Maules Creek Community Council Inc
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14 June 2011

Committee Secretary
Senate Standing Committees on Rural Affairs and Transport
PO Box 6100
Parliament House
Canberra ACT 2600

Dear Sir/Madam;

Re: Coal Seam Gas and the Murray-Darling

We are writing to you on behalf of the Maules Creek Community regarding coal seam gas (CSG) exploration in our area. We have serious concerns about the CSG industry, the lack of contemporary regulation and the risky operational practices, which are standard for the industry. Our generic concerns are outlined in Appendix 1.

We have serious concerns as to the location of PEL 459. This PEL covers the Kaputar National Park and the associated Nandewar Range. This PEL is located in the headwaters of the Maules Creek Catchment which is a tributory to the Namoi River and the Murray Darling Basin.

The evidence to date shows that the extraction processes for CSG, the risk to ground water and the contamination of the surface from "produced water" (See Appendix 2) makes this land use patently unsuitable for highly sloping land at the top of a major water catchment.

In addition researchers have found that the Maules Creek Catchment that flows from the Nandewar Range contains a unique Groundwater Dependent Ecosystem (GDE) that can be seriously impacted by changes in groundwater levels or groundwater chemistry. Either impact is a normal part of the CSG industry that requires drilling with drilling fluids and dewatering the coal seams.

The GDE of the Maules Creek Catchment are nationally significant and are currently being assessed as a threatened Ecological Community under the EPBC Act. The application for listing under the EPBC Act can be found in Appendix 3.

Given that the company is largely foreign owned and the gas will be exported leaves us in no doubt that any CSG developments in this area are unlikely to positively improve the environment or the welfare of our district and for this reason we are totally opposed to the development of this exploration lease.

Thank you for your consideration of this matter. Should you wish to discuss it further, please contact any of the individuals listed above or go to www.maulescreek.org.

Regards
MCCC Inc

Appendix 1 – Concerns re Coal Seam Gas

Coal seam gas represents a major threat to the Murray-Darling Basin.

The proposed scale of the industry across NSW and Queensland means that the cumulative impacts on rural landscapes, water resources, communities and the environment will be severe.

In the Namoi Catchment in NSW, the coal seam gas industry is posed to impact not only on the best farmland but also the best bushland, and it looks set to simultaneously degrade both our productive base and our ecological base.

Experience with coal seam gas exploration and pilot production in the Pilliga Forest, part of the Murray-Darling Basin, has revealed the following serious threats to the Basin:

- Saline water spillage leading to tree deaths, salt scalds and contaminated soils.
- Overflow of drill ponds leading to contamination of creeks.
- Potential de-watering and cross-contamination of aquifers, including the Great Artesian Basin.
- Discharge of treated water changing the ecology of local creek systems and reducing water quality.
- Use of large volumes of water for drilling and fracking, leading to increased pressure on water resources.
- Construction of major toxic water storage impoundments and associated environmental impacts.
- Toxic water storages left open to wildlife, leading to animal deaths.
- Clearing and fragmentation of high conservation value vegetation.
- Destruction of large areas of habitat for threatened species.
- Dramatically increased fire risk.
- Threats to important groundwater dependent ecosystems and wetlands
- Pipelines degrading important agricultural lands and risking high conservation value areas such as Travelling Stock Routes

If allowed to continue, the coal seam gas industry will:

- Transform rural landscapes into industrial zones

- Forever change the socio-economic profile of communities, with a fly-in/fly-out workforce that does not participate in the community.
- Undermine regional communities who depend on cohesion and resilience
- Represent a serious threat to water resources, including the Great Artesian Basin
- Result in farmers losing control of their land
- Provide property rights to miners rather then the custodians of the land
- Undermine the rights and interests of Traditional Owners
- Represent a health risk due to methane leakage and aquifer contamination.

We believe that, due to these serious risks:

- Coal seam gas extraction should be banned in the Murray-Darling Basin.
- It should be prohibited on prime farmland, bushland and anywhere associated with important aquifers.
- Landholders should have the right to veto coal seam gas extraction or exploration.

Appendix 2 - Risks to Groundwater and Surface Contamination

See Attached Document – Risk to Groundwater from CSG.pdf

This document from Bridle and Harris outlines in detail impacts to groundwater in the Surat Basin. Given that the Surat Basin and Queensland in general is more impacted by CSG than the MDB at this point, the above document is a look into one potential future.

See Attached Document – CSG Produced Water.pdf

This document from Hann details the contaminants in the “produced” water from a coal seam gas well. The produced water is a major issue and at present companies are simply dumping the brine or the solids in the sea. How this can be allowed is beyond belief.

Appendix 2 – Application for EPBC Listing of GDE of the Maules Creek Catchment

Nomination Form - Threatened Ecological Community - 2011 Assessment Period
Use this form to nominate or change the listed status of an ecological community on the list of threatened ecological communities under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

The information set out in this form is required for the nomination of a threatened ecological community (TEC) under Division 7.2 subregulation 7.05 (3) of the *EPBC Regulations 2000*. Nominations which do not meet the Regulation requirements are ineligible for consideration and will not be prioritised for assessment.

The Regulations are available from: www.environment.gov.au/epbc/about/index.html

Please read these important notes for completing this form:

- The nomination form is separated into seven sections, each comprised of a series of questions.
- Complete the form as far as possible. Please use as much space as is required to fully answer each question. Where there is insufficient information available to answer a question please indicate this rather than leaving the answer blank.
- The Threatened Species Scientific Committee (the TSSC) has developed Guidelines to assist nominators in providing the necessary information about a nominated ecological community to enable its assessment. The Guidelines should be read in conjunction with this form.
- The Guidelines include important information to assist in completing particular sections and questions of this form. They include the statutory criteria for the 'critically endangered', 'endangered' and 'vulnerable' categories.
- The Guidelines also include indicative thresholds, which may be used by the TSSC to assess whether an ecological community is eligible for listing against the criteria prescribed by the EPBC Regulations. It should be noted that the TSSC does not adhere strictly to these thresholds, but has regard to them when making judgements about ecological communities on a case-by-case basis. In particular, they may not be applicable to all types of ecological communities.
- The completed nomination form is intended to be read and understood by the TSSC without the need to refer to any external references. Therefore all questions must be answered in writing, with relevant sources quoted directly and full references to source documents, or personal communications with experts, provided in the nomination.
- It is important for the TSSC to have clear and comprehensive information and the best case on which to judge an ecological community's potential eligibility against the EPBC Act criteria for listing. Clear and comprehensive nominations (where data exists) have a greater likelihood of being prioritised for assessment.
- To ensure you have the most up to date information, it is recommended that you contact relevant Natural Resource Management authorities in the region(s) where the ecological community occurs. For details see: www.nrm.gov.au.
- Completing this form assists the TSSC to gain an understanding of the ecological community at the national scale. In that sense, it is important that you **consider the full, national extent of an ecological community,** not just its occurrence in specific areas or regions.

Important notes continued

- For all facts and all information presented - identify your references and sources of information. Document the reasons and supportive data. Indicate the quality of facts/information and any uncertainty in the information. For example, was it based on a peer-reviewed research publication or anecdote; or on observed data, an inference/extrapolation from the data, or a reasonable premise not yet supported by hard data?

- Personal communications - The opinion of appropriate scientific experts may also be cited (with their approval) in support of a nomination. If this is done the names of the experts, their qualifications and contact details should also be provided at the end of this nomination.

- Confidential material – Identify any confidential material and explain the sensitivity.

- Tables – Can be included at the end of the form or prepared as separate electronic documents included as appendixes or attachments. Refer to tables in the relevant area of the text.

- Maps – Must be supplied and are to be adequately labelled. If maps cannot be supplied electronically, please provide them in hardcopy.

- Photographs – Are to be adequately labelled and used as supporting material only. The criteria need to be addressed in written form.

- Cross-reference relevant areas of the nomination form where needed (but answer each question thoroughly).

- If the ecological community is considered to be affected by climate change, please refer to the Appendix 2 of the Guidelines: **Addressing climate change as an important threat** prior to completing the nomination form.

More detailed information on all listing categories for threatened ecological communities can be found in Section 182 of the EPBC Act and the statutory criteria can be found in Division 7.1 of the *EPBC Regulations 2000*. These are available at: www.environment.gov.au/epbc/about/index.html

For questions regarding nominations contact:

The Director
Ecological Communities Section
Department of Sustainability, Environment, Water, Population and Communities
GPO Box 787
Canberra ACT 2601
Telephone (02) 6274 2317

Section 1 - Nominator Details Note: Nominator details are subject to the provision of the *Privacy Act 1988* and will not be divulged to third parties if advice regarding the nomination is sought from such parties.	
Full Name	Phillip Laird, Alistair Todd
Organisation or Company name	Maules Creek Community Council Inc
Postal address	“Middle Creek”, Boggabri. NSW. 2382.
Email	upthecreek2382@gmail.com
Phone	
Fax	
I declare that the information in this nomination form and any attachments is true and correct to the best of my knowledge.	
Signature **(Or insert electronic signature)**	
Date signed	22.3.2011

Section 2 - Summary of eligibility	
Name of the ecological community	Groundwater Dependent Ecosystems of the Maules Creek Alluvial aquifer
Listing Category for which the ecological community is nominated under the EPBC Act	
Current listing category (Please check box)	☐ Critically endangered ☐ Endangered ☐ Vulnerable ☒ None – not listed
Proposed listing category (Please check box)	☒ Critically endangered ☐ Endangered ☐ Vulnerable
Select one or more of the following criteria under which the community is nominated for EPBC Act listing. (Please check box). For further details on these criteria please refer to the Guidelines for to this form. The information you provide in Section 5 should support the criteria you select.	☐ Criterion 1 – Decline in geographic distribution ☒ Criterion 2 – Small geographic distribution coupled with demonstrable threat ☐ Criterion 3 – Loss or decline of functionally important species ☐ Criterion 4 – Reduction in community integrity ☐ Criterion 5 – Rate of continuing detrimental change ☐ Criterion 6 – Quantitative analysis showing probability of extinction

Section 3 – Description, Condition, Threats & Recovery

Please answer all of the questions, providing references where applicable. If no or insufficient information exists to answer a question, in accordance with the *EPBC Regulations 2000*, you must indicate this instead of leaving the question blank.

The answers may be provided within this form, with attachments as required, or in separate document. If the nomination is provided in a separate document you must provide; all contact details requested in Section 1 including the signed declaration; a completed summary of eligibility (Section 2) and ensure that responses clearly indicate which question number they refer to.

Conservation Theme

*Please note: There is no conservation theme for the 2011 assessment period

1. Does the nomination meet any of the conservation themes selected for this assessment period?

***Not applicable in 2011.**

Classification

By nominating a broader community, you will enable the Committee to consider the national extent and condition of the community and determine the limits of the listed ecological community.

2. What is the name of the ecological community?

Note any other names that have been used recently, including where different names apply to different jurisdictions. For example, is it known by separate names in different States or regions?

"Groundwater Dependent Ecosystems in the Maules Creek Alluvial Aquifer (GDEMCAA). "

Groundwater Dependent Ecosystems are defined as:

"Ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater". WMA (2000) amendment (Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources, 2008, Order Schedule 1, Dictionary, Department of Water and Energy 2008)

The primary component of this community includes the:
Subsurface Ecosystems – Underground Ecosystems
1. Subsurface Phreatic Aquifer Ecosystems. (Stygofauna - an assemblage of subterranean aquatic invertebrates);
2. Baseflow Stream (Hyporheic or subsurface riverine water ecosystems);

And secondary component includes the:
Surface Ecosystems – Above ground ecosystems
3. Groundwater Dependent Wetlands such as springs;
4. Baseflow (Groundwater fed) surface water Streams such perennial stream sections and permanent pool ecosystems);
5. Phreatophytes - Groundwater Dependent Terrestrial (vegetation) Ecosystems.

3. What authorities/surveys/studies support or use the name?

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.

Serov, P, Anderson MS, Acworth RI & Berhane D 2009, *Bio-indicators of Groundwater-Surface Water Connectivity*. Presentation to the Australian Society of Limnology, Alice Springs, 2009.

Serov, P. In preparation 2011. A Revision of the Family Psammaspididae with a Description of New Species. *In*. Evolution of the Anaspidacea. This research is for the partial fulfillment of the Degree of Ph.D. at the University of New England. Confidential material

4. How does the nominated ecological community relate to other communities that occur nearby or that may be similar to it? Does it intergrade with any other ecological communities and, if so, how wide are the intergradation zones? Please describe how you might distinguish the ecological community in areas where there is overlap (also see Description section below).

In order to put the significance of this nomination in perspective it is necessary to provide some brief background information on Groundwater Dependent Ecosystems or GDEs' associated with alluvial aquifers. In particular, the subsurface phreatic community type, as it has not been previously listed and yet may be one of the most biologically significant and environmentally sensitive ecosystem types within Australia, in terms of conservation value.

The nominated ecological community is the subsurface phreatic (or subterranean) aquifer ecosystems and is composed of both metazoan (macroinvertebrate) species termed 'Stygofauna' and bacterial (biofilm) communities. Phreatic refers to the organisms that live solely within the groundwater. This community exists underground in the aquatic, saturated zone of alluvial aquifers.

In addition to this community there are also a range of ecosystems supported by the Maules Creek Alluvium Aquifer. These include:

Subsurface Ecosystems – Underground Ecosystems

6. Subsurface Phreatic Aquifer Ecosystems. (Stygofauna);
7. Baseflow Stream (Hyporheic or subsurface riverine water ecosystems);

and

Surface Ecosystems – Above ground ecosystems

8. Groundwater Dependent Wetlands such as springs;
9. Baseflow Streams (surface water perennial streams and pool refugia ecosystems);
10. Phreatophytes - Groundwater Dependent Terrestrial (vegetation) Ecosystems.

Alluvial aquifers are unconsolidated aquifers consisting of particles of gravel, sand, silt or clay (Tomlinson & Boulton, 2008). Within alluvial aquifers, groundwater is stored in the pore spaces in the unconsolidated floodplain material. Shallow alluvial groundwater systems are associated with coastal rivers and the higher reaches of rivers west of the Great Dividing Range. These groundwater systems are often in direct connection with surface water bodies such as rivers and wetlands. Alluvial aquifers are generally shallower than sedimentary and fractured rock aquifers. Due to their shallow and unconfined nature, alluvial aquifers are highly susceptible to contamination/pollution and excessive drawdown of the watertable from pumping.

The importance of aquifer ecosystems in terms of biodiversity is that groundwater environments within unconsolidated alluvial and fractured rock aquifers (as well as karstic aquifers) harbour a dynamic and diverse range of invertebrate communities that are composed of most of the major taxonomic groups (ie Crustacea, Oligochaete, Mollusca, Insecta) found in the surface water habitats, however, many of the lower (Order to species) are no longer found in surface environments or have surface water relatives (Humphreys, 2002; Marmonier *et al*,. 1993; Rouch and Danielopol, 1997; Sket 1999b; Danielopol *et al.*, 2000).There is also a marked bias towards the crustacean and oligochaete groups (Marmonier *et al*,. 1993; Rouch and Danielopol, 1997; Sket 1999b; Danielopol *et al.*, 2000 Tomlinson & Boulton, 2008). Most of these species are new to science.

Research in Australia on these stygofaunal communities have, until recently, been concentrated within Western Australia (Humphreys, 2002) with far less attention being given to the stygofauna of Eastern Australia. However, surveys conducted by government agencies (NSW Office of Water, DECCW), Universities (University of New England, NSW Institute of Technology, Sydney University and Macquarie University) as well as individual researchers have found that this area, and in particular NSW, is at least as diverse as the regions previously recognised as biodioversity hotspots or centers of high stygofauna biodiversity such as Western Australia (Eberhard *et al.*, 1991, Eberhard and Spate, 1995; Serov, 2002; Thurgate *et al*, 2001; Tomlinson *et al.*, 2007; Tomlinson & Boulton 2008). Within and around the Maules Creek Catchment there have been a number of surveys and studies on the groundwater attributes and the associated groundwater dependent ecosystems conducted by researchers affiliated with the NSW Office of Water, University of New England, NSW Institute of Technology in association with Cotton CRC.

The most significant and potentially sensitive groundwater organisms are those in aquifers and cave GDEs (i.e. those that are totally dependent on groundwater). These invertebrate communities are intrinsically adapted to these very specialised environments.

These ecosystems and organisms have many values including the following:

- Most are rare or unique
- Retain phylogenetic and distributional relictual species and communities;
- And therefore, the ecosystems surviving in aquifers and caves are amongst the oldest surviving on earth.
- High proportion of short range endemics.
- Develop or retain narrow range habitat requirements (i.e. narrow range endemic species). To survive, these species and communities continue to rely on the continuance of certain groundwater levels/pressure and water chemistry; and
- Develop specialised morphological and/or physiological adaptations to survive in groundwater environments.

- They have water quality functions, biodiversity value and add to the ecological diversity in a region.

Australia is biogeographically distinct in its groundwater fauna (Humphreys, 2002) and the subterranean fauna of NSW is biogeographically distinct from other Australian 'hotspots' (Eberhard and Spate, 1995; Serov, 2002; Thurgate *et al,* 2001). In addition to the diversity aspect, our ecological perspective of groundwaters has broadened to consider the subsurface system as having a complex and interactive boundary with surface ecosystems at a range of scales. Groundwater fauna, especially stygofauna are extremely sensitive to the environmental characteristics of the water they inhabit and thus potentially are useful indicators of groundwater health (Tomlinson & Boulton, 2008, Serov *et al,* 2009).

The other importance characteristic of alluvial aquifer communities is that their dispersal capabilities are entirely dependent on the subsurface hydrological connectivity of the aquifer with other aquifers and narrow physiological tolerance ranges in water chemistry. As this community is adapted with specialized morphological features, narrow environmental tolerances (Gibert, *et al.* 1994; Gibert & Deharveng, 2002; Marmonier *et al,.* 1993; Rouch and Danielopol, 1997; Sket 1999b; Danielopol *et al.*, 2000; Serov, 2002; Serov *et al*, 2009, Tomlinson & Boulton, 2008), and have no desiccation tolerant life stages (i.e. they cannot disperse via surface rivers and streams or via aerial dispersal of eggs). They are therefore, solely restricted to this environment. Tomlinson & Boulton (2008) outline the characteristics of subsurface aquifer communities. These communities can be isolated by a number of barriers including geological, hydrogeological, climatic and differences in water chemistry. As a result of these barriers to dispersal subterranean communities in general, have a high potential for speciation and very short range endemism and are highly vulnerable to habitat change resulting in local or total extinction of species.

Stygofauna surveys in NSW, and more specifically within and around Maules Creek Catchment (note that Maules Creek Catchment Alluvium is also known as Zone 11 in the Namoi Catchment Water Sharing Plan commencing in July 2006. See Map on page 4 contained in Appendix 1), have identified the Maules Creek alluvial aquifer contains a diverse and highly endemic stygofauna community. This isolation and aerial extent of the community has been identified and confirmed by a broad sampling of the region the includes:

1) The hyporheic zones of the Maules Creek as well as upstream and downstream of the Namoi River,

2) All government monitoring bores and a number of privately owned wells and bores within the Maules Creek Catchments both for stygofauna and water chemistry.

Regional sampling has also been conducted in upper Namoi in the Peel and Cockburn River alluvium, east and west along the Namoi River, north-west on the Gwydir River as far as Moree, and south throughout the Hunter River and Upper Hunter River Tributaries including the Pages River. The closest community identified within the Namoi River catchment so far, is located within the, Halls Creek, Peel and Cockburn Rivers west and east of Tamworth, approximately 140 km to the east along the river in a straight line.

Although other aquifer ecosystems have been identified within the region, there are none so far identified within the Namoi River or its smaller tributaries from east of Gunnedah to near Tamworth to the west of Narrabri. The Namoi River and Maules Creek below Elfin Crossing is devoid of any stygofauna community based on current surveys. The community is restricted to an area encompassing the floodplains upstream of Elfin Crossing to the base of the Nandewar Ranges (See map and aerial photos on page 1, 6 and 7 of Appendix 6 Potential Stygofauna Landscapes) and includes the tributaries of Maules Creek, Horsearm Creek, and Middle Creek so far. This restricted distribution is delineated by a geological barrier, and a water chemistry barrier(Anderson & Acworth, 2007, Anderson, 2008, Serov *et al*, 2009).

Therefore, it is considered highly unlikely to impossible that the community intergrades with any other subsurface alluvial groundwater dependent ecosystem (refer Description section below).

<u>Legal Status</u>

5. What is its current level of protection under Australian State/Territory Government legislation? Please record whether there is an existing State listing for all or part of the nominated ecological community, its listing category (e.g. critically endangered, vulnerable) and its title. If not listed as threatened, is there any other form of protection under State/Territory legislation?

The only level of protection the GDEMCAA currently has is that the component stygofauna, being newly described native species, are listed as ‘protected’ under NSW legislation as are all native species in the state. There is currently no State listing for all or part of the GDEMCC. The Artesian Basin thermal springs or mound springs are listed as an endangered ecological community under both State and Commonwealth legislation; however the GDEMCAA does not constitute part of these listings as it is not associated with artesian springs.

<u>Description</u>

6. List the main features that distinguish this ecological community from all other ecological communities? Characteristic (or diagnostic) features can be biological (e.g. taxa or taxonomic groups of plants and animals characteristic to the community; a type of vegetation or other biotic structure), or associated non-biological landscape characteristics (e.g. soil type or substrate, habitat feature, hydrological feature). Please limit your answer to those features that are <u>specific</u> to the ecological community and **can be used to distinguish it from other ecological communities.**

The main features which distinguish the GDEMCAA from all other ecological communities are:

Biodiversity Features:

The species associated with this alluvial aquifer are solely restricted to this locality. Most are morphologically specialised, which includes total lack of eyes ie. blind and unpigmented. Although not all species have been identified to species level as yet, the significant species include the Syncarida Family Psammaspididae (*Psammaspides dawitii* new species), the second only record of subterranean Coleopteran family Dytiscidae, (*Carabhydrus* new species) in eastern Australia and the first record of subterranean Coleoptera Family Elmidae and the first record of Thysanura, Family Nicoletiidae taken from a bore.

A description of some of the groups discovered include.

Syncarida

Photo 1. Synarida, Psammaspididae, *Psammaspides* n. sp. (©P.Serov 2011)

The Division Syncarida is one of the most interesting invertebrate groups found in Australian inland waters. They are an ancient group that branched off from the main stream of the Eumalacostraca or higher Crustacea at a very early period perhaps as far back as the Late Devonian (about 400-380mya), with today's extant taxa still retaining a primitive body structure (Schram, 1984).

The current classification of the Syncarida is broken up into: the minute, interstitial Bathynellacea, which have a world-wide distribution and are suggested to be the most primitive; the fossil Palaeocaridacea which were restricted to North America and Europe during the Carboniferous to Permian (approximately 360-250mya) and the Anaspidacea. The Anaspidacea have a distinctly Gondwana distribution from NZ, Australia and South America and include the shrimp like *Anaspides* and *Allanaspides*, found only in Tasmania. The Psammapididae, known currently from 10 undescribed species in caves in NSW (Eberhard and Spate, 1995) and one described hyporheic species *Psammaspides willaimsi* Schminke 1974, in northern NSW (Schminke, 1974) and one in Northern Tasmania.

The syncarids have always been indicators of cool temperate permanently wet habitats as they have no stage in their life cycle that can tolerate desiccation.
The syncarid fauna collected from the alluvial aquifer, along with the Cyclopoid Copepoda, represent the main species of obligate groundwater fauna. All species collected will be new, as there have been no described species from this area. The syncarids collected belong to the Family Bathynellidae were collected from one site and, the Psammaspididae, *Psammaspides dawitii* nsp. Serov (in preparation) is endemic to this locality.

The importance of the discoveries of this obligate groundwater fauna is that they represent relicts of a bygone era and give us a glimpse of another time before the browning of Australia, to a time when Australia was covered in lush, wet, rainforest with numerous waterways, swamps and deltas.

The fact the groundwater habitats have served as refuges and centres of speciation in fluctuating environments of generally increasing and spreading aridity, particularly in the Pleistocene, provides tools for studying the past history of particular taxa. The syncarids are one of these groups. They have a wide distribution at the family and generic level but appear to be highly restricted at the species level due to their inability to withstand any degree of desiccation in any stage of their life cycle and have narrow environmental requirements. In effect they represent biological time capsules (Serov, 2002).

Gastropoda

The gastropod snails are currently being examining by Stephanie Clark, one of Australia's leading mollusc expert. There are at least two subterranean species that belong to the Hydrobiidae and preliminary indications are that they are at least new species and potentially new genera and are regionally significant.

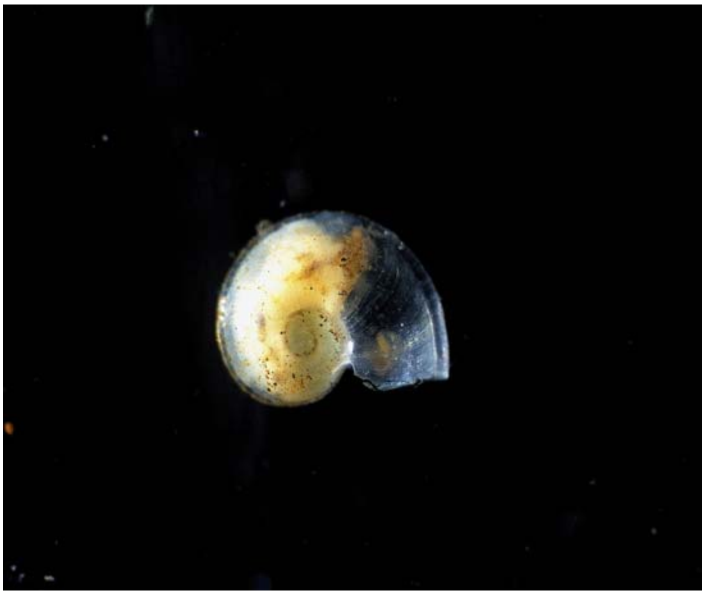


Photo 2. Gastropoda, Hydrobiidae n. Sp. (©P.Serov 2011)

Water beetles (Coleoptera Families Dystiscidae and Elmidae)

The discovery of blind water beetles within the Maules Creel alluvium is highly significant as there has been only one species of the Dytiscidae genus *Carabhydrus* previously discovered in NSW by Watts in 2007 from the Pages River in the Hunter River Catchment 160km to the southeast. The family Elmidae has no described species in eastern Australia recorded from subterranean environments. The significance of these new species is that 1) they are originally surface aquatic macroinvertebrate that have migrated to the subsurface environment and are now only found at least 12m underground, 2) are morphologically adapted to the subterranean environment (are blind), and 3) as they are either surface air breathing invertebrates (Dytiscidae) or require high DO levels (Elmidae) they indicate there is both large voids in and at the interface of the watertable and a large enough community that supports before predators (Dytiscidae) and algal grazers (Elmidae). The Elmidae as a family are regarded by the SIGNAL (Chessman *et al*, 1997) aquatic ecosystem condition assessments as being highly sensitive to environmental disturbance and therefore are indicators of streams in very good condition. The overall high biodiversity and number of sensitive taxawithin the aquifer is indicative of the aquifer being in very good condition.

Photo 3. Dytiscidae, *Carabhydrus* n. sp. (©P.Serov 2011)

Amphipoda

Within eastern Australia, Amphipods (followed closely by Syncarids), are the dominant and most widespread of the stygofauna (Thurgate etal, (2001)). They are common in karsts in NSW and Tasmania and are the only described stygofauna so far from North Queensland (Thurgate etal, (2001)). The two main families in eastern Australia and NSW are the Paramelitidae and Neoniphargidae. The highest diversity of Amphipoda in Eastern Australia belongs to the Paramelitidae, which includes 35 stygobite species from eight genera, however, the vast majority of these species occur in Tasmania. The Neoniphargidae, however, is the most diverse family in NSW with 87% of stygal species being restricted to the karsts of NSW, where most species are restricted to a single karst (Thurgate etal, (2001)). These figures will also be reflected within alluvial aquifers.

Photo 4. Amphipoda, Neoniphargidae n. sp. (©P.Serov 2011)

Copepoda

The subclass Copepoda has three freshwater representatives: the Calanoida, Harpacticoida and Cyclopoida. The Calanoida is a predominantly epigean group that are numerically important in large lakes and reservoirs, with the Cyclopoida (Shiel, 1995). The Cyclopoida represent the most common group collected during the study and dominated the stygofauna within the Peel and Cockburn aquifer. Given their wide distribution in the samples from the river to the aquifer it is suggested that there are possibly several species, with one or two species occurring in each of the main ecosystems. The Harpacticoids are rare epiphytic/epicanthic taxa that are poorly known taxonomically for Australia (Shiel, 1995). This group is also probably highly speciose with probably several species in the collection. In this study they were prominent within the stygobites.

Isopoda

The Phreatoicidae Isopoda dominate the subterranean isopods in NSW, however, they are not as diverse or as common as the Amphipods or Syncarida (Thurgate etal, (2001)). They are restricted in distribution and occur in two karst areas in NSW and have highly disjunct epigean populations in swamps and sphagnum bogs in high altitudes along the Great Dividing Range. All are cold-water species derived from Pre-Gondwanan stock, and are restricted to areas of the continent not inundated by the sea during the Cretaceous and where cool, permanent waters are found. The occurrence of Phreatoicids in the hyporheic zone indicates the river has strong connections with the groundwater intrusions or springs.

Photo 5. Isopoda, Janiridae, *Heterias* n. sp. (©P.Serov 2011)

Hydrological Feature:

The Maules Creek Catchment (MCC) is separated from the larger Namoi Catchment by a subterranean volcanic ridge known as the Boggabri Volcanics. (See map on Page 12 in Appendix 2 and the diagram on page 6 of Appendix 9). The Boggabri Volcanics act as a dam wall creating an underground reservoir north of Elfin Crossing and forcing groundwater up to the surface as an upwelling zone at Elfin Crossing (Anderson & Acworth, 2007, Anderson, 2008, Serov *et al* 2009). The studies by Anderson, 2008, and Serov *et al* 2009 demonstrated that the changes in water chemistry associated with exposure to oxygen and the increase in redox reactions inhibited or eliminated stygofauna beyond Elfin Crossing. It is believed the effect of this subterranean structure has been to isolate the community over time, and that this isolation has lead to the development of an endemic and regionally significant groundwater dependent community within the Maules Creek alluvial aquifer. This research also demonstrated the narrow environmental tolerance ranges of the stygofauna community,

Habitat Feature:

As shown by the Anderson and Achworth (2007) on page 25, the MCC has alluvial and coal aquifers which are linked. The linkage provides a specific water chemical balance to which the Maules Creek stygofauna have adapted and evolved over time.

7. Give a description of the biological components of the ecological community. For instance, what species of plants and animals commonly occur in the community; what is the typical vegetation structure (if relevant).

The subterranean community in the Maules Creek aquifer contain 'macro' organisms termed 'stygofauna' (invertebrates that can be seen with the naked eye), 'micro' organisms termed 'meiofauna' (invertebrates that can only be seen with a microscope) and bacteria (biofilm) communities. In terms of global composition, crustaceans dominate the larger stygofauna. There is generally a paucity of insects which makes the insects collected here very significant, while the crustaceans, oligocheates (worms) and gastropods (snails) are regionally significant (Botosaneanu, 1986; Culver and Sket, 2000; Sket 1999a). Although no bacteria surveys have been conducted, a rich stygofauna community exists (including biofilm grazers) which in turn indicates a rich microbial and bacteria community also exists.

The community composition is regionally rich, composed of crustacean, oligocheates, gastropoda and insects. A list of species collected is attached below although not all have been identified to species.

1 Oligochaete
2 Acarina
3 Amphipoda, Neoniphargidae
4 Copepoda sp 1
5 Copepoda sp 2
6 Janiridae, Heterias nsp.
7 Ostracoda sp.1
8 Ostracoda sp.2
9 Ostracoda sp.3
10 Phreatoicidae, Crenoicus nsp.
11 Psammaspididae, *Psammaspides* dawitii nsp.
12 Bathynellidae, Bathynella nsp.
13 Ceratopogonidae
14 Orthocladinae
15 Tanypodinae
16 Chironominae
17 Collembola
18 Haliplidae
19 Psocoptera
20 Gastropoda, Hydrobiidae – 2 species
21 Nematoda
22 Turbellaria
23 Gordiidae worms
24 Dytiscidae, *Carabhydrus* nsp
25 Dytiscidae, nsp
26 Elmidae nsp.
27. Insecta, Thysanura, Nicoletiidae,

(See page 30 Appendix 4 for some photos of species)

8. Give a description of the associated non-biological landscape/seascape characteristics or components of the ecological community. For instance, what is the typical landscape/seascape in which the community occurs? Note if it is associated with a particular soil type or substrate; what major climatic variables drive the distribution of the ecological community (e.g. rainfall). Note particular altitudes or geographic coordinates (e.g. latitudes).

One of the first and main features that highlighted this aquifer as a GDE system was the presence of perennial pools in an otherwise ephemeral system in a semi arid region of western NSW. Most of the streams of the Maules Creek catchment only run after substantial rain and then dry up completely to a sand and boulder river bed. The small series of pools occur approximately ten kilometres in a straight line from the Namoi River on both Maules Creek and Horsearm Creek, which join just upstream of the crossing. Groundwater levels across the alluvium are also very shallow(about 2-12 m averaging 5-8m) and has resulted in most property owners relying on groundwater for stock and domestics purposes. The permanent pools support a rich surface aquatic invertebrate and fish fauna and a riparian zone of River Red gums as well as Melaleuca species in limited locations. A characteristic of these pools that separates them from most western streams across the region is that they are clear, with sandy gravel substrates as opposed to highly turbid waters with fine silt substrates.

Another unique feature of these pools and riffles is the presence of phreatic (obligate groundwater fauna) within 10-20cm depth in the hyporheic zone (an ecotone within the river bed) indicating a direct linkage with the deeper alluvial aquifer (Serov *et al* 2009).

Alluvial aquifers are groundwater stores that occur in unconsolidated sediments associated with rivers. These groundwater systems occur under the floodplains of rivers west and east of the Great Dividing Range. Groundwater in these systems is usually very shallow and can occur at the ground-surface supporting wetlands, or within a few metres below the ground surface supporting a range of terrestrial vegetation and extend to over 100 metres in depth depending on the structure and size of the river and alluvium. These groundwater systems are often in direct connection with surface water bodies such as rivers and wetlands. Groundwater within these systems can support terrestrial vegetation, wetlands, hypogean ecosystems as well as base flow river systems and riverine hyporheic ecosystems (the zone within the river bed).

Another distinctive feature of this aquifer is the high water quality (including low conductivity) course sand, gravel and boulder composition that contains relatively large voids as indicated by the large size of the species occurring in it. The Syncarida can reach up to 15mm. It is a highly porous, with course sand, gravels and boulder layers reaching approximately 20m depth. .

9. Provide information on the ecological processes by which the biological and non-biological components interact (where known).

Stygofauna communities and alluvial aquifers are intrinsically linked with the catchment around them due to the porosity of the aquifer material. Many land and water use activities within a catchment have the potential to affect GDE function and viability by altering surface and subsurface conditions that are outside the physiological tolerance ranges or dispersal capabilities of groundwater reliant communities. There are a growing number of examples of catastrophic crashes in groundwater ecosystems due to water chemistry alteration such as the activation of acid sulphate soil or saline intrusions (Ergil, 2000) and water level fluctuations caused by over-extraction. Further, contaminants such as heavy metals and other pollutants are rendering groundwater toxic to the environment and millions of humans (Nickson *et al.*, 1998 cited in Boulton, 2005).

It has long been known that many aquatic invertebrate groups occur only in restricted locations due to narrow physiological requirements such a low temperatures, low conductivity in NSW and high levels of dissolved oxygen (Humphreys, 2002; Marmonier *et al,.* 1993; Rouch and Danielopol, 1997; Sket 1999b; Danielopol *et al.*, 2000). These communities have long been recognized as being ideally suited for the assessment of groundwater health and condition as they are diverse, occupy many niches within the aquifer and caves, are one of the major contributors to the processing of energy through an aquifer system and respond directly to physico-chemical changes within the aquatic environment. The composition of this community reliably reflects both natural and threatening processes operating within a catchment. The distribution and specific habitat requirements of each component at both the species and community levels, enables the use of their diversity as an indicator of ecological disturbance.

In just the same way as any other group of organisms whether they are arboreal mammals or aquatic invertebrates within streams or fish in a coral reef, subterranean invertebrates or stygofauna occupy defined habitats and specific niches within that habitat.

Below is a list and description of each of the major groups collected and their association with the aquifer.

Table 1. List of aquatic invertebrate community classes.

Habitat Class	**Subclass**	**Order**	**Family**
Stygobite?	Acarina	Hydracarina	Hygrobatidae
Stygobite	Amphipoda		Undetermined
Hyporheic/ Stygobite	Annelida	Oligochaeta	Undetermined
Hyporheic/Stygoxene	Copepoda	Canaloida	Undetermined
Stygobite	Copepoda	Cyclopoida	Undetermined
Stygobite	Copepoda	Harpacticoida	Undetermined
Stygobite	Gastropoda	Undetermined	Undetermined
Stygophile/hyperheic	Insecta	Diptera	Ceratopogonidae
Stygophile	Insecta	Diptera	Chironomidae
Stygophile	Insecta	Ephemeroptera	Caenidae
Stygoxene/stygophile	Insecta	Ephemeroptera	Leptophlebiidae
Stygoxene/stygophiles	Insecta	Plecoptera	Gripopterygidae
Stygoxene/hyporheic	Insecta	Trichoptera	Ecnomidae
Stygoxene	Insecta	Trichoptera	Hydroptilidae
Hyporheic/Stygobite	Isopoda	Phreatoicoidea	Crenoicus sp
Hyporheic/Stygobite	Isopoda	Janiridae	Heterias sp
Stygophiles/Hyporheic	Ostracoda	Undetermined	Undetermined
Stygobite	Syncarida	Anaspidacea	Psammaspididae
Stygobite	Syncarida	Bathynellacea	Bathynellidae
Stygobite	Syncarida	Bathynellacea	Parabathynellidae
Stygobite	Turbellaria	Undetermined	Undetermined

Table 1 summarises the overall composition and habitat classification of the main fauna groups collected.

The habitat class is based on where the taxa were found, ie. in a bore close to the river or distance from the river, in the hyporheic zone or surface water habitat.

Definitions:

Stygobite - Organisms that are specialised subterranean forms, obligatory hypogea. Some are ubiquitous, widely distributed in all types of groundwater systems (both karst and alluvia).

Stygofauna - This an all encompassing term for all animals that occur in subsurface waters (Ward et al. 2000).

Stygophiles - Have greater affinities with the groundwater environment than stygoxenes, because they appear to actively exploit resources in the groundwater system and /or actively seek protection from unfavourable situations in the surface environment resulting from biotic or stochastic processes. Stygophiles can be divided into 1) occasional or temporary hyporheos and 2) permanent hyporheos. The occasional or temporary hyporheos include individuals of the same species that could either spend their lives in the surface environment, or spend a part of their lives in the surface environment and a part in groundwater (Ceratopogonidae fly larvae). The permanent hyporheos is present during all life stages in either groundwater or in benthic habitats (Gibert, 1994.) and possess specialist adaptations for living in this environment.

Stygoxenes - Organisms that have no affinities with the groundwater systems, but occur accidentally in caves and alluvial sediments. Some planktonic groups (Calanoida Copepoda) and a variety of benthic crustacean and insect species (Simuliidae Fly larvae, Caenidae Mayflies) may passively infiltrate alluvial sediments. (Gibert, 1994.)

The study conducted by Serov et al 2009 demonstrated that aquifers that are hydraulically connected to streams can be impacted by changes to stream flow and surface activities and vice versa. The subsurface (stygofauna) communities have long been acknowledged to be intrinsically adapted to their environment both in terms of their specialised morphology, physiologies, habitat requirements and long life cycles. Links between flow regime, geochemical conditions and the abundance, diversity and composition of the stygofauna community should, therefore be anticipated and utilised. These linkages were investigated along a 1 km reach of Maules Creek, in a semi-arid environment, NW New South Wales, Australia. Maules Creek is a small, essentially, ephemeral, tributary of the Namoi River. Vertical streambed profiles of hydrochemistry and stygofauna were collected at five different locations along the creek.

The results demonstrated a heterogenous and complex ecosystem with relatively consistent downstream gradients, in terms of overall animal and species numbers from the upstream sites to the downstream sites. These gradients are directly reflected in the changes in water chemistry. Generally the streambed pore waters became more reduced in a downstream direction and with depth, with a clear inverse correlation between stygofauna numbers and diversity and pore water concentrations of Fe^{2+} and Mn^{2+}. This relationship between water chemistry and fauna distribution correlated to the overall stream/groundwater exchange patterns.

This study highlights the direct correlation between water management, water chemistry and ecosystem functioning between groundwater and surface water in hydraulically connected systems. The study also indicates that stygofauna can be used as biological tracers of groundwater discharges and recharge and has major implications for the management of both surface ecosystems and groundwater ecosystems.

10. Does the ecological community show any consistent regional or other variation across its national extent, such as characteristic differences in species composition or structure? If so, please describe these.

This ecological community type does show some regional variation across its national extent. Reference will only be given to the distribution pattern exhibited by the Anaspidacean syncarids as a surrogate for the whole community based on work conducted for a PhD by Peter Serov that is still in preparation.

Although the general stygofauna community composition appears similar at the broad categories of order, the family levels show a state variability, genus levels vary across states and regionally, while species are highly restricted to one aquifer or karst system. In terms of the Anaspidaceans distribution, they represent one of the classic Gondwanan relictual groups that also include the Phreatoicoidea isopods and Hydrobiidae snails. These relictual groups have connections with New Zealand, South America and Southeast Australia, encompassing Northern NSW down to Victoria and SE South Australia through to Tasmania.

Within the Psammaspididae there are only two currently described species, *Psammaspides williamsi* Schminke 1974 from Halls Creek NW of Tamworth and *Eucrenonspides oinetheke* Knott and Lake, 1980 from Devonport, Tasmania. However, in1992, the NSW National Parks and Wildlife Service began a program surveying the subterranean invertebrate fauna of NSW caves in order to determine the conservation status of each cave system. The result of this survey has been the discovery of sparse but widespread fauna containing significant distributional and phylogenetic relic species and 10 new species of Psammaspididae (Serov, 2002).

Surveys of alluvial aquifers has revealed more species that are each restricted to either one aquifer or only part of an aquifer, as in the case of Hunter River species. The family is currently being divided into at least 5 or more genera. The family extends from north eastern NSW along the Great Divide, skips Victoria and occurs sporadically along the western side of Tasmania to the South West corner (Serov, 2002). The genus *Psammaspides* includes the new Maules Creek species *P. dawitii* nsp. Currently, *P. dawitii* nsp is the most north western extension of the range of the Psammaspididae with the same habitat being occupied by a new family of Anaspidacea, Family A (Serov, 2002) to the north and east of the current distribution of the genus *Psammaspides*. This family is currently being described.

The distribution of the Family Psammaspididae and other orders that occur within the alluvial ecosystems pre-dates the formation of the Great Dividing Range (~90-120 million years) and the separation of Tasmania from Australia. The distribution of genus and species reflect more modern drainage systems although their wide, sporadic occurrences could only have occurred during much wetter periods when these aquatic systems were connected. As the landscape dried and the required habitats reduced communities became isolated and over time speciated. The distribution of other elements mentioned above will show similar regional distributions.

11. Does the ecological community provide a habitat for any listed threatened species? If so, please note whether the species are listed on State/Territory and/or national lists and the nature of its dependence on the ecological community.

The GDEMCC does not provide habitat for any currently listed threatened species under Australian, State or Territory legislation.

12. Identify major studies on the ecological community (authors, dates, name of study and publishing details where relevant).

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.

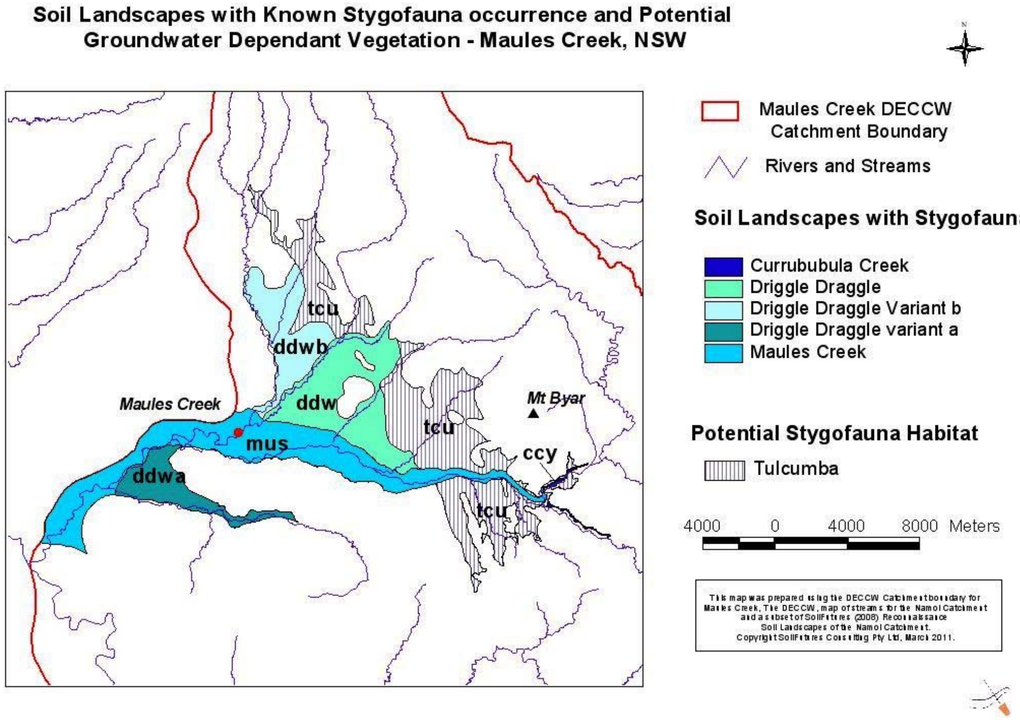
Serov P, Anderson MS, Acworth RI & Berhane D 2009, *Bio-indicators of Groundwater-Surface Water Connectivity*, in preparation.

Distribution

13. Describe the national distribution in Australia. If possible, include appropriate bioregions (see The Guidelines) where the ecological community occurs. Attach or provide any maps showing its distribution (this is required by the *EPBC Regulations 2000*) with details of the source of the maps, or explain how they were created and the datasets used.

The national distribution of the community is restricted to the Maules Creek Catchment which is a sub-catchment of the Namoi River in NSW. The area lies within the Liverpool Plains province of the Brigalow Belt South Bioregion. See pages 4 and 5 of Appendix 1.

The Maules Creek Catchment (MCC) is shown below and this Stygofauna and potential GDE map was prepared by Soil Futures in March 2011 from Namoi CMA soil mapping data.



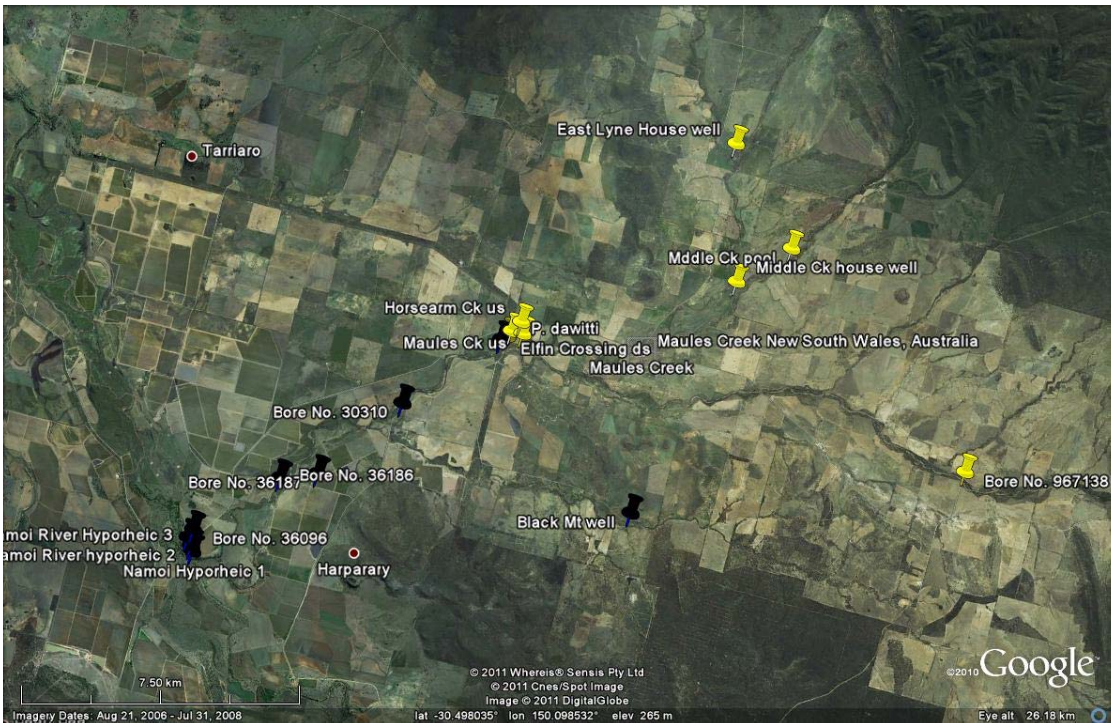
The MCC map shows the potential GDEMCAA community by soil type and in particular the location of the alluvium. (The key to this map is included in Appendix 6 – Potential Stygofauna Landscapes.)

When compared to the Google Earth co-ordinates pinpointing positive sampling results shown in question 14 a, the impact of the Boggabri Volcanics in isolating and restricting the GDEMCAA community upstream from Elfin Crossing is apparent.

14. What is the national distribution (in ha) for the ecological community? For answers a, b, c & d - Please identify whether any values represent extent of occurrence or area of occupancy (as described in the Guidelines); For answers a, b, c & d - Please provide details of the source(s) for the estimates and explain how they were calculated and the datasets used.
14 a. What is the current distribution (in ha)?

Although the extent of the alluvial aquifer is known the full range occupied by the GDE MCAA is unknown as this community has only recently been identified and scientific investigations are continuing. However preliminary sampling would indicate it covers and area of approximately 10,000 ha within the upper and lower Maules Creek Catchment (MCC).

The following Google Earth maps show the distribution of stygofauna within MCC and from a regional context as far as is known at the moment. Yellow pins are positive stygofauna sites and black pins are negative - no stygofauna. The resolution of the boundary of extent will improve with more sampling but at the moment it is enough to highlight the restricted nature of this community.



(©P.Serov 2011)

(©P.Serov 2011)

14 b. What is the pre-European extent or its former known extent (in ha)?

The pre-European extent of this community is only within its current range. The geology, hydrogeology and climatic conditions that have created the aquifer would pre-date the arrival of Europeans.

14 c. What is the estimated percentage decline of the ecological community?

Not Applicable

14 d. What data are there to indicate future changes in distribution may occur?

A characteristic of stygofauna species within alluvial aquifers worldwide, including Maules Creek Alluvium, is their narrow environmental tolerance ranges of water chemistry parameters as a result of occupying an ecosystem that does not change dramatically over time in terms of water levels, water chemistry and water quality parameters such as temperature, salinity and dissolved oxygen. Therefore any change in these parameters outside of their natural range may have significant impacts on the community. Maules Creek Catchment and its surrounds is currently the target of a number of coal mine proposals being assessed in NSW. The proposed mining projects propose the removal of large areas of native vegetation, intercept aquifers, change water quality parameters and involve groundwater extraction which will impact on groundwater levels and their dependent ecosystems. Changes in distribution due to impacts on the water table are shown by the Groundwater Impact contour maps provided by the Boggabri Coal Environmental Assessment. See drawing A5 from Appendix 2 to see anticipated cumulative impacts to ground water levels over 100 years.

Further changes in distribution could occur as a result of the extraction of Coal Seam Gas. Unfortunately, little information is available due to limited legislative environmental reporting requirements in NSW. However, two companies Santos and Macquarie Energy are exploring in the area. See exploration lease map in Appendix 5 and the location of proposed exploration boreholes on page 61 of Appendix 7.

15. Is the ecological community considered to be naturally rare or restricted, based on its original (e.g. pre-European) distribution? An ecological community is considered to be naturally restricted if it has a pre-European area of occupancy that is less than 10 000 ha or a pre-European extent of occurrence that is less than 100 000 ha (refer to the Guidelines).

Yes. As indicated earlier the aquifer ecosystems are restricted in distribution, however the species within the GDEMCAA community is considered to be restricted to only this locality due to a natural granite dam wall created by the Boggabri Volcanics which not only formed the habitat but also isolates the community within the Maules Creek catchment. According to NSW Office of Water the entire Maules Creek catchment (known as Zone 11) is 17,361 Ha which is less than 100 000 ha and the pre-European extent of occurrence of the GDE is therefore less than 100 000ha. Due to areas of the MCC which do not contain suitable aquifers types, the GDEMCAA community is smaller than the area known as Zone 11.

Patch size

16. What is the typical size (in ha) for a patch of the ecological community (if known)? Explain how it was calculated and the datasets that are used. Relevant data includes the average patch size, the proportion of patches that are certain sizes, particularly proportions below 10 ha and below 100 ha, but also below 1 ha and above 100 ha (for example).

Insufficient data is currently available to calculate a typical patch size.

17. Quantify the smallest percentage or area required for a patch of the ecological community to be considered viable. This refers to the minimum size of a remnant that can remain viable without active management. It may be determined through the requirements for dominant native species, level of species diversity, or the nature of invasive weeds.

Unlike terrestrial ecosystems where animals or plants can be easily be sighted and measured, the subterranean environment makes it logistically very difficult if not impossible to determine patch size requirements for the associated species. The habitat within the aquifer is also not homogenous as the structure of the aquifer is usually composed of layers, lenses or palaeochannels of porous material that is either habitat or pathways for the stygofauna to move to the most appropriate environment. The determination of the distribution of the community as a whole or individual species within it is solely restricted to the number of access points into the alluvial such as bores, wells, springs or upwelling zones in the riverbeds. Due to the small size of the alluvium, the highly restricted nature of the community, and the habitat being aquatic, the current size of the Maules Creek Catchment Alluvium would be considered the smallest area for the community to remain viable using the precautionary principal. The high porosity and connected nature of this alluvium means that an impact on either the water quality through a diffuse or point source of pollution or a lowering of the water table is rapidly transmitted through the aquifer and the river systems associated with it.

Functionality

18. Is the present distribution of the ecological community severely fragmented? If so, what are likely causes of fragmentation? If fragmentation is a natural or positive characteristic of this ecological community, please explain this and state the reason. Severely fragmented refers to the situation in which increased extinction risk to the ecological community results from most remnants being found in small and relatively isolated patches.

No. The present distribution of the ecological community is not fragmented as far as can be ascertained from the continuity and consistent composition of the community. Indications as to condition and a lack of fragmentation are derived from sampling evidence, whereby each sample that is taken from various locations within the MCAA generally yields similar assemblages of stygofauna.

19. Has there been a loss or decline of functionally important species? This refers to native species that are critically important in the processes that sustain or play a major role in the ecological community and whose removal has the potential to precipitate change in community structure or function sufficient to undermine the overall community's viability.

Although this is not known, it is considered unlikely there has been a loss of functionally of important species due to isolation of the ecological community. There certainly does not appear to be any change in composition since 2007 when the first surveys were conducted.

19 a. If yes, which species are affected?

Not Applicable.

19 b. How are they functionally important and to what extent have they declined?

Not applicable.

<u>Reduction in community integrity</u>

20. Please describe any processes that have resulted in a reduction in integrity and the consequences of these processes, e.g. loss of understorey. Include any available information on the rate of these changes.

This recognizes that an ecological community can be threatened with extinction through on-going modifications that do not necessarily lead to total destruction of all elements of the community. Changes in integrity can be measured by comparison with a benchmark state that reflects as closely as possible the natural condition of the community with respect to the composition and arrangement of its abiotic and biotic elements and the processes that sustain them. Please provide a description of the benchmark state where available. For further information please refer to the Guidelines.

There has been no study conducted over time to quantify if there has been a decline in the community integrity although stygofauna surveys on several occasions since 2007 have recorded the same community composition therefore indicating no major change to the species composition.

To date the only impacts on the aquifer have been minor and do not appear to have resulted in a reduction in the integrity of the GDEMCAA. The local impacts have been from extraction by adjacent cotton farms that resulted in short term, localised drops in the water table which in turn reduced or dried out the pools at Elfin Crossing and also dropped the levels of water in stock/domestic wells and bores. These impacts have not had any detectable impact on the subsurface aquifer community as yet and there have been no changes in water chemistry. However, should the coal mining development currently proposed in the Maules Creek area proceed, there is a high potential for an increased impact on the existing groundwater environment through interception of groundwater flows, changes to recharge rates and alterations to groundwater chemical composition. It is considered likely these changes to the groundwater environment will threatened the integrity and viability of the stygofauna populations within the Maules Creek catchment.

<u>Survey and Monitoring</u>

21. Has the ecological community been reasonably well surveyed? Provide an overview of surveys to date and the likelihood of its current known distribution and/or patch size being its actual distribution (consider area of occupancy and area of extent, including any data on number and size of patches).

A survey has been conducted on all government monitoring bores throughout the catchment including those upstream and downstream of Elfin Crossing. As well many privately owned wells and bores have been surveyed.

The unique nature of the stygofauna community within the Maules Creek Catchment has only been recently recognised as a consequence of the work by Serov *et al*, 2009, and the surveys conducted for a PhD study entitled . Serov, P. in preparation 2011. A Revision of the Family Psammaspididae with a Description of New Species. *In*. Evolution of the Anaspidacea. This research is for the partial fulfillment of the Degree of Ph.D. at the University of New England. <u>This is Confidential material.</u>

22. Where possible, please indicate areas that haven't been surveyed but may add to the information required in determining the community's overall viability and quality.

Sufficient surveys have been conducted to indicate that the community is broadly delineated by the edges of the alluvium however, additional surveys within the Upper Maules Creek and

Back Creek areas to the east and the western and northern margins are required to fine tune the community composition contours and outer boundaries.

23. Is there an ongoing monitoring program? If so, please describe the extent and length of the program.

There is no on-going monitoring program at this time.

<u>Condition Classes and Thresholds</u>

24. Do you think condition classes/thresholds apply to this ecological community? If not, give reasons.

The Committee recognises that ecological communities can exist in various condition states. In reaching its decision the Committee uses condition classes and/or thresholds to determine the patches which are included or excluded from the listed ecological community (see the Guidelines for details of the process of determining condition classes).

There is insufficient information at this time to know for certain whether condition classes/thresholds apply to this community. However, based on the very good numbers of stygofauna specimens collected during current sampling within the Maules Creek Catchment compared with other surveys conducted across NSW by the groups mentioned earlier it is considered the community is in good condition across its known range which is delineated by the edge of the alluvium. Maules Creek is an unregulated stream with very little water extracted for irrigation. Further irrigation demand is falling, due to allocation reductions of 40% in the Namoi Water Sharing Plan and water buy-backs. It is therefore considered, that if management remained the same, the community would remain in good condition.

25. If so, how much of the community would you describe as in relatively <u>good condition</u>, i.e. likely to persist into the long-term with minimal management?

Based on preliminary sampling 100% of the community would be regarded as in relatively good condition.

26. What features or variables do you consider to be most valuable for identifying a patch of the ecological community in relatively <u>good condition</u>? Variables for establishing the highest condition class may include: patch size; connectivity; native plant species composition; diversity and cover (for example in overstorey; mid-shrub and/or understorey layers); recognised faunal values; and cover of weeds or other invasive species.

The three most important variables that control the distribution and complexity of stygofauna within the aquifer are:

1) The composition of the aquifer matrix that provides the community with habitat and connectivity throughout its range,

2) Consistent water chemistry/quality which is integral to ecosystem survival and function

3) Consistency in water levels within the natural range. This is essential for maintaining consistent water quality, temperature profiles and oxygen levels as well as maintaining appropriate water levels/connectivity for the other associated GDE such as the surface aquatic ecosystems, including springs and permanent pools and riparian/floodplain vegetation.

Aquifer condition is determined by measuring the fluctuations in physicochemical parameters such as water chemistry, water temperature, dissolved oxygen, in conjunction with water table levels (depth to water table) and community composition over time. Historically stygofauna communities typically do not vary in composition significantly over time therefore an impact would be indicated by a drop in biodiversity or the loss of particular elements/species of the community structure.

27. How much of the community would you describe as in relatively medium condition, i.e. likely to persist into the long-term future with management?

Cannot be determined.

28. Please describe how you would identify areas in medium condition using one or a combination of indicators such as species diversity, structure, remnant size, cover of weeds or other invasive species, etc.

As in Question No. 26.

29. How much of the community would you describe as in relatively poor condition, i.e. unlikely to be recoverable with active management?

None at the moment.

30. Please describe how you would identify area in poor condition using one or a combination of indicators such as species diversity, structure, remnant size, cover of weeds or other invasive species, etc.

As in Question No. 26.

Threats

Note: If you plan to identify climate change as a threat to the ecological community, please refer to Appendix 2 of the Guidelines for information on how this should be addressed.

31. Identify PAST threats to the ecological community indicating whether they are *actual* or *potential*. For each threat describe:

31 a. How and where it impacts on this ecological community.

One actual past threat to the GDEMCAA came from water extraction for irrigation at a location near “Elfin Crossing” on the Boggabri Volcanics. This is an area where water rises up to the surface. The increased water extraction dried up Maules Creek and impacted on groundwater levels in surrounding stock and domestic bores. Community action led to ‘cease to pump’ triggers and reductions in water allocations so the threat level has now been reduced to a potential threat.

The pumping event was limited to a part of one cotton growing season in 2006 - 2007 and the underground reserves were not depleted to the top of the catchment. While stygofauna populations in the lower Maules Creek catchment would have been significantly impacted it is likely that viable populations of stygofauna were able to survive further up the catchment.

31 b. What its effects have been so far. Indicate whether they are known or suspected; provide supporting information or research.

While the exact nature of the effect of the impact of this water extraction on the groundwater dependent ecosystems is unknown it is suspected it could have been catastrophic should the pumping event have continued. Whatever affect it did have appears to have been temporary as water levels slowly recovered over a period of months and after a run of better seasons stygofauna are now prolific in the area.

31 c. What its expected effects are in the future. Include or reference supporting research or information.

If the management strategies are continued and water levels and quality are maintained there is not likely to be any further threat from water extraction due to irrigation.

31 d. Is the threat only suspected? Give Details.

Given the sensitive nature of the stygofauna community any changes to the water levels or water chemistry outside of the natural fluctuations will pose a likely and significant threat to the survival of this community.

31 e. Does the threat only affect certain patches? Give Details.

The impact from the extraction was limited to the Elfin Crossing pools and its immediate surrounds because it was localised and occurred over a short period therefore posing a temporary threat. A more prolonged extraction from the aquifer, however, could potentially drain the entire catchment or reduce the water table in the aquifer making the GDE community unviable.

32. Identify CURRENT threats to the ecological community indicating whether they are *actual* or *potential*. For each threat describe:

There are potential threats to the ecological community arising from the proposed expansion of coal mining and coal seam gas exploration in the Maules Creek catchment.

32 a. How and where it impacts on this ecological community.

Large Scale Coal Mining

A major expansion of coal mining in Leard State Forest in the Gunnedah Basin is being proposed. Two companies, Boggabri Coal which is currently operating and Maules Creek Coal which is in a planning stage, propose to increase total production from 2 million tonnes per annum (MTPA) to 20 MTPA in 4 years with the ramp-up scheduled to commence in late 2012.

Leard State Forest is located within the MCAA area and contains a large area of EPBC listed White Box Grassy Woodland. As part of the mining expansion approx 3000 ha (approximately 36%) of Leard State Forest is proposed to be cleared by the above coal mining companies.

The impacts of this development on the ecological community will occur in the following ways:

Actual threat to the GDE community via a reduction in groundwater levels.

1. Increased mining will increase demand on the Maules Creek Sub Basin aquifers due to extraction of water from the open-cut pits and nearby water bores for dust suppression and coal washing.
2. Reduced recharge due to capture of water on mine sites and diversion of surface water flows for use on the mine site.
3. Aquifer interception will reduce groundwater.
4. Aquifer Depressurisation Effect will reduce aquifer levels.
5. Permanent mine voids will fill with groundwater and cause long term reductions in ground water due to evaporation extracting water from the void.

See drawing A5 in Appendix 2 – Boggabri Coal Ground Water Assessment for cumulative 100 year contour maps provided by Boggabri Coal that show areas of impact on ground water in the MCC.

Note that this modelled 100 Year Cumulative Groundwater contour map is under question by peer review due to inadequacies around the assumptions, calibration and verification of the modelling process. Assumptions excluding impacts of existing nearby irrigation extraction may lead to greater cumulative impacts than that shown in the map.

The adjacent Maules Creek Mine has submitted modelled cumulative impact maps in their Environmental Assessment to the NSW Dept of Planning. Due to the proposed 300 meter depth of the opencut pit this model has been expanded to include impacts within a 30 km radius of the proposed mine site. Note the bottom of the Maules Creek Catchment is approximately 280 m above sea level. A 300 meter deep pit will have major implications to ground water and to the viability of the GDEMCAA.

Actual threat to the GDE community via changes in water chemistry.

1. Changes to the water chemistry due to extraction of coal and general disturbance of alluvial and coal aquifers impacting on the existing connectivity and relative flows from each of these aquifers.
2. Changes to the recharge of aquifers due to diversions in surface flows in mine sites in the Leard State Forest.
3. Recharge will likely go into different aquifers at different rates due to changes in the geological material onsite. See Page 9 of the included Appendix 3 - Soil Futures Review of the Boggabri Coal EA.

Coal Seam Gas Extraction (CSG)

The entire MCC is covered by CSG exploration leases. Petroleum Exploration Lease (PEL) 1 being explored by Santos and PEL 459 explored by Macquarie Energy. Page 18 of Appendix 7 shows an aerial photo and GPS co-ordinates of the location of a proposed Macquarie Energy CSG exploration borehole in the vicinity of Black Mountain Creek within the MCC and upstream from the property "East Lyne" where stygofauna samples were found.

CSG extraction by dewatering of the coal seams will impact on the GDE community as the University of NSW Connected Waters study (Anderson and Achworth 2007) has proven that there is an existing linkage between the alluvial aquifer and the coal seam aquifer in the MCC.

The impacts of this exploration and subsequent mining development on the ecological community will occur in the following ways:

Actual threat to the GDE community via a reduction in ground water levels.

1. Pumping of coal seam water will lower alluvial aquifer levels. This has been demonstrated to be a major impact as it has occurred in areas of Queensland where there is aquifer connectivity. See Appendix 11 for further discussion of the impacts of CSG dewatering practices on aquifers in Queensland.

Actual threat to the GDE community via changes in water chemistry.

1. Due to aquifer connectivity, pumping of coal seam water will change rate and direction of flow between the aquifers leading to changes in water chemistry.
2. Use of drilling fluids for exploration that contain toxic chemicals will change the water chemistry. This actual threat is clearly identified by the company on page 61 of Appendix 7 – Maqaurie Energy PEL 459 REF.
3. Use of fracking fluids that contain toxic chemicals will change the water chemistry. Hazardous chemicals such as ethylene glycol, formamide, naphthalene, ethoxylated nonylphenol and sodium persulfate are commonly used in fracking mixtures. See Appendix 10 for a discussion of these chemicals.
4. Inability to contain coal seam water and brine on sloping, porous sites will lead to contamination of groundwater.

32 b. What its effects have been so far. Indicate whether they are known or suspected; provide supporting information or research.

To date the existing Boggabri Coal mining operation is suspected to have had some limited impact relating to containment of surface runoff in mine site. Relatively low production levels of 1.5 – 2 MTPA, relatively small and shallow pit of 120 meters and the absence of coal washing mean that the impact on aquifers due to the de-pressurisation effect and water usage have not fully impacted on the GDEMCAA.

32 c. What its expected effects are in the future. Include or reference supporting research or information.

Due to a proposed tenfold increase in coal production, expected effects include reductions in ground water levels and changes to water chemistry. Exploration drilling by CSG companies will cause changes to water chemistry due to the use of drilling and fracking fluids.

32 d. Is the threat only suspected? Give Details.

No.

Coal Mining - The effects on the ground water are documented by the Boggabri Coal Environmental Assessment and will also be documented in the Maules Creek Coal Environmental Assessment. Therefore the threat is currently "proposed" but if expansion of the coal mining industry in the catchment is approved then the threat is "likely".

CSG – Aquifer connectivity is shown by Anderson, M. S. and Acworth, R. I, 2007. The CSG exploration companies in NSW are not required to document the environmental impacts of exploration in any way. Production has not started, however based on the documented leaky wells, fracking fluids, drilling fluids, and evaporation pits that are typical of the Queensland CSG industry the threats are "likely" rather than suspected.

32 e. Does the threat only affect certain patches? Give Details.

Due to the high connectivity and porosity of the Maules Creek Alluvial Aquifer and the entire Maules Creek catchment being covered by CSG exploration the threat is to the entire GDEMCAA.

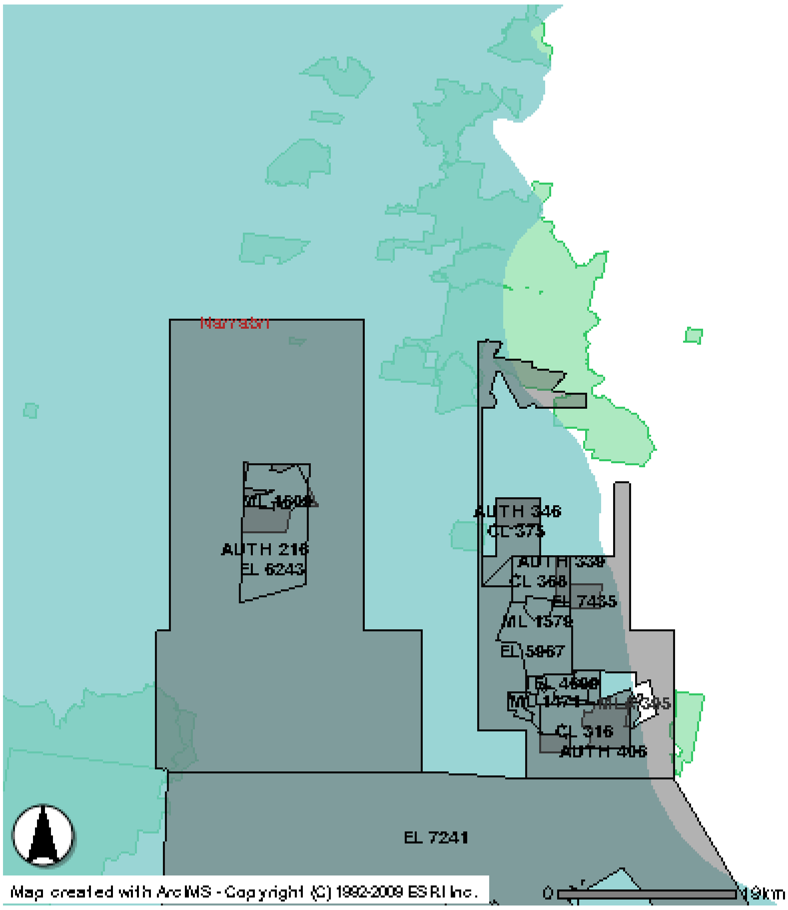
33. Identify FUTURE threats to the ecological community indicating whether they are *actual* or *potential*. For <u>each</u> threat describe:

33 a. How and where it impacts on this ecological community.

CSG – Due to the aquifer connectivity described above, CSG poses an actual future threat to the GDEMCAA community. Impacts on *water chemistry* due to leaky wells, fracking fluids, drilling fluids and evaporation pits and groundwater *levels* will significantly change the habitat of the GDEMCAA affecting its viability and long-term survival. These impacts are standard operational procedure for the CSG industry.

Coal – Further expansion of mining over and above that currently proposed is possible as an Exploration Lease that covers the Maules Creek catchment up to the boundary of the Kaputar National Park has not yet been allocated. See the pendant shaped exploration lease against the Kaputar National Park. in the following Tasmap printout. (http://www.minerals.nsw.gov.au/tasmap/jsp/Viewer.jsp?cmd=login)

The Kaputar National Park is the source of much of the water in the Maules Creek Catchment and the granting of Coal Leases below this water shed would be catastrophic to the GDEMCAA due to increased demands on the water for coal mining purposes and changes in water chemistry.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Map created with ArcIMS - Copyright (C) 1992-2009 ESRI Inc.
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33 b. What its effects have been so far. Indicate whether they are known or suspected; provide supporting information or research.

Suspected impacts. Supporting Information not available.

33 c. What its expected effects are in the future. Include or reference supporting research or information.

Supporting information not available.

33 d. Is the threat only suspected? Give Details.

The future threat is documented and therefore expected. There will be expected reductions in groundwater and likely changes to water chemistry as a result of coal mine expansion and coal seam gas exploration. Based on existing knowledge, these effects will be detrimental to the aquifer (stygofauna) community as well as the other surface GDE communities listed above (See Q.4).

33 e. Does the threat only affect certain patches? Give Details.

The threats from the expansion of coal mining and coal seam gas exploration will be Maules Creek catchment wide. From the CSG exploration drill site at the top of the sub-catchment near "Happy Valley" (see Borehole J on page 18 of Appendix 7 - Macquarie Energy PEL 459 REF) to the bottom of the sub-catchment near Elfin Crossing. This effectively covers the entire area of the GDEMCAA.

34. Identify any catastrophic threat/s (if not included above), explain its likely impact and indicate the likelihood of it occurring (e.g. a drought/cyclone in the area every 100 years). Catastrophic threats are threats with a low predictability that are likely to severely affect the ecological community.

Drought, irrigation and mining (coal and gas) would all increase the pressure on the groundwater in the MCC and lead to a catastrophic impact to the stygofauna community and the other associated GDE's.

35. Identify and explain any additional biological characteristics particular to the community or species within it that are threatening to its survival (e.g. low genetic diversity). Identify and explain any models addressing survival or particular features.

Not Known..

35 a. How does it respond to disturbance?

Not Known.

35 b. How long does it take to regenerate and/or recover?

It is unknown how long the GDEMCAA would take to recover from a disturbance. However, it is considered the GDEMCAA is unlikely to recover once water table is permanently lowered or if the chemical composition of the water table is significantly altered as this is an isolated community that cannot be repopulated from another source.

Threat Abatement and Recovery

36. Identify key management documentation available for the ecological community, e.g. recovery plans, conservation plans, threat abatement plans or site specific management plans (e.g. for a reserve).

None available.

37. Give an overview of how threats are being abated/could be abated and other recovery actions underway/proposed. Identify who is undertaking these activities and how successful the activities have been to date.

In order to prevent impacts to the GDEMCAA it is imperative that;

1. A “No Go” area for Coal Mining and CSG be declared in the MCC.
2. A detailed sampling campaign of the MCC be undertaken to determine the extent of the GDEMCAA.
3. Current exploration within the MCC should cease.
4. No new mining approvals should be granted within the MCC and
5. Existing mining operations within the MCC should be phased out at the end of the current lease periods.

38. What portion of the current extent of the ecological community is protected in a reserve system?

None.

38 a. Which of these reserves are actively managed?

Not applicable

38 b. Give details including the name of the reserves, and the extent the ecological community is protected within these reserves.

Not applicable

38 c. Note which, if any, reserves have management plans and if they are being implemented.

Not applicable

39. Give locations of sites for proposed management, preferably that have been identified in recovery plans and key sites considered to demonstrate those remnants of highest quality and/or most under threat.

Maules Creek Catchment being the only known location of this ecological community and an area under imminent threat from coal mining and coal gas exploration would be the location of any proposed management actions.

40. Give details of recovery actions that are or could be carried out at the local and regional level, e.g. develop and implement management plan for the control of specific weed species (regional), undertake weeding of known sites (local).

Properly funded research into the extent and range of the stygofauna of the MCC could be carried out to better understand the ecology of the component species, their habitat requirements, relationship to other GDE communities and resilience to disturbance. Increase landholder and public awareness of stygofauna to improve recording of sightings.

41. Is there an existing support network for the ecological community that facilitates recovery? e.g. an active Landcare group, Conservation Management Network.

No.

42. Describe methods for identifying the ecological community including when to conduct surveys, e.g. season, time of day, weather conditions; length, intensity and pattern of search effort; and limitations and expert acceptance; recommended methods; survey-effort guide. Include references.

The ecological community can be identified by the presence of stygofauna. Detailed stygofauna surveys should be undertaken using the methods described in Appendix 8. Although stygofauna typically do not show marked seasonal variation in numbers or composition if bores are used as the survey location, the survey frequency should be limited to a minimum of three to six monthly periods between surveys, with a preferred six monthly frequency to avoid the issue of habitat depletion. Once a bore has been sampled it can take a period of time for the stygofauna to recolonise the space depending on the porosity of the aquifer at that point and the construction of the bore. This is not an issue with larger wells and sampling the hyporheic zone.

43. Are there other any aspects relating to the survival of this ecological community that you would like to address?

No.

Section 4 - Indigenous Cultural Significance

44. Is the ecological community, or key species within the ecological community, known to have Indigenous cultural significance to groups within the Australian jurisdiction? If so, to which Indigenous groups? In addition, please provide information on the nature of this significance.

Not known although it is likely that the permanent water holes or springs would have some indigenous cultural significance due the semiarid nature of the area. Food sources such as fish, water birds and yabbies are plentiful in the area.

Section 5 - Justification for this nomination

In order for the nomination to be considered further, one or more of the following criteria needs to be fulfilled and substantiated. A clear case for why the ecological community is eligible for listing under the criteria is required, including evidence as to how it meets the requirements for listing under a particular listing category, e.g. ‘ David et al (1999) finding of 95% decline in geographic distribution suggests it should be listed as critically endangered’.

At least one criterion must trigger the thresholds of a listing category as indicated in the TSSC Guidelines, but the nomination does not need to be eligible for listing under all 6 criteria. Criteria may be of different levels of listing category e.g. Criterion 1 – critically endangered and Criterion 3 vulnerable.

45 Provide data that demonstrates why the ecological community meets at least one of the following criteria for the nominated listing category. This data may already have been provided in previous sections. Please refer to the data again and demonstrate how it specifically meets at least one of the following criteria. Advice on how to interpret the listing criteria is provided in the Guidelines.

Criterion 1: Decline in geographic distribution.

NA

Criterion 2: Small geographic distribution coupled with demonstrable threat.

The GDEMCAA has a small geographic distribution being limited to a single catchment (MCC total catchment size of 17,361 Ha) within the Brigalow Belt South Bioregion in NSW. Component species within the GDEMCAA, in particular, the stygofauna have only recently been discovered (Serov et al 2009) and are in the process of being described, but are regarded as new species to Australia (Serov, in preparation 2011). The condition of this community is considered good, based on available evidence (number and range of species in samples). The occurrence of this community within an unregulated catchment that has had very little water extraction for irrigation is considered to be a contributing factor in its condition. However, the proposed expansion of mining and coal gas exploration within Maules Creek catchment poses an imminent threat to this small endemic community through likely changes in water table levels and water chemistry. The additional disturbances and demands by mining on the groundwater aquifer and potential changes to the aquifer water chemistry from both mining and gas exploration in the MCC is a serious and demonstrable threat to this GDE community. Potentially these activities, should they proceed, will place the GDEMAA and its endemic stygofauna at risk of extinction..

Criterion 3: Loss or decline of functionally important species.

NA

Criterion 4: Reduction in community integrity.

NA

Criterion 5: Rate of continuing detrimental change.

NA

Criterion 6: Quantitative analysis showing probability of extinction.

NA

Section 6 - References

Note: The opinion of appropriate scientific experts may be cited (with their approval) in support of a nomination. If this is done the names of the experts, their qualifications and full contact details must also be provided in the reference list below. Harvard style of referencing is preferred.

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.

Botosaneanu, L. (1986) *Stygofauna Mundi. A Faunistic, Distrbutional, and Ecological Synthesis of the World Fauna Inhabiting Subterranean Waters (Including Marine Interstitial).* E.J. Brill, Leiden

Chessman, B.C., Growns, J.E. and Kotlash, A.R. 1997. Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: application to the Hunter River system, New South Wales. *Marine and Freshwater Research,* **48**:159-172.

Culver, D.C. and Sket, B. (2000) 'Hotspots of subterranean biodiversity in caves and wells', *Journal of Cave and Karst Studies* 62:11–18.

Danielopol, D.L., Pospisil, P. and Rouch, R. (2000) Biodiversity in groundwater: a large scale view. *TREE* 15:223-224.

Eberhard, S., Richardson, A.M.M. and Swain, R. (1991) *The Invertebrate Cave Fauna of Tasmania*, Zoology Department, University of Tasmania, Hobart.

Eberhard, S. and Spate, A. (1995) *Cave Invertebrate Survey: Toward an Atlas of NSW Cave Fauna*, NSW Heritage Assistance Program NEP 94 765.

Gibert, J., Danielopol, D., and Stanford, J.A. (Eds), (1994), *Groundwater Ecology*, Academic Press.

Gibert, J., and Deharveng, L. (2002) Subterranean ecosystems: a truncated functional biodiversity. *Bioscience* 52: 473-481.

Humphreys, W.F. (2002) *Groundwater ecosystems in Australia: an emerging understanding*

Marmonier, P., Vervier, P., Gilbert, J. and Dole-Oliver, M. (1993) Biodiversity in Groundwaters. *Tree* V8 No 11.

Rouch, R. and Danielopol, D.L. (1997) Species richness of microcrustacea in subterranean freshwater habitats. Comparative analysis and approximate evaluation. *Int. Revue ges. Hydrobiol*. 82: 121-145.

Serov, P. (2002). "A preliminary Identification of Australian Syncarida (Crustacea). ." Cooperative Research Centre for Freshwater Ecology. Identification and Ecology Guide 44: 1-30.

Serov, P. In preparation 2011. A Revision of the Family Psammaspididae with a Description of New Species. *In*. Evolution of the Anaspidacea. This research is for the partial fulfillment of the Degree of Ph.D. at the University of New England. Confidential material.

Serov, P, Anderson MS, Acworth RI & Berhane D 2009, *Bio-indicators of Groundwater-Surface Water Connectivity*. Presentation to the Australian Society of Limnology, Alice Springs, 2009.

Schram, F. R. (1984). "Fossil Syncarida." Transactions of the San Diego Society of Natural History. 20(13): 189-246.

Sket, B. (1999b). The nature of biodiversity in hypogean waters and how it is endangered. *Biodiversity and Conservation* 8: 1319-1338.

Thurgate, M.E., Gough, J.S., Clarke, A.K., Serov, P. and Spate, A. (2001) *Stygofauna diversity and distribution in Eastern Australian cave and karst areas*. Records of Western Australian Museum Supplement 64: 49-62.

Tomlinson, M., Hancock, P.J. and Boulton, A.J. (2007) ‘Groundwater faunal responses to desiccation and water table change’, paper presented at *XXXV Congress of the International Association of Hydrogeologists, Groundwater and Ecosystems*, Lisbon, Portugal, 17–21 September 2007

Tomlinson, M. and Boulton, A. (2008). Subsurface Groundwater Dependent Ecosystems. A Review of their biodiversity, ecolological processes and ecosystem services. *Waterlines* Occasional Paper No.8.

44. Please provide copies of key documentation/references used in the nomination.

Key documentation is contained in Appendices 1 through 11.

45. Has this document been reviewed and/or have relevant experts been consulted? If so, indicate by whom and provide their contact details.

Yes.

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Appendix 1 - Impacts of Ground Water Extraction at Maules Creek.pdf

Appendix 2 - Boggabri Coal Groundwater Assessment.pdf

Appendix 3 - Soils Review of Bog EA.pdf

Appendix 4 - Surface water groundwater interactions.pdf

Appendix 5 - Coal Seam Gas Exploration Leases.pdf

Appendix 6 - Potential Stygofauna Landscapes.pdf

Appendix 7 - Macquarie Energy PEL 459 REF.pdf

Appendix 8 – Stygofauna sampling technique.pdf

Appendix 9 - Geochemical and Geophysical Sampling Campaign.pdf

Appendix 10 - NTN Fracking Briefing Paper 2011.pdf

Appendix 11 - Risk to groundwater from CSG.pdf

Section 7 – Completed nomination form checklist

Please check all items on this list have been completed or are included with your nomination

Non-inclusion of items on this list risks non-compliance with the *EPBC Regulations 2000* which could mean your nomination will not be eligible for consideration.

☒ I have read and applied the "Guidelines for Nominating and Assessing the Eligibility for Listing of Ecological Communities as Threatened according to the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and the EPBC Regulations 2000" to this nomination
☒ Nominator details including name, address contact phone number included
☒ Name of the EC
☒ Any other names it is known by
☒ Map included or attached
☒ **References cited**
☒ If questions are left unanswered, a statement indicating that insufficient information is available

A description of:
☒ Biological components of the ecological community
☒ Non biological components of the ecological community
☒ Key interactions and functional processes
☒ Characters distinguishing it from other ecological communities
☒ Key species (dominant, characteristic or diagnostic, threatened etc)
☒ Known or estimated current extent of the ecological community
☒ Past/current/future threats including actual/potential, how/ where, how being/how could be abated
☒ **Which listing category/categories it should be listed under and why**

How to lodge your nomination

Completed nominations must be lodged by 5pm, on the closing day of the annual call either:

1. via email to: epbc.nominations@environment.gov.au

OR

2. via post to:

The Director
Ecological Communities Section
Department of Sustainability, Environment, Water, Population and Communities
GPO Box 787

Canberra ACT 2601