



**Chief Scientist
& Engineer**

Final Report of the Independent Review of Coal Seam Gas Activities in NSW

September 2014



www.chiefscientist.nsw.gov.au/coal-seam-gas-review



**Chief Scientist
& Engineer**

The Hon Michael Baird MP
Premier
Minister for Infrastructure
Minister for Western Sydney
Parliament House
SYDNEY NSW 2000

Dear Premier,

Final Report – Independent Review of Coal Seam Gas Activities in NSW

In February 2013 your predecessor wrote requesting I undertake an independent review of coal seam gas activities in NSW. I now submit the final report of that Review.

This report presents the Review's findings and recommendations. Detailed support for the outcomes of the Review is provided in the accompanying reports and information papers released as part of the Review.

In presenting this final report I wish again to acknowledge the assistance of many people – the experts who advised the Review; those who took the time to write submissions or talk to my team; colleagues from government departments in NSW and other jurisdictions; colleagues in industry, research organisations, learned academies and professional associations; and the CSG review team itself which worked hard to make sense of a complex and contentious issue.

Yours sincerely,

Mary O'Kane
Chief Scientist & Engineer
30 September 2014

EXECUTIVE SUMMARY

This report is the final and overarching report of the independent review of coal seam gas activities in NSW (the Review) undertaken by the Chief Scientist and Engineer. It presents the main findings and recommendations of the Review along with a summary of Government decisions regarding CSG over the time of the Review and a description of the Review process.

The Review was commissioned on 21 February 2013 by the former Premier, in a climate of community unease about CSG extraction.

The initial report of the Review was released in July 2013. In June 2014 the Review released reports on related matters referred to it by Government (cumulative impacts of activities in the Sydney Water Catchment, and placement of monitoring equipment for NSW water resources). At that time it also released a report on whether adequate financial mechanisms are in place to deal with possible environmental impacts from CSG and related operations.

With the release of this final report, the Review is also releasing reports on regulatory compliance and managing risk.

In preparing these reports, the Review drew on information from a large number of experts from around the world in a range of fields. It also consulted extensively with community groups, industry and government agencies.

Having considered all the information from these sources and noting the rapid evolution of technological developments applicable to CSG from a wide range of disciplines, the Review concluded that the technical challenges and risks posed by the CSG industry can in general be managed through:

- careful designation of areas appropriate in geological and land-use terms for CSG extraction
- high standards of engineering and professionalism in CSG companies
- creation of a State Whole-of-Environment Data Repository so that data from CSG industry operations can be interrogated as needed and in the context of the wider environment
- comprehensive monitoring of CSG operations with ongoing automatic scrutiny of the resulting data
- a well-trained and certified workforce, and
- application of new technological developments as they become available.

All of this needs to take place within a clear, revised, legislative framework which is supported by an effective and transparent reporting and compliance regime and by drawing on appropriate expert advice.

Of course, as the technologies involved are applied in new regions where the detailed hydrogeology is not yet fully characterised, there could be unexpected events, learnings, or even accidents. This is common for new applications in the extractive industries and underlines the need for Government and industry to approach these issues with eyes wide open, a full appreciation of the risks, complete transparency, rigorous compliance, and a commitment to addressing any problems promptly with rapid emergency response and effective remediation. It also highlights the need to record and capitalise on the data and knowledge gained from CSG extraction activities in new regions and to take advantage of new technology developments which, if harnessed appropriately, can make CSG production increasingly safer and more efficient over time.

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1 ABOUT THE REVIEW

1.1 THE REVIEW AND ITS REPORTS

The independent review of coal seam gas activities in NSW (the Review) undertaken by the Chief Scientist & Engineer began in late February 2013. The Terms of Reference for the Review are at Appendix 1. This report is the final and overarching report of the Review.

Over the past 19 months, the Review has examined the coal seam gas (CSG) industry, the potential environmental, human health and social impacts of CSG extraction, and the legislative and regulatory framework within which CSG operations occur in NSW.

The Initial Report of the Review (CSE Initial Report) was released in July 2013. It provided an overview of the issues and made five recommendations. Since then, the Review has released and is releasing reports on major topics identified through the Review, including:

- insurance and related financial coverage to manage environmental impacts (CSE Insurance)
- compliance systems and processes (CSE Compliance)
- risks to human and environmental health (CSE Risks).

The Review has also provided advice on other related matters requested by Ministers, specifically:

- the placement of monitoring equipment for water resources (CSE Monitoring)
- measuring cumulative impacts of activities which impact ground and surface water in the Sydney Water Catchment (CSE Catchment).

A full list of all the reports released by the Review is given at Appendix 2. All are available on the Chief Scientist & Engineer's website (<http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review>).

In addition, the Review team is releasing information papers on fracture stimulation, abandoned wells and on managing the physical interface between the CSG industry and other activities. As well, more than 20 background information papers by experts were commissioned on a range of topics, with more than one paper for more controversial topics. These background papers are also available on the website.

1.2 PROCESS OF THE REVIEW

Overall the process of the Review was developed in the knowledge that the issues to be examined were contentious, complex, technical and wide ranging. For this reason it was clear that the Review needed to canvass many different opinions and experts covering a range of perspectives and fields, but it had to do this in a way that maintained a level of independence and avoidance (or awareness) of organisations' conflicts of interests.

The Chief Scientist & Engineer established a team within the Office of the Chief Scientist & Engineer (the Review team) to support and facilitate the Review work. The size of the task required the team to grow from the small team already in place in the Office. The fact that the Review team included individuals with a diverse range of academic and professional backgrounds, including computer engineering, chemical engineering, mechanical engineering, petroleum engineering, hydrogeology, medicine, agriculture, chemistry, environmental science, high-tech equipment compliance systems, public policy and communication, brought a range of perspectives to the issues involved. While the Review team members were not CSG experts, their range of experience meant the Review was able

to formulate detailed technical queries and undertake informed analysis and interpretation of relevant issues and information, drawing on experts advising the Review as necessary.

Throughout the Review the team has pursued the philosophy of operating as transparently as possible, publishing all submissions received apart from those marked 'confidential' on the website of the Chief Scientist & Engineer, talking to the media on request and publishing commissioned papers on the website. Those working on the Review, either in the team or as commissioned experts, were asked to declare all real and possible conflicts of interest with a register established and decisions about how to handle conflicts being determined on a case-by-case basis with decisions formally recorded.

The range and complexity of the issues meant that a great many individuals and organisations needed to be canvassed, ranging from independent impartial experts, to key players in the CSG landscape; from those deeply supportive, to others fighting to prevent the industry's further development.

To address the terms of reference and understand the complexities of the issues, the Review team conducted substantial literature searches (CSE Initial Report §1.4.1) and read widely in the peer-reviewed literature as well as the 'grey literature' reports from organisations, industry and associations. During the course of the Review, a range of material was developed and released by other Australian bodies including the Commonwealth (particularly through the IESC processes), the Queensland Government, CSIRO and other organisations. This was taken into account by the Review.

Consultation was undertaken widely with independent academic experts, government agencies, natural gas industry and service companies, industry bodies, wider industry, community activist groups and the broader community to understand the key issues from a range of perspectives. These consultations were done through public submissions, background technical information papers, formal meetings, visits, workshops, interviews and information requests.

Technical assistance and expertise was drawn particularly from universities, publicly funded research organisations, the learned academies and technical consulting firms. Such assistance included commissioned papers, occasional advice on formulating issues, assistance with identifying experts, peer review of the Review reports, and participation in meetings.

A series of background technical information papers was commissioned on a range of issues related to the CSG industry. Independent experts, who had minimal or no actual, potential or perceived conflicts of interest, were engaged to write the papers. The rationale, process and development for the papers is discussed in the Initial Report §1.4.2. More than 20 background papers have been developed and are available on the website (<http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review/csg-background-papers>).

The Review inspected CSG exploration and related water-management activities at Narrabri and Gloucester and inspected CSG production and related activities at Camden. It also inspected the Apex Energy CSG exploration site in the Sydney Catchment.

A call for public submissions to the Review was made to enable the Review to understand the issues and concerns from various perspectives (CSE Initial Report §1.4.5). Submissions were welcomed throughout the entire Review and provided considerable insight into specific issues. A total of 266 submissions was received. The submissions are available on the website (<http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review/public-submissions>).

Consultations involving community members and local councils were held across the State in Camden, Campbelltown, Gloucester, Sydney Catchment, Taree, Gunnedah, Narrabri (including the Pilliga) and the Liverpool Plains.

The team also consulted with government agencies in NSW, across Australia, and overseas.

Consultations with NSW Government agencies formed an important part of the Review, and were used to provide information on the current regulatory system, how the system has operated previously, and what reforms have been put in place more recently. The Review had many face-to-face meetings and teleconferences over the period with agencies, and also surveyed relevant agencies to identify data holdings and systems. The Review sought formal advice on specific issues as required. The Review team also worked closely with the Land and Water Commissioner, drawing on his ongoing consultations across the State on CSG.

The team met with relevant officers from Queensland, Western Australian and South Australian agencies to understand the processes and issues being dealt with in those states. Discussions were held with various Commonwealth Government agencies and agencies from overseas including from Canada, New Zealand, USA and UK. The government agencies associated with resource and environmental management in these other jurisdictions were consulted through meetings, phone discussions and email, with some of these agencies also assisting the Review by providing peer review of report sections, in particular as they related to their jurisdictions.

Various stakeholders from the CSG industry, including companies providing services to the CSG industry, community groups, industry bodies and associations, including from the wider business sector, were invited to meetings with the Review team to discuss key issues and concerns – including those raised in submissions. The Review team met many of these organisations multiple times, including meeting with peak bodies and key stakeholders in the final few weeks of the Review to ensure that the team kept abreast of any new issues that may have arisen.

The Review also ran several workshops aimed at resolving some of the more difficult issues. To understand the complexities associated with cumulative impacts in the Sydney Water Catchment, the Review held two workshops where it brought together top-level experts in relevant fields (see CSE Catchment §1.3.3). To inform the work on CSG risks, four workshops were held. These were a novel way of bringing together stakeholders (many expert) from industry, research organisations, government and the community so participants could hear, debate, consider and, in some cases, resolve opposing viewpoints. Attendees at these workshops were selected for their knowledge, expertise and interest in the issues related to CSG and related activities. Government officials, researchers, and representatives from extractive industries, peak bodies, learned academies and community groups took part, providing a diverse range of backgrounds, expertise and views. Further to this a series of targeted meetings was held with expert practitioners from individual government agencies, research organisations and industry to delve further into specific issues in particular the risks and technical controls available to manage CSG (see CSE Risks §1.2.1).

By far the most complex and time-consuming task the Review undertook was the Compliance Study and its investigation of the processes and systems for ensuring compliance with legislative instruments, regulations and conditions applying to CSG extraction in NSW. The approach to reviewing compliance activity was informed by consultation, public submissions, well inspections, site visits and extensive interaction with the various agencies responsible for compliance with the legislation and regulations pertaining to CSG extraction (see CSE Compliance §1.2), but was challenged by difficulties

in obtaining data to demonstrate compliance, and indeed it ended up being the rate-limiting step for the Review.

1.3 HOW THIS REPORT IS STRUCTURED

This final report provides the overall findings and recommendations of the Review. The individual reports, listed at Appendix 2, provide the detail, evidence and rationale behind various findings and recommendations.

The main findings of the Review are in Chapter 3 and its recommendations are in Chapter 4. As much has happened in Government regarding CSG over the course of the Review, these developments are summarised in Chapter 2 to provide contemporary context for the findings and recommendations.

2 DEVELOPMENTS IN GOVERNMENT AND RELATED ENTITIES SINCE THE REVIEW STARTED

During the course of the Review, a number of regulatory, administrative and process changes have been brought in by NSW Government as well as Commonwealth and local entities to address issues related to CSG.

Legislative reform has included a range of amendments to the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (SEPP), which brought about initiatives such as the Gateway Process, Strategic Agricultural Land mapping, residential CSG exclusion zones and their 2km buffers, as well as Critical Industry Clusters in the Upper Hunter, and clarified the State Significant Development criteria for CSG exploration wells. Further changes to the SEPP were also introduced to stipulate criteria to protect water resources, habitat and amenity; to ensure that decisions around approvals balance economic (resource) and environment issues; and to require the consent authority to consider biodiversity mitigation and offsets.

The *Protection of the Environment Operations Act 1997* and the *Protection of the Environment Operations (General) Regulation 2009* were amended, positioning the Environment Protection Authority (EPA) to be the lead regulator for environmental and human health impacts of CSG; and introducing a risks-based approach to environmental licensing.

Soon to be completed are a review of the *Petroleum (Onshore) Act 1991* and the introduction of a new title instrument that aims to ensure that activity approvals and conditions travel with the petroleum title. The Codes of Practice for Fracture Stimulation Activities and Well Integrity are also being reviewed, while Codes for Safety Management Systems and Emergency Response are being developed.

During the period of the Review, the Commonwealth Government has also introduced legislative changes that impact NSW CSG industry, in particular the introduction of the 'water trigger' under the *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999*, requiring the CSG-related proposals that are likely to impact significant water resources to be referred to the Commonwealth. Later amendments devolved the Environmental Impact Assessment authority from the Commonwealth to NSW, with the Commonwealth accrediting the NSW processes.

Several changes have also been made to the administrative arrangements in NSW Government agencies for dealing with CSG. These have included the establishment of the Office of Coal Seam Gas in NSW Trade & Investment; the establishment of the position of Land and Water Commissioner; and a review followed by a restructure of the Division of Resources and Energy (DRE) in NSW Trade & Investment, following the appointment of a new Deputy Secretary. Furthermore, the responsibility for collecting minerals royalties (including for petroleum) has been transferred from DRE in NSW Trade & Investment to the Office of State Revenue in the Treasury and Finance cluster of NSW Government, effective from July 2014.

Efforts have also been made to streamline and coordinate processes across regulators, including through a Memorandum of Understanding (MOU) and the establishment of a cross-agency working group on CSG. In addition, several agencies have taken steps to improve regulatory capability and capacity through recruiting staff, purchasing additional

instrumentation and developing materials to improve officers' knowledge of the CSG industry.

On exploration licence issues, the NSW Government has:

- put a hold on CSG exploration and extraction in the Sydney Water Catchment Special Areas
- put a 6 month freeze on new petroleum exploration licence applications, which was extended by a further 12 months to September 2015
- undertaken to audit existing petroleum exploration licences
- designated the Santos Narrabri Gas Project and AGL's Gloucester Gas Project as Strategic Energy Projects
- signed an MOU with Santos to streamline the assessment process for the Narrabri Gas Project
- renewed AGL's Gloucester petroleum exploration licence and granted an activity approval to fracture stimulate four wells.

Initiatives that relate to land access have been introduced by Government and other entities, such as a review of the process for arbitrating land access arrangements for exploration commissioned by NSW Government followed by the announcement in August 2014 that all recommendations of that review were endorsed and will be implemented progressively. A voluntary Code of Practice for Land Access was developed by DRE. An MOU was executed by NSW Farmers, Cotton Australia, NSW Irrigators Council, AGL, and Santos agreeing common principles of access to private agricultural landholders' property.

Other broader initiatives that affect CSG extraction include:

- an Energy Security Summit that examined emerging issues of gas supply for NSW
- the release of the Water Monitoring Framework developed by the NSW Office of Water, which includes a Groundwater Baseline Project commissioned by the Land and Water Commissioner
- an announcement by the Minister for Natural Resources, Lands and Water of a scheme to credit the return of groundwater to the water sources from which it was extracted
- development by the NSW Office of Water of Guidelines to assist proponents to develop Groundwater Monitoring and Modelling Plans
- release of a framework by the NSW Office of Water that describes the assessment criteria for the Aquifer Interference Policy to aid the development of a project proposal or Environmental Impact Statement.

Other developments, not directly related to CSG, that could impact the industry include:

- the release in October 2013 of the Independent Commission Against Corruption's report *Reducing the opportunities and incentives for corruption in the state's management of coal resources*, that makes a range of relevant recommendations on managing the coal mining industry in NSW
- a number of agency amalgamations and restructures including the formation of Bulk Water NSW from the Sydney Catchment Authority and State Water, and the creation of the new Department of Planning and Environment.

3 FINDINGS

This chapter presents the high-level findings of the Review. The evidence and reasoning supporting these findings is provided in the various detailed reports of the Review, listed at Appendix 2.

Stakeholders have significant concerns

- Land is a key issue and one that strikes an emotional chord due to the strong affinity Australians have with their land and its central role in the livelihood of rural communities. There is a perceived lack of support for rights of landowners in terms of access to their land. Lack of consultation, inadequate compensation, property value decreases, and potential legacy issues are also cited as major issues by landowners as are the negative impacts on amenity and a lack of adequate benefits for their neighbours and their communities.
- Water is another key issue. Primary producers and others fear that CSG developments will negatively impact prime agricultural land by depleting aquifers and contaminating groundwater reserves. They argue that it could result in reduced food production.
- Other major concerns, especially from community groups, are short- and long-term negative environmental impacts (and who will pay to remediate land); managing produced water and associated by-products such as salts; possible impacts on human and animal health; the distributed nature of the industry (giving rise to concerns including malfunctioning unattended wells and heavy traffic on minor roads); and the cost to the taxpayer of regulating the industry.
- Certain processes such as fracture stimulation ('fracking') and, to a lesser extent, horizontal drilling, are of particular concern in the context of CSG although the use of these techniques in other industries (underground water access in the case of fracture stimulation and infrastructure provision in the case of horizontal drilling) is more accepted.
- There is concern about lack of adequate and respectful consultation. Stakeholders cited the failure of industry proponents and government agencies at all levels to engage, provide information, communicate and address community concerns before proceeding with development. On the issue of consultation and adequate information provision, the Review notes that getting the balance right between overall benefit to society and impact on individuals is a recurrent challenge for governments especially for issues as divisive as CSG. While the Review found that consultation and information provision could be significantly improved, it is clear that there are many in the community whose level of concern is such that they are likely to remain opposed to CSG production in NSW under any conditions.
- A large number of those who expressed their opposition to CSG to the Review also made it clear that they were not opposed to CSG *per se* but were opposed to CSG production in heavily populated areas and in areas of intensive agricultural production.
- Local councils, especially rural councils, are concerned that they are not receiving adequate funds to cover rapid infrastructure upgrades (such as upgrades to local roads and other amenities) necessary to deal with the CSG industry coming to a rural locality.
- The CSG industry is concerned that it is being adversely affected financially by what it perceives to be an uncertain, often changing, and increasingly tough regulatory regime in NSW.
- There is a perception in some parts of the community that CSG extraction is potentially more damaging and dangerous than other extractive industries. This perception was heightened following the release of the American movie *Gasland* in 2010. The Review examined this issue in detail and concluded that while the CSG industry has several

aspects that need careful attention, as do almost all industries, it is not significantly more likely to be more damaging or dangerous than other extractive industries.

- Many perceive the CSG industry to be a new industry that is being fast-tracked without adequate attention to significant concerns. CSG production has been happening at significant levels in North America (where coal seam gas is generally referred to as coal bed methane) for two decades and in NSW for 13 years (at Camden by Sydney Gas, later AGL). CSG from NSW sources currently accounts for 5% of the NSW gas supply. In the 1990s the Government introduced measures such as a five-year royalty holiday (followed by a five-year incremental sliding scale of royalties from 6% up to 10%) to encourage the petroleum industry. This benefit was removed at the end of 2012. Some of the companies that began exploring during this time were responsible for incidents that led to increased concerns about the industry generally.
- Complex and opaque legislation and complex regulatory processes. This concern was raised repeatedly by community, the CSG industry and government agencies. It can lead to considerable administrative burden for those needing to comply, those assessing compliance and those trying to understand the legislative and regulatory regime from the community for the purpose of investigating concerns. This complexity can also lead to gaps, overlaps, contradictions and wasted time in inefficient oversight. The Review agrees that the legislation and regulatory processes need to be addressed.
- Inconsistent legislation. Many industry and community groups have alerted the Review to varying legislative and regulatory regimes for things similar to those relating to CSG extraction. Legislation and regulation covering the construction of wells and production of gas from coal seams as part of coal mining activities is less stringent than that for CSG production. Similarly a 2km buffer zone approach has been introduced for CSG extraction, but no such zone is in place for conventional gas or other types of unconventional gas extraction.

Lack of trust

- CSG companies are viewed as untrustworthy by some members of the community in both urban and rural areas. This lack of trust seems to stem particularly from some CSG exploration companies: being perceived to be in violation of land access regulations; being perceived by some to bully vulnerable landholders; not managing sub-contractors appropriately; engaging in questionable environmental practices; and not reporting accidents to the regulator quickly enough.
- Despite the limited extent of CSG development across NSW, Government is perceived by some as favouring the CSG industry for allowing it to proceed in areas where there has been considerable community opposition. Government is also perceived by some as not managing regulatory compliance effectively and not supporting compliance activities with sufficient penalties where CSG companies have infringed regulations.
- Government and industry information about CSG is perceived by some as lacking independence and, accordingly, is not trusted.
- Among groups trying to understand CSG impacts there is concern about lack of access to raw data, and especially baseline data associated with a locality, before CSG exploration and production commences. While the Government open data access provisions of recent years go some way to addressing this concern, the fact that most companies are not releasing this data in raw form (and are not required by Government to release it) leads to increased suspicion.
- There is considerable social tension and animosity between some neighbours in some local communities where CSG operations are proceeding or proposed. On the one hand there are those who are concerned about potential negative impacts of CSG extraction and see those who want its introduction as 'selling out' to CSG companies. On the other hand, landowners and community members who are in favour of CSG often feel that the debate has been 'hijacked' by environmental activists who are 'using' the community for their own ends.

There can be benefits to individuals, industry and communities

- Industry, particularly the manufacturing industry, believes having increased amounts of locally produced gas helps deal with concerns about rising gas prices and possible future shortages. This is a particular issue for several companies that have long-term gas purchase contracts expiring. As well as raising concerns about price, several industry and government figures have also expressed concern about potential gas shortages, in the light of the high-value contracts for the export of gas from the new LNG plants at Gladstone. The impending increase in export capacity is anticipated to lead to greater demand for CSG production and to cause Australian east coast gas prices to rise to meet the export price.
- With effective consultation addressing stakeholder concerns and appropriate levels of compensation, CSG development can provide new revenue streams for landholders and their communities. With appropriate support arrangements in place, landholders can make money from CSG production on their land. While local councils have to ensure their communities can cope with the industry influx, industry activity can bring benefits to communities, especially to rural communities, in terms of increased employment, rents and servicing opportunities.

CSG extraction and related technologies are mature and Australia is well equipped to manage their application

- Unconventional gas production is now a major industry especially in North America where, on balance, it is generally highly valued because of the energy security it provides. On the back of this, there is now considerable investment and experience in the development and refinement of technologies to maximise production while minimising adverse impacts. In Australia related technologies have now been extensively deployed successfully for some years (including at Camden in NSW). The independent petroleum engineering, geological and geophysical experts advising the Review consider that such technologies (including fracture stimulation and horizontal drilling technologies), with appropriate safeguards, are suitable for use in many parts of the sedimentary basins in NSW, noting that drilling in any new location is, to an extent, a learning-by-doing activity as there will always be local geological attributes specific to an individual resource development. These activities can and should be guided by companies investing in geophysics and other characterisation techniques to inform the best drilling and extraction approaches to take.
- There is a long history of working in the subsurface in Australia for the extraction of resources such as minerals, coal, gas, oil, water and, to a lesser extent, geothermal heat. This has led to a good understanding by Australian governments of what is needed to regulate subsurface activities for the purposes of safety, health, minimising environmental impact and protecting high-priority resources such as water. As a consequence Australia has built up high-quality expertise and knowledge of subsurface activities. In the public sector it has government agencies such as Geoscience Australia and State resources departments; research-intensive Earth Science and Mining Engineering departments in universities; publicly funded research agencies such as CSIRO and ANSTO; various collaborative research centres; and relevant national collaborative research infrastructure. In the private sector Australian resources companies have reputations as leading in the applications of world best practice. With Australia heavily invested in resources development, most of the global resources industry service companies have a major presence here. Australia also has a well-educated workforce.
- Australia has a strong track record in water technology innovation and management. Water is a key issue for Australia so we have developed significant capabilities in water management. This includes water treatment, operations and infrastructure for water and fluids management, management of byproducts such as salts, waste disposal,

remediation and rehabilitation. These activities are backed by considerable research and science expertise especially in government agencies, universities, CSIRO, the Bureau of Meteorology and various Cooperative Research Centres. This means that Australia is in a good position to rise to the challenge of managing the various water issues associated with CSG production.

There are things we need to know more about

- While Australia has a long history of working in the subsurface, there is still considerable uncertainty associated with the development of any new resource province. Currently CSG activities tend to be considered mainly at a site-specific level. A better understanding of the industry impacts at scale and over time is needed. To enable better planning decisions and better management of cumulative impacts, it will be necessary that industry collects and provides to Government significantly more data than at present including data from a wider range of sources. With a diverse range of resources, including coal, CSG and underground water, hosted in our sedimentary basins, there is a need to understand better how the different resources and their development regimes interact. More detailed knowledge of the structure and composition (especially regarding hydrogeology) of the sedimentary basins is needed to enhance productivity for the CSG industry through more precise resource characterisation and better subsurface and surface environmental management.
- There is a need to understand better the nature of risk of pollution or other potential short- or long-term environmental damage from CSG and related operations, and the capacity and cost of mitigation and/or remediation and whether there are adequate financial mechanisms in place to deal with these issues. This requires an investigation of insurance and environmental risk coverage, security deposits, and the possibility of establishing an environmental rehabilitation fund. Doing this is essential to ensure that the costs and impacts from this industry are not a burden for the community.
- Legacy issues, including better understanding of inappropriately abandoned wells, need attention.

Risks can be managed

- Management of potential risks associated with CSG, as with other industries, requires effective controls; high levels of industry professionalism; systems to predict, assess, monitor and act on risks at appropriate threshold conditions; legislation; regulation; research; and commitment to rapid remediation, continuous improvement and specialist training. The Review studied the risks associated with the CSG industry in depth and concludes that – provided drilling is allowed only in areas where the geology and hydrogeology can be characterised adequately, and provided that appropriate engineering and scientific solutions are in place to manage the storage, transport, reuse or disposal of produced water and salts – the risks associated with CSG exploration and production can be managed. That said, current risk management needs improvement to reach best practice.
- In particularly sensitive areas, such as in and near drinking water catchments, risk management needs to be of a high order with particularly stringent requirements on companies operating there in terms of management, data provision, insurance cover, and incident-response times.

New knowledge and technologies are becoming available but need to be harnessed to make CSG extraction safer and more productive

- Rapid advances in knowledge and technologies in a wide range of fields (especially in information and communication technologies; numerical modelling; geology, geophysics and petroleum engineering; and new materials) are occurring and can be harnessed to improve CSG production efficiency and to minimise adverse impacts. Some of the most notable recent developments include:

- data technologies especially in the area of big data, data analytics and data fusion. These technologies use very large amounts of data from diverse sources to enable better understanding of complex earth systems with an improved grasp of the uncertainties in modelling for purposes such as characterising CSG resources and predicting groundwater impacts. For these powerful technologies to be effective, significantly more data from a wider range of sources need to be collected
- visualisation technologies that allow for detailed inspection of data. These include using 3D and movie techniques which are often particularly useful in allowing experts from a wide range of disciplines to inspect and analyse large amounts of complex data easily and quickly. They are also used for training and testing responses to hazardous situations
- sensor and monitoring technologies – both in-line and remote monitoring technologies – are becoming very cheap and are increasingly integrated with onboard signal processing and communications technologies. This means that the very large amounts of surveillance data they produce can be preprocessed locally then rapidly sent to a central data repository
- artificial intelligence techniques that allow for intelligent, real-time interrogation of monitoring data with alerts when anomalies are detected
- developments in petroleum engineering that allow for better matching of combinations of appropriate technologies for particular geological situations
- developments in new materials.
- In order to speed the beneficial uptake of new technology developments for an industry as contentious as CSG, the Review concludes that Government needs access to such expertise on a permanent basis, such as by creation of a standing committee comprising top experts from relevant disciplines, to advise it when to act on new technology developments as they become available.

There are no guarantees

- All industries have risks and, like any other, it is inevitable that the CSG industry will have some unintended consequences, including as the result of accidents, human error, and natural disasters. Industry, Government and the community need to work together to plan adequately to mitigate such risks, and be prepared to respond to problems if they occur.

4 RECOMMENDATIONS

The final recommendations of the Review are presented below, grouped according to themes. Some of the recommendations have been modified, simplified or combined, compared with the form in which they were first presented in previously released reports of the Review; however their intent has not changed.

Intent, communication, transparency and fairness

Recommendation 1

That Government make clear its intent to establish a world-class regime for extraction of CSG. This could be articulated in a clear public statement that covers:

- the rationale/need for CSG extraction
- a clear signal to industry that high performance is mandatory, compliance will be rigorously enforced and transgressions punished
- a fair system for managing land access and compensation
- a mechanism for developing a clear, easy-to-navigate legislative and regulatory framework that evolves over time to incorporate new technology developments
- mechanisms for working closely and continuously with the community, industry, and research organisations on this issue.

Recommendation 2

That Government ensure clear and open communication on CSG matters is maintained at all times. This includes:

- simplicity and clarity in legislative and regulatory requirements
- ensuring openness about CSG processes in line with an open access approach; publishing all relevant approval requirements, decisions and responses, and compliance and enforcement outcomes on appropriate government websites and making CSG data from companies, Government and research organisations available through a centralised Government data repository
- measurable outcomes to track performance against commitments to reform.

Recommendation 3

That Government investigate as a priority a range of practical measures for implementation (or extension of current measures) to allow affected communities to have strengthened protections and benefits including fair and appropriate:

- land access arrangements, including land valuation and compensation for landholders
- compensation for other local residents impacted (above threshold levels) by extraction activities
- funding (derived from the fees and levies paid by CSG companies) for local councils to enable them to fund, in a transparent manner, infrastructure and repairs required as a consequence of the CSG industry.

Recommendation 4

That the full cost to Government of the regulation and support of the CSG industry be covered by the fees, levies, royalties and taxes paid by industry, and an annual statement be made by Government on this matter as part of the Budget process.

Legislative and regulatory reform and appropriate financial arrangements

Recommendation 5

That Government use its planning powers and capability to designate those areas of the State in which CSG activity is permitted to occur, drawing on appropriate external expertise as necessary.

Recommendation 6

That Government move to a single Act for all onshore subsurface resources (excluding water) in the State, constructed to allow for updating as technology advances. This will require a review of all major Acts applying to the resources sector.

Recommendation 7

That Government separate the process for allocation of rights to exploit subsurface resources (excluding water) from the regulation of the activities required to give effect to that exploitation (i.e. exploration and production activities); and that it establish a single independent regulator. The regulator will require high levels of scientific and engineering expertise, including geological and geotechnical ability, environmental and water knowledge and information, and ICT capability including data, monitoring and modelling expertise; and will be required to consult – and publish details of its consultations – with other arms of Government and external agencies, as necessary. The regulator will also require appropriate compliance monitoring and enforcement capability.

Recommendation 8

That Government move towards a target and outcome-focused regulatory system, with three key elements:

- regularly reviewed environmental impact and safety targets optimised to encourage uptake of new technologies and innovation
- appropriate and proportionate penalties for non-compliance
- automatic monitoring processes that can provide data (sent to and held in the openly accessible Whole-of-Environment Data Repository) which will help detect cumulative impacts at project, regional and sedimentary basin scales which can be used to inform the targets and the planning process.

Recommendation 9

That Government consider a robust and comprehensive policy of appropriate insurance and environmental risk coverage of the CSG industry to ensure financial protection short and long term. Government should examine the potential adoption of a three-layered policy of security deposits, enhanced insurance coverage, and an environmental rehabilitation fund.

Managing risk by harnessing data and expertise

Recommendation 10

That Government commission the design and establishment of a Whole-of-Environment Data Repository for all State environment data including all data collected according to legislative and regulatory requirements associated with water management, gas extraction, mining, manufacturing, and chemical processing activities. This repository, as a minimum, would have the characteristics that it:

- is accessible by all under open data provisions
- has excellent curatorial and search systems
- houses long-term data sets collected as part of compliance activities
- can accept citizen data input
- can be searched in real time
- is spatially enabled
- is able to hold data in many diverse formats including text, graphics, sound, photographs, video, satellite, mapping, electronic monitoring data, etc., with appropriate metadata
- is the repository of all research results pertaining to environmental matters in NSW along with full details of the related experimental design and any resulting scientific publications and comments
- is the repository of historical resources data with appropriate metadata

Various legislative amendments or other incentives will be needed to direct all environment data to the Repository.

Recommendation 11

That Government develop a centralised Risk Management and Prediction Tool for extractive industries in NSW. This would include a risk register, a database of event histories, and an archive of Trigger Action Response Plans. The tool would be updated annually based on Government and company reporting and would include information on risk management and control approaches and draw on data from the Whole-of-Environment Data Repository for the State. The risk tool would be reviewed and commented on by relevant expert and regulatory bodies. The risk tool would be used to assist with:

- assessing new proposals
- assessing compliance
- improving prediction capability for consequences of incidents in risk assessments
- improving prediction capability of risk likelihoods
- informing project design amendments to decrease risk levels (such as undertaken in the Dam Safety Committee)
- informing the calculation of cumulative impacts
- flagging issues or risks that require a higher level of regulatory protection such as inclusion in legislation.

Recommendation 12

That Government establish a standing expert advisory body on CSG (possibly extended to all the extractive industries). This body should comprise experts from relevant disciplines, particularly ICT and the earth and environmental sciences and engineering, but drawing as needed on expertise from the biological sciences, medicine and the social sciences. The prime functions of this expert body would be to advise Government:

- on the overall impact of CSG in NSW through a published Annual Statement which would draw on a detailed analysis of the data held in the Whole-of-Environment Data Repository to assess impacts, particularly cumulative impacts, at project, regional and sedimentary basin scales
- on processes for characterising and modelling the sedimentary basins of NSW
- on updating and refining the Risk Management and Prediction Tool
- on the implications of CSG impacts in NSW for planning where CSG activity is permitted to occur in the State
- on new science and technology developments relevant to managing CSG and when and whether these developments are sufficiently mature to be incorporated into its legislative and regulatory system
- on specific research that needs to be commissioned regarding CSG matters
- on how best to work with research and public sector bodies across Australia and internationally and with the private sector on joint research and harmonised approaches to data collection, modelling and scale issues such as subsidence
- on whether or not other unconventional gas extraction (shale gas, tight gas) industries should be allowed to proceed in NSW and, if so, under what conditions.

Recommendation 13

That Government establish a formal mechanism consisting of five parallel but interacting steps. The five steps are given below.

- Companies or organisations seeking to mine, extract CSG or irrigate as part of their initial and ongoing approvals processes should, in concert with the regulator, identify impacts to water resources, their pathways, their consequence and their likelihood, as well as the baseline conditions and their risk trigger thresholds before activities start. These analyses and systems should be incorporated in project management plans to meet regulator-agreed targets. Appropriate monitoring and characterisation

systems would be developed as part of these project management plans and then installed. The monitors would measure baseline conditions and detect changes to these, as well as providing data on impacts and triggered risk thresholds.

- Data from the monitors should be deposited (either automatically or in as close to real time as possible) in the State Whole-of-Environment Data Repository by all the extractive industries. Increasingly automated tools to interrogate data in the Repository should be developed, and these used to search data for discontinuities and compliance alerts.
- As a separate process, the expert advisory body would examine on a frequent basis all data relevant to a region or a sedimentary basin. This data would come from a range of sources (the companies' monitoring data along with triangulation/cross-validation data such as that from satellites, reports from local councils, seismic data, subsidence maps, information from cores, etc.). The expert body would use this data review to check for any factors signalling problems in that region and, if any are found, recommend to Government the appropriate action to be taken with regard to the relevant parties.
- In a parallel process, the Government should commission, construct and maintain a variety of models of each region and in particular one that seeks to address cumulative impacts. These models should feed into the land use planning process and the activity approvals processes, and should assist in target setting for new projects.
- Government, working with other appropriate Australian governments, should commission formal scientific characterisation of sedimentary basins starting with the East Coast basins, and concentrating initially on integration of groundwater with the geological, geophysical and hydrological context. Viewing these integrated systems in models and in interpretation could be described as a 'Glass Earth' approach to understanding the dynamics of activities and impacts in the basins.

Training and certification

Recommendation 14

That Government ensure that all CSG industry personnel, including subcontractors working in operational roles, be subject to ongoing mandatory training and certification requirements. Similarly, public sector staff working in compliance, inspections and audits should be given suitable training and, where appropriate, accreditation.

Legacy and consistency matters

Recommendation 15

That Government develop a plan to manage legacy matters associated with CSG. This would need to cover abandoned wells, past incomplete compliance checking, and the collection of data that was not yet supplied as required under licences and regulations. There will also need to be a formal mechanism to transition existing projects to any new regulatory system.

Recommendation 16

That Government consider whether there needs to be alignment of legislation and regulation governing extraction of methane as part of coal mining and the application of buffer zones for gas production other than CSG with the relevant legislation and regulation provisions governing CSG production.

APPENDIX 1 TERMS OF REFERENCE

Review of coal seam gas activities in NSW

At the request of the NSW Government, the NSW Chief Scientist & Engineer will conduct a review of coal seam gas (CSG) related activities in NSW, with a focus on the impacts of these activities on human health and the environment.

The Chief Scientist & Engineer is to:

1. undertake a comprehensive study of industry compliance involving site visits and well inspections. The Chief Scientist's work will be informed by compliance audits undertaken by regulatory officers, such as the Environment Protection Authority and other government agencies
2. identify and assess any gaps in the identification and management of risk arising from coal seam gas exploration, assessment and production, particularly as they relate to human health, the environment and water catchments
3. identify best practice in relation to the management of CSG or similar unconventional gas projects in close proximity to residential properties and urban areas and consider appropriate ways to manage the interface between residences and CSG activity
4. explain how the characteristics of the NSW coal seam gas industry compare with the industry nationally and internationally
5. inspect and monitor current drilling activities including water extraction, hydraulic fracturing and aquifer protection techniques
6. produce a series of information papers on specific elements of CSG operation and impact, to inform policy development and to assist with public understanding. Topics should include:
 - operational processes
 - NSW geology
 - water management
 - horizontal drilling
 - hydraulic fracturing (fracking)
 - fugitive emissions
 - health impacts
 - wells and bores
 - subsidence.

The NSW Chief Scientist & Engineer will provide an initial report to the Premier and the Minister for Resources and Energy on her findings and observations by July 2013.

APPENDIX 2 REPORTS AND BACKGROUND PAPERS WRITTEN AND/OR COMMISSIONED BY THE NSW CHIEF SCIENTIST & ENGINEER DURING THE INDEPENDENT REVIEW OF COAL SEAM GAS ACTIVITIES IN NSW

Reports written by the NSW Chief Scientist & Engineer for the Independent Review of Coal Seam Gas Activities in NSW

Available at <http://www.chiefscientist.nsw.gov.au/reports>

- Initial Report on the Independent Review of Coal Seam Gas Activities in NSW
- Environmental risk & responsibility and insurance arrangements for the NSW CSG industry
- On measuring the cumulative impacts of activities which impact ground and surface water in the Sydney Water Catchment
- Placement of monitoring equipment for water resources in NSW
- Study of regulatory compliance systems and processes for coal seam gas
- Managing environmental and human health risks from coal seam gas activities
- Final Report of the Independent Review of Coal Seam Gas Activities in NSW

Information papers written by the NSW Chief Scientist & Engineer for the Independent Review of Coal Seam Gas Activities in NSW

- Information paper: On managing the interface between coal seam gas activities and other land uses (Setbacks)
- Information paper: Fracture stimulation activities
- Information paper: Abandoned wells

Reports commissioned by the NSW Chief Scientist & Engineer for the Independent Review of Coal Seam Gas Activities in NSW

Available at <http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review/csg-background-papers>

	Topic	Expert name and organisation	Title of paper
1	Baseline human health	Dr Pavla Vaneckova & Assoc Professor Hilary Bambrick: University of Western Sydney – Centre for Health Research	Approaches to baseline studies of human health in relation to industries with potential environmental impact
2	CSG processes	Professor Peter Cook: PJC International, National Centre for Groundwater Research and Training, Flinders University	Life Cycle of Coal Seam Gas Projects: Technologies and Potential Impacts
3	Community concerns	Dr Melanie Taylor, Ms Natalie Sandy & Professor Beverley Raphael: University of Western Sydney - School of Medicine, Disaster Response and Resilience Research Group	Background paper on community concerns in relation to coal seam gas
4	Data management	Dr Ian Gibson, Intersect Australia	NSW Coal Seam Gas: Data Background Paper
5	Gas dispersion modelling	Professor Peter Rayner & Dr Steven Utembe: University of Melbourne - School of Earth Sciences	Modelling the Airborne Dispersion of Pollutants from Coal Seam Gas Extraction
6	Geology	Dr Craig O'Neill and Dr Cara Danis: Macquarie University - Department of Earth and Planetary Science	The Geology of NSW: The geological characteristics and history of NSW with a focus on coal seam gas (CSG) resources
7	Geology	Professor Colin Ward and Assoc. Professor Bryce Kelly: University of New South Wales - School of Biological, Earth and Environmental Sciences	Background Paper on New South Wales Geology: With a focus on basins containing coal seam gas resources
8	Groundwater	Mr Doug Anderson, Ms Priom Rahman, Ms Erica Davey, Mr Brett Miller, Dr William Glamore: University of New South Wales - Water Research Library	Background Paper on Groundwater Resources in Relation to Coal Seam Gas Production
9	Horizontal drilling	Professor John Carter: Advanced Geomechanics	Background Paper on Horizontal Drilling
10	Legislation and regulation	Ms Sue Graebner, Independent consultant	Legislative framework for CSG exploration and production. Released as appendix to CSE report, "Study of

			regulatory compliance systems and processes for coal seam gas”
11	Methane	Dr Linda Stalker: CSIRO	Methane origins and behaviour
12	Produced water	Assoc Professor Damian Gore and Dr Peter Davies: Macquarie University - Department of Environment & Geography	Macquarie University Background paper on produced water and solids in relation to coal seam gas production
13	Produced water	Dr Stuart Khan and Ms Geena Kordek	Coal Seam Gas: Produced Water and Solids,
14	Risk, insurance & management	Mr Bernard Evans: Hicksons Lawyers	Paper 1 - Insurance and Environmental Securities; Attachment: Environmental risks arising from CSG operations
15	Risk, insurance & management	Mr Tony Abbott: Piper Alderman	Insurance and Environmental Securities; Attachment: Risk Model Evaluation
16	Sedimentary basins	Assoc Professor Tim Rawling & Professor Mike Sandiford: University of Melbourne - Melbourne Energy Institute	Multi basin usage/cumulative impact,
17	Seismicity	Professor Mike Sandiford and Mr Gary Gibson: The University of Melbourne - Melbourne Energy Institute	Seismicity and Induced Earthquakes
18	Seismicity	Dr Barry Drummond: Independent consultant, formerly with Geoscience Australia	Background Paper on Seismicity
19	Subsidence causes	Dr Jubert A Pineda and Professor Daichao Sheng: The University of Newcastle - ARC Centre of Excellence for Geotechnical Science and Engineering	Subsidence: An overview of causes, risks and future developments for Coal Seam Gas production
20	Subsidence monitoring	Dr Simon McClusky and Dr Paul Tregoning: The Australian National University - School of Earth Sciences	Background paper on subsidence monitoring and measurement with a focus on coal seam gas (CSG) activities
21	Subsidence monitoring	Cooperative Research Centre for Spatial Information	Subsidence monitoring in relation to coal seam gas production
22	Water treatment	Emeritus Professor Chris Fell: Fell Consulting Pty Ltd	Water treatment and coal seam gas
Other reports written by or commissioned by the NSW Chief Scientist & Engineer prior to the Independent Review of Coal Seam Gas Activities in NSW			
<ul style="list-style-type: none"> Hydraulic fracturing for coal seam gas (CSG) stimulation in NSW, by Dr Rob Jeffrey: CSIRO CSE draft letter on the likelihood of hydraulic fracturing 			