An overview of possible impacts from coal seam gas development in Northern Rivers, New South Wales

Integrated Project by Elfian Schieren, 2012

Photo: Elfian Schieren, 2012

School of Environment Science, Engineering and Management, Southern Cross University
Contents

1. Introduction
2. Energy and coal seam gas development
   2.1 Economic viability underpinning coal seam gas development
   2.2 Renewable, sustainable energy development
      - Solar
      - Wind
      - Biogas
   2.3 Coal seam gas development at a global scale
   2.4 Coal seam gas development in Australia
3. Coal seam gas extraction process
   - Drilling and dewatering
   - Hydraulic Fracturing
   - Produced Water
4. Risks to water resources from coal seam gas development
   4.4 Ground water use
   4.5 Water produced by coal seam gas
   4.6 Contamination of Groundwater
5. Other Consequences of coal seam gas development
   5.4 Impacts to agricultural production
   5.5 Health impacts on humans and animals
   5.6 Impacts on greenhouse gas emissions
   5.7 Impacts on seismic activity
   5.8 Economic impacts
   5.9 Cumulative impacts
6. Potential for coal seam gas development in Northern Rivers, New South Wales
   6.1 Northern Rivers Region
   6.2 Using trade-offs and opportunity costs in evaluating CSG development
   6.3 Prospects for development in Northern Rivers region
   6.4 Energy development in Northern Rivers region
   6.5 Northern Rivers community actions and groups in response to CSG development
7. Discussion
8. Conclusion
Abbreviations:
CSG – Coal Seam Gas
GHG – Greenhouse gas
NSW – New South Wales
QLD – Queensland

Key Terms:
Coal seam gas – methane extracted from coal seam geology via drilling, dewatering and fraccing
CSG development – any area undergoing CSG exploration or production or building of CSG infrastructure such as pipelines
Energy – production of electricity for commercial and domestic purposes including sale/export of energy in resource form
Greenhouse gas – gases emitted by fossil fuel burning that increase the concentration of gases causing climate change in the atmosphere
Ground water – water found in subterranean aquifers
Ground water contamination – contamination of ground water resources from chemicals, organic compounds and heavy metals
Produced water – water produced through coal seam gas extraction processes containing drilling or fraccing fluid substances or compounds mobilized from the coal seam
Renewable energy – naturally occurring, theoretically inexhaustible source of energy that is not from fossil fuel
Abstract

Australia is a fragile continent in need of economically and environmentally sustainable development. Australia is a large energy producer and has recently undergone a massive expansion of the coal seam gas (CSG) industry in QLD and NSW in response to global market prices and energy demand. This report aims to provide a preliminary appraisal of the ability for CSG development to contribute to sustainable development in Northern Rivers, NSW where considerable investment into CSG is planned. The report identifies a multitude of uncertainties regarding impacts from CSG and a lack of sound science underpinning most predictions. Of particular concern are impacts to water, health, emissions and long term economic functioning especially at the regional scale. With regard to the potential range and scale of the various impacts it is considered imperative to improve the scientific database of CSG impacts. Cumulative impacts are considered an essential component of future research due to the likelihood of them occurring. Sound science underpins good management and when the consequences are considered potentially “disastrous” precautions should be taken to ensure that development has a solid scientific basis. The report concludes that CSG might best be developed in areas of low environmental, social and economic value to reduce extraction costs and possible trade-offs between other long term industries.

1. Introduction

The burning of fossil fuels for energy underpins all modern economic activities and has greatly assisted modern social development (Australian Department of Resources Energy and Tourism, 2011). More than a century ago the idea was raised that greenhouse gas emissions from the burning of fossil fuels had potential to cause global warming (Hoffart et al, 2002). Since then human induced greenhouse gas emissions from the burning of fossil fuels such as oil and coal have significantly increased levels of greenhouse gases in the atmosphere (IPCC, 2007). Atmospheric levels of CO₂ have increased from 280ppm to over 380ppm since 1989 (Garnaut, 2008). In recent years research revealed a rising trend in average global temperatures associated with these increased concentrations of greenhouse gases (IPCC, 2007). Current climate simulations suggest a mean global warming of between 1.5 to 5.8°C in the next hundred years (IPCC, 2007). The impacts of climate change on food and resource security are greatly concerning to governments and policy makers. Extreme weather events such as severe droughts, floods and high or low temperature anomalies are thought to correlate with rising temperatures and pose a serious threat to agriculture and coastal societies (Rosenzweig et al, 2001). Increasing global population and consumption rates place further stress on global ecosystems. Economic systems are also being put under pressure to maintain growth in energy production, mainly to cater for high consumption lifestyles in developed countries (Satterthwaite, 2009).

Increasing energy demand from growing domestic and overseas economies, pressure for climate change mitigation and finite oil supplies is prompting industries toward the production of alternative fuel sources (Australian Department of Resources, Energy and Tourism, 2011). The Australian Federal Government (2011) emphasizes the need for large scale investment to meet the energy demands of a growing population and achieve a reduction in greenhouse gas emissions. Australia is
the world’s ninth largest energy producer with an abundance of renewable and non-renewable energy sources and investment in new energy sources is considered essential to future economic growth (Department of Resources, Energy and Tourism, 2011). In Australia much of the energy transition to lower emissions will be achieved through the use of gas-fired power instead of coal power and expansion in renewable energy development. In particular coal seam gas (CSG) and geothermal technology are considered crucial elements to developing Australia’s energy future (Australian Department of Resources, Energy and Tourism, 2011). Increasing use of gas for electricity has seen exponential growth in development of Australian CSG reserves located in Queensland (QLD) (30.3%) and, to a lesser extent, New South Wales (NSW) (2.5%). Together these reserves total 32.8% of all Australian gas reserves including conventional gas (Australian Energy Regulator, 2011). One of the areas opening up for coal seam gas development is the Northern Rivers region in Northern NSW, a move that has raised considerable community concerns as to the environmental and social impacts of CSG (CSG Free Northern Rivers, 2012). This report aims to provide a preliminary appraisal of the possibility for CSG to contribute to sustainable development in the Northern Rivers region of NSW. The report is only a brief look at a likely large and complex issue, intending only to provide a broad and brief review of the potential CSG impacts in consideration with the character and development in Northern Rivers.

2. Energy and coal seam gas development

2.1 Economic viability underpinning coal seam gas development

Unconventional gas in the form of coal seam gas, shale gas, basin centred gas and tight gas is considered the most viable alternative to coal fired power as it widely considered being the next cheapest energy source to coal (Rutovitz et al, 2011). New technological advancements such as hydraulic fracturing and directional drilling are now allowing companies to access these resources and boosting the global production of nonconventional gases like coal seam and shale gas (Osborn et al, 2011). These technological advances and strong international gas prices have unlocked Australia’s coal seam onshore and offshore gas reserves for production and export (Australian Department of Resources Energy and Tourism, 2011).

2.2 Renewable, sustainable energy development

There are many options available for cleaner and renewable energies and Australia is well placed with renewable resources to lead development in this area. A recent cost assessment of the different energy options in Australia revealed that renewable sources are becoming more competitive with fossil fuel energy production (Australian Bureau of Resources, Energy and Economics, 2012). There has been a rapid drop in solar photovoltaic technology costs resulting from increased global production of photovoltaic modules (Braga et al, 2008) and production of biogas from landfill is now cheaper than
energy from brown coal (Australian Bureau of Resources, Energy and Economics, 2012). A major limitation for renewable energy as a substitute for coal fired power is the ability for base load power generation either from constraints in available technology or power capacity (Needham, 2008). Competition for land between different renewable energy systems could limit their prospective as electricity producers (de Vries et al, 2006).

- **Solar Power**

A major limitation for solar power has always been loss of energy production during cloudy weather inevitably requiring large energy storage for these periods. Batteries have been the main option and are considered an expensive and inefficient method of energy storage (Zweibel et al., 2007). New technological advancements have invented compressed air storage where solar is used to pump compressed air into underground caverns, abandoned mines, empty gas reservoirs and aquifers. This air is then released on demand to turn turbines aided by burning small amounts of natural gas, reducing the normal gas usage by 60%. This system is being successfully used in Germany (Zweibel et al., 2007) and through integration with gas electricity production, could potentially extend the life of conventional natural gas or biogas reserves during the transition to renewable energy systems.

- **Wind Power**

Wind power is considered one of the most economically viable options for renewable energy production exhibiting lower energy costs than biomass or solar systems (de Vries et al, 2006). Research on the energy footprint of two wind farms (onshore and offshore) near Denmark found that, based on a 40% efficiency, the farms paid back their energy requirements within 0.26 to 0.39 of a year, around 2% of the 20 year lifetime of the turbine (Schleisner, 1999). Germany has rapidly promoted the use of wind power and has developed new technologies such as high-voltage direct current (HVDC) to overcome current limitations in providing an efficient, economical and reliable solution to non-renewable energies (Kirby, 2002). Using underground cable and improved control capabilities, the HVDC makes it economically feasible to connect small scale, renewable power generation into the main AC grid (Weimers, 1998).

- **Biogas**

There is considerable research and investment into energy from waste such as biogas production from landfill or manure and bio-hydrogen from domestic food waste and wastewaters (Van Ginkel et al., 2004). Biogas from landfill, pig and cow manure, sewage and food wastes is now widely used as a transport fuel for cars in Europe, particularly in Italy which has over 650 000 biogas fuelled cars and buses (European Biofuels Technology Platform, 2009). Biogas production has been driven by increased regulations and taxes on waste disposal, a growing need for renewable fuels, industry
initiatives and the need to improve air quality (National Society for Clean Air and Environmental Production, 2006). Biogas is cheaper to run than petrol and diesel, 55% and 40% respectively but have larger capital costs causing most biogas to be used for electricity production. The environmental benefits, such as CO₂ savings, from biogas usage are considered to be high particularly when combined with the benefit of waste reduction (National Society for Clean Air and Environmental Production, 2006).

Reconfiguration of the current electricity grid is essential to integrate renewable power inputs (Needham, 2008). A new technology named the Smart Grid using decentralised management stations which allow for a more rapid response to fluctuations in power demand is being trialled in Newcastle, Ku-Ring-Gai, Newington, some Sydney areas including the CBC and the rural town of Scone as part of the National Energy Efficiency Initiative (Australian Department of Resources, Energy and Tourism, 2012). The Smart Grid system may be more effective in dealing with the varied input from renewable sources, coping with base load limitations and offers money savings through the use of smart meters that alleviate the need for meter reading (Dopita and Williamson, 2010). Most science places renewable energy sources as intermittent dispersed sources unviable for base load power operations without transmission, storage and power conditioning (Hoffart et al, 2002). Technological advancements happening in Europe and even Australia suggest that many of these hurdles can be overcome. Hybrid renewable energy systems are considered to have the potential to improve economic viability and customer acceptance of renewable electricity production (Nema et al., 2009).

Carbon pricing in Australia is helping renewables to become more economically viable but the Australian Federal Government states that, according to the global market, renewable energy is not yet competitive enough with gas prices for large scale investment to be considered (Australian Department of Resources, Energy and Tourism, 2011). However, the largest recorded growth in energy consumption in 2009-10, in Australia, was in renewable energy which grew by 17.1% in comparison to gas consumption at 4.5% (Schultz and Petchey, 2011).

2.3 Coal seam gas development at a global scale

International gas prices and technological advancements are prompting many countries to explore coal seam gas as a greener energy alternative and cheap fuel source. Natural gas contributes 23.5% of total global energy consumption and is expected to increase to 26.32% by 2030 (Global Investment House, 2006). There has been increase in the demand for Gas-to-Liquids (GTL) especially in European and Asian mega cities which are trying to switch to cleaner fuels. GTL is most suited for the transportation fuels market giving it the advantage over renewable energies which are not as viable for export (Global Investment House, 2006). There are currently around 12 GTL exporting countries (Figure 2) including Russia, South America, Egypt, Norway, Equatorial Guinea, America and Australia (Global Investment House, 2006). Coal seam gas is considered a prime export resource for
GTL in Australia and many other GTL producing countries. Figure 2 shows the volumes of natural gas produced worldwide by each country showing that Australia is a significant producer of natural gas on the global market. Since 2004, demand for coal seam gas has increased by 164% largely driven by strong demand from Asia and the global push for new energy sources to reduce greenhouse gas emissions (SMI CCSG, 2011).

Figure 2. World map of gas production by country (http://geology.com/oil-and-gas/natural-gas-production-map/)

2.4 Coal seam gas development in Australia

Australia is a fragile continent in terms of ecology and economic development with limited water resources and capacity for food production, possibly not yet realised yet due to a relatively small population. Conservation and sustainable development are considered essential to the future of Australia (Moffatt, 1992). So far a small population size and large mineral resources has allowed Australia to be a large exporter of goods especially minerals but the future is uncertain for the ecological systems underpinning the economy in Australia as the impacts of export industries and high consumer demand begin to take toll (Moffatt, 1992).

CSG is considered a viable cleaner energy source than coal and global demand from Asia and Europe have turned CSG into a valuable export for Australia. Rising global energy prices and increasing domestic and overseas electricity demand are major drivers in the expansion of CSG production (Australian Department of Resources, Energy and Tourism, 2011). Australia has large reserves of coal seam gas within the Surat and Bowen Basins in Queensland, the Clarence-Moreton, Sydney, Gunnedah and Gloucester Basins in NSW and further exploration is expected in other coal basins in Victoria and Western Australia. Initial attempts to develop CSG in the Bowen Basin in 1976 were unsuccessful due to a lack of understanding of regional geology of targeted coal measures, lack of
knowledge on importance of stress regimes and their influence on coal permeability, and inappropriate well completion techniques (Baker and Slater, 2008).

Coal seam gas is viewed as a vital contribution to Australia’s economic growth and energy security, and an efficient energy and exportable fuel source in a carbon conscious market (Australian Department of Resources, Energy and Tourism, 2011). There are now 1600 commercial production gas wells and a further 1400 exploration wells in Queensland (Jones, 2011).

Figure 3. Australian LNG exports by destination (Jacobs, 2011)

The Gladstone project in Queensland is the world’s first CSG to LNG development that began as a joint venture between Santos, Petronas, Total and Kogas in 2011. Three more major CSG to LNG projects are underway by Arrow Energy, Origin and ConocoPhillips and the BG Group (British Gas) (Jacobs, 2011). In 2009/10 coal seam gas (CSG) accounted for 13% of total Australian gas production on the Eastern Gas Market produced in Queensland, New South Wales, Victoria and South Australia (Rutovitz et al, 2011). Assuming that all CSG produced is used in Gas-to-Liquids (GTL) projects the high demand estimates suggest that CSG will make up around 7% of total LNG exports (Fainstein et al., 2002). However this figure is unlikely as around half of CSG produced will be used in domestic energy production (Australian Energy Regulator, 2011). Australian LNG supplies the Asia-Pacific market with most LNG going to Japan until 2005 when the market expanded to China and in 2008 to include India (Figure 3). Since 2003 the Australian gas exports have increased two and a half fold (Figure 3) (Jacobs, 2011).

Using estimates of rates of consumption, consumption increase and the proven and probable reserves of gas (Conventional = 8,000PJ, CSG = 28,000PJ) indicates that conventional gas will be viable for another 9 years and CSG for another 27 years. When including projected exports from the Liquefied Natural Gas Project at Gladstone, approximately 1440PJ per year, the lifetime of all Australian...
produced CSG reserves is reduced to 16 years (Rutovitz et al., 2011) or maximum estimate 20 years (Australian Energy Regulator, 2011).

Queensland has the largest CSG reserves and NSW the second largest (Figure 4). Most of these reserves have not been extracted yet as the industry is still relatively new and expected to undergo massive expansion in near future (Figure 4) (Jones, 2011). Companies involved in CSG exploration and production in Australia include Queensland Gas Corporation (QGC) (owned by British Gas), Arrow Energy (jointly owned by PetroChina and Royal Dutch Shell), Metgasco, AGL, Origin, Linc Energy, Red Sky Energy, Santos, Conoco Phillips and Australia Pacific LNG. PetroChina, co owner of Arrow Energy, is a subsidiary of the China National Petroleum Corporation, one of the world’s largest oil companies (Arrow Energy Pty Ltd, 2012).

Figure 4. Australia’s conventional and coal seam gas reserves (Jones, 2011)

The coal seam gas industry is only around 30 years old, relatively new compared to other mining industries, and there is limited data on the potential impacts to the environment, the economy and society. There have been several concerns brought to public attention through anecdotal evidence from the United States and other CSG development countries such as Australia. These concerns centre
mostly on the potential impacts to groundwater quality and quantity, human and animal health, greenhouse emissions, earthquakes and long term impacts to the economy.

3 Coal seam gas extraction process

Functionally coal seam gas is the same as natural gas which is methane, formed from the decay of organic matter in anaerobic (low oxygen) environments. Coal seam gas differs from conventional gas in extraction method and geology. Conventional gas is generally found in sandstone or limestone in pockets or reservoirs from which the gas flows easily once tapped (Rutovitz et al, 2011). Coal seam gas is found within subterranean coal seams of hard coal such as anthracite to soft lignite or bituminous coals. Coal seams are less permeable and require more invasive processes to extract the methane (Zupanick, 2001). The general processes include drilling and dewatering initially and hydraulic fracturing to increase permeability when these processes are not adequate to create gas flow.

- Drilling and dewatering

Gas wells are drilled using a system of enclosed fire retardant fluids to reduce friction and keep the drill from setting the coal seam or other geological layers on fire (Spehe, 1999). The methane is held tightly in the coal seam in a saturated environment and requires a dewatering process before the gas can be released (Rutovitz et al, 2011). The coal seam is a highly saturated environment and gas wells often produce water or other liquids such as oil or hydrates. These liquids have the potential to inhibit gas flow from the well and have to be removed via pumping mechanisms (Evans, 1980). The water removed from the coal seam is called “produced water“ and can contain potentially hazardous compounds such as salts and chemicals so has to be treated and disposed of accordingly (Rutovitz et al, 2011).

- Hydraulic Fracturing

If the dewatering of the coal seam is unable to release the gas it is necessary to fracture the seam to increase permeability. Hydraulic fracturing or fraccing involves pumping large volumes of fracting fluid at high pressure into the coal seam to create a fracturing that can extend to around 400m into the coal seam (Puri et al, 1991). Fraccing fluid is often but not always water and contains proppants and chemicals to increase fracturing capacity. Gel like fluids are considered more effective at transporting the proppants and gel compounds are added to a water base to thicken it. Most fraccing fluids contain a mixture of bactericides, pH control and anti-solidifying chemicals (NTN, 2011). Very small amounts of the chemical are used in the fluids but huge volumes of fluid are required to complete the fracturing process which can result in large amounts of chemicals needing to be disposed of (Rutovitz et al, 2011). This method is not always desirable particularly when the coal bed is thin or near a
submerged aquifer as the fractures can permit transfer of water either into or out of the well bore (Puri et al, 1991).

- Produced Water

The process of dewatering and fraccing brings water to the surface that contains chemical characteristics drilling and fraccing fluids but also of the formation and hydrocarbon being extracted. This water, known as produced water, contains large amounts of salts, oils and grease, various inorganic and organic compounds or chemical additives and naturally occurring radioactive material. It is estimated that over 71 billion barrels (1 barrel = 158.76 L) of produced water is generated annually around the globe from oil and gas production which then needs to be treated and disposed of or utilised for other purposes (Veil et al., 2004).

4. Risks to water resources from coal seam gas development

4.1 Groundwater use

Impacts of overexploitation and contamination of water are particularly concerning to residents in CSG development regions. Most of the CSG development in QLD and NSW overlies the Great Artesian Basin where a huge expansion of CSG exploration and commercial CSG production has occurred in the Surat Basin (Queensland Water Commission, 2012). Processes used to remove methane from coal seam, such as dewatering, involve the exchange of large volumes of water from a higher to a lower grade of produced water (Queensland Water Commission, 2012). The process of dewatering creates a vacuum into which water from overlying or adjacent aquifers will tend to flow and can potentially remove large amounts of water from subterranean aquifers quicker than recharge can occur (Winders, 2012). This can create cones of depression in the water table causing drawdown in existing bores which is particularly concerning for bore water users as it has the potential to impacts rural domestic water supplies (Winders, 2012). Density of CSG wells could be a potential factor in groundwater impacts. Petroleum extraction well clusters have been shown to cause detrimental impacts to groundwater levels in the Eastern Province, Saudi Arabia (Abderrahman et al., 1995).

Produced water can be considered a reduction in water due to the fact that it involves contaminating higher quality water with salts and other drilling or fraccing compounds or compounds naturally occurring in the coal seam. This creates a potential loss of opportunities to use the water for potable and other domestic purposes (NTN, 2011). Modelled predictions on the long term impacts of CSG water production in the Walloon Coal Measures suggest up to 150m depressurisation which would cause a maximum drawdown of 21m within existing bores (Queensland Water Commission, 2012).
Declining ground water levels are expected to start impacting the Condamine Alluvial, a major water resource in Western Downs, QLD, by 2017 and estimate a net loss of 1,100M/L per year over the next century (Queensland Water Commission, 2012).

Several farmers in Western Downs have already experienced drawdown in their bores. Mining companies promise to “make good” any inconveniences to the landowner but the economic viability of making good is questionable. A hydro-engineer and feedlot owner from Western Downs estimates that water loss to a bore supplying 200 head of cattle would cost $216 per day, equal to $78,840 per year (Winders, 2012). There are currently 21,000 bore users at risk of drawdown impacts suggesting there is a considerable cost involved for gas companies “making good” if even only half of these people demand compensation (Queensland Water Commission, 2012). It is estimated that only 528 of registered bore users will experience such water loss as to trigger make good agreements but this figure is based on modelling (Queensland Water Commission, 2012) and may not be totally accurate.

According to Australia Pacific LNG, Origin and Conoco Phillips (2012) there will be an estimated 75,000ML – 140,000ML/year removed from the Great Artesian Basin (GAB) through CSG production. Their estimates state that the GAB is recharged by 912,120ML/year and therefore will not suffer significant impacts from CSG (Australia Pacific LNG, 2012). According other estimates by SMICCSG (2011), based on current production schedules CSG, water production is expected to peak around 200,000ML/year in the Surat Basin alone. The difference in these figures illustrates the uncertainties of CSG water impact assessments. Proper scientific assessment of water impacts is restricted by the fact that much of the existing data is held by coal seam gas companies in industry confidence (NSW Parliament, 2012). Generally, impacts are considered by most studies to be variable and dependent on geology and level of CSG development (SMICCSG, 2011). Most likely the more serious drawdown impacts will be regional and localised (Abderrahman et al., 1995). Globally, water scarcity in the face of population increase and climate change is considered a far greater threat to the global community than climate change itself and recommended as a priority management for all nations (Vorosmarty et al., 2008).

### 4.2 Water produced by coal seam gas

Water produced by CSG extraction contains compounds from fraccing and/or drilling fluids and mobilised heavy metals, hydrocarbons and radioactive elements from within the coal seam (NTN, 2011). Many of the compounds both used in fraccing and drilling are not being clarified by CSG companies in their public information as they are considered to be industry “secrets” (NTN, 2011). According to the CSIRO (2011) the water produced from the coal seam can be strongly saline containing mostly sodium chloride but also sodium bicarbonate and other compounds. Research has found traces of highly toxic BTEX chemicals in an Arrow Energy fraccing operation in QLD. BTEX stands for benzene, toluene, ethylbenzene and xylene constituting a compound that is naturally found
in fossil fuel deposits such as coal and has also been used in fraccing fluids (NTN, 2011). The QLD and NSW government have now banned the use of BTEX in fraccing fluids (NTN, 2011). Chemicals still commonly used in fraccing fluids in Australia are listed in Table 1. Approximately 200,000L of fluid can be used during a fraccing treatment and even a very small amount of benzene has the potential to poison thousands of litres of water (NTN, 2011). Drilling fluids contain many compounds including biocides, corrosion inhibitors, salts (sodium chloride, zinc bromide, calcium chloride, potassium chloride), barium sulphate, emulsifiers, sodium hydroxide, potassium hydroxide, amides, bactericides, ammonium bisulphate and sodium sulphate amongst others. These compounds vary in toxicity levels and health effects (IPIECA and OGP, 2009).

Table 1. Types of Chemicals Commonly Used in Fraccing Fluids in Australia (NTN, 2011).

<table>
<thead>
<tr>
<th>Additive Type</th>
<th>Main Compound(s)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluted Acid</td>
<td>Hydrochloric Acid, Muriatic Acid</td>
<td>Dissolves minerals</td>
</tr>
<tr>
<td>Biocides</td>
<td>Glutaraldehyde, Tetrakis hydroxymethol phosphonium sulfate</td>
<td>Eliminates bacteria in water that produce corrosive products</td>
</tr>
<tr>
<td>Breaker</td>
<td>Ammonium persulfate/ sodium persulfate</td>
<td>Delayed break gel polymer</td>
</tr>
<tr>
<td>Corrosion inhibitor</td>
<td>n,n-dimenthy formamide, methanol, naphthalene, naphtha, nonyl phenol, acetaldehyde</td>
<td>Prevents corrosion of pipes</td>
</tr>
<tr>
<td>Friction Reducer</td>
<td>Mineral oil, polyacrylamide</td>
<td>Reduces friction of fluid</td>
</tr>
<tr>
<td>Gel</td>
<td>Guar gum</td>
<td>Thickens water</td>
</tr>
<tr>
<td>Iron Control</td>
<td>Citric acid, thioglycolic acid</td>
<td>Prevent metal oxides</td>
</tr>
<tr>
<td>KCl</td>
<td>Potassium chloride</td>
<td>Brine solution</td>
</tr>
<tr>
<td>pH adjusting agent</td>
<td>Sodium or potassium carbonate Ethylene glycol</td>
<td>Maintains pH</td>
</tr>
<tr>
<td>Scale inhibitor</td>
<td>Sodium or potassium carbonate Isopropanol,</td>
<td>Prevents scale deposits in pipe</td>
</tr>
<tr>
<td>Surfactants</td>
<td>2-Butoxyethanol</td>
<td>Affects viscosity of fluid</td>
</tr>
<tr>
<td>Crosslinker</td>
<td>Ethylene glycol</td>
<td>Affects viscosity of fracking fluid</td>
</tr>
</tbody>
</table>
Figure 5. Historic Water Production from Petroleum and Gas Wells in the Surat Cumulative Management (Queensland Water Commission, 2012)

Water production figures (Figure 5) from 1995-2010 state that over 20,000ML/year is produced from CSG activities within the Surat Basin alone (Queensland Water Commission, 2012). Figure 5 shows that CSG developments have caused a dramatic increase in petroleum industry water production since the Surat Basin developments around 2005. Most produced water is expected to be treated and used or injected into aquifers or reinjected into the coal seam (Arrow Energy, 2012). Produced water is treated using reverse osmosis which involves forcing water through a semi-permeable membrane to remove contaminants. The process has limitations in its ability to remove organic compounds, being capable of removing only those above a certain size (Bodalo-Santoyo et al., 2004). The reverse osmosis technology also involves large capital and operating costs particularly in energy and materials and there still remains the issue of having to dispose of precipitated salts and contaminants (Greenlee et al., 2009).

4.3 Contamination of Groundwater

Major threats to ground water quality are from salinity, acidity, nutrients and contaminants such as heavy metals, industrial chemicals and pesticides. Contamination of ground water can have significant economic impacts through decreasing agricultural and horticultural productivity, causing environmental damage in ground water dependent ecosystems and pose serious risks to human and animal health (Geoscience Australia, 2011). Opportunities for contamination from CSG occur via interconnectivity between aquifers and gas wells, disposal of produced water and leakages (NTN, 2011). Problems such as borehole fractures and compression failures (Asquith and Krygowski, 2004) may allow the transmission of fluids and gases into permeable rock layers adjacent to gas wells. Reports from the United States indicate that leakage from holding ponds and wells has occurred into
nearby streams and in some cases risen to the surface in fields via aquifers (Bamberger and Oswald, 2012). In Tara, QLD spraying produced water onto roads as a dust suppressant is considered a viable option for disposal (Arrow Energy Pty Ltd, 2012). Contaminants entering the environment through these channels can be transported elsewhere via wind and water posing health risks to animals and humans (see section 5.2 for details).

Queensland residents report of methane leaking into the Condamine River in Western Downs region (Wroe, 2012). Another Queensland resident reports that his domestic bore experienced explosions and can catch fire if naked flame is held to it (McCarthy, 2012). Arrow Energy’s Environmental Impact Statement (2012) states that the Condamine Aquifer overlies the Walloon Coal measures in several places and that there is possible connectivity between the two. According to the Queensland Government and Origin Energy, the methane leaking through the river is naturally occurring due to a shallow coal seam under the surface. Origin Energy made clear it was their understanding the leakage was natural because they had no production wells nearby, however, they were unable to be absolutely certain and made no mention of possible locations of exploration wells (Rego, 2012). Research in America discovered that methane concentrations have occurred in high to explosive levels (above 7-10mg/L) near to gas extraction wells. Levels of 19.2 and 64 mg/L of methane were recorded from bore wells in gas extraction areas in Pennsylvania and New York (Osborn et al, 2011). An assessment of 58 gas wells in Tara in QLD identified 26 leaking wells, 5 of which were leaking above the lower explosive limits for methane (Australian Department of Employment, Economic Development and Innovation, 2010). A NSW inquiry into coal seam gas concludes that the potential impacts to water resources could be disastrous and that urgent scientific research is needed to assess the potential for these impacts to occur (NSW Parliament, 2012).

5. Other consequences of coal seam gas development

Along with potential impacts to water resources coal seam gas development can also create risks to agricultural lands, public and animal health and seismic stability.

5.1 Impacts to agricultural production

Water underpins all agricultural production and is likely the major concern in possible CSG impacts to farming. However, CSG infrastructure can also use up large areas of land despite claims to be minimal in its surface impact. Figure 4 shows an aerial view of CSG development in Chinchilla revealing the vast network of roads and well sites. There are two kinds of wells, exploration and production wells. Exploration wells are generally spaced one well per 30 to 60 km² and production wells are typically spaced 600m – 1200m or more (Queensland Government, 2011). Each well is surrounded by a 75 x 75m up to one hectare clearing to allow for the movement of drilling vehicles
and for protection from possible bush or grass fires. Sites may also be fenced for safety and as a barrier to livestock (APPEA, 2012). This means that for every square kilometre of land or 100ha


property there is a possibility for 5 well sites equalling 28125m² up to approximately five hectares plus road surface area, that may be unavailable for agriculture during the life of the well and for sometime after the well has been abandoned. One NSW standard for rural collector roads describing non arterial roads that collect and distribute traffic in an area as well as abutting property calls for a 23m wide road reserve (Young Shire Council, 2010). Based on these dimensions it can be estimated that for approximately 6km of road accessing five wells sites on a 100ha property there may be 150 000m² of exposed road surface on top of well site areas. Exposed soil is vulnerable to erosion (Morgan, 1995) and the CSG network of roads combined with well sites creates a considerable area of erodible soil. There is also a possibility that CSG development can disturb contaminated land causing potential environmental damage from the mobilisation of contaminants (Arrow Energy, 2012).

Anecdotal evidence suggests other types of disturbance may be caused by CSG development on farmland. One QLD farmer has now chained and padlocked his gate to the mining company working on his land after he found several of his heifers choking on plastic rubbish left by the company. The farmer has reported major interruptions to usual livestock and farm operations because of the pipeline and gates left open by subcontractors. They have also found and had to remove used toilet paper and faeces from their paddocks left by the subcontract workers (Rowling, 2012a). Another QLD farmer is risking her entire farming future by selling her breed stock to raise money to sue the mining company on her land for breach of contract. She has been unable to earn her income caused by inaccessibility from the pipeline dividing her land in half and believes she has not been properly compensated (Rowling, 2012b).
5.2 Health impacts on humans and animals

There is considerable community concern over health risks to livestock and domestic animals likely to come into close contact with CSG infrastructure in their pastures. Bamberger and Oswald (2012) conducted one of the only studies on this issue in the USA. Their research illustrated strong associations with impacts to animal and human health caused by contact with high production wells, pipeline leaks, improper wastewater disposal (dumped on road and property), well flaring, storm water runoff from well site, fracking spill, drilling fluid spill and leaking holding ponds. These include gastrointestinal, reproduction and dermatological irritation, upper respiratory irritation and failure, burning of eyes, headache, neurological, musculoskeletal and urological damage and sudden death (Bamberger and Oswald, 2012). During this study two direct impact situations where recorded. One involved the spilling of hydraulic fluids into a cow pasture that killed 17 cows in one hour; the second was the result of a faulty valve on a barrel containing hydraulic fluid which leaked into a pasture causing the goats within to experience reproductive defects for the next two years (Bamberger and Oswald, 2012). Seven cattle farms were involved in the study and all showed the same trend that at least 50% of the herd was affected by death or inability to produce live born calves when contacted with contaminated water. Necropsies revealed liver, kidney and respiratory failure as the main causes of death. Petroleum hydrocarbons were found in the small intestine, lesions to lung, trachea, liver and kidneys suggested exposure to other toxicants (Bamberger and Oswald, 2012). In two separate cases a control and experimental group was inadvertently provided when one herd of cattle was exposed to creek water contaminated by CSG produced water and another herd were in other pastures with separate water source. In both cases results showed that in the experimental group around 35% died and 36% experienced reproductive problems compared to 0% in the control group (Bamberger and Oswald, 2012). Other cases reported and confirmed by medical physicians include arsenic heavy metal poisoning of children and dogs using contaminated bore water. Mobilisation of heavy metals, volatile organic compounds and radioactive substances from the coal seam are thought to occur in addition to chemicals from fracking and drilling (Bamberger and Oswald, 2012). Research on the health risks from air contamination concludes that residents within half a mile of gas wells risk sub-chronic health effects to neurological and respiratory systems from exposure to aliphatic hydrocarbons, trimethylbenzenes and butadienes (McKenzie et al. 2012).

A citizen based study in the USA revealed high levels of carcinogenic chemicals including benzene and acrylonitrile at 3 to 3000 times higher than safe levels in CSG areas. This report states that the companies involved in exploration and production are exempt from two key provisions of the Clean Air’s Act National Emissions Standards for Hazardous Air Pollutants and are therefore able to avoid complying with public health standards (Larson et al., 2011). The same study revealed that families in areas around gas wells reported rotten egg smells followed by headaches, nosebleeds and rashes (Larson et al., 2011). These symptoms coincide with symptoms reported by nine different families
living in Tara, QLD near CSG wells who are suffering nose bleeds, diarrhoea, nausea, vomiting, sore eyes and rashes. These families also report smelling gas on their properties (Climate Spectator, 2012).

5.3 Impacts on greenhouse gas emissions

The projected increase in demand for natural gas as a cleaner energy alternative to coal is one of the main drivers behind global coal seam gas production. The burning of natural gas (largely methane) is generally viewed as having much lower greenhouse emissions compared to coal (Rutovitz et al, 2011). According to the APPEA (2012) coals seam gas is a clean burning fuel producing up to 70% fewer greenhouse gas (GHG) emissions than some existing coal technology. Burning methane produces less emissions but when viewing emissions in terms of the entire life cycle of methane the difference between CSG and coal may not be as significant as claimed. An Australia report into the life cycle GHG emissions from electricity sources revealed that CSG was only marginally better than coal. CSG was found to be 13-20% more GHG intensive than conventionally produced Liquid Natural Gas (LNG) and only 5% less than the most efficient coal power. The more intense extraction process creates the potential for high emissions throughout the life cycle of CSG production (Hardisty et al, 2012).

Methane (CH\(_4\)), like carbon dioxide (CO\(_2\)), is a long lasting greenhouse gas that persists in the atmosphere for a long time and has long term impacts on climate. According to science CH\(_4\) is 20 times more effective as a GHG than CO\(_2\) a factor which needs to be considered when assessing the life cycle impacts (IPCC, 2007). A paper prepared for the National Climate Assessment revealed that CH\(_4\) is the second largest contributor to human caused global warming after CO\(_2\). Natural gas systems are the single largest source of methane emissions in the United States representing almost 40% of the total fluctuation (Howarth et al, 2012).

It seems that some climate assessments by CSG companies overlook the potential impacts of fugitive emissions from CH\(_4\) production. Arrow Energy made only one reference to fugitive emissions in their environmental impacts statement (EIS) by “preventing flaring and venting as far as practicable” (Arrow Energy, 2012, pp. 22) at gas wells and did not mention methane leaks or include impacts from transport or production of GTL or leakages from well heads (Arrow Energy, 2012). QGC (2012) acknowledges fugitive emissions as a possible emission source and in their EIS notes that the highest methane emissions source comes from pipeline leakages at 8.7kg/diesel equivalent CO\(_2\). However, the time scales for these emissions were not included and nor were well head fugitive emissions. Gas wells have been reported leaking in Queensland by local surveys and government safety assessments. Out of 58 wells tested in Tara, QLD a total of 26 were reported leaking, 5 of which were reported above the lower explosive limits of methane, meaning that the methane concentration was dense enough to ignite (Department of Employment, Economic Development and Innovation, 2010). Compared to conventional gas which requires only a few well heads CSG is extracted from many
small reservoirs and requires a large number of well heads of different sizes which dramatically increases potential for fugitive emissions (Grudnoff, 2012). The hundreds of kilometres of pipeline used to transport CSG also offer many opportunities for fugitive emissions. Combined with increases in emissions from wells during and after fraccing this suggests that CSG emissions are far higher than conventional gas but still lower than shale gas and only marginally lower than efficient coal burning technologies (Grudnoff, 2012).

National and international accounting for global warming potential (GWP) of CSG operations have mostly used the 100 year horizon which places methane’s GWP as 25 times more than CO₂ (Rutovitz et al, 2011). But when the 20 year horizon was used methane’s global warming potential was nearly 3 times higher at 72 times (Hardistry et al, 2012). It may seem optimistic to use a 100 year horizon when so much scientific evidence indicates that the next two decades will be crucial for climate change direction. Research indicates that a warming of 1.8 degrees Celsius above the 1890-1910 base line will trigger a mass melting of permafrost in the arctic constituting a rapid release of methane into the atmosphere from decomposition of the peaty soils. It is expected this melting will set in motion a positive feedback loop for global warming caused by trapping of more heat from greenhouse gases and reduction in surface albedo creating more heat absorption and increased melting (Anisimov, 2007). It is crucial to include in assessments that CH₄ dominates the global greenhouse footprint in the short term particularly when climate mitigation strategies over the next ten to twenty years are considered the most influential on economic and social futures (Howarth et al, 2012).

5.4 Impacts on seismic activity

There is some concern from the community that drilling and fracking activities can potentially cause earthquakes of a magnitude that may endanger lives and infrastructure. The process of drilling and injecting and extracting fluids into bedrock can change the existing stress state in the rock and cause seismic activity to occur (Styles, 2012). A phenomenon known as borehole breakout and drilling induced fracture can occur when the removal of rock material within the borehole causes the stresses in the surrounding rock to cause compressive or tensile failure in the bore wall (Figure 6) (Asquith and Krygowski, 2004).
Usually these seismic events are localised and very small only detectable with seismic testing equipment. Sometimes the stress spreads further and moderate size tremors can be felt at the surface by people living nearby. CSG engineers try to alleviate the chance of this happening by computer simulation of rock stress, fracture behaviour and seismic activity (Beck, no date). According to British media the mining company Cuadrilla admitted to being the most likely cause for two earthquakes of 2.4 and 1.5 relative magnitude in Blackpool in April, 2012 (White, 2012). Further research confirmed that hydraulic fracturing was in fact responsible for triggering the earthquakes in Blackpool (Styles, 2012).

5.5 Economic impacts

Economic impacts of CSG are difficult to estimate and have not yet been properly studied. Most of the evidence so far for economic impacts from CSG development is either anecdotal or based on economic modelling by mining companies. There are both positive and negative economic impacts associated with CSG development. Economic growth is considered an important part of modern society and CSG provides another resource that can further the economy. Currently the emerging CSG industry in the Surat Basin, Queensland is estimated to be worth around $100 billion and can provide around 12,500 jobs for Australia (Advance Western Downs, 2010). While this is in some respects a very positive impact, the direction of benefits from CSG development is not always towards the regions in which it operates. Some of the major players in Australian CSG development are foreign owned such as Arrow Energy, QGC and ConocoPhillips meaning that many of those profits will not remain in Australia (Moran, 2012). Furthermore many of the 12,500 jobs will be fly-in-fly-out qualified workers and not local people. In Moranbah, QLD, CSG development has seen huge influxes of temporary workers into small towns causing long term residents to sell their houses.
to mining companies who rent them to mine workers or knock them down and turn them into workers camps (Carlisle, 2012). Median house prices have more than doubled and selling rates (Figure 7) in Moranbah have increased rapidly since CSG development began in the early 2000’s (Residential Tenancies Authority, 2012). This trend has forced Moranbah locals to move unable to handle the rising rent prices (Lagan, 2012). Loss of long term residents means loss of the local workforce and this has forced many businesses to close down (Saggers, 2012). Even Moranbah’s KFC has to shorten their opening hours and the general store shut down after losing 200 customers (Carlisle, 2012).

![Figure 7. Median sale prices and number of sales in Moranbah, Queensland from 1997 to 2012 (Figure from Median rents quick finder, Residential Tenancies Authority, 2012).](image)

In other areas If using the theory of economic efficiency or pareto-optimality it is understood that in a market that reaches equilibrium it is impossible to make someone better off without making someone else worse off (Asafu-adjaye, 2005). It seems that this theory may apply in CSG development where large economic profits are likely to be created to the detriment of local and regional economies.

### 5.6 Cumulative impacts

Cumulative impacts refer to the additional effects of impacts added to past, present and foreseeable impacts which are difficult and most often not assessed in Environmental Impact Assessments (Burris and Canter, 1997). The NSW Government Inquiry (2012) into coal seam gas acknowledges the need for more research into the cumulative impacts of the relatively new CSG industry. GeoScience Australia (2010) concludes that the perhaps most significant issue in CSG development is the uncertainty around possible cumulative, regional scale impacts. Lack of data sharing by coal seam gas companies is a significant hindrance to the development of quality science and more accurate assessment of cumulative impacts (NSW Government, 2012).
6 Potential for coal seam gas development in Northern Rivers, New South Wales

6.1 Northern Rivers region

The Northern Rivers falls within the Far North Coast Region of New South Wales that extends from the Queensland border south along the coast to Evans Head and west to Woodenbong and Tabulam (NSW Department of Planning, 2005). The population is over 450,000 and has been growing at 2% per year one of the highest rates outside capital cities in Australia (NRCMA, 2007).

The Far North Coast is recognised for significant environmental values, attributed to wide variations in climate, altitude, landforms and geology that support a diverse array of flora and fauna, including many threatened and iconic species such as the koala (NSW Government, 2010). Northern Rivers is the most biologically diverse region in New South Wales and third most in Australia (NSW Department of Planning, 2006). Water underlies all aspects of economic and social development in the region and is fundamental to the region’s image. Dedication to water conservation is evident in all council’s active development of Integrated Water Cycle Management Plans to reduce demand on surface and groundwater and improve recycling and reuse opportunities (NSW Department of Planning, 2006). Protecting and enhancing the environment and conserving natural resources are considered paramount to the regions sustainable future (NSW Department of Planning, 2006).

Favourable climate, protected environmental values and recreational opportunities have led to the region being widely recognised as an international and domestic tourist destination (Destination NSW, 2012). Tourism has an important economic and social role bringing over $2 billion to the economy per annum (NRCMA, 2007). Estimates are that the tourism industry employs over 7000 people in the region (NSW Department of Planning, 2006) and there is much opportunity for expansion of the industry, provided the environmental and social values it hinges on are preserved (Buultjens et al., 1996).

Lismore has a strong primary industry, construction and manufacturing sector employing 8.4% of the population (NSW Department of Planning, 2006). The latest statistics show that fresh food crops are worth $984 million with macadamias as the largest single producer at $35 million (Australian Bureau of Statistics, 2011). Accommodation and food industries are expected to grow with continuation of tourism growth in the area. The greatest employment opportunities are in retail, hospitality, tourism, education, health, agriculture, forestry and fishing (NSW Department of Planning, 2006). Southern Cross University is an important contributor to the local economy spending over $50 million per annum and providing a major source of income to local businesses and significant employment opportunities (Buultjens et al., 1996).
Agriculture is an important industry for the North Coast having been one of the first industries in the region since 1870 (Henderson, 2002) and currently bringing over $1 billion per annum to the region (NRCMA, 2007). Agriculture is the region’s third largest employer and exporter and fourth highest contributor to the gross regional production (NSW Government, 2010). The spread of urban and industrial development is an increasing pressure on the economic and social value of agriculture in the region and protection of agricultural land on the NSW North Coast is a long term government initiative for the region (Australian Department of Infrastructure, Planning and Natural Resources, 2005). Due to a relatively wet climate and land disturbance, soil loss from erosion is another pressure on the agricultural industry with an estimated soil loss of 60 tonnes per/ha/year on bare ground, 30 tonnes per/ha/year in macadamia farms and over 10 tonnes per/ha/year in pasture (Woodlots and Wetlands, 2008).

6.2 Using trade-offs and opportunity costs in evaluating CSG development

The definition of trade off refers to the balancing of objectives that are not simultaneously achievable or simply the giving up of one thing in return for another or that the investment into one option causes a loss in another (Asafu-adjaye, 2005). This concept needs to be applied in economic, social and environmental evaluation of CSG development. If agricultural production is reduced forever because of 20 years of CSG development than this would be considered a trade off. Another concept is opportunity cost which refers to the value of a resource in its next best alternative use or the benefits that may have been obtained from a foregone alternative investment (Asafu-adjaye, 2005). This concept is particularly relevant in situations where resources are scarce or finite and investment into one form of use will mean that the resource is no longer available for another investment (Asafu-adjaye, 2005). The downgrading of higher quality water to lower quality represents an opportunity cost as the range of potential uses is reduced by the loss of quality.

6.3 Prospects for development in Northern Rivers region

It was indicated by representatives of the landholders, townspeople and Northern Rivers management groups that education and secure local employment were considered among the most important aspects of economic development (NSW Government, 2010). With projected rises in the population there will be a need to strengthen local economic activity and associated employment. Continued diversification of the economic base is considered essential to sustain the region’s economic growth (Buultjens et al., 1996). The Northern Rivers Regional Industry and Economic Plan (2005) identified tourism, horticulture, health, aquaculture, residential development and construction, forestry, meat and dairy, and transport as key industry sectors with growth opportunities. A distinct challenge for the region is the need to create 32 500 jobs by 2031 to support the growing population (NSW Department of Planning, 2005).
The vision for the future of Northern Rivers involves three main objectives

1. To have physically healthy people and natural environments and maintain a high level of mutual trust, support and cooperation within and between communities.
2. Creating a sustainable future by recognising the links between economy, environment and quality of life – now and in the future. Ecologically, economically and socially sustainable development, are all equally important and the Strategy strives for a balance between these goals.
3. Diverse communities are considered a valuable asset and need to continue to be an integral part of the region’s growth. (NSW Department of Planning, 2005).

6.4 Energy development in Northern Rivers region

Clean renewable energy and other sustainable initiatives have immense support in the Northern Rivers. Lismore and Byron areas have the highest uptake of rooftop solar in rural NSW (Regional Development Australia, 2012). Regional Development Australia Northern Rivers recommended that the government give priority for development of renewable energy sources in the region and implement a Sustainable Energy Action Plan on the North Coast (Regional Development Australia, 2012). Sustain Northern Rivers group is a collaborative platform for climate change action, created in 2008, which is based on fostering networks, supporting local groups and projects and centralising resources (Sustain Northern Rivers, 2010). The Northern Rivers Regional Strategy has a large scale plan for the ecological sustainability of the region developed with the partnership of Northern Development Taskforce, Northern Rivers Regional Organisation of Councils, the Northern Rivers Regional Development Board and Planning NSW (NSW Government Department of Planning, 2006).

Coal seam gas development in the Northern Rivers has arisen due to the fact that the region overlies the Clarence-Moreton Basin that stretches from Southeast Queensland to Northeast NSW. The main source of coal seam gas within the Basin is found in the Walloon Coal Measures that extend into the Surat Basin of Southwest Queensland (Arrow Energy, 2011). There are currently three companies with mineral licenses in the region (Figure 8). Arrow Energy which was recently taken over by Shell and PetroChina in 2009 is undertaking CSG exploration in the Clarence-Moreton Basin (Arrow Energy, 2011). Red Sky Energy, in partnership with ERM Power, is exploring and developing gas acreage held by Clarence Moreton Resources Pty Ltd (Proactiveinvestors Australia, 2012). Metgasco represents the third company involved in CSG exploration within the Clarence Moreton Basin (Metgasco, no date). Metgasco is developing the 145km Lions Way Pipeline from Western Downs region to Newcastle (Figure 9) part of a pipe system connecting Wullumbilla to NewCastle for transportation of CSG to Gladstone to produce and export LNG to China (Metgasco, 2011). Metgasco has also been approved for the development of the Richmond Valley Power Station in 2010 (Metgasco, 2010).
The coal seam gas industry is being considered by gas companies as a major economic benefit to communities through the creation of employment, regional investment and flow on benefits. With regard to CSG development in the Northern Rivers region Metgasco managing director Peter Henderson states: “The effects of these newly created jobs and the significant expenditure will flow through to all parts of the Northern Rivers community. The new jobs created will mean that these people will buy more food, fuel, furniture and electronic goods from local businesses. The whole community will benefit from the growth of our operations” (Henderson, P. (2012) Metgasco). On the other hand lack of strategy and prioritisation around coal seam gas development concern NSW farmers who question why this industry is being allowed to potentially threaten food production, the environment and the community when CSG reserves in NSW represent only 0.7% of all the profitably extractable gas reserves in Australia (Thomas, 2011).

Figure 8. Coal seam gas exploration licenses and existing well sites in Northern Rivers, Northeast NSW (Poractiveinvestors, 2012).
6.5 Northern Rivers community actions and groups in response to CSG development

The Northern Rivers community have expressed strong opposition and concern about the development of CSG in the region. Since the birth of the Keerong Gas Squad in 2010 growing awareness of the negative impacts from CSG has led to an uprising of community groups against CSG development. There are now over 20 local anti CSG groups in the area including Kyogle Group Against Gas, Gasbusters (a non violent direct action group based in Lismore), Rock Valley Gas Rangers, Mid-Clarence Group Against Gas and many more. These groups are working together with the nationwide Lock the Gate group and CSG Free Northern Rivers, a regional group. The efforts from these groups have forged such events as the Rock the Gate Rally, Rock the Gate Movie and Rock the Gate the Musical (CSG Free Northern Rivers, 2012). This campaign has created the CSG Free Roads initiative using door to door community surveys to determine the community stance on CSG followed by a formal declaration to the Mayor that the road is CSG Free and protected by community action. There is ongoing continuum of events and campaign initiatives within the region and more information can be found on websites such as www.lockthegate.org.au and www.csgfreenorthernrivers.org.au (CSG Free Northern Rivers, 2012).
7. Discussion

This section will attempt to draw together the general CSG impacts as they relate specifically to Northern Rivers region, NSW and identify some of the opportunity costs and trade-offs associated with CSG development in that area. It attempts to provide an overview of the impacts of CSG development in the Northern Rivers region, NSW, and how this might potentially be a net benefit or cost. Impacts such as effects on biodiversity have not been included in this study but in consideration of the high biodiversity values of Northern Rivers, NSW it is recommended that further research could be undertaken on this subject.

Firstly it is necessary to acknowledge that the CSG industry represents a major economic growth for Australia in terms of resource export. Strong international gas prices and a growing gas market see CSG as a valuable export for Australia and considered vital to the future of Australian energy development (Australian Department of Resources, Energy and Tourism, 2011). However the relatively short life of the industry, around 19 – 27 years (Rutovitz et al, 2011) and multitude of possible impacts, may affect the net value of the industry when viewed in relation to potential costs to other longer term resources and industries such as water and agriculture. For Northern Rivers there is a need for economic growth and employment opportunities (NSW Department of Planning, 2006) and some believe that CSG can provide for these needs. Lack of scientific assessment of the trade-offs between short term, fly in-fly out employment in CSG developments and employment in other industries such as tourism and agriculture creates uncertainty as to whether there is a net employment benefit for the region. If using the theory of economic efficiency and considering foreign and external investors against possible trade-offs (Asafu-adjaye, 2005) there is a possibility that benefits will be distributed away from the region at a cost to the local economy. Other substitutes such as biogas may provide employment and exports at a lesser cost to the community. Biogas appears to be the most viable liquid fuel alternative to CSG and further assessment of potential biogas production from waste in Northern Rivers, NSW could provide comparable options.

The Northern Rivers region has a strong community with a diverse economy that highly values the environment and sustainable development. Growth in local food production provides valuable input to the regional gross output and these values are considered to be highly important to the regional image as a major drawcard for investment and growth (NSW Department of Planning, 2006). There is considerable anecdotal evidence from Queensland and the United States to suggest that trade-offs will occur between these values as landscapes become industrialized and local economies change possibly displacing long term residents (Saggers, 2012). The underlying reasons for these changes, such as rising house prices (Figure 7) and land surface impact (Figure 4) can be mostly verified by scientific and statistical evidence although the range of sources is limited and potentially biased. The potential for loss of local community and food production values, that are such a major asset to the region, calls
for a comprehensive assessment of CSG impacts on the agricultural and rural community in Northern Rivers, NSW.

While the scientific data for water and public health impacts is limited there are several similarities between different studies and anecdotal evidence that enable some tentative assumptions. The Northern Rivers region has a large population of rural dwellings and towns and a social and economic dependence on environmental resources such as clean water, conservation and enhancement of environmental assets, agriculture and sustainable development (NSW Department of Planning, 2006).

It appears scientifically certain that produced water contains a variety of compounds from drilling and fraccing fluids and mobilization that vary in their toxicity to humans and the environment (NTN, 2011). Some of the health risks are quite serious such as long term damage to various systems in the body and possible sudden death of livestock (Bamberger and Oswald, 2012). There is substantial evidence to suggest that CSG developments create a multitude of opportunities for contamination of the environment to occur. Anecdotal evidence from Queensland correlates with many of these symptoms although it is currently not feasible to make direct assumptions due to lack of scientific data (Larson et al., 2012 and Bamberger and Oswald, 2012). Due to the high density of rural living in Northern Rivers and the range of disposal issues associated with CSG produced water it seems that there is high probability for contact between contaminants, humans and livestock. Similarities in scientific and anecdotal evidence on health issues and the potential severity of health impacts definitely indicate that further research should be undertaken before CSG development continues. The scientific confidence of impacts to groundwater seems to be mostly limited by lack of understanding of the groundwater principles and lack of research (NSW Parliament, 2012). However, there are considerable anecdotal and scientific records that groundwater contamination can occur throughout development and operation (Asquith and Krygowski, 2004., Wroe, 2012., Arrow Energy, 2012 and Osborn et al., 2011). There was some indication that treatment of CSG produced water could engender significant capital and operating costs (Greenlee et al, 2009) without dealing with the actual contaminants of concern. This process needs to be evaluated as a scientific tool to provide a more accurate estimation of the opportunity cost of CSG development.

Anecdotal evidence suggests that CSG is not always compatible with agriculture according to the interruptions and costs to farming operations experienced by farmers in QLD with CSG development on their land (Rowling, 2012). Although there is little or no scientific data and no Australian studies apparent, the existence of reported incidents and possible trade-offs between CSG industry and agriculture emphasizes a strong need for further research. Impacts from CSG related road and well site development also warrant investigation considering their potential to increase soil erosion (Woodlots and Wetlands, 2008).
With regard to climate change, while CSG has more potential as an export (Department of Resources, Energy and Tourism, 2006) therefore allowing other countries to reduce GHG emissions it may not be the best option for clean energy production Northern Rivers, NSW. There is evidence to suggest that the actual reduction in emissions from CSG compared to existing coal technology is marginal (Howarth et al., 2012), especially in comparison to renewable energy (Schleisner, 1999). It seems apparent that Australia has considerable renewable energy resources and that technological advances overseas are providing opportunities for these to be integrated effectively for power generation (Schleisner, 1999., Van Ginkel et al., 2004., Weimers, no date. and Zweibel et al., 2007). Given that Northern Rivers shows such high support for renewable energy development (NSW Department of Planning, 2006), investment in this region might be better served in renewable energies such as solar, wind and wave power. When considered in conjunction with other issues such as food and water security the renewable direction seems more apparent, instead of CSG which is more likely to have adverse impacts on these other factors. The potential for biogas to be a viable liquid gas export (National Society for Clean Air and Environmental Production, 2006) requires further investigation as it may provide a direct, possibly sustainable alternative to CSG for the Northern Rivers region, NSW. Accurately assessing CSG emissions seems to be central in defining the industry’s value as a transition fuel and adoption of the correct emissions horizon is a key factor in accurately assessing climate impacts of CSG along with the correct identification and inclusion of fugitive emissions (Howarth et al., 2012).

Other impacts such as increased seismic activity warrant further investigation but priority may not be as great a concern in Northern Rivers as it may be in areas with higher earthquake potential. Considering the range, scale and longevity of risks that have been raised, a proper assessment of cumulative impacts seems predominantly important before further large scale developments are pursued, particularly in areas of such high density and environmental value as the Northern Rivers.

Conclusion

The magnitude of scientific uncertainty surrounding the impacts of CSG combined with the possible severity of these potential risks highlights the need for precautionary measures. The NSW government itself admits with regard to water contamination that the consequences could be “disastrous”. When words such as this are used they should not be taken lightly. Furthermore there are sufficient parallels between scientific and anecdotal evidence that many of these risks are quite likely to be realised and therefore should not be ignored. The Northern Rivers is a vital community with many growth opportunities in a variety of industries and these are true long term values for the region. Regional scale impacts appear to be a significant problem associated with CSG development. Extensive independent scientific research should underpin such a development to engender community security and improve prediction accuracy and management strategies. This study has managed to provide a
brief assessment of the possible impacts associated with CSG development in Northern Rivers, NSW and has highlighted the imperative need for further research in several areas. These areas include but do not end with:

- Impacts to water resources, paying particular attention to groundwater removal, groundwater contamination and treatment and disposal of CSG produced water
- The potential for and identification of regional social and economic impacts in the long term to provide a basis for cost-benefit analysis
- Impacts to human and animal health with particular regard to contact with contaminated water and air in CSG development areas
- A comprehensive assessment of the net treatment and disposal costs for CSG produced water based on sound science
- Assessment of the emissions reduction value in comparison to renewable resources
- Assessment of the economic viability of renewable energy development in Northern Rivers, NSW with special attention to biogas as a liquid fuel export
- A comprehensive assessment of the cumulative impacts from CSG drawing on an improved, sound scientific base

CSG development may be a more commercially viable option in areas of Australia where there is less environmental or social capital, thus reducing the scale of trade-off and opportunity cost impacts that may consequently increase overall extraction costs. Furthermore the value of other industries and resources need to be properly calculated and weighed against CSG development to ensure that the best possible option and management for the region is being undertaken.

References


on 8/09/2012


Rego, P. (2012) “Methane bubbles blamed on CSG wells”, ABC Rural, retrieved from: http://www.abc.net.au/rural/qld/content/2012/05/s3514869.htm on 18/08/2012


