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

The Australian Council of Environmental Deans and Directors
The authors:
John Williams FTSE BSc Agr (Hons1) PhD (USYD) MAIAST
Tim Stubbs B Eng (Env) (Hons)
Ann Milligan BSc(Ag) Hons Grad Dip NRM Policy and Planning

An analysis of coal seam gas production and natural resource management in Australia

Issues and ways forward.

A report prepared for The Australian Council of Environmental Deans and Directors
by John Williams Scientific Services Pty Ltd

October 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

October 2012
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.
Some Background…
Simple Drill Well Layout for CSG Production

- Coal Seam
- Overlying Formations
- Underlying Formations

Typically 200 to 800 metres

- Water
- Gas flow

Pump unit

Gas to pipeline

Water to treatment plant

Coal Seam

Overlying Formations

Underlying Formations
Basic schematic of a coal seam gas well

Key Features

1. Variable speed electric motor with pump drive assembly is mounted on wellhead.

2. Surface Conductor (steel) passes through topsoil into solid sandstone. It is drilled first and cemented into place to provide a stable foundation for subsequent drilling (by preventing the hole from collapsing).

3. Surface Casing (steel) passes through the entire Pilliga sandstone layer. It is cemented into place so that good quality water from the Pilliga cannot drain away, and to ensure poor quality water from deeper layers cannot enter the Pilliga.

4. Production Casing (steel) runs all the way from the surface to the target coal seam. It is cemented into place and further ensures that water cannot move from one layer of the earth to another layer.

5. Shaft driven pump is used to pump water from the well. Gas flows up through the well to the surface.

6. The well extends below the production casing through the target coal seam into the rock (‘basement’) below the coal. Water and gas flow from the target coal into the well. Water from the target coal seam contains around 1% dissolved solids and, without processing, is not suitable for agricultural or other uses.

Source: NSW LEGISLATIVE COUNCIL Inquiry into Coal Seam Gas P9
## Differences between conventional and unconventional gas

<table>
<thead>
<tr>
<th></th>
<th>CONVENTIONAL GAS</th>
<th>COAL SEAM GAS</th>
<th>SHALE GAS</th>
<th>TIGHT GAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geological setting</td>
<td>Well defined structures within permeable sandstone overlain by a low permeability seal</td>
<td>Coal seams within relatively low permeability shales</td>
<td>Within pores/fractures in low permeability shales</td>
<td>Within pores/fractures in very low permeability rocks</td>
</tr>
<tr>
<td>Style of entrapment</td>
<td>Structural or stratigraphic traps</td>
<td>Adsorption on coal surface or in fractures</td>
<td>Adsorption on shale surface or in fractures</td>
<td>Trapped in pore spaces</td>
</tr>
<tr>
<td>Production</td>
<td>Driven by natural reservoir pressure</td>
<td>Dewatering and/or fracturing required</td>
<td>Fracturing required</td>
<td>Fracturing or acidisation required</td>
</tr>
<tr>
<td>Potential water impacts</td>
<td>Negligible (water not displaced through production)</td>
<td>Potentially major in some areas due to hydraulic effects of displacing water in coal seams and contamination by fracing chemicals.</td>
<td>Likely to be minor apart from where there are more permeable rocks or structures present or if fracturing impacts on aquifers (hydraulically or chemically)</td>
<td>Likely to be negligible due to the low proportion of water present, except if fracturing impacts on aquifers (hydraulically or chemically)</td>
</tr>
</tbody>
</table>
Figure 1: Location of Australia's gas resources and infrastructure

Department of Resources, Energy and Tourism
Minister for Resources and Energy: The Hon. Martin Ferguson, AM MP
Secretary: Mr Drew Clarke

Geoscience Australia
Chief Executive Officer: Dr Chris Pigram

Bureau of Resources and Energy Economics (BREE)
Executive Director/Chief Economist: Professor Quentin Grafton
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
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EDR</td>
<td>113,400</td>
<td>35,905</td>
<td>-</td>
<td>-</td>
<td>149,305</td>
</tr>
<tr>
<td>SDR</td>
<td>59,600</td>
<td>65,529</td>
<td>-</td>
<td>2,200</td>
<td>127,329</td>
</tr>
<tr>
<td>Inferred</td>
<td>~11,000</td>
<td>122,020</td>
<td>22,052</td>
<td>-</td>
<td>155,072</td>
</tr>
<tr>
<td>All identified resources</td>
<td>184,000</td>
<td>223,454</td>
<td>22,052</td>
<td>2,200</td>
<td>431,706</td>
</tr>
<tr>
<td>Potential in-ground</td>
<td>Unknown</td>
<td>258,888</td>
<td>Unknown</td>
<td>435,600</td>
<td>694,488</td>
</tr>
<tr>
<td>resources</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources identified,</td>
<td>184,000</td>
<td>258,888</td>
<td>22,052</td>
<td>435,600</td>
<td>900,540</td>
</tr>
<tr>
<td>potential and undiscovered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Conventional gas demonstrated resources as of January 2011; CSG demonstrated resources as of January 2012. Note CSG 2P reserves and 2C resources are used as proxies for EDR (economic demonstrated resources) and SDR (sub-economic demonstrated resources) respectively. Source: Geoscience Australia
What we discovered...

- In principle, CSG production is no different to any other land use development within a landscape and should be treated as such.
Integrated action, based on sound science, to Manage water in the landscape for all users, for now and the future.
Planning resources are disproportionally focussed on development assessment rather than strategic planning.
Regional Strategic Planning

- From any understanding of how the Australian landscape functions it is possible to use principles of Integrated Catchment (Watershed) Management to create a mosaic of appropriate land uses given the underlying capacity of natural systems to support desired set of values.
Regional Strategic Planning

- It is possible and desirable to use our knowledge of landscape process to work out upfront where we can safely mine and where mining would compromise agriculture, water resources, biodiversity, other land uses and landscape environmental function.
Regional Strategic Planning

- It is folly to secure one natural resource while putting at risk renewable long term resource use. The need is paramount for:
  - good long term regional land use planning to avoid such perverse outcomes
  - Recognition of limitation of EIS approach...leads to death by 1000 cuts!
  - Need non statutory regional and landscape planning to inform statutory planning
Regional Strategic Planning

- Good regional and catchment action planning (CAP) with appropriate spatial definition should be able to identify
  - no go areas for mining for gas and coal
  - go with care areas in which mining can be conducted without unacceptable perverse outcomes within a regulation framework.
Regional Strategic Planning

- The mining Acts for unconventional gas production and CSG in general need reform to bring them in line with ESD principles and the objectives of the State Acts which govern Native Vegetation and Water Resources, Agricultural and Biodiversity (eg In NSW the Native Vegetation and Water Management Acts)

- Integrated Catchment Management is now possible and mining along with urban development and all land use should sit.
Integrated catchment management

Basic principles:

1. Take a holistic approach to the management of land, biodiversity, water and community resources at the water-catchment (watershed) scale
2. Involve communities in planning and managing their landscapes
3. Find a landscape functional integration between resource use for mining, agriculture, tourism, urban development etc...
Principles for a new planning system

- Planning based on best available information
- Planning at the right scale
- Whole-of-government alignment
- Community engagement
- Cumulative Risk management
- Independent audit, monitoring and evaluation
- Open access to information

Strategic Planning Principles

- whole-of-government;
- part of a consistent hierarchy of aligned, nested plans;
- integrated across different levels of government;
- able to be adjusted in response to changing circumstances;
- developed with early and effective community engagement;

[Productivity Commission benchmarks]
1. ESTABLISHING the CONTEXT

- Identify NRM assets
  - Acquire spatial data
  - Identify data gaps
- Collect additional data
- Build asset data set

NRM ASSET LAYERS

2. IDENTIFYING RISKS

- Identify current mines
- Digitise mining footprint

BASE CASE MINING LAYER

- Tabulate relative risks of mines types and mine sizes
- Develop risk matrix for each asset

RISK MATRIX for each ASSET

- Review mining impacts
- Set additional mining scenario (m=m+1)
- Digitise scenario mining footprint

SCENARIO MINING LAYER

- Develop asset-based rule set for impact mapping of consequence
- Classify assets into impact classes

BASE CASE IMPACT LAYERS

- Reclassify assets into impact classes

SCENARIO IMPACT LAYERS

3. ANALYSING RISK

- Identify NRM assets
  - Acquire spatial data
  - Identify data gaps
- Collect additional data
- Build asset data set

SCENARIO IMPACT LAYERS

4. EVALUATING RISK

- Review mining impacts
- Tabulate relative risks of mines types and mine sizes
- Develop risk matrix for each asset

CUMULATIVE RISK STATEMENT

- Reset to base case
- Set new mining scenario (m=1)
What we discovered...

- CSG production and protection of water resources and aquatic ecosystems is a significant natural resources issue.
Leakage

Groundwater flows to coal seam???

De-watering

Re-injection
Figure 2.18: Block diagram of general stratigraphy of Surat Basin. Source: QUT b (2011).
De-watering of coal measure must have impacts on water flows in stratigraphy
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.
The following issues, with respect to unconventional gas production and water resources, must receive attention

- 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 fraccing fluids. Management of fraccing fluids and any resultant contamination is a high profile issue with the general public.
What we discovered...

- CSG production and protection of biodiversity and landscape function via vegetation and habitat management is a critical but neglected natural resource issue.
Figure 3.2: Tracks and patches cleared in native vegetation for CSG operations.
Figure 3.3: Part of the Pilliga Forest in the northern part of NSW.
What we discovered...

- CSG production and protection of agricultural and forestry land for food, fibre production and carbon sequestration needs better resolution as part of whole of landscape planning.
Can Agriculture co-exist with gas?
What we discovered...

- Economic impact of CSG production is very significant and offers opportunity for good public policy to broaden benefits and provide foundation for future community wellbeing.
Table 4.1. Summary of effects and increases in output likely from a proposed NSW coal seam gas development. (Allen Consulting 2011)

<table>
<thead>
<tr>
<th>Region</th>
<th>Construction phase</th>
<th>Operation phase</th>
<th>Cumulative impact to 2035</th>
<th>NPV (@7% real)</th>
<th>NPV (@12% real)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSW</td>
<td>$253 million per annum</td>
<td>$821 million per annum</td>
<td>$15.2 billion</td>
<td>$5.8 billion</td>
<td>$3.1 billion</td>
</tr>
<tr>
<td>Regional</td>
<td>$28 million per annum</td>
<td>$470 million per annum</td>
<td>$8.5 billion</td>
<td>$3.0 billion</td>
<td>$1.6 billion</td>
</tr>
<tr>
<td>National</td>
<td>$309 million per annum</td>
<td>$531 million per annum</td>
<td>$10.7 billion</td>
<td>$4.2 billion</td>
<td>$2.5 billion</td>
</tr>
</tbody>
</table>

Per cent change

<table>
<thead>
<tr>
<th></th>
<th>NSW</th>
<th>Regional</th>
<th>National</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2011</td>
<td>0.06</td>
<td>0.80</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Figure 4.4. Assumed linear growth in gas production from NSW fields in the ACIL Tasman model. (ACIL Tasman 2011)

Figure 4.2. A projection of the capacity of 'Northwest' NSW to produce CSG. (Santos 2011)
It’s a zero sum game.
The development of a two-speed economy
Figure 4.9. Diagram to explain input-output modelling (Rolfe et al. 2011, Figure 2)
Must build regional and local capacity to capture economic benefits

Figure 4.11. Advertisement for the Industry Capability Network in Queensland.
Economic Diversity is critical

- 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.
What we discovered...

Social impact of CSG production is becoming better understood and new insights provide opportunity for innovative government policy, community awareness and action
Information sharing, transparency and planning

- Information sharing, communication and transparency are critical for enabling good governance and change management at the community level.

- Information is also critical for effective ongoing 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.
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,
- Investment in skills, housing, planning and soft infrastructure
- This will 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.
Call for a new focus in research and academic leadership to support 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.

- New needs in teaching, research and academic leadership to foster public discourse and development of public policy.
Call for a new focus in research and academic leadership to support policy

- More science and engineering knowledge in, for example, hydrology, structural geology, hydrogeology, drill engineering and new technologies, and predictive modelling capacity.
- 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.
Call for a new focus in research and academic leadership to support policy

- 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.
In conclusion ...

- In principle, the production of gas is no different from any other land-use development within a landscape.
- 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.
In conclusion ...

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.
In conclusion ...

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.
The Energy/Water/Food/Environment NEXUS
21 Century Challenge