

# Some ways forward for coal seam gas and natural resource management in Australia



An outline of the report  
'An analysis of coal seam gas production and  
natural resource management in Australia:  
Issues and ways forward'

*prepared for*  
The Australian Council of  
Environmental Deans and Directors

*by*

**John Williams Scientific Services Pty Ltd**

October 2012



Williams J., Stubbs T. & Milligan A. (2012)  
Some ways forward for coal seam gas and natural resource management in Australia.  
An outline of the report 'An analysis of coal seam gas production and natural resource management in Australia: Issues and ways forward' prepared for the Australian Council of Environmental Deans and Directors by John Williams Scientific Services Pty Ltd, Canberra, Australia. October 2012.

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ISBN 978-0-9874098-6-7

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**Information sources and referencing**

This outline and the report on which it is based were derived from an extensive range of literature, most of which is accessible via the internet. The authors have sought to ensure that sources for their use of text, figures, diagrams and images are provided as references. If inadvertently the authors have failed to adequately acknowledge a source of material used they would appreciate prompt notification so the matter can be corrected in the electronic copy of the document and a full acknowledgement provided.

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## Summary recommendations

We recommend that the way forward, at the highest level, for managing natural gas production is to treat it in the same way as the other many industries competing for land, water and biodiversity resources in our landscapes.

We recommend two key steps to support adoption of this approach.

### Recommendation 1

The approach used for assessing coal seam gas developments (and any other developments) should be, first, to understand regional landscape capacity (how much degradation can the landscape incur before it starts to lose function), and then to determine if there is capacity for the development without crossing landscape limits.

### Recommendation 2

Current development approval processes should be updated to approve new developments only on the basis of landscape limits and the expected cumulative impacts of the existing and proposed developments.

These recommendations, requiring a whole-of-system analysis, and use of new methods and thinking such as cumulative risk assessment, differ from the approaches currently in use in both NSW and Queensland.

We are convinced that the ideal, for all development within a landscape, is to permit only those landscape activities that are within the capacity of that landscape to maintain its function indefinitely. To achieve that ideal, an examination of cumulative impact is essential.

Explorers and producers of coal seam gas and other unconventional natural gases in Australia potentially benefit the Australian economy. In an energy-hungry world, natural gas is a very valuable commodity, both within Australia and as an exported product.

Paradoxically, the exploration and, particularly, production of unconventional gases also have the potential to damage Australia's renewable natural resources. Our natural resources are vital to the ecological and hydrological functioning of the Australian landscape and, in the long term, the resilience of the Australian economy.

Gas production, like other, existing, land uses, makes demands of the Australian landscape, competing with biodiversity and with the production of other forms of energy, food, fibre and, in some cases, human settlement.

It would be folly to risk our essential natural resources and the ecosystem services they are capable of delivering over the long term, in the interest of securing a relatively short-term energy resource – gas.

This paper proposes we stop giving legal exemptions to gas production. We must invest in achieving a good understanding of the interactions between natural resources. We need to know more about natural resources' limits and resilience under increasing usage. In the short term, we need to develop tools for management and assessment of cumulative impact, and build them into use progressively. Right now, we have a chance to do this, with gas developments still in the early stage. There is no need to rush.

## Unconventional gas production ... is just another land use

In principle, the production of gas is no different from any other land-use development within a landscape, and it should be treated as such.

Managing the production of 'unconventional gases' such as coal seam gas (CSG), is essentially just another demand, to be managed as part of the whole landscape. Gas production, just like other existing and accepted land-uses, poses risks to the condition of nearby water, soil, vegetation and biodiversity. It has the potential to reduce the capacity of renewable natural resources to supply human, as well as ecological, needs.

It is important to see unconventional gas exploration, production and operations in this context. The potential impacts of extracting this resource could be significantly less than the impacts and degradation already experienced as a result of agricultural and urban development over the past two centuries in Australia.

Having said that, it is clear that operations related to extracting unconventional gases, whether from coal seams or shales and

other rock types, *do* have the potential to impact negatively on natural resources and their long-term uses. Human settlement could also be negatively impacted: both low-density settlement, in rural areas of NSW and Queensland now, and high-density settlement in the future, with exploration already nearing the outer suburbs of Sydney.

Therefore it is imperative to manage the regulation of gas production operations in a whole-of-landscape framework that can take account of long-term cumulative impacts. We argue that to help avoid perverse outcomes governments at all levels must adopt land-use planning that is knowledge-based and strategic, looking ahead to the long term.

This report proposes that Australia must engage proactively in regional strategic planning. It must have the capacity to inform and determine statutory processes that are well-founded on whole-of-landscape analysis. Such an approach will take us forward from the existing and historical piece-by-piece approval mechanism that has undermined Australia's biodiversity and so much of its originally productive landscape.

We discuss the matter further in the report *An analysis of coal seam gas production and natural resource management in Australia*, of which this summary booklet is an outline.

In the following pages we give a picture of where we are now, ways to move forward and challenges that lie ahead.

## Natural gas — various forms

'Natural gas', 'coal seam gas', 'shale gas' and 'tight gas' are four types of naturally occurring combustible mixtures of hydrocarbon gases. They are predominately methane with varying proportions of heavier hydrocarbons and other gases such as carbon dioxide. These natural gases are formed when organic matter is altered by organisms in biogenic processes, often in shallow geological sediments, or by high temperatures and pressures known as thermogenic processes<sup>1</sup>, usually deeper in the earth's crust.

Natural gas (also called 'conventional gas'), which is piped to homes and businesses across Australia, has accumulated over millennia in pressurised subsurface reservoirs in sandstone, onshore and offshore. It can readily be produced (extracted) by conventional and uncontroversial drilling methods. Conventional gas can be almost pure methane ('dry') or associated with ethane, propane, butane and condensate ('wet'). Dry gas has less energy content than wet gas. Conventional gas can also be found with oil in oil fields.

Coal seam gas (CSG), shale gas and tight gas occur in 'unconventional' deposits, such as coal beds (coal seam gas), or in shales (shale gas), or in other fine-grained rock types and low quality reservoirs (tight gas), or as gas hydrates. These gases cannot be extracted by conventional drilling. They are dispersed through rock strata and are held in place by water or other pressures which must be relieved to release the gas.

Typically, in Australian sedimentary basins, CSG is extracted from coal seams at depths of a few hundred metres to 1 kilometre, while shale gas and tight gas are found at greater depths.

Dewatering can be necessary to release CSG. This process can entail bringing large volumes of water to the surface where it may need treatment before use in, say, agriculture, or it must be stored in ponds or otherwise disposed of. For shale and tight gas production, dewatering is not required.

Hydraulical fracturing (see box on 'fracking', page 8) is typically needed to release shale gas and tight gas from their host rocks; horizontal drilling also is increasingly being applied. By contrast, not all coal seams need fracking to release CSG.

<sup>1</sup> See References, page 19.



# Impacts and issues

All land uses have a cumulative impact on the functioning of the landscape and ecosystems. It is vital to understand the cumulative effects of all land uses, not just gas operations.

In relation to gas operations, **the following possible impacts need to be considered, separately and together:**

- effects on biodiversity via effects on habitat and vegetation;
- impacts on land used for agricultural and forestry production;
- effects on surface-water and groundwater resources;
- air emissions, including from processes related to gas production;
- social impacts, including effects on community amenity; and
- economic impacts, local, regional and national.

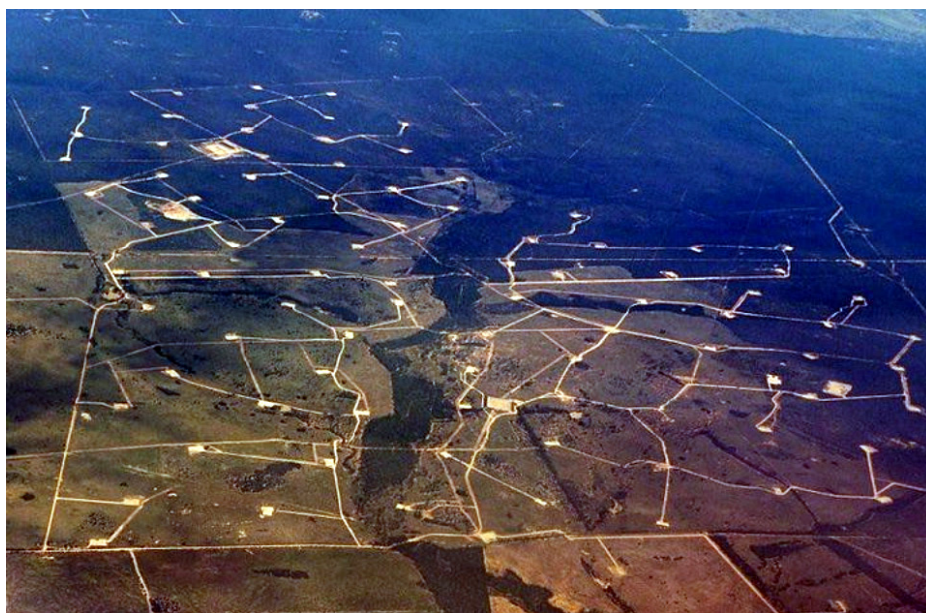
## Impacts on natural resources

### (i) Biodiversity

Establishing gas infrastructure can involve direct clearing of bushland, fragmentation of patches of native vegetation, spread of invasive species and increased fire risk. Depending on the scale of the gas field, these can represent a serious threat to native vegetation, biodiversity and landscape function. During

CSG operations, dewatering of coal seams could change the hydrology of wetlands (including Ramsar wetlands) and groundwater-dependent ecosystems.

Evidence from CSG developments to date indicates that severe effects are possible, particularly in landscapes that have already been extensively cleared. Fragmentation of blocks of native vegetation is yet to be dealt with adequately in the policy and regulatory environments of either State or Commonwealth legislation.



This aerial view of a gas field in Queensland shows the potential for gas production to have a large distributed footprint across agricultural and natural landscapes.

The Native Vegetation Acts in both NSW and Queensland deal well with issues of clearing of native vegetation for other land uses; however, overall, CSG operations are exempt from these Acts. If there is a particular threat to threatened species, then the Commonwealth *Environment Protection & Biodiversity Conservation Act 1999* can be brought to bear, as can the State threatened species legislation. Unfortunately these Acts do not easily deal with broad-scale fragmentation of bushland and loss of habitat.

The cumulative impact of surface installations for CSG operations can be expected to undermine future habitats and the management of threatened species of both plants and animals. Gas exploration and production will need greatly increased attention to its impacts on terrestrial and aquatic biodiversity. Current approaches are fragmented and appear inadequate.

Landscape function and biodiversity appear not to be primary concerns in the regional strategic land-use planning mechanisms of either NSW or Queensland. This is a major environmental and natural resource issue and it has not received much attention in terms of public debate or government–industry discussions.

## **(ii) Agricultural and forestry land resources**

CSG production generally compromises the landscape for productive agricultural and pastoralist activities (which now potentially include carbon sequestration) as well as for its habitat values and its scenic and aural qualities. Consequently, CSG production has to be seen as a new land use competing with other land uses in a region.

Concerns have been raised that CSG activities could affect food production by reducing the usability of strategic agricultural land and water resources. Extensive grazing appears to be one form of agriculture that may be better than others at co-existing with CSG production.

Co-existence between cropping and CSG production is a vexed issue and this will be very true for co-existence with irrigated agriculture, although use of treated water for irrigated agriculture and horticulture has shown promise in short-term trials.

A balanced co-existence of mining and the various forms of agriculture and forestry is possible — with careful management. For this reason, good bioregional planning and assessment is a fundamental issue that requires priority attention.

An Independent Expert Scientific Committee (IESC) is currently pioneering the first steps in conducting bioregional assessment. This body, working with state agencies, is well placed to provide leadership in the development of strategic regional planning and assessment of cumulative risk.

## **(iii) Surface-water and groundwater resources and ecosystems**

Water resources are affected in different ways by CSG extraction and shale gas extraction. To extract CSG, it is necessary to extract water from the coal seam or overlying geological strata. The water is usually of low quality and large volume, and its storage and/or disposal present significant costs and challenges.

Shale gas and tight gas, however, are usually in much deeper strata. To extract gas in these geological formations water is pumped into the well, to produce pressure to fracture the rock (by hydraulic fracturing or ‘fracking’; see box on page 8) and release the gas.



### **Independent Expert Scientific Committee (IESC)**

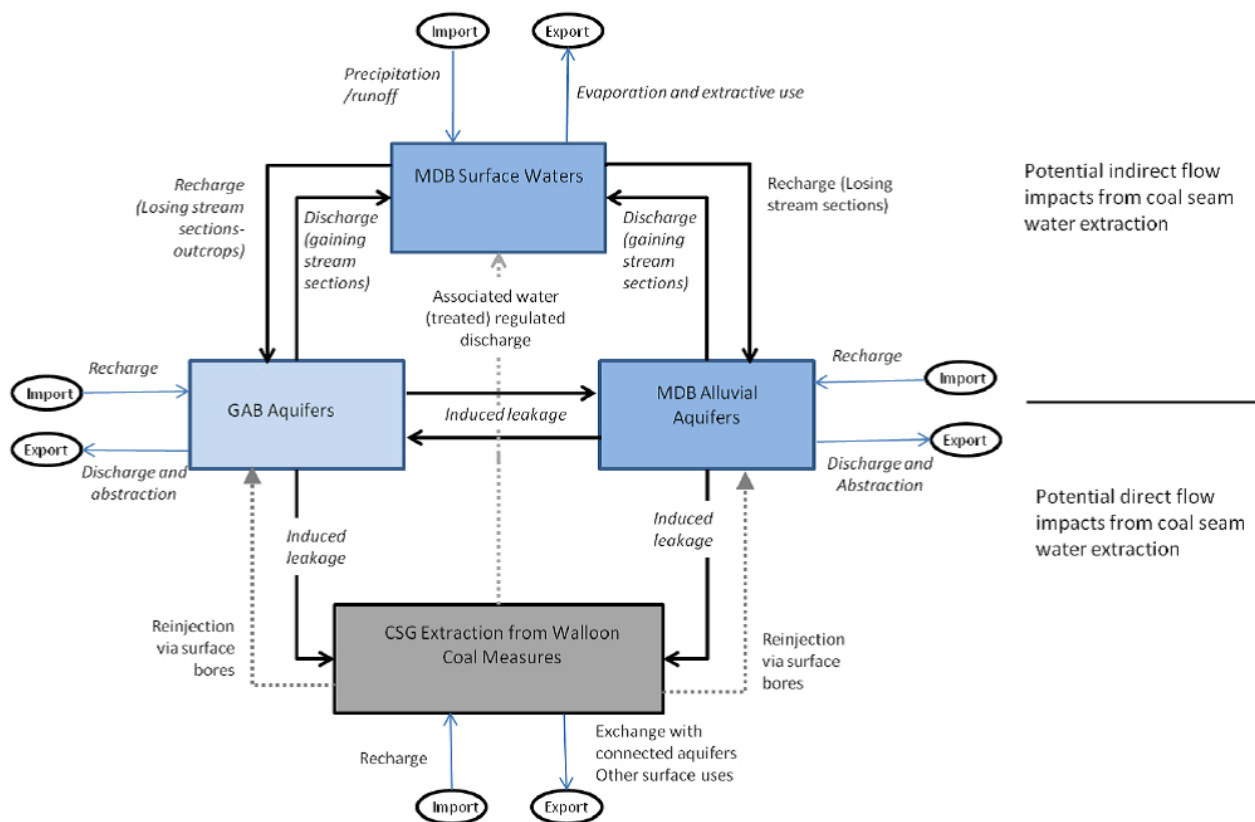
A new Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) has just been established in 2012, supported by Federal Government investment of \$150 million over five years. The Committee is tasked with providing scientific advice to governments about relevant CSG operations and large coal-mining operations where they have significant impacts on water.

It is proposed that the Committee will commission bioregional assessments, and research into the impacts of CSG and coal-mine developments on water resources, and methods for minimising those impacts.

**The following issues, with respect to unconventional gas production and water resources, must receive attention:**

- water extraction to de-pressurise coal seams, and the impacts of subsequent water pressure changes on water movement to and from freshwater aquifers located in other strata of the geological basin;
- replacement of the extracted water in coal seams once gas production has ceased. The water originally extracted is likely to have been disposed of or used, and must be replaced from sources rarely specified and by some redistribution mechanism within the geological stratigraphy. This is shown as the recharge or import terms to the coal seam in the water-balance diagram by Moran and Vink, reproduced below<sup>2</sup>. Methods of recharge have so far received very little attention. Re-injection is one option.
- disposal of the extracted water and salt and other chemical entities liberated from coal and other geological fabric during the dewatering process;
- the containment management and disposal of fracking fluids. Management of fracking fluids and any resultant contamination is a high profile issue with the general public.

Conceptual diagram of effects on the water balance (surface-water and groundwater) in relation to coal seam gas extraction.<sup>2</sup> (GAB = Great Artesian Basin. MDB = Murray-Darling Basin. CSG = coal seam gas)



## The use of hydraulic fracturing ('fracking')

Hydraulic fracturing (also called 'fracking' or 'fracking') is the process of pumping a fluid down a potential gas well to a depth appropriate for producing the gas. The pressure this creates causes the surrounding coal or rock to crack, or fracture, and the fluid then flows into the cracks. The fluid is usually water with some additives including a suspended proppant — usually a sand or similar material that will keep the induced hydraulic fracture open during or following a fracturing treatment. When the pumping pressure is relieved, the water disperses leaving a thin layer of the sand to prop open the cracks. This layer acts as a conduit to allow the natural gas to escape and flow to the well so that it can be recovered.

The pressure required to fracture coal seams without impacting on nearby aquifers requires careful management. There needs to be analysis of the stress distribution in the geological stratigraphy, and of the strength of overlying and underlying strata. Progressive monitoring and reporting of the outcomes of the fracturing activity are also required.

Concerning potential risks of unconventional gas production, the National Water Commission in 2011 wrote<sup>3</sup>:

*The practice of hydraulic fracturing of a coal seam to increase its output of coal seam gas has the potential to induce connection and cross-contamination between aquifers, with impacts on groundwater quality.*

However, in several of eastern Australia's sedimentary basins the coal seams already have numerous natural fractures and need no fracking.

Fracking for shale or tight gas, which can occur at much greater depths than coal seams in Australia, may carry less risk of damaging important aquifers.

Fracking has been banned, at least temporarily, in the states of NSW and Victoria. Queensland and Northern Territory, on the other hand, allow the use of fracking.

In the United Kingdom, the Royal Society and the Royal Academy of Engineers have recently published an extensive analysis<sup>4</sup> of the key science and engineering issues associated with fracking for shale gas in Britain.

Public concern has focused on the risks of groundwater being contaminated by the fracking process. However, there is a far greater risk that the substances associated with fracking could contaminate the surface-waters near well sites. This was reflected in the NSW Parliamentary Committee's concerns that any leaks or spills of fracking fluids or produced water could contaminate water resources.<sup>5</sup>

The Committee recommended that the open storage of fracking fluids and 'produced water' be banned. In both NSW and Queensland, the chemicals used in the extraction of CSG must be disclosed as part of the application process. Agencies assessing the application determine whether the use of those chemicals is safe for both the community and environment.

New techniques, such as horizontal drilling underground, use smaller inputs of these chemicals and are emerging as an alternative to fracking in CSG production. This technology also allows greater distances between production wells in a gas field.

CSIRO studies<sup>6</sup> have examined the risks of groundwater contamination from CSG operations and conclude that there is only a low risk.

In contrast to these assurances for CSG in Australia, concerns remain in the USA that fracking for shale gas extraction has the potential to induce connection and cross-contamination between aquifers, with impacts on groundwater quality.<sup>7</sup>

Irrespective of the degree of actual risk, these activities continue to stimulate significant public debate over possible and perceived risks. Robust data and monitoring, combined with modelling of likely outcomes and honest provision of the facts to the public, are essential.

The US experience is that public understanding of shale gas extraction has failed in the past because industry and government have not been transparent in process, data and analysis.

Australia can learn from this.<sup>8</sup>



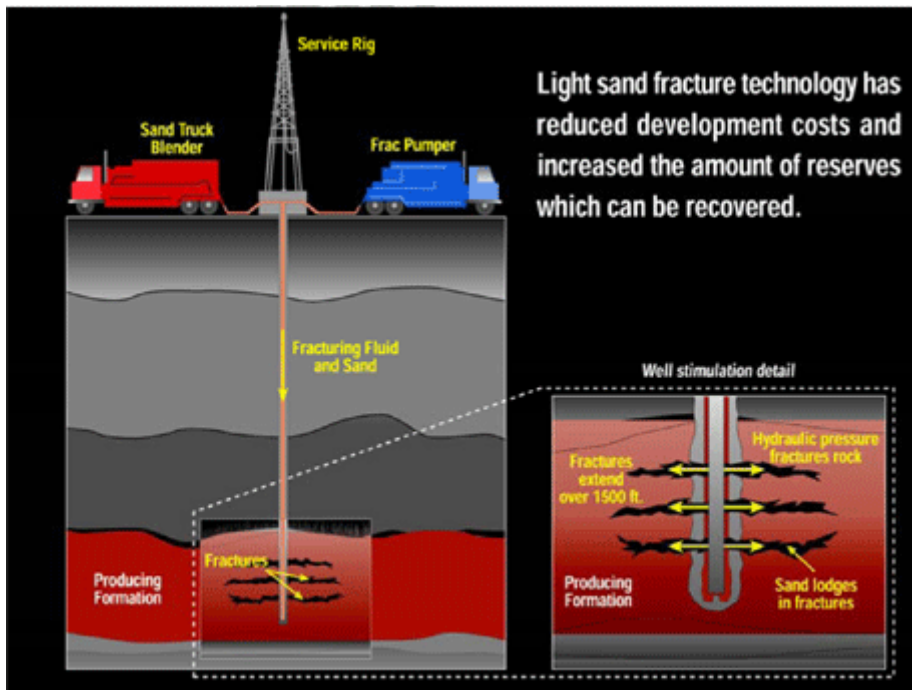
Shale gas production requiring fracking needs access to water to pump into the well. Such access is not necessarily easy in arid regions or during dry conditions and is likely to require a water licence, possibly in competition with licensing for urban, agricultural or other industrial uses. After use, the water, now perhaps contaminated with salts and other substances, is pumped back to the surface, where disposal or storage may become an issue and there is risk that the contaminants may pollute nearby surface waters.

Storage can involve large evaporation ponds, and if the water is salty there is salt to dispose of later. Disposal of the water is not simply a matter of emptying it into the nearest stream because, depending on the volume, timing and quality, such actions can have negative effects on the ecological health and biodiversity of that stream.

Rapid pumping of water from underground aquifers can lead to subsidence of land at the ground surface, affecting relative heights of land and water, and flow patterns. Hydraulic fracturing is implicated in causing small earth tremors.

Thanks to the increasing amount of work in Australia becoming available on the subject of CSG production in relation to the protection of water resources, it is now clear that the potential impacts of CSG on water resources are significant, require very careful attention, and merit being the focus of much public concern.

Here again, the establishment of the Independent Expert Scientific Committee is an important step forward. Of critical importance will be the development of a formal nexus between the work of the IESC and the State regulatory processes for land-use planning, particularly in NSW and Queensland. The exchange and procurement of relevant information, and the capacity to deliver that information in regional strategic planning, will be of paramount importance.



Generalised diagram of the hydraulic fracturing ('fracking') process.<sup>9</sup>

#### **(iv) Air emissions and greenhouse gas impacts**

The four natural gases discussed here, all composed largely of methane, a very powerful greenhouse gas, are widely considered to be an environmentally cleaner fuel than coal. They do not produce detrimental by-products such as sulfur, mercury and ash, and they provide twice the energy per unit of weight with half the carbon footprint during combustion.

Australia is unlikely to reach the intensity and density of gas production infrastructure and air emissions which have caused considerable public concern in the USA. There, air pollution arises from emissions of benzene and other volatile substances involved in shale gas production and transport by diesel-powered vehicles.

No independent Australian field studies have been done so far, but assessment of fugitive methane emissions from CSG and shale gas production will increasingly need to be based on robust scientific observation and prediction. Currently this is lacking.

In its climate-change impact, gas is no better than coal if the gas must be converted into and back from a liquid before it can be burnt. That is the case with CSG shipped overseas, for example. On the other hand, burning domestically sourced gas instead of coal avoids the liquefaction step, and consequently produces less greenhouse gas emissions overall. A NSW Parliamentary Inquiry<sup>5</sup> concluded that the greenhouse gas emissions of energy produced from CSG are, at worst, likely to equal those from coal.

To pump groundwater to the surface burns energy and therefore contributes to greenhouse gas concentrations, whether the water is needed for human use or to dewater a coal seam or aquifer for CSG production. There are positive and negative feedback loops involved in mining a gas for use as a greenhouse-gas friendly energy source if the mining operation itself also emits greenhouse gases.<sup>10</sup>

### **Social impacts**

There is an increasing number of useful reports and journal publications on the social impacts of mining and CSG developments, particularly in Queensland. These studies are bringing greater clarity to some anecdotal perceptions of social impacts arising from such operations, and they are beginning to inform government policy, community awareness and action.

Several studies indicate broad social issues that will need to be addressed in the projected expansion of the CSG industry. These are some examples of the issues raised.

- Information sharing, communication and transparency are critical for enabling good governance and change management at the community level. Information is also critical for effective on-going management of regional opportunities from the CSG energy boom. Information is crucial for being able to plan, to make policy decisions and to evaluate past policies.

### **Legacy issues**

The legacy issue of exploration wells and decommissioned gas-field wells has not received adequate attention in terms of the means to maintaining their integrity indefinitely. By integrity, we mean that these wells should remain completely sealed into the indefinite future, not leaking gas, water or any contaminants within the geological stratigraphy these wells have intercepted.

In some ways that is a large challenge. Wells tapping into combustible hydrocarbon gases can leak and catch fire, as has been seen in 2012 in Queensland.

Fire and bushfire management around gas fields in Australian bushfire-prone landscapes is a dormant issue, as is the question of how active or decommissioned wells perform during floods or earthquakes.



- Gain and revenue sharing, and economic diversification, are essential to increase the social acceptability of mining operations and to increase the local economic opportunities from mining which create wealth but usually not in an evenly distributed way. Economic diversification leveraged off the energy boom is essential to the long-term well-being of the regional communities. The evidence in the literature indicates that economic development based on mining industries alone over the long term will not allow for sustained economic growth.
- Investment in hard and soft infrastructure is crucial to meet the demands of an increased population. Investment in roads, utilities, health-care, policy, transport and other services, as well as in skills, housing, planning and soft infrastructure needs to be increased accordingly, to allow local communities to deal proactively with the inter-related aspects of social change as well as maintain their communities as desirable places to live and work.

The establishment of regional development plans and the actions outlined in, for example, the Queensland Government's Surat Future Directions Statement, indicate a way forward. This is an active area of policy and program development which needs the support of good applied social and economic research.



Potential economic benefits to a region need to be set against the social challenges posed by coal seam gas developments. White lines and patches in the photo show a network of new infrastructure superimposed on the existing agricultural and natural landscape.

## ***Economic impacts***

Industry economic modelling has suggested that the CSG industry could deliver thousands of new jobs and billions of dollars in investment to regional areas, and generate billions of dollars in royalties. However, the economic benefit from CSG production is contested in public debate. In part, that is because of perceptions of how the economic benefit is or should be distributed between state capital, regional centre and local community, and particularly how the social and economic costs tend to fall on local governments, community and individuals.

A brief examination of the economic modelling suggests that a rapidly growing CSG industry in Queensland and NSW has the potential to deliver very significant economic benefits to the state and to the nation. As expected the magnitude of the predicted benefit is dependent on the reliability of the estimates of size and rate of expansion of the CSG infrastructure, and on the income streams from local gas consumption and export of liquefied natural gas.

The distribution of the economic benefit can be strongly skewed towards benefits accruing to capital cities and large centres, with many of the costs and social impacts falling on small regional and local communities and on the individual landholder. Also, while not well documented there is mounting evidence that property values are affected negatively by proximity to and presence of gas infrastructure in Queensland.

The fact that the gas resource is held in trust by government should be a reason for good public policy to ensure there is genuine equity in the way wealth from gas is shared across the community. There appears, however, to be some scope to mediate how the economic benefits and costs are distributed, depending on how the development of the industry is governed, managed and supported by good public policy.

## Benefits and risks of CSG operations

Thorough independent risk assessment is essential if policy is to respond appropriately to cumulative impacts, positive and negative, of CSG exploration and production and possibly also decommissioning of wells.

Many of the potential impacts listed below may be relatively minor if gas well operations are sparsely distributed. In practice, wells are often spaced less than 1 000 metres apart. Thus they can be expected act in synergy, compounding each other, and possibly generating emergent new impacts in areas where gas operations impose densely on the landscape.

### *Potential impacts on natural resources*

- Loss of patches of vegetation through clearing to make space for gas infrastructure, including possible eradication of threatened plant species.
- Fragmentation or isolation of populations of species, with possible loss of genetic variability, and inbreeding and its consequences.
- Interruption to food resources and territorial ranges for fauna.
- Improved access for predators and for pest plant and animal species and diseases.
- Restriction of normal adaptive behaviour in native species, including by restricting access to vegetation corridors for use during climate change.
- Hydrological effects on aquatic ecosystems (dependent on surface-water or groundwater) and terrestrial ecosystems (including agricultural) if:
  - nearby storage ponds (holding extracted water) overflow in rain or flood, or if
  - large volumes of water taken from coal seams are disposed of into streams, or if
  - extracted water (in dewatering) needs to be replaced at decommissioning, or if
  - dewatering of coal seams
    - \* lowers the local water table, or
    - \* changes flow in other aquifers, or
    - \* causes land subsidence.
- Leakage of methane into the air, with associated risk of fire and impacts on global greenhouse gas concentrations.
- Leakage of industrial chemicals and gases associated with CSG operations.
- Erosion and sedimentation associated with installing infrastructure to move the gas across Australia or overseas.

### *Potential impacts of CSG production on people and the economy*

- Net increases in the national and state gross domestic product.
- Benefits in employment and capture of economic opportunities in regions where CSG is being produced, possibly at the expense of employment and economic opportunities in other adjacent industries and in other regions of Australia.
- Loss of income in rural communities through damage to or loss of access to land, and loss of amenity and of land value.
- Increased pressure on local infrastructure and increased costs of local services particularly accommodation.
- Loss or contamination of water resources (as above), both surface and/or groundwater.
- Damage to property from earth tremors in relation to mining operations.



# Where we are now ... and ways forward

Australia's combined identified resources of natural gas, both conventional and unconventional, have been put at more than 431,000 petajoules, sufficient for 184 years of use at current rates of production. Identified potential resources amount to more than twice that amount of gas, although a large proportion is classed as sub-economic for development.<sup>11</sup>

Current CSG developments tend to be situated where existing gas infrastructure is available, which also tends to be where there are already other productive resources, including land, surface water and groundwater resources.

For instance, in NSW there is advanced exploration and appraisal within the Sydney, Gunnedah, Clarence–Moreton and Gloucester basins. Relating those basins to agricultural development, the Namoi catchment is part of the Gunnedah sedimentary basin, as is the highly valued agricultural land of the Liverpool Plains.

In Queensland the productive basins are the Surat and the Bowen where there is both ongoing exploration and development and existing coal mines. The significant agricultural land resources of the Darling Downs, at least, overlie the Surat basin.

Conventional gas (natural gas) is already piped to eastern Australia from the Cooper basin in South Australia, where companies are also finding unconventional gas resources. Beneath the Cooper and basins in NSW and Queensland is the Great Artesian Basin, one of the largest artesian groundwater basins in the world.

The other states and Northern Territory also have unconventional gas resources. For instance, in Victoria, tight gas resources occur in Gippsland and there is also exploration in the Otway basin west of Melbourne.

## Current government and regional policy

How does current government policy to protect Australians and the environment deal with the potential for cumulative effects of land uses, particularly gas operations? In NSW and Queensland alone of the states and territories and the Commonwealth, the policy and laws and regulations to protect the environment in relation to mineral extraction make mention of cumulative impacts on land or water resources.

In NSW the Government is, arguably, trying to take a strategic approach for the expansion of CSG mining, through the development of Strategic Regional Land Use Plans across the state.

However the use of Strategic Regional Land Use Plans — and the NSW approach in general — is currently quite piecemeal. It lacks the capacity to manage the development of the CSG industry at an appropriate scale and in a way that delivers positive outcomes, not only for CSG proponents or farmers but for the landscape.

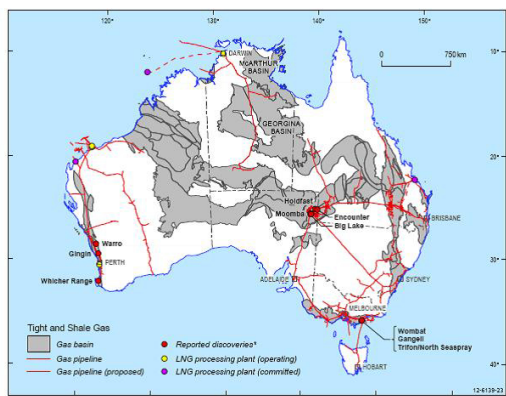
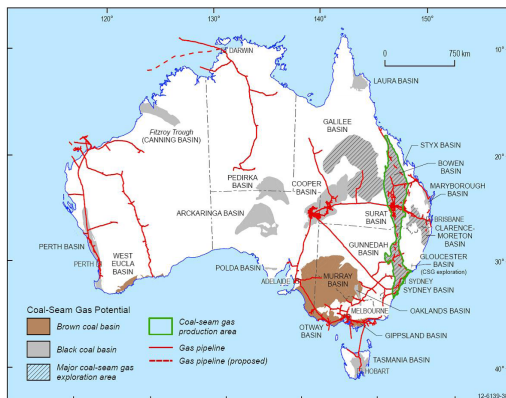


Figure 23: Basins with tight gas and shale gas resource potential and gas infrastructure. Note: \* Shows the locations of all shale and tight gas discoveries with reported contingent resources. Source: Geoscience Australia

Basins (shaded in grey) with coal seam gas potential (top map) and tight and shale gas potential (bottom map)<sup>11</sup>

The current process is skewed heavily towards meeting the concerns of a vocal lobby about potential impacts on agricultural land. Meeting the concerns of this group may not result in strategic decisions for the benefit of the landscape or the broader community.

In Queensland, which has been wrestling with the challenges of the rapid development of the CSG industry for longer than NSW, the legislative framework is further developed. Mining does not need to comply with the planning regime in Queensland because mining is an exempt development under the *Sustainable Planning Act 2009*.<sup>12</sup>

However, the Queensland Government has recognised that groundwater extraction from multiple gas fields adjacent to each other will have overlapping impacts. Consequently, the government has identified 'Cumulative Management Areas'.

Within a Cumulative Management Area, the Queensland Water Commission was responsible for assessing impacts and establishing integrated management arrangements via an 'Underground Water Impact Report' based on water-level impacts in aquifers over time, as predicted from its regional groundwater flow model. On approval, an Underground Water Impact Report becomes a statutory instrument under the *Water Act 2000*, and individual petroleum-tenure holders are then legally responsible.

At regional level, the Queensland Murray-Darling Committee (QMDC) is the natural resource management body in Queensland with the largest amount of CSG development occurring within its area. The QMDC has worked with stakeholders to develop a policy to address mining and energy industry impacts on natural resources.<sup>13</sup> The document provides no framework for linking the policies to the legislative requirements placed on CSG proponents. Nor does it explain how the policies are integrated into the planning system.

Overall, at present the Queensland Government has no mechanism for dealing with CSG at a landscape scale across all asset classes. Although CSG operations' effects on groundwater are addressed at a regional scale, it is not clear how surface water, vegetation, biodiversity and agricultural land issues are being managed at a landscape and cumulative level to ensure natural resource management objectives of the region are achieved.

In other jurisdictions affected by exploration for unconventional gas, the alarm raised in NSW and Queensland — and the USA where shale gas has been the main issue — has alerted governments to develop or refine their relevant policies. In Victoria, where exploration appears to focus on tight gas, there is so far no apparent consideration of how to deal with cumulative impacts. However, the Department of Primary Industries website states:

*Development of Victoria's resources must be carried out in a sustainable manner. The environment must be protected and positive outcomes achieved for regional communities.*

In Western Australia, it appears more likely that shale gas, rather than CSG, will be produced. The different extraction depths and requirements for water to extract shale gas mean that it is less



Ecologically valuable habitat, dependent on the surface and groundwater regimes being maintained.

likely that aquifers will be affected there. In South Australia, onshore gas production has been in progress for many years at the Moomba gas field, outback in the Cooper Basin, and legislation aims to “eliminate as far as reasonably practicable risk of significant long term environmental damage”.

### **Federal government**

At federal level, the Australian Government becomes involved in the licensing and regulation of a CSG project when the project has the potential to have an impact on matters protected under national environment law. Examples include nationally threatened and migratory species, wetlands of international importance, and national or world heritage places.<sup>14</sup>

Relevant projects must undergo an environmental assessment to determine whether their likely impacts are acceptable under the legislation. The assessment process under national environment law includes opportunities for public comment.

When deciding whether to approve CSG projects under national environment law, the Environment Minister must consider likely significant impacts on matters protected under national environment law. The Minister must also consider economic and social matters and the principles of ecologically sustainable development. In assessing CSG proposals, the Minister may consider cumulative impacts, but is not required to.

If an approval is granted, environmental conditions are usually attached, as an attempt to minimise environmental impacts. State/Territory conditions are also considered in the development of federal conditions.

### **Science and engineering to guide policy**

As already mentioned, an Independent Expert Scientific Committee (IESC) has been established in 2012, with Federal Government support for five years, to provide scientific advice to Australia’s governments.

A new National Partnership Agreement, being developed with the states through the Council of Australian Governments (CoAG), has been signed by NSW, Queensland, Victoria and South Australia. When considering approvals for CSG and large coal mining developments that are likely to affect water resources, the signatory governments are required to seek the advice of the IESC.

Together, the states and Commonwealth are creating a National Harmonised Framework for CSG, to consider industry interactions with water management, well integrity, hydraulic fracturing and chemical use and community engagement. This framework could be developed as a possible means to deliver a risk analysis approach to consider cumulative impacts.





## Gas operations add to cumulative impact

What is likely to happen in the long term in a situation where CSG wells, combined with other types of mining or alone, add to impacts already exerted on natural resources — by groundwater pumping, clearing of native vegetation, drainage from irrigated lands, and so on?

In northern NSW the managers of the land and water of the Namoi River catchment have realised that the combined pressures of existing coal mines and expected CSG exploration will add to the impacts from existing land uses on the natural resources and ecosystem services of the area. The Namoi Catchment Management Authority (CMA) has recognised that mining has the potential to deliver substantial benefits to the region over the long term. They also recognise that mining (not just CSG) is a potential threat to the natural resource assets of the catchment.

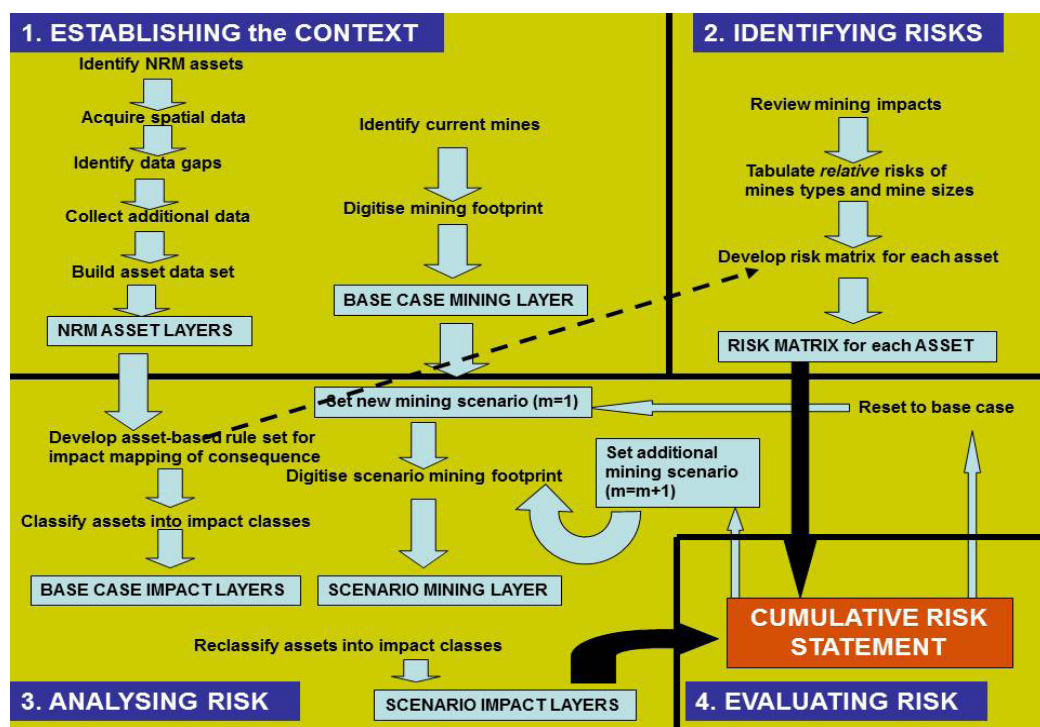
The challenge for the CMA was to assess not only the impacts of any one mining development on the natural resource assets of the catchment, but also to be able to assess the potentially cumulative impacts of a number of mining developments.

Working with Eco Logical Australia, the Namoi CMA has used its detailed understanding of the natural resource assets of its region and its strategic vision for the catchment, expressed in the Namoi Catchment Action Plan, to build a framework inside which a risk assessment process can be undertaken for mining and coal seam development. The framework can assess both the risks associated with an individual project and the cumulative risks of any new project or projects when added to the existing pressures on the natural resources.

Using this framework and a GIS modelling tool, the CMA is producing a cumulative risk statement on the individual and cumulative impacts associated with any real or hypothetical mining scenario. The diagram shows the potential outputs that the tool

would produce for a hypothetical scenario of new mines in the catchment.

The CMA is also looking at developing the tool so that mining and CSG developers can run a range of scenarios to determine how best to structure their operation to minimise, or remove completely, any negative impacts on the natural resource assets of the Namoi catchment.





## Call for a new focus in research and academic leadership to support policy

The production of unconventional gases such as CSG, in a context of wise management of natural resources, highlights new needs in teaching, research and academic leadership to foster public discourse and development of public policy.

- A whole-of-system perspective in teaching and research would elucidate the nature of the crossovers and feedbacks between gas energy production, climate-change mitigation, water resources, food and fibre production and protection of biodiversity.
- More science and engineering knowledge in, for example, hydrology, structural geology, hydrogeology, drill engineering and new technologies, and predictive modelling capacity, along with a great deal more field data on geology and groundwater systems will be absolutely essential to managing unconventional gas production and its interface with natural resource management.
- New tools, which enable cumulative risk analysis of multiple land-use developments within a landscape to be understood and evaluated, are critical to the proposals in this report. Without new knowledge and its application in a whole-of-systems perspective, the way ahead will be littered with attempts to solve one problem whilst creating another.
- Economic analysis provides valuable insights into how the impacts of CSG can be understood and managed effectively with good public policy and governance. A better future will depend on robust knowledge being applied to marshal economic benefits in the interests of all.
- Social impact analysis appears to show that regional development planning — where social, economic and environmental matters related to gas operations are brought together to drive action — has much to commend it. The challenge is to bring social, economic and environmental concepts together to lead the way to sustained and enduring action on the ground.

## Achievable or theoretical?

In practice, for groundwater resources at least, scientists and engineers are seriously constrained in their capacity to evaluate cumulative impacts — both quality and quantity — from multiple gas field developments. For analysis and modelling they need more than the rudimentary data and decision tools available at current levels of investment in practical geology and hydrogeology and field research.

Particularly in the Great Artesian Basin and its associated sedimentary basins there will be increasing exploration and development of hydrocarbons including natural gas. Science must be able to examine quantitatively, and predict by modelling, potential effects on aquifer interaction, vertical recharge, structural integrity and artesian pressure from existing and new fields for gas and mineral production. Therefore, new field data are essential for describing the hydrological processes actually operating in the ground.

A regional-scale multi-layer model of the cumulative effects of multiple developments will need to be developed to assess and manage the impacts, using a regional-scale monitoring and mitigation approach. Such a model could be used to set the parameters for an adaptive management framework in which monitoring and mitigation strategies can be developed and be applicable at both the project and regional scale. The aim is to support long-term monitoring and management of groundwater resources and ecological communities dependent on groundwater (such as in mound springs fed by the Great Artesian Basin).

We consider that concerted Commonwealth and State action will be necessary to develop such a model as a high priority.<sup>15</sup>

# In conclusion ...

Australia needs enduring and sustainable production of its huge gas resources, as well as continuing production of other forms of energy, water, food, fibre, minerals and other human needs.

Our renewable natural resources do not have unlimited capacity. There is only so much fresh water available in our rivers and aquifers, only so much native vegetation, biodiversity, fresh air to breathe, productive soils, estuaries and beaches.

This report proposes that therefore Australia must engage proactively in regional strategic planning, and have the capacity to inform and determine statutory processes that are well-founded on whole-of-landscape analysis. Such an approach will take us forward from the existing and historical piece-by-piece approval mechanism that has undermined Australia's biodiversity and so much of its originally productive landscape.

Constantly diminishing our renewable natural resources leads to a loss of landscape function which in turn means our landscapes cannot deliver the things we need from them. These needs range from healthy soils and fresh water for growing our food to energy to power our society and the clean air and open space required for recreation and wellbeing. There are also many other benefits in between, some of which we may not yet fully understand or be able to quantify.

In principle, the production of gas is no different from any other land-use development within a landscape, and it should be treated as such. Gas production is one more demand on the landscape. However, with this new demand we have the opportunity to assess our *total cumulative demands* on Australia's natural environment, both above and below the ground

Well managed, the potential impacts of extracting our gas resources could be significantly less than the impacts and degradation already experienced as a result of agricultural and urban development over the past two centuries in Australia.

It is important that public discourse, and research and academic leadership in social and economic disciplines as well as science and engineering, come together to help Australia develop appropriate public policy and legislation to protect our future.

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