna, in streams and creeks near the project boundary, which makes it likely that they will be found within the boundary as well. While stygofauna in this area are not listed specifically under the EPBC Act, we believe that their discovery should be considered and assessed as part of this assessment. The Department's own State of the Environment Report in 2006 identified groundwater fauna and their protection as an emerging issue.[1] In particular it highlighted the lack of knowledge about stygofauna and lack of baseline conditions to record data about them.

The main issue that has come to light in recent studies of the area is the inability of the area to revegetate if cleared. The original EIS and the current referral both refer to the fact that once mining is concluded the area will be rehabilitated and form habitat for the endangered EEC. We understand that there is currently few areas available locally to offset the impacts on the endangered EEC. It is therefore integral that this area continues to be used to preserve the endangered EEC. Research undertaken by Soil Futures Consulting Pty Ltd on the Environmental Assessment completed for the extension area indicates that it will not be possible to restore the land to its previous land capability once it is mined. The different in soil moisture storage of 6041 ML show it is doubtful in the long term whether any long term tree or simulated vegetation community is possible in the area. This problem is in fact demonstrated by the areas to date that have been mined and are being rehabilitated.

Cumulative Impacts

One of the main ways that the project has changed is that the cumulative impact of mining in the area has changed. At the time the original EIS was done there was one confined mine in Leards State Forest. There is now a number of projects that will impact on the area as follows:

(i) Boggabri existing mine- within an area of 1289 hectares within Leards State Forest;
(ii) Boggabri extension (which is the current project referred) that contributes to the clearing of another 658 hectares. The project boundary for both projects will cover some 3400 hectares
(iii) Maules Creek Coal project which has been separately referred and covers an area of 2000 hectares covering a boundary of 3500 hectares.

We have attached a map that shows the impact on the area from all of the projects. These will all have significant impacts on the State Forest as it is only of 8000 hectares in total.

We therefore submit that there is a substantial change in circumstances. We would invite you to specifically consider the cumulative impact of the Extension and Existing Operations, by virtue of s74A of the EPBC Act, which provides that you can decide to not accept the referral of a matter when it is part of a larger action. We submit that the Extension Project is a component of a larger project, namely the Boggabri Coal Mine, as the Extension Project is a continuation of coal mining at the Boggabri Mine and is adjacent to the existing site. There is also another mine proposed

According to the proponent's own assessment, there will be significant loss of habitat and displacement of various threatened species involved in the Extension Project. Given that the Extension is adjacent to the current operations, it follows that no small loss of habitat has already been suffered in the area. We submit that this cumulative loss should be taken into account in your deliberations and specifically in the Environmental Assessment.

Yours faithfully
Environmental Defender's Office (NSW) Ltd

Kirsty Ruddock
Principal Solicitor

[1] See Dr Bill Humphreys, "Groundwater Fauna" prepared for the 2006 Australian State of the Environment Committee, Department of Environment and heritage, Canberra <http://www.environment.gov.au/soe/2006/publications/emerging/fauna/index.html>

Appendix 7

Economists at Large review of the Continuation of Boggabri Coal Mine Economic Assessment, February 2011 provided by Economists at Large

Economists at Large review of the *Continuation of Boggabri Coal Mine Economic Assessment, February* 2011.

Introduction/summary

Economists at Large have undertaken a review of *Appendix Q - Economic assessment of the environmental impact statement into the continuation of the Boggabri Coal Mine* (the Economic Assessment), located in north-central New South Wales. This review was made at the request of the Maules Creek Community Council (MCCC). We have found several issues that call into question aspects of the analysis presented by the Economic Assessment. These issues are:

- No economic analysis of scenarios have been undertaken other than cessation of mining in 2011 and a 21 year, open cut extension despite seven alternative scenarios being mentioned in the Environmental Assessment report.
- Mixing of private financial values and public economic values within the cost-benefit analysis.
- Miscalculation and/or omission of external costs and benefits.

The result of these issues is that the assessment - the cost-benefit analysis and then carried on into the economic impact assessment - present values that inflate public benefits and under estimate public costs. The assessment seems to avoid discussion of distribution of benefits between stakeholders and fail to assess all alternative methods of expanding this mine.

In summary, the overstatement of benefits and understatement of costs of the project mean that the modelling results for the Economic Impact Assessment are heavily compromised and should not be used for decision making purposes.

Lack of alternative scenarios

One of the most important parts of Environmental Impact Assessment (EIA) and economic evaluation of projects is to examine alternative options and select the scenario which optimises the welfare of the community. This is made clear in all guides to EIA and cost benefit analysis, including one co-written by the consultants of this report:

"*The main aims of an economic efficiency analysis are to…provide a framework for the evaluation of feasible alternatives*"(Gillespie & James 2002).

See also the World Bank Handbook on Economic Analysis:

"One of the most important steps in project evaluation is the consideration of alternatives throughout the project cycle, from identification through appraisal." (Belli et al. 1997)

Despite this, the Economic Assessment and the EIA that that this assessment forms an appendix of, focus on only two alternatives – complete cessation of mining this year or a 21 year extension using open cut methods. The Economic Assessment claims:

Boggabri Coal's alternatives for the mining of coal are essentially limited to different scales, designs, technologies, processes, modes of transport, timing, impact mitigation measures, etc. However these alternatives could be considered to be variants of the preferred proposal rather than distinct alternatives. (p6)

But on pages 42 to 45 of the Continuation of Boggabri Coal Mine Environmental Assessment by Hansen and Bailey, seven alternatives are mentioned, including an underground mining option (option 6). As noted by the MCCC, these options have never been subjected to proper benefit-cost analysis, allowing them to be compared to each other and to the presented option. The alternatives have been dismissed as technically and economically feasible, but not desirable – from the perspective of the project proponent.

While the consultant's brief for the Economic Assessment was, no doubt, only to compare the two options, proper economic analysis would have compared several options using cost-benefit analysis from the perspective of broad net social impact. As the consultant's co-authored guidelines to economic analysis also state:

The main aim of an economic evaluation is to provide information that will assist decision makers make efficient use of available resources to maximise the well-being or welfare of the community. (Gillespie & James 2002)

It is feasible that other options may produce a smaller return for the operators but a larger overall return to the community due to a better mix of values.

Mixing of private, financial values and public, economic values within the cost-benefit analysis.

Private, financial assessment

Many items included in the benefit-cost analysis mix financial analysis with economic analysis. Financial analysis should focus on dollar values and the profitability of a project to those operating it, while economic analysis should look at the costs and benefits to the society the project will impact upon, in this case primarily the state of NSW and local communities.

The following items from the Economic Assessment should be included in the financial analysis of the project:

- Opportunity cost of capital
- Capital expenditure
- Operating expenditure
- Decommissioning costs
- Avoided decommissioning costs
- Revenue (sale value of coal)

These values, less the royalties owed to the state of NSW and tax paid represent the economic rents – profit – that the proponent is expecting to gain.

Table 1. Summary of the financial costs & benefits

(From Economic Assessment and Economists at Large analysis)

Costs		
Opportunity cost of mine land	$5,000,000	
Opportunity cost of capital	$7,000,000	
Capital costs	$778,000,000	
Operating costs	$3,328,000,000	
Decommissioning costs	$11,000,000	
Royalties	$625,566,633	
Total costs		$4,754,566,633
Benefits		
Avoided decommissioning costs	$46,000,000	
Revenue	$5,343,000,000	
Residual value of capital	$8,000,000	
Total benefits		$5,397,000,000
Net private benefits to operators		$642,433,367

We see in Table 1 that the expected profit to the operators of this project will be around $642M discounted at 7% over the life of the project. Note that the royalty figures here are based on the DPI NSW website figures of 8.2% royalties for open cut coal, at the proponent's suggested price of $94/tonne. The royalty figures here are also discounted at 7% over the life of the project – why they were not discounted in the Economic Assessment (p8) is not clear, and another example of public benefits being overstated while public costs are minimised.

Other issues – capacity

The modelling may overstate the case of the mine as it is based on "peak production levels…and peak employment levels" (p.21). As reported on page 6, the current operations are up to 5 Mtpa, however the Idemitsu Australia website reports that only 1.55 Mt were exported in 2009[1], indicating that the mine doesn't currently operate at full capacity -

[1] http://www.idemitsu.com.au/Operations/Boggabri_Coal/Overview_-_Ownership.aspx

assuming that the majority of the coal is exported[2]. It is beyond the scope of this analysis to fully investigate the factors impacting on whether or not a mine operates at full capacity, however use of full capacity figures serves to inflate any estimates provided by the analysis. This is an important omission from the sensitivity analysis conducted as part of the economic analysis. Production levels were not included in the sensitivity analysis but are as important as the price of coal or capital and operating costs.

Other issues - Discount rate

The discount rate of 7% used through the main part of the Economic Assessment could be considered low. If looking at private investment, the appropriate discount rate to apply to calculate a net present value (NPV) is typically based on the opportunity cost of capital, typically the weighted average cost of capital (WACC) used in the industry concerned. We assume (because the proponent has not made it clear) that the rate of 7% used in the main appendix is a real discount rate (adjusted for inflation) and in addition is a pre-tax discount rate since tax is not included as a cost in the analysis provided. Given this, the discount rate seems low. The discount rate of 10% used in sensitivity analysis may have been more suitable, though conservative, for an Australian commercial rate of return.

If a higher discount rate of 10% were applied to the analysis provided, the net benefits would decrease by approximately one fifth.

A framework for economic assessment of projects

The net present value of the project to the community is difficult to assess using the Economic Assessment, as many of the costs are not listed or understated, while the benefits are likely overstated.

Economic assessment of a resource should consider what economists call its Total Economic Value (TEV). TEV consists of three components – direct use values, indirect use values and non-use values. Direct use values of the area of the proposed Boggabri mine extension include agriculture, recreation and transport.

---

[2] Note that the description of operations at Boggabri from the Idemitsu website states “Coal from the pit is loaded into rear dump trucks and transported to the ROM crusher pad. Coal is then crushed and loaded into B-double trucks for transport to the rail loadout facility via a private 17 km haul road. The coal is then railed to the Port of Newcastle for export.”

Indirect uses refer to how a natural resource produces environmental goods such as air quality, water quality, soil fertility, etc that are enjoyed by people, towns and businesses, even if they are not paid for or consciously used and produced.

Non-use values refer to the value that people gain simply from knowing that a natural or cultural resource – be it a beautiful area, unique country town or threatened species exists.

Although the Economic Assessment discusses direct and indirect use values as well as non-use values, we see that there are several weaknesses in the estimates arrived at.

Direct Use Values

While the direct use values of mining are discussed in the Assessment, there is little discussion of the potential costs to direct uses such as recreation within the state park, or agriculture in the surrounding area.

The calculations of the opportunity cost of use of the state forest land the Economic Assessment only include the value of timber that would be harvested from this land in the future and make no effort to calculate the total economic value of the park, which would also include recreational use values, indirect use values and existence values (see p7-8 of the Economic Assessment).

The park is used by shooters, trail bike riders, naturalists and hikers according to the MCCC. We assume that these users will lose access to a large part of the state park for the duration of the project, and the nature of open-cut mining means that some of the recreational values associated with the site may never be regained. Little information is available on numbers of recreational users, and estimating the economic value of recreation in the area is beyond the scope of this review. However, it is important to note that these values exist, can be significant and have not been included in the economic assessment. A report investigating recreational values of park areas in Victoria, which the same consultants were involved in, estimated consumer surplus values of $30 per visitor (Hassal & Associates & Gillespie Economics 2004). Why similar values were not estimated and included in this report is unclear.

The impact on agriculture in the project area is also hardly considered in the economic assessment. The acquisition of surrounding properties and impacts on properties not to be acquired is discussed, but the implication of these acquisitions on the agricultural production of the area is not considered. Other parts of the MCCC submission address these points in detail, specifically:

- Decline in Rural Property Values
- Competing Land Use
- Farm Productivity
- Shire Rate Increases
- Housing Affordability

These points should have been addressed and quantified in the Economic Assessment.

The project area is also used for road transport that may be compromised. This is also addressed in the MCCC submission and seems to have been inadequately factored into the Economic Assessment.

Indirect use values

Several externalities relating to the mine proposal are mentioned without considering indirect use values of the project site that may be lost – air quality, noise and vibration, water impacts and visual impacts. These impacts of the proposed mine may be mitigated by the acquisition of surrounding properties, though this debated by other submissions, but no attention is paid to the loss of air quality, the qualities of peace and quiet and visual amenity that are provided by existing woodland and the state park.

While the water impacts of the mine may be contained – again something that is debated by experts – the loss of watershed and aquifer recharge is not considered in the Economic Assessment. The discipline of environmental economics provides many tools for measuring these costs and why some effort to quantify them was not included in the Assessment is not clear. Other parts of the MCCC submission address water, air quality issues, though without economic quantification.

Another indirect use of land is as a greenhouse gas (GHG) sink. While the GHG emissions of the mine operations themselves are discussed in the Assessment, there is no mention of the value of the state forest as a carbon sink which will be lost.

The GHG emissions of burning the coal produced by the Boggabri mine is the elephant in the room of the GHG discussion. This is addressed in more detail in part of the MCCC's submission by Prof Ian Lowe. Professor Lowe's estimate that the burning of 7Mta of coal produces 20-25million tonnes of CO2, would result in costs of $0.6 billion to $0.75 billion per year at the Economic Assessment's chosen carbon price of $30 per tonne. This is considerably more than the annual revenue of the mine.

The cost of burning this coal is distributed across the globe through climate change, and how much of it should be relevant to the discussion of NSW and the mine area is debateable. At the very least the BCA should state the cost per tonne of CO_2e, at which the NPV is reduced to zero. This would at least the put this externality into perspective alongside the alleged benefits.

Given the global cost of carbon emissions the BCA should state the costs unequivocally. It may indeed be true that on a global basis this project is a net negative whilst it is a benefit to NSW. Good public policy and sound BCA requires sound, transparent analysis that allows the truth to stand where it may. If the public of NSW decided to profit at the expense of the global community then they should be aware of the choice they are making and not have it covered up as this analysis appears to do. In addition, however, it is logically and internally inconsistent of the Economic Assessment that it includes discussion of benefits that will be exported internationally to Idemitsu owners, without discussing the export of the costs.

Non Use values

Social value of employment

The Economic Assessment discusses and places a value on the existence values that the NSW public places on rural jobs and communities, but with little discussion of similar values that might be placed on endangered habitat types or aboriginal heritage.

While discussion of the social and economic value of employment is valuable, it is critical in any such discussion of wider economic impacts to include a full explanation of both the benefits and the costs associated with a project. This consideration and valuation of employment clearly focuses purely on the benefits, with little regard for the many costs.

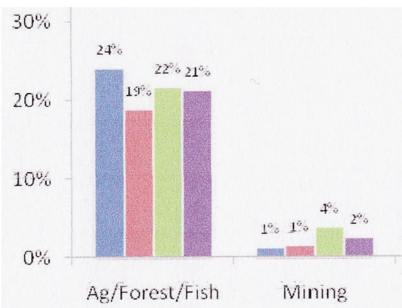
The economic logic of applying existence values to employment is theoretically correct. It may be possible that the Australian public is willing to pay to preserve the jobs in the Boggabri coal mine. Whilst possible this is a highly unlikely probability that the Australian community would pay to support these jobs in a mining boom or at any other time, given the extensive labour shortages in this industry and country and the high wages already being earned at alternative mining locations. Is it logical that the Australian community would pay workers to continue at Boggabri when other mines, possible even nearby, are looking for such workers? Any claim of this magnitude must be backed by some form evidence by appropriate peer reviewed willingness to pay studies subjected to the same thorough standard as WTP studies conducted for environmental existence values.

It is also important to realise that the values mentioned in the Economic Assessment regarding employment are derived not from a study relating to the Boggabri mine, but to a mine in the Illawarra, Bulli Seam Operations (see (Gillespie Economics 2009). This is important, as the two mines differ in two significant ways.

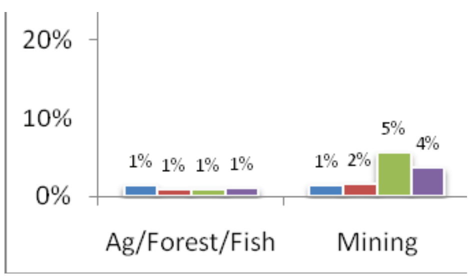
Firstly, the Illawarra Bulli Seam operation is an underground, longwall mine, while Boggabri is open cut. The choice modelling survey presented to respondents was based on environmental issues such as land subsistence and impacts on local streams – hardly comparable to open cut mining of a state park with listed threatened ecosystems. If Option 6 of the Boggabri mine extension proposal was being considered, perhaps this would be a relevant study, but it seems unlikely respondents would give similar answers to the open cut option.

Secondly, the Bulli Seam operation is in an area where coal mining plays quite a different role in the local economy. Note in the graphs below, taken from the Bulli Seam report and the Boggabri Mine extension Economic Assessment, that coal mining is a larger part of the Illawarra economy than agriculture, while in the Boggabri area agriculture is dominant.

Taken from Figure 3.1 of Boggabri Mine Extension Economic Assessment, p16



Taken from figure 3.1 Bulli Mining Operations Socio-Economic Assessment p31



In the above graphs the bars represent employment, household income, gross regional product and regional output as a proportion of the respective regional economies. It seems unlikely that respondents would place the same value on 238 mining jobs in an agricultural area, in a open cut mine that may threaten agriculture, as they would on 1,170 mining jobs in an underground mine in a traditional mining area. We suggest that the $238M figure for social value of employment generated by the Boggabri mine is misleading and should be revised before being incorporated into decision making.

Existence values of habitat

The Boggabri Mine Extension proposal results in the destruction of federally listed "box-gum" woodlands and grasslands. In the Economic Assessment this loss is given a zero economic value as it will be "offset". Whether or not this habitat can be replaced by offset plantings is beyond our field of expertise, however, it is contrary to environmental economic practice, where natural habitat is assigned an existence value, much like the social value of employment discussed above. Even if people have no plans to visit this habitat, they will still place a value on knowing that it exists in its natural state. The assignment of a zero value to this cost is inappropriate.

There are many studies that discuss the existence values of Australian ecosystems, see for example (Gillespie Economics et al. 2007) which found the Victorian public placed a value of up to $3.29 per household per 1,000ha on river red gum forest conservation. It is unclear why a value has not been estimated for the values the NSW public places on the 1,500ha of woodland that will be cleared for this project.

Aboriginal Heritage

Aboriginal heritage is not assigned a value in the Economic Assessment as their "monetisation …is problematic" (p10). This is disappointing as the consultants have estimated aboriginal heritage values in other studies, such as (Gillespie Economics 2009, see p10 and p28 of the associated CM survey appendix). Why the social value of employment was transferred from this Illawarra study to the Boggabri study, but not values of Aboriginal heritage is unclear.

Cost Benefit assessment of economic values

In light of the above analysis, it is instructive to review the analysis presented in the Economic Assessment.

Costs	*EA valuation*	*Economists at Large opinion*
Opportunity cost of state forest land	$2,000,000	Understated. Recreational use and indirect use values not included. Based only on timber values. Also does not consider loss of agricultural productivity through the purchasing of existing rural properties.
Air quality	Zero value, offset by acquisition of some properties	Understated as does not consider impact on agriculture and the impact of the acquisition program
Greenhouse gasses	$138,000,000	Heavily understated, with no consideration of carbon sinks or of end use of coal.
Noise and vibration	Zero value, offset by acquisition of some properties	Understated as no consideration made of impact of the acquisition program
Ecology	Zero value due to environmental offset program	Understated as does not consider existence value of natural habitat, or take into account the near impossibility of replacing it to the same quality.
Groundwater	Zero value	Understated, as does not consider the loss of forested areas for groundwater recharge.
Traffic transport	Zero value	Unknown
Aboriginal Heritage	Zero value "negligible impacts"	Understated, aboriginal heritage values are calculated in other studies and should be included as a cost of this project.
Visual impacts	Zero value	Understated as does not consider the loss of local visual amenity
Surface water	Negligible impacts	Understated as does not consider the loss of runoff area into watersheds.
Total costs	$140,000,000	Heavily understated due to the above issues.
Benefits	*EA valuation*	*Economists at Large opinion*
Royalties	$642,433,367	Overstated due to assumption that mine always operates at full capacity.
Social and economic values of employment	$234,000,000	Heavily overstated, as this value has been transferred from an underground mine in the Illawarra, an area with different socio-economic background.
Total benefits	$876,433,367	Overstated due to the above issues
NPV	$736,433,367	Heavily overstated due to the above issues. Unclear if this is a positive value and therefore if the project should proceed. It seems unlikely that the open cut option for the project is the optimal scenario for the local community or the state of NSW.

The overstatement of benefits and understatement of costs of the project mean that the modelling results for the Economic Impact Assessment are heavily compromised and should not be used for decision making purposes. It should also be noted that aggregate output or expenditure figures do not represent real economic value, only the size of a particular activity. A more accurate measure of economic value would be based on the value added to the Australian economy as a result of the gross figures above.

Conclusion

Economists at Large believe the Economic Assessment of the Boggabri Coal Mine Extension Project should be revised before a decision is made on the project. The Assessment confuses analysis of private financial decision making with economic assessment, which, combined with the lack of alternative scenarios, makes assessing the value of the project to the public difficult.

The understatement of costs and overstatement of benefits of the project, by omission or methodology, further reduce the usefulness of the Assessment. We hope that this review clarifies some of the Assessment and we would be happy to further explain any points.

Francis Grey Simon O'Connor Tristan Knowles Rod Campbell

(Directors of Economists at Large)

Email: info@ecolarge.com
Tel: +61 3 9005 0154
Fax: +61 3 8080 1604

References

Belli, P., Anderson, Jl, Barnum, H., Dixon, J., Tan, J., 1997. *Handbook on Economic Analysis of Investment Operations*, World Bank, Operations Policy Department.

Gillespie Economics, 2009. *Bulli Seam Operations, Appendix L, Socio-Economic Assessment*, Prepared for Illawarra Coal Holdings Pty Ltd.

Gillespie Economics, DCA Economics & Environmental & Resource Economics, 2007. *River Red Gum Forests Investigation – Socio-Economic Assessment*, Prepared for the Victorian Environmental Assessment Council.

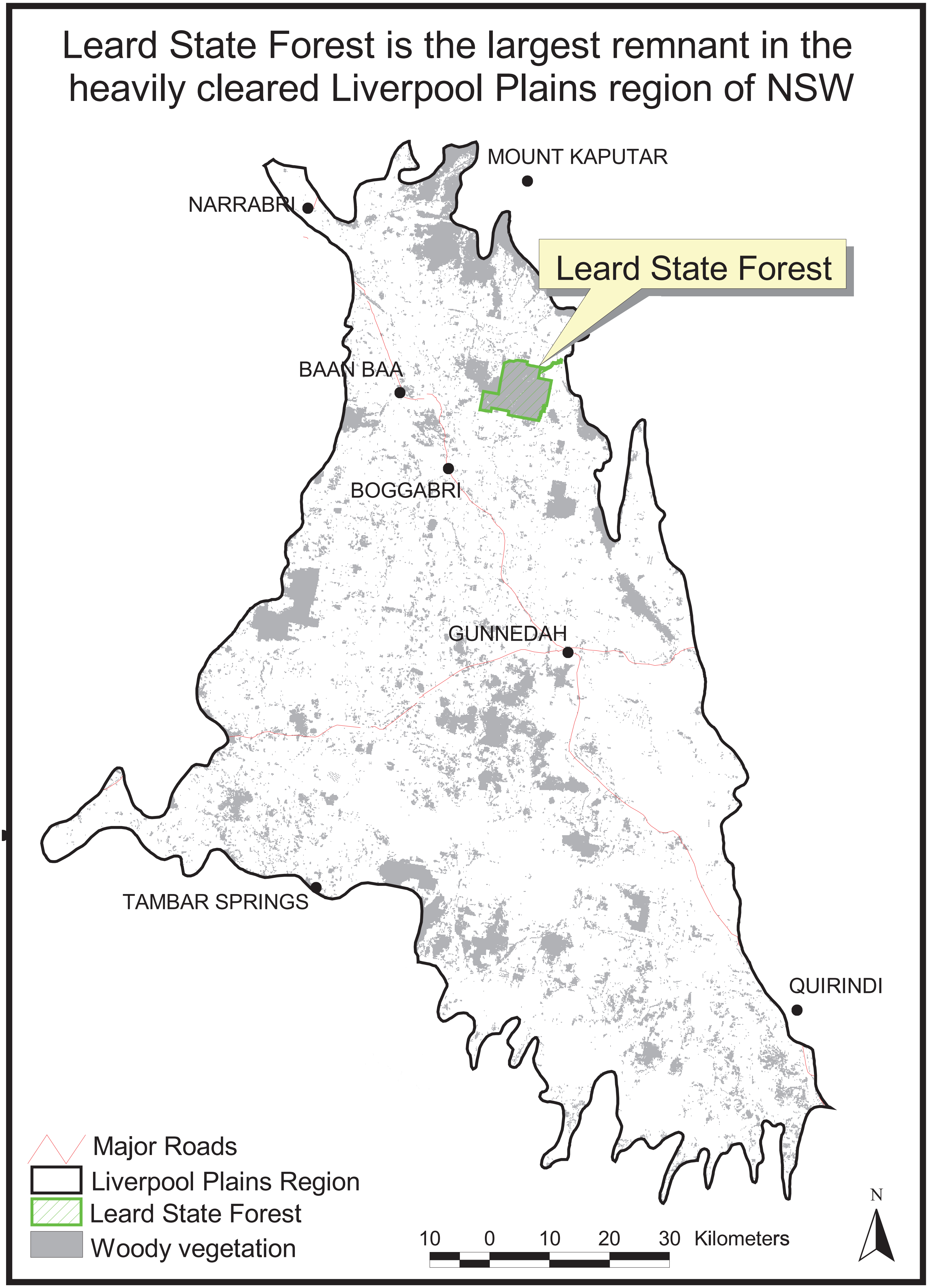
Gillespie, R. & James, D., 2002. *Guideline for economic effects and evaluation in EIA*, Prepared for Planning NSW. Available at: http://cmsdata.iucn.org/downloads/11_guideline_for_economic_effects.pdf.

Hassal & Associates & Gillespie Economics, 2004. *Quantifying the Economic Value of River*

Dependent Industries in the Southern Murray-Darling Basin, Prepared for Australian Conservation Organisation.

Appendix 8

Map of remnant forest in the Liverpool Plains region provided by Carmel Flint, National Parks Association



Leard State Forest is the largest remnant in the heavily cleared Liverpool Plains region of NSW
MOUNT KAPUTAR
NARRABRI
Leard State Forest
BAAN BAA
BOGGABRI
GUNNEDAH
TAMBAR SPRINGS
QUIRINDI
Major Roads
Liverpool Plains Region
Leard State Forest
Woody vegetation
10 0 10 20 30 Kilometers
N

Appendix 9

Copy of Supplementary General Manager's Report to Narrabri Shire Council, August 2010

14. COUNCIL REPORT

Subject: Maules Creek Community Council; Leards Forest Road - SR12

Author: Director Engineering Services

Conflict of Interest: Nil

RECOMMENDATION 1: That Council receive and note the minutes of the public meeting at the Maules Creek Community Hall on 14 December 2009 in relation to the proposed closure of Leards Forest Road - SR12, as a result of mining activities of Boggabri Coal Pty Ltd

RECOMMENDATION 2: That Council receive and note the petition in relation to the proposed closure of Leards Forest Road - SR12, as a result of mining activities of Boggabri Coal Pty Ltd

RECOMMENDATION 3: The Council receive and note the report outlining the Maules Creek Community Council's concerns and recommendation in relation to the proposed closure of Leards Forest Road - SR12, as a result of mining activities of Boggabri Coal Pty Ltd

RECOMMENDATION 4: The Mayor and Council staff meet with Boggabri Coal Pty Ltd to discuss the concerns and recommendations of the Maules Creek Community Council in relation to the proposed closure of Leards Forest Road - SR12, and a possible solution to these concerns.

Issues

The purpose of this report is to allow Council to receive a petition and note the concerns and recommendations from the "Maules Creek Community Council" in relation to the future of Leards Forest Road - SR12

Background

The proposed impact on Leards Forest Road - SR12 by the expansion of the Boggabri Coal Pty Ltd coal mine is well documented and has been discussed at length by Council.

*****

The development conditions for the coal mine state that;

> *"In the event of Shire Road 12 (Boggabri – Maules Creek) being closed as a result of the development, a deviation via Shire Road 26 (Boggabri – Goonbri) and 167 (Goonbri - - Stewarts) shall be constructed and maintained at the applicant's cost and to the satisfaction of the Narrabri Shire Council."*

*****

At a public meeting held at the Maules Creek Community Hall on the 14 December 2009 Council staff explained the potential impacts of the Boggabri Coal Mine on Leards Forest Road - SR12. The minutes of the meeting are provided in **Attachment 14.**

*****

After an analysis of the costs associated with the above condition Council has advised Boggabri Coal Pty Ltd that Council prefers a deviation along SR11 instead of the SR26 and SR167. This arrangement has had in principle agreement from both sides. Council believes the cost of such work would be $7.8 million (Resolution 176/2010). Boggabri Coal are yet to formally "offer" this as a solution.

> *"176/2010 RESOLVED on the motion by Councillor Kelly/Bates that the Council endorse the contributions from Boggabri Coal Pty Ltd for their expansion project as follows:*

Upgrade to the Boggabri Caravan Park and Swimming Pool Complex	*$1,600,000*
Recognition of Ben Lexcen through a statue	*$ 50,000*
Various seating allocations throughout Boggabri	*$ 20,000*
Boggabri HACC (this allocation to be made direct to Boggabri HACC)	*$ 200,000*
Upgrade to Harparary Road and bridge including three culverts	*$7,800,000*
Total Allocations	*$9,670,000*

"

*****

Current Situation

Various emails from the Maules Creek Community Council can be summarised as follows.

The residents of Maules Creek had a community meeting at 1.30 PM on Sunday the 25th of July to address community concerns regarding the impact of coal mining in the Maules Creek and surrounding areas. The meeting was well attended and passed three resolutions with the third resolution being in the area of the Narrabri Shire Council.

The three resolutions have been reproduced as follows;

1. Positive force:

> "That the meeting recognise that the mining companies have a legitimate right to mine and that our community should foster a positive relationship with the mining companies for the benefit of both parties."

2. Form a committee:

> "That the meeting elect a committee to be known as "Maules Creek Community Council" for the purposes of:

(i) Gathering and disseminating mining and related information to the community.

(ii) Liaising with the various mining companies, government and other bodies on behalf of the community.

(iii) Develop a shared strategic direction that allows us to address concerns as to the negative impacts of mining on our community and enable us to work with the various companies for the good of the community.

(iv) Work with our local community groups to coordinate future community program budgets.

3. Prepare a petition and resolution to Council regarding the Leards Forest Road issue:

Agreed that a motion would be put to Council as follows:

"That, irrespective of any agreement to seal the Harparary Road (Shire Road 11) to the Kamilaroi Highway near Baan Baa, this meeting of ratepayers consisting mainly of people from the Maules Creek area, wish to communicate to the Council that if Shire Road 12 through the Leard Forest is closed, then a gravel road be constructed on or near the public road from the "T" intersection near Thornfield to connect with the Manilla Road, East of the Leard Forest."

Following meeting and discussions with Council staff Recommendation 3 has been refined on the 9 August 2010 as follows

"That, irrespective of any agreement to upgrade the Harparary Bridge and/or Harparary Road (Shire Road 11) to the Kamilaroi Highway near Baan Baa, Council agree that in the event Shire Road 12 through Leard Forest is closed (whether permanently or temporarily, and whether wholly or partially), a deviation through or adjacent to Leard State Forest be constructed and maintained throughout the closure period."

The petition referred to in recommendation 3 is provided as **Attachment 14**.

The Maules Creek Community Council provided the following in support of Recommendation 3 above;

1. The Leards Forest Road provides a link for the emergency services. For example, emergency medical access in times of flood, a important route for fire fighters in the advent of fire, it provides direct access to Upper Maules Creek to the Boggabri Police should they be required. **No access could have very serious consequences in times of emergency and for this reason alone the access should be retained.**
2. The link to the Manilla Road is vital for farming interests as it provides a freight corridor for farm inputs such as fertiliser and store stock and is the outlet for produce such as finished stock to the Tamworth abattoir, feed grain to the chicken sheds and feedlots, malt barley to the maltsters in Tamworth, feeder cattle to Caroona Feedlot and the Gunnedah Saleyards. The additional distance will add significantly to farm freight costs.

3. The link to the Manilla Rd is very important to older and sick residents as most of the districts medical specialists reside in Tamworth. In addition serious medical conditions usually require a stay in the Tamworth Base Hospital and closing the Leards Forest Road will add an extra 50 kms each way for sick, elderly and infirm residents who must travel to Tamworth regularly.
4. Professional, recreational, educational and shopping facilities are all located in Tamworth and the residents of Maules Creek have for many years used the Leards Forest Road to access these. It is our expectation that the Boggabri Coal mine should in no way impact on these by way of additional cost in money, time or convenience.
5. The Leards Forest Road provides the most direct link for Maules Creek and surrounding area workers to the Boggabri Coal Mine. Imagine the ridiculous situation where a Maules Creek miner or contractor would be required to drive to the Boggabri Mine from Maules Creek to the Kamilaroi Highway and Manilla Road and back to Maules Creek.

The Maules Creek Community Council obviously have concerns in relation to the permanent closure of Leards Forest Road - SR12, as a result of mining activities of Boggabri Coal Pty Ltd.

In the interest of long term good community relations Boggabri Coal may be in a position to satisfy Council and the Maules Creek Community Council.

Attachments

Attachment 14:	Minutes of Public Meeting held 14 December 2009 Petition from Maules Creek Residents

Financial Implications

The approximate cost to construct and maintain 11 km of Leards Forest Road - SR12 (ie around the perimeter of the mining lease) in the same condition as it currently is (on the same natural ground conditions), would be

Construction	$900,000 (assuming gravel is purchased)
Annual Maintenance	$ 10,000 / pa
Annualised Resheeting	$ 45,000 / pa (assuming gravel is purchased)

The reconstruction costs would be an additional financial burden if Council met them. Should Leards Forest Road - SR12 be left open and Council was responsible for its maintenance and resheeting the above costs would represent a loss of potential savings.

Statutory/Legal Implications

Nil

Environmental Implications

Nil

Management Plan/Strategic Plan

Nil

Narrabri Shire
Heart of the North West

NARRABRI SHIRE COUNCIL

Narrabri Shire Council & Maules Creek Residents

MINUTES

Meeting held on Monday 14 December 2009 at 6.30pm at Maules Creek Hall.

1. **Welcome – Attendees Present**
   - Paul Keech, Director Engineering Services
   - Nick Wilton, Environmental Services Manager
   - Lew Oldfield, Special Projects Engineer
   - Cr Lester Kelly
   - Cr Cathy Redding
   - Cr Peter Ethridge
   - Cr Ken Bates
   - Raoul Edwards, Resident
   - Derek Williams, Resident
   - Lloyd Finlay, Resident
   - Chris Morse, Resident
   - Jim Holmes, Resident
   - Steve Bradshaw, Resident
   - Bruce Laird, Resident
   - Joan Bradshaw, Resident
   - Peter Buckman, Resident
   - Doug Whan, Resident
   - Rex Hannaford, Resident
   - Syd Brown, Resident
   - Col Gleudear, Resident ??
   - Joyce Brown, Resident
   - Marty & Karen Brennan, Residents
   - Kelly Foran, Resident
   - Helen Busby, Resident
   - Glenn Holmes, Resident
   - Tamara Palmer, Resident
   - Kiara Woods, Resident
   - Todd Coleman, Resident
   - Cathy Coleman, Resident
   - Leone Buckman, Resident
   - Rachel Morse, Resident
   - Wilma Laird, Resident
   - Peter Morse, Resident
   - Colin Greenaway, Resident
   - Amy Johnson, Resident
   - Sue Johnson, Resident
   - J Duncan, Resident
   - P Woods, Resident
   - Greg Johnson, Resident
   - M Busby, Resident
   - AM Rasmussen, Resident

2. **General Business**

- Cr Lester Kelly made introductions and welcomed everyone to the meeting.
- Paul Keech gave a general introduction to the meeting regarding coal mining in Leards Forest and the potential impact on Leards Forest Road (SR12).
  - 1988 – Development Application for Mining in Leards Forest was established;
  - Council's preferred conditions were presented to the meeting (Extract from Letter to Department of Planning 27/7/1988):

    "x *In the event of Shire Road No. 12 (Boggabri – Maules Creek) being closed as a result of the development, a deviation via Shire Roads No. 26 (Boggabri – Goonbri) and 167 (Goonbri – Stewarts) shall be constructed and maintained at the applicant's cost and to the satisfaction of the Narrabri Shire Council."*

Telephone: (02) 6799 6866
Fax: (02) 6799 6888
Email: council@narrabri.nsw.gov.au
46-48 Maitland Street
Post Office Box 261
NARRABRI NSW 2390

- The development condition relating to SR 12 was also explained to the meeting:

  "9. (a) *The applicant shall maintain road access at all times for residents of Maules Creek and meet the requirements of the Council in the selection and construction and maintenance of alternative road access and meet the cost of such road works;"*

- Advised that the Mine already have the approval to close SR12 and the purpose of this meeting is to discuss the alternative routes.
- An overview of mining expansion was displayed and advised that it will be approx 5-10 years before the operations will impact on SR12.
- Alternative Route Options
  - To "tic-tac" either side of SR12 as the mining operations move throughout the forest;
  - Improve and connect SR26 along the eastern side of the forest to the northern end of SR12;
  - Seal the remainder of SR11 and replace Harparary Bridge.
- The issue of flooding and all weather access was raised;
  - SR 12 is the main road out of the area in times of flooding
  - Residents need access to Manilla Road (MR357)
  - Residents feel that the only "all weather" access would be through SR26 or east of the mining operations
- If SR26 is to be the alternate route the causeways and bridges would need to be upgraded, and would also like to see inclusion for "Wide Loads"
- Paul Keech advised the meeting that there has been no Council resolution regarding this arrangement and that this is the starting point to finding a solution.
- The residents felt that Council was pushing for the SR11 route as there would be more financial incentive for the Council to get this road sealed and a new bridge.
  - Paul Keech advised that SR 11 is a collector road and any contribution to a collector road would be an advantage to Council however at this stage Council is not pushing for any specific solution and is happy to discuss any and all options.
- Residents were very concerned that SR 12 could close without a "viable" alternative route in place.
  - Paul Keech advised that is why Council is holding the public meeting early to ensure that Council understands all of the issues before deciding what it believes is a viable alternative route to SR12.
- A resident advised that they would like to see SR26 as a B-Double Route
  - Paul Keech advised that this would be investigated, but unlikely.
- A resident advised that they would like to see no mine trucks allowed on Shire Roads and if they do have to cross the road that the Mine Trucks have to stop not the local traffic.

Telephone: (02) 6799 6866

Fax: (02) 6799 6888
Email: council@narrabri.nsw.gov.au

46-48 Maitland Street
Post Office Box 261
NARRABRI NSW 2390

- A resident advised that the matter should be referred to the Local Traffic Committee and the Local Rescue Committee for their comment.
- A resident asked what the next step is that needs to be taken.
    - Paul Keech advised that the minutes of this meeting would be presented to a future meeting of Council and that Council will continue discussions with Boggabri Coal and the community until Boggabri Coal indicate when they would like to close SR12.

3. Conclusion

- The residents of Maules Creek that were represented at this meeting agree that they would prefer an alignment to the east of the mining operation (ie: SR26 or similar) as the alternative route around the Leards Forest with the main objective being to connect Maules Creek to a main road via a “flood free” route.

4. Meeting Closed 7.35pm

- Cr Kelly closed the meeting and thanked everyone for attending

Telephone: (02) 6799 6866

Fax: (02) 6799 6888
Email: council@narrabri.nsw.gov.au

46-48 Maitland Street
Post Office Box 261
NARRABRI NSW 2390

Leards Forest Road Petition – 25/7/2010

To: Robin Faber
Mayor
Narrabri Shire Council
Narrabri. NSW. 2390.

We the undersigned electors of the Narrabri Shire request that the council:-

1. **Recognise that the Maules Creek community have always had a road service to the Manilla Road and beyond and that the community wants this service maintained.**
2. **Recognise that the community has a legitimate need to travel to the Manilla Road and beyond. For example emergency medical, access in times of flood, transport of livestock and grain, etc**
3. **Confirm that the council will ensure that it will work toward the communities preference for a direct route from Upper Maules Creek to the Manilla Road.**
4. **Maintain a proper flow of information so as to keep the community informed as to the status of the works.**

Name	Address	Signature
Fiona Morse	"Willowdale" Boggabri	[illegible]
Natalie Cameron	"Middle Creek" Boggabri 2382	N Cameron
Kelly Foran	"HAPPY VALLEY" Boggabri 2382	K Foran
Brenda Simmonds	Mountain View Boggabri 2382	K K Simmonds
Cathy Coleman	Cardean 897 Maules Creek Rd	Cathy Coleman
Rosalyn Druce	"Wongaba" Maules Ck Bogg. 2382	R Druce
Andrea Todd	25 [illegible]	[illegible]
LLOYD PENNY	"MT WINFIELD" BOGGABRI	[illegible]
WILLIAM LAIRD	'ROSELYN' BOGGABRI 2382	[illegible]
Ellen Fleming	Oakleigh Boggabri	Ellen Fleming
REX HANNAFORD	'RIVERS' BOGGABRI	[illegible]
Margaret Young	'Warrinbool' Maules Creek	M. Young
BILL POWNALL	KULABAH NARRABRI	[illegible]
Keith Greenaway	Glencoe Boggabri	Keith Greenaway
[illegible]	'HANOVER' BOGGABRI	[illegible]
Doug Wland	Tommy Boggabri	[illegible]
[illegible]	[illegible] Boggabri	[illegible]
B Todd	'East Lynne' Boggabri	[illegible]
Peter Todd	" "	[illegible]
John Busby	"Montrose" Boggabri	[illegible]
Clare Felton-Taylor	PO BOX 630 Narrabri	C. Felton-Taylor
Tracey Laird	Middle Creek South Maules Creek	[illegible]
RICK LAIRD	MIDDLE CREEK SOUTH Maules Ck	[illegible]
ROD WOOLFORD	635 BLACK MOUNTAIN CK R	[illegible]
C Simmonds	Mountain View Boggabri	[illegible]