**Submission No 412**

# INQUIRY INTO COAL SEAM GAS

**Organisation**: Doctors for the Environment Australia Inc.

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Doctors for the Environment Australia
www.dea.org.au

# Submission to the Parliament of New South Wales Coal Seam Gas Inquiry

## 15 September 2011

Submission from
Doctors for the Environment Australia Inc.

DEA

# CONTRIBUTORS

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# SUMMARY


- Doctors for the Environment Australia regards the development of coal seam gas (CSG) mining in Australia as a significant threat to public health

- The current level of assessment, monitoring and regulation of CSG exploration and mining activities in Australia is inadequate to protect the health of current and future generations of Australians

- There is the potential for public health to be affected directly and indirectly through CSG operations

    - through contamination of water, air and soil
    - through diversion of water and land away from agricultural food production
    - from mental health impacts on communities who have had environmental changes imposed upon them

- Contaminants of concern include many of the chemicals used for hydraulic fracturing as well as toxic substances produced through this process and mobilised from the sedimentary regions drilled. Some of these compounds can produce short-term health effects and some may contribute to systemic illness and/or cancer many years later

- Publicly available information on the chemicals used for this purpose in Australia is inadequate, as is their assessment and regulation

- Evidence from several countries has shown that environmental exposures are occurring which may put people at risk, and these concerns have led to moratoria on further mining operations

- There is a significant threat of ground water pollution, for the hydrological systems involved are complex and inadequately researched. CSG mining in the Great Artesian Basin is unwise because of the potential for contamination in a system which may not be renewable

- The monitoring of potential contamination of water supplies in coal seam gas mining areas is inadequate. It should be greatly expanded, independently audited and publically accessible

  Coal seam gas mining uses prodigious amounts of water, which will compete with human and agricultural needs. Great Artesian Basin water is essentially a non-renewable resource. It is already at an advanced stage of depletion. Remaining water should be used with great care and only for essential agricultural and human purposes

- Human health relies on having clean safe drinking water and unpolluted air. Coal seam mining operations should not be allowed to endanger

these basic health needs of Australians. Any development of this industry requires adequate scientific studies and the application of precautionary principle

- The CSG process can divide previously close-knit rural communities, increasing tension and disharmony, impact on local economies, and threaten other industries. The final common pathway for effects from these impacts may be poorer mental health, with increases in depression and anxiety

- The long-term impacts of unconventional gas mining in the United States suggest significant damage to the ecological systems upon which human life exists. There are significant health impacts in loss of good agricultural land in the face of the long-term need to feed Australians. The impact on Australia's ability to feed other countries as the world moves to increasing food shortages must also be considered

- The projected economic gains from the industry have been widely promulgated but a full cost-benefit analysis of the impacts on the wider economy of a massively expanded CSG industry has not been done. Financial benefits from employment, mining royalties and the export of coal seam gas must be offset against damage to agriculture, food exports, tourism, soil, water and air quality, and human health and well-being

- Coal seam gas (CSG), like all fossil fuels contributes to greenhouse gas emissions and therefore climate change. As such it contributes to the globally increasing burden of ill-health due to climate change

- The carbon footprint of CSG (>95% methane) is widely regarded as being about half that of coal. This assumption is based upon the premise that there is minimal leakage of methane between the production well and the end user. Unburnt methane however is a potent greenhouse gas with many times the global warming potential of carbon dioxide. Because the leakage of methane during mining, processing, storage and transport is unquantified there is some doubt as to whether CSG has in practice the lighter carbon footprint. Detailed independent full lifecycle analysis of the carbon emissions of the Australian CSG industry with comparison to coal and renewable energy is needed. Whatever the case far stricter regulation regarding fugitive emissions is necessary

- CSG's growing acceptance as a 'transitional fuel' could be used to delay the transition to renewable and carbon-free forms of energy. This must not be permitted to occur

- Notifications of terms of reference and dates of CSG and coal projects are poorly advertised and response times inadequate

- The Commonwealth has failed to assess many chemicals that are used in coal seam mining and New South Wales has proceeded without this information

- Doctors for the Environment Australia considers that the EIA processes used have been inadequate and have failed to assess health impacts appropriately before projects were approved

# RECOMMENDATIONS

- RECOMMENDATION 1: Use of Great Artesian Basin water should be restricted to human consumption and minimal wastage agricultural practices

- RECOMMENDATION 2: For the protection of human health, the NSW government should impose a moratorium on all new CSG operations until health risk assessments of procedures and chemicals performed on an industry wide basis have been undertaken.

- RECOMMENDATION 3: There should be full mandatory disclosure of the composition and quantities of chemicals used in all CSG operations, including public information on potential health effects.

- RECOMMENDATION 4: Comprehensive independently audited water monitoring programs should be required for CSG operations. Results should be publicly available.

- RECOMMENDATION 5: Air quality monitoring and reporting should be required near CSG operations.

- RECOMMENDATION 6: Independently audited monitoring and reporting should be required in relation to volumes and contaminants of waste water produced, and disposal methods.

- RECOMMENDATION 7: There should be wide economic analysis of the benefits versus the costs of the CSG industry in Australia, including health and social costs.

- RECOMMENDATION 8: Agricultural land and landscapes with high conservation values should be protected from CSG exploitation.

- RECOMMENDATION 9: The mental health impacts of CSG mining should be recognised as part of Health Impact Assessment (see recommendation 12) prior to any approval of developments.

- RECOMMENDATION 10: Landholders and communities should have a say in the approval process for CSG operations and have the right of veto.

- RECOMMENDATION 11: Independent Australian full lifecycle comparative analyses of the carbon emissions from the CSG industry, the coal industry and the renewable energy industries are needed. Stringent regulation and monitoring of fugitive emissions from all fossil fuel

industries is necessary. The availability and profitability of coal seam gas must not be used to delay the switch to renewable and non-carbon energy sources.

- RECOMMENDATION 12: A nationally consistent Health Impact Assessment process should be mandatory for coal seam gas activities.

## ABOUT DOCTORS FOR THE ENVIRONMENT AUSTRALIA

Doctors for the Environment Australia is a voluntary organisation of medical doctors in all Australian states and territories. We work to address the diseases – local, national and global – caused by damage to the earth's environment. The medical profession has a proud record of service to the community. This record not only includes personal clinical care, but also involvement in global issues that threaten the future of humanity. We aim to use our scientific and medical skills to educate governments and industry, the public and our colleagues to highlight the medical importance of our natural environment. To our patients we try to provide a role model in the care of the environment for this is part of a preventative health ethos.

Doctors for the Environment Australia is a branch of the International Society of Doctors for the Environment (ISDE), based in Switzerland, which is a global network of concerned medical professionals. There are now branches in 35 other countries. ISDE has significant achievements in Europe and has established strong links to and influence in the European Community and WHO.

## INTRODUCTORY REMARKS

### Terms of reference

Doctors for the Environment Australia notes that with few exceptions each of the terms of reference has the potential to impact on human health. This submission therefore is structured to address each health impact rather then follow the chronology of the terms of reference.

### Coal Seam Gas (CSG) mining in the context of human health

Health is not simply the absence of disease, it is life in an environment that is supportive of human essential needs and which does not contain harmful substances which can cause ill health in the future. The basis of public health is prevention of harm based on careful scientific assessment of possible hazards, their risks and methods of prevention. Therefore it deals particularly with clean air, clean water and nutritious and uncontaminated food. Increasingly public health has a global dimension since actions in one country may affect the health of people in other countries. These are all issues pertinent to the assessment of the health hazards of mining coal seam gas.

Global environmental changes such as climate change, biodiversity loss, and degradation of ecosystems on land and in the oceans pose major, increasing threats to sustainability, population health and survival. In medical terms climate stability, biodiversity and healthy ecosystems are the life support systems for humanity. These threatened determinants are enmeshed in a wide set of 'global changes' exemplified by the growing scale, speed and intensity of social, economic and environmental change. In today's increasingly interconnected world, human health is recognised as having wide social, economic and environmental determinants.

This submission draws attention to our concerns about the potential health impacts of the CSG industry on Australians through direct or indirect contact with toxic substances via water, air and food. Within Australia, this affects water and land (food) resources and their sustainability and determines whether the industry is a social and economic positive or negative. These impacts are covered in **section (1)** and we contend that they require urgent consideration by the Committee.

Internationally, the CSG industry involves Australia's commitment to the health of all nations with our emerging obligations to reduce green house emissions. These matters are dealt with in **section (2)**.

Although many of these factors are interdependent we will examine some of them separately.

**Section (3)** covers the need for Heath Impact Assessment, Conclusions and Recommendations.

**Section (1)**

# STATE HEALTH IMPACTS

## IMPACT ON WATER RESOURCES

Clean, drinkable water is an absolute need for maintaining human health.

Australia's management of its major water resources leaves much to be desired. Like many other nations we have over-utilised groundwater stores and aquifer water without proper scientific study as to the consequences, and sometimes even when we knew the likely consequences.

### Great Artesian Basin water

If very carefully used this Basin is potentially a source of potable water for some generations to come, a vital resource in a drying continent. Studies of its sustainability are inadequate, but suggest that its renewal is extremely limited – perhaps non-existent. In the last 100 years some 50 million megalitres have been withdrawn with 80% of the water wasted. It is estimated that only 20 million megalitres or so of available water remains. http://www.onlineopinion.com.au/view.asp?article=993&page=0

In general governments do not accept the existing recharge data because they wish to exploit it and indeed do so, for example the Olympic Dam mine uses 30 million litres of water per day from the Basin. When this was opposed on environmental grounds an Indenture Act was passed that overruled environmental considerations and indeed future human need.

Contamination of Basin water with exogenous or endogenous chemicals **must** be avoided, and for that reason, CSG procedures with their known high-probability contamination of adjoining water bodies should therefore be banned in the small part of the Basin which is in New South Wales.

### Ground water

The scientific understanding of groundwater and aquifer flows is poor and the consequences of high pressure injections cannot be modelled sufficiently to ensure that contamination of drinking water can be avoided. Reference has been made below to the various reports expressing concern. The Rudd government established The National Centre for Groundwater Research & Training, at Flinders University. The centre has said:

*"Groundwater is now recognised as a crucial asset that must be an integral part of Australia's long-term water planning. But to effectively manage this resource requires far more knowledge of sub-surface water systems than is currently available. Because existing data is limited or non-existent,*

*management decisions are being made using hydrogeologic conceptual models that can be grossly misleading".*

Should coal seam gas mining occur and then from the public health perspective it is important that water sources are constantly monitored for methane; chemicals used in fracking and toxic contaminants from sediments over the life of the mine and for a long period after the mine is closed.

### Water consumption by CSG operations

Given that climate change predictions point to increasing water shortages in SE Australia, the vast quantities of water required for CSG operations is of concern. The JP Morgan report 2010 indicated that CSG activities in Queensland Surat and Bowen Basins alone are estimated to extract between 125-350 gigalitres of water per year over the coming 20 to 30 years. This equates to approximately an additional 30-80% of current water volumes being extracted from the Great Artesian Basin per annum solely from CSG activities and this has the potential to affect water in adjacent states. http://lockthegate.org.au/documents/doc-268-jpm-csg1.pdf

In the USA, the EPA estimates that 35,000 wells are fractured annually, using the equivalent amount of water used each year in 1 to 2 cities of 2.5 million people, or 40 to 80 cities with a population of 50,000. http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/HFStudyPlanDraft_SAB_020711-08.pdf

- ***RECOMMENDATION 1: Use of Great Artesian Basin water should be restricted to human consumption and minimal wastage agricultural practices in recognition of the finite nature and advanced depletion of this resource.***

## POTENTIAL FOR ADVERSE HEALTH IMPACTS THROUGH WATER, LAND AND AIR CONTAMINATION

The current level of assessment, monitoring and regulation of CSG exploration and mining activities in all states of Australia is inadequate to protect the health of current and future generations of Australians. There is the potential for public health to be affected directly and indirectly through CSG operations through contamination of water, air and soil.

The relatively new technology of hydraulic fracturing (fracking) is being rapidly rolled out in Australia and elsewhere, without the legal and administrative protections necessary to ensure that public health is not harmed and that environmental damage does not leave a legacy for generations.

We ignore this situation at our peril – there have been other instances, such as the case of asbestos, where a product that was mined was considered an

economic boon and a benefit to society at the time, but where in the absence of appropriate regulation and research on health impacts, a legacy of disease has caused suffering to thousands.

## The process of mining coal seam gas and hydraulic fracturing

The procedure of hydraulic fracturing, as used to assist production in 10% to 40% of Queensland wells and nearly all US wells for coal seam gas, involves the pressurised injection of fluids commonly comprising water and chemical additives into rock to open up or enlarge fractures. When the underground rock formation is fractured, a "propping agent" is pumped into the fractures to keep them open and allow gas to flow. A proportion of the fracturing fluids is then returned to the surface and needs to be treated or disposed of in some way. http://www.gwpc.org/e-library/documents/general/Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs.pdf

The gas extraction process requires coal seams to be depressurised through the withdrawal of water. As the water pressure is reduced the gas is released from the coal. Depressurisation affects the water levels in coal seams and can potentially affect interconnected aquifers overlying or underlying the coal seam, and water supply to water bores in the surrounding area.

A US EPA document notes:
"*Large hydraulic fracturing operations require extensive quantities of supplies, equipment, water and vehicles, which could create risks of accidental releases, such as spills or leaks. Surface spills or releases can occur as a result of tank ruptures, equipment or surface impoundment failures, overfills, vandalism, accidents, ground fires, or improper operations. Released fluids might flow into a nearby surface water body, infiltrate into soil and near-surface ground water, potentially reaching drinking water aquifers".*
Whilst these remarks were directed at shale gas mining, many of the concerns apply similarly to coal seam gas mining.
http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/HFStudyPlanDraft_SAB_020711-08.pdf

## Water contamination

Chief amongst the potential threats to health is the contamination of surface and ground waters, particularly where these may be drinking water sources. Vast quantities of water are required for fracking, and only a reported 60% or possibly less of the volume of fluid injected may be recovered (this is difficult to estimate as records are not required). Aside from the issues of loss of water for other beneficial uses, contamination of drinking water with the chemical additives themselves, their degradation products, and compounds that can be mobilised from sediments during the process pose an unacceptable risk to health.

A recent report by JP Morgan indicated a range of risks, including reduced water quality from cross contamination of water tables, addition of drilling chemicals, gas migration to existing water bore wells, and problems with treatment, disposal and storage of waste water brought to the surface.
http://lockthegate.org.au/documents/doc-268-jpm-csg1.pdf
There are already examples in the US and in Australia where harmful chemicals, such as benzene, have been found in ground water subsequent to coal seam gas exploration and mining.
http://www.scientificamerican.com/article.cfm?id=drill-for-natural-gas-pollute-water
http://www.smh.com.au/environment/toxins-found-at-third-site-as-fracking-fears-build-20101118-17zfv.html
http://news.smh.com.au/breaking-news-national/carcinogens-found-in-csg-project-20110828-1jg77.html

**Health effects of chemicals used in or generated by CSG operations and hydraulic fracturing**

Effects on human health of chemicals depend on a range of factors including dose, route and duration of exposure. Long-term concerns of some chemicals used in or generated by CSG mining include hormonal system disruption, fertility and reproductive effects, and development of cancer. These types of effects may not be immediately obvious, but can nevertheless occur with very low chemical exposures and have far reaching consequences.

It is currently not possible to undertake adequate health risk assessments of these operations as insufficient information has been gathered on the nature and doses of chemicals entering water and air and the exposures of people to these chemicals. One of the biggest problems is the lack of transparency around the chemicals used, and the lack of monitoring under the normal protections afforded to drinking water supplies.

A recent report by a US House of Representatives Committee noted
*"As the use of hydraulic fracturing has grown, so have concerns about its environmental and public health impacts. One concern is that hydraulic fracturing fluids used to fracture rock formations contain numerous chemicals that could harm human health and the environment, especially if they enter drinking water supplies. The opposition of many oil and gas companies to public disclosure of the chemicals they use has compounded this concern."*
http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf

That committee's inquiry found that over a four year period, 14 leading oil and gas companies used more than 2,500 hydraulic fracturing products containing 750 chemicals and other components, which constituted (excluding water added at the well site) 780 million gallons of hydraulic fracturing products. A number of these chemicals were known to be hazardous to health through release into water and/or air including endocrine-disrupting and cancer-causing agents.

Colborn et al attempted to review the chemicals used in gas extraction and found the available data fraught with gaps. However, they managed to independently compile a list of 944 products used, containing a total of 632 chemicals. They noted that more than 75% of the chemicals could affect the skin, eyes, respiratory and gastrointestinal systems. Approximately 40-50% could affect the brain and nervous system, immune and cardiovascular systems and kidneys. Over a third could affect the endocrine (hormonal) system and a quarter could lead to cancer and mutations.
http://www.endocrinedisruption.com/files/Oct2011HERA10-48forweb3-3-11.pdf

A recent UK study reviewed information on chemicals supplied to New York State using a European chemical substances database and found that 58 of the 260 substances listed were of concern: 17 were classified as toxic to aquatic organisms, 38 were classified as acute toxins to humans, 8 were known carcinogens, 6 were suspected carcinogens, 7 were classified as mutagenic and 5 were classified as having reproductive effects.
http://www.tyndall.ac.uk/sites/default/files/tyndall-coop_shale_gas_report_final.pdf

Lloyd-Smith and Senjen (2011) found extremely limited data available about fracking fluids used in Australia and a lack of any comprehensive hazard assessment of the chemical mixtures used and their impacts on the environment or human health. Furthermore, only two of the 23 most commonly used fracking chemicals said to be used in Australia have been assessed by the National Industrial Chemical Notification and Assessment Scheme (NICNAS), and neither of these has been specifically assessed for use in fracking. This leaves the population vulnerable to a range of potential health threats.
http://ntn.org.au/wp-content/uploads/2011/04/NTN-Fracking-Briefing-Paper-April-2011.pdf

APPEA has listed 45 compounds used during fracking in Australia and companies frequently infer safety of these products due to the fact some are components of household products. However any poisons information centre will advise to store household chemicals safely out of reach in a locked cupboard. Just because we may have hair bleach or antifreeze in the cupboard does not mean it is safe to drink it in our coffee. Specific chemical names and CAS numbers are frequently not provided to communities, making it almost impossible for residents to obtain independent information and advice.

For example the NICNAS assessment of persulphate salts used in hair bleaching preparations (and also fracking) state they are *"hazardous chemicals and ...harmful if swallowed, irritant to the skin and eyes and able to cause allergic responses"* but companies do not provide this sort of information to the public.
http://www.nicnas.gov.au/Publications/CAR/PEC/PEC18/PEC_18_Full_Report_PDF.pdf
Some compounds such as benzene can present a risk to health even in minute concentrations. Benzene and other BTEX chemicals (benzene, toluene, ethylbenzene and xylene) are frequently found in petroleum compounds and can be mobilised during CSG operations. They are in a class of chemicals

known as volatile organic compounds which easily vaporise so people can be exposed through drinking water, bathing or breathing in vapour.

Long-term exposure to benzene can affect the bone marrow, causing anaemia, and increasing the risk of leukaemia, and can affect unborn children.
http://www.atsdr.cdc.gov/tfacts3.pdf
The Australian drinking water guidelines for benzene state "no safe concentration for benzene in drinking water can be confidently set" so the guideline is set at below the level of detection, which is 1ppb (the equivalent of a drop of water in a swimming pool).
http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh34_adwg_11_06.pdf

Toluene and ethylbenzene can damage the nervous system, liver and kidneys and ethylbenzene is a possible human carcinogen.
http://www.atsdr.cdc.gov/tfacts110.pdf, http://www.atsdr.cdc.gov/tfacts56.pdf
BTEX chemicals have been used as fracking fluids, even though they have now been banned in Queensland. However, the fracking process itself can release BTEX from natural gas reservoirs, allowing them to escape into aquifers or the surrounding air.

A 2010 assessment of the impacts of proposed coal seam gas operations in the Murray-Darling Basin noted:
"*No data have been made available to examine the possible implications of hydrocarbons, eg, BTEX, in associated water*"
http://www.environment.gov.au/epbc/notices/assessments/pubs/coal-seam-gas-operations-impacts.pdf

A range of other hazardous chemicals are reported to be used in Australian fracking operations, for example ethylene glycol, glutaraldehyde, fumaric acid, 2-butoxyethanol.

Ethylene glycol is used to make anti-freeze. When ethylene glycol breaks down in the body, it forms chemicals that crystallize, collecting in the kidneys and affecting kidney function. It also forms acidic chemicals in the body, affecting the nervous system, lungs and heart.
http://www.atsdr.cdc.gov/tfacts96.pdf

Glutaraldehyde is very irritant to skin, eye, throat and lungs. Repeated skin contact can cause allergic reactions.
http://www.cdph.ca.gov/programs/hesis/Documents/glutaral.pdf

Fumaric acid is an irritant of skin and mucous membranes.
http://www.sciencelab.com/msds.php?msdsId=9927173

2-butoxyethanol is easily absorbed and rapidly distributed in the human body and is particularly toxic to red blood cells, carrying the risk of haemolysis, and damage to spleen, liver and bone marrow.
http://toxnet.nlm.nih.gov/cgi- bin/sis/search/f?./temp/~FGaXfN:1

It should also be noted that with any chemical mixture it is not only the effects of each chemical which may be problematic, but also the potential for multiple unpredictable chemical combinations.

## Production and disposal of contaminated waste water

Waste water with additives returned to the surface pose problems with treatment, disposal and storage. This water can contain volatile organic compounds, high concentrations of ions and radioactive substances. Substances that can be mobilised from rock formations may include arsenic, cadmium, chromium, lead, selenium, thorium, radium and uranium. CSG water brought to the surface is often highly saline and not suitable for agricultural or domestic purposes.
http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/HFStudyPlanDraft_SAB_020711-08.pdf

Waste water has to be stored in tanks or pits at the well site, where spillage can occur and then has to be recycled for future use in fracking, injected into underground storage wells, discharged into nearby surface water or transported to wastewater treatment facilities.

The 2011 Tyndall Centre (University of East Anglia, UK) report notes that *"flowback fluid is likely to be of greater concern than that of the fracturing fluid itself, and is likely to be considered as hazardous waste in the UK."*
http://www.tyndall.ac.uk/sites/default/files/tyndall-coop_shale_gas_report_final.pdf

Even when technologies such as reverse osmosis are utilised to remove contaminants from water, they cannot be guaranteed to remove all chemicals.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1801584/pdf/canmedaj01125-0017.pdf

Residual chemicals used on food crops may present a contamination risk. The large amount of salt that needs to be removed also needs to be somehow disposed of and our rural landscapes already are suffering from excess salinity.

## Air contamination

Fracking chemicals can also be volatile and be released into the air, where they exert their effects through inhalation. Volatile organic compounds can be released during drilling, during methane separation from other gases and by compressors and other equipment. Fracking chemicals and produced water held in evaporation ponds can be released into the local atmosphere and inhaled. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817691/pdf/ehp0115-a00076.pdf

In addition to direct effects, volatile organic compounds can contribute to production of ground-level ozone, a known respiratory irritant with detrimental effects on lung function. It was been reported that in 2006, the Colorado Air Quality Commission approved several new restrictions on the oil

and gas industry in an effort to curb emissions from ozone-forming compounds affecting air quality in the region.
http://www.earthworksaction.org/Coloairpollution.cfm

While large emitters of air pollution are regulated under current legislation, small individual "emission units" including drill rigs, condensate tanks, compressors, and other equipment are not, and yet because of the sheer number of drill sites, cumulatively they may contribute significantly to air pollution without adequate monitoring or controls.

## Exposure to Methane through air and water

Research in the US has found systematic evidence for methane contamination of drinking water associated with shale-gas extraction.
http://www.propublica.org/documents/item/methane-contamination-of-drinking-water-accompanying-gas-well-drilling

Gas can migrate from coal seams to aquifers where a pathway exists. It can migrate some distance though natural or man-made geological pathways. Investigation is complicated by the fact that tracing a definitive source of contamination can be difficult, as groundwater supplies and gas deposits are often separated by considerable distances.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2866701/pdf/ehp-118-a199.pdf

Methane is a colourless odourless flammable gas, which can form an explosive mixture with air at levels as low as 5%. Methane can displace air and cause symptoms of tiredness, headaches and dizziness.
http://www.dhs.wisconsin.gov/eh/chemfs/fs/Methane.htm

A recent example in Victoria of a community affected by methane gas pollution can be found in the case of the Cranbourne's Brookland Greens housing estate where a class action was brought by residents who were evacuated from their homes due to explosive levels of methane gas coming from a neighbouring landfill. This has recently resulted in a settlement of $23.5 million. In this case the source was a local landfill, but similar concerns apply wherever there is a source of uncontrolled methane which can migrate underground. http://www.abc.net.au/news/stories/2011/03/25/3173631.htm

Methane in drinking water is a concern for human health and it also acts as an indicator to show the potential for contamination with other compounds from the drilling and fracturing processes.
Assoc Prof Heiger-Bernays of Boston University School of Public Health has been quoted as saying: "*We normally think of methane toxicity in terms of inhalation, and by that route, we know it can displace oxygen, which creates an asphyxiation hazard... we know virtually nothing about how methane might affect people who ingest it.*" By interacting with chlorine in water, methane might produce chlorinated hydrocarbons that are known to be toxic by ingestion.
http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.119-a348

## Lack of health research to establish safety

Despite the range of potential health problems posed by unconventional gas operations, peer-reviewed published studies on the health impacts are virtually non-existent, as the research has not been done. Prof Bernard Goldstein from the School of Public Health at the University of Pittsburgh is reported as saying in relation to the US experience that claims of safety made by industry and regulators lack credibility in the face of a growing litany of accidents and contamination problems. An unfinalised document of a study conducted by the Colorado School of Public Health of a proposed 200 well natural gas operation concluded that residents could experience chemical exposures and accidents from industry operations.
http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.119-a348.

## Need for the precautionary principle to be observed in the absence of health data

A recent article in the American Journal of Public Health (Finkel & Law, 2011) called for the precautionary principle to be used in relation to fracking, stating "*of concern is that endocrine-disrupting chemicals may alter developmental pathways, manifesting decades after exposure*".
http://ajph.aphapublications.org/cgi/content/abstract/101/5/784

The European Parliament has recently released a report stating "*Because of the complex nature of possible impacts and risks to the environment and to human health of hydraulic fracturing consideration should be given to developing a new directive at European level regulating all issues in this area comprehensively*".
http://www.europarl.europa.eu/document/activities/cont/201107/20110715ATT24183/20110715ATT24183EN.pdf

- ***RECOMMENDATION 2: For the protection of human health, the NSW government should impose a moratorium on all new CSG operations until health risk assessments of procedures and chemicals performed on an industry wide basis have been undertaken.***

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- ***RECOMMENDATION 6: Independently audited monitoring and reporting should be required in relation to volumes and contaminants of waste water produced, and disposal methods.***

# The economic and social implications of CSG activities as they affect health in CSG Communities.

The pathways for the influence of socioeconomic status on health are numerous and complex. Indeed any new industry affecting the social and economic variables of an individual or community will have health outcomes. It is with this in mind that the following sections explore a number of ways the coal seam gas industry will impact on local economies, community social capital, and the mental health of communities living in a gas field.

Community and individual health is influenced by circumstances and factors associated with socioeconomic status. The Health Report 2010 from the Australian Institute of Health and Welfare describes the "socio-economic gradient of health" where health status closely follows social and economic status along a continuous gradient from advantage to disadvantage.
http://www.aihw.gov.au/publication-detail/?id=6442468376&tab=2

Expanding the industry many-fold in NSW will multiply any adverse impacts on the general health of CSG communities. As many of these impacts are only now being researched, a "primum non nocere" (first, do no harm) approach is warranted.

## Economic impacts

There are economic benefits of the mining and resources boom. Like most of our coal, most of our coal seam gas will be exported. This activity brings jobs and state revenue. Do these economic benefits filter back to the communities impacted directly by coal seam gas mining? And are those benefits enough to offset the negative economic impacts, which will include all externalities such as the costs of health care?

In 'gas communities' in the United States there are economic 'winners and losers'. The winners are those leasing their land, finding work in the industry or business from the industry. The losers are those with no land to lease, not employed by the gas industry, and paying more for rent, goods and services. In fact many gas industry jobs go to interstate workers rather than to local residents.
http://solveclimatenews.com/news/20110517/fracking-marcellus-shale-natural-gas-montrose
http://solveclimatenews.com/news/20110518/natural-gas-marcellus-shale-pennsylvania-communities-fracking?page=show

In Australia the majority of jobs in the gas industry are also outsourced. In Queensland the Gladstone LNG plants under construction on Curtis Island currently employ 800 people. 500 of them are fly-in, fly-out workers. Within

two years the total number of workers will rise to 6000 with another 2000 contractors and an even greater proportion will be from outside Gladstone and Queensland, many from overseas.
http://www.theaustralian.com.au/news/nation/bn-gas-plan-draws-workers-of-the-world/story-e6frg6nf-1226128461505

Whilst much is said of the jobs gained by the CSG industry little thought is given to those jobs lost in other industries. We agree with the comments of Professor Ross Garnaut, who said: (page 91)
http://www.garnautreview.org.au/update-2011/garnaut-review-2011/garnaut-review-2011.pdf
*"The Governor of the Reserve Bank of Australia, Glenn Stevens, noted in February 2011 that the high prices for Australia's resource exports meant that other industries had to invest and produce less: 'on this occasion, the nominal exchange rate has responded strongly'*, he said. *'This ... gives price signals to the production sector for labour and capital to shift to the areas of higher return.'"*
*"In other words, Australia is enjoying a resources boom and for each new coal mine or gas plant that opens up, there must be a cut in jobs and investment in some combination of tourist hotels and restaurants, universities, steel mills, farms and other businesses producing exports or competing with imports. If it is a big investment in gas and coal, a lot of jobs and investment have to go. Prop up jobs in one area, and even more have to go in others."*
And he asks the question *"But why should all Australians carry the costs of the gas industry's exceptional expansion and prosperity? Why should the education, farming, tourism and manufacturing industries pay for the extra emissions that have come with the exceptional prosperity of the coal and gas industries, when their own prospects have been damaged by the resources boom?"*

In addition to these wide ranging effects on job creation and job losses, the CSG industry will directly affect land values. Land values in the presence of a Petroleum Exploration License for CSG are set to decrease. In the Southern Highlands this has been estimated to be by 30%, even before exploration commences. Further reductions are inevitable once the extraction process reduces the productivity and amenity of the land. This substantial cost is being borne by landholders. It has been postulated that if the gas industry were to fully compensate landholders for these losses it would make CSG extraction uneconomic.
(Southern Highlands Coal Action Group, presenting to Federal Senate Rural Affairs and Transport References Committee Inquiry, Management of the Murray Darling Basin, impacts of CSG, 9th September 2011)

In summary, the economic impact of CSG extraction on a rural community may be positive for a few but negative for many more. Thus the industry may divide previously close-knit rural communities, increasing tension and disharmony. Even those benefiting economically may be suffering due to the social impacts of the industry and the division of their community. Community disruption, breakup of settled communities and job losses are all well-recognised health hazards. It is ironic that some politicians express concern at the imagined job losses in successful resource industries resulting from a

carbon emissions tax, but not at the loss of long-standing sustainable jobs in farming and tourism in country areas.

This raises the issue of the need for a full economic balance sheet. Will the income from CSG royalties exceed the costs of damaged agricultural land, use and contamination of water resources, health and social disruption costs and the externalities of green house emissions?

## Agricultural Impacts

The CSG industry threatens Australia's ability to feed itself and an increasingly hungry world by damaging the ecology of soils and therefore the health and productivity of agricultural land. A Federal Government report from its Science, Engineering and Innovation Council indicates that Australia could become a net importer of food, as the country's population continues to grow and climate change cuts agricultural production. Importing food can be more expensive and will raise the cost of living. Supply chains can be susceptible to disruption by military conflict and natural disasters. Food miles and the carbon footprint of the food we eat will increase. The nutritional value of fresh foods will diminish due to prolonged time in transit between farm and table. Limited nutrition affects health in many ways, in particular by increasing the risk of the two biggest causes of death in Australia: cardiovascular disease and cancer.

CSG infrastructure involves a well every half to one kilometer and a network of roads, gas and water pipelines with their surrounding easements. This infrastructure alone breaks up productive land and makes it hard to farm. The NSW Irrigator's council confirms that CSG infrastructure makes large scale irrigation impossible. In addition the loss of productive land from gas infrastructure is considerable. The Nature Conservancy, USA, estimates that 8.8 acres of land are required per shale gas well, including roads and ponds. If collecting and distributing pipelines are included in the calculation, the area doubles.
http://solveclimatenews.com/news/20110421/natural-gas-fracking-environmental-footprint-marcellus-shale-pennsylvania-forests?page=2

A detailed assessment of the sustainability and productivity of agricultural lands occupying potential CSG fields should be integral to the approval process for CSG projects. Soil is fundamental to human survival. The debate regarding CSG has focused largely on water effects. It is vital that impacts on our agricultural soils are also considered. Australian soils are mostly low in carbon and nutrients. Rainfall in many areas is scarce and will become more variable still with climate change. We note with concern that the New South Wales government has failed to exclude highly productive land from CSG development before this and other Inquiries are completed. At the senate enquiry, the NSW department expressly denied there would be "no go" areas for CSG. They assert that there is no reason that CSG and farming cannot co-exist (under their new "aquifer interference policy" which will safeguard aquifers).

The Liverpool Plains south of Gunnedah has some of the best soil in Australia but is earmarked for CSG mining. The soil there is a black or grey vertosol, well structured, high in nutrients and with excellent water holding capacity and the ability to hold salt below the level of the roots. The Liverpool Plains is a highly productive region for crops, as the patchwork appearance from air attests. Land values there are five times the surrounding areas. Wheat, canola and sorghum yields are up to 4 times those of other growing areas. This has not been taken in to account when approving CSG mining in the area. As well as the loss of productive land from infrastructure, and the contamination and reduction of water supplies, CSG development may poison these very valuable soils due to flooding from containment/evaporation ponds used to hold wastewater from gas wells. Flood events will become more frequent with changing climate. The risk of contamination of crops under Australian conditions needs to be assessed urgently.

## Export and Tourism Industries Impacts

NSW has many valuable export and tourism industries, on which the health of rural communities depend, other than fossil fuels and minerals. Sales of Hunter Valley wines in 2004-05 totaled over $362 million with over $40 million in exports. Australian wines are internationally acclaimed. CSG mining in the Hunter Valley winegrowing area threatens this valuable industry.

The vineyards and wineries of the Hunter Valley support a thriving tourist industry. Official statistics for the Hunter Region for 2008/09 estimate that $1.3 billion was spent by visitors - 58% by domestic overnight visitors. A total of 6.3 million visitors went to the region – 68% were domestic day visitors. Fifty three per cent of domestic visits and 93% of international visits were related to food and wine. Fourteen per cent of domestic visits and 74% of international visits were related to nature-based activities.
http://www.ret.gov.au/tourism/Documents/tra/Regional%20tourism%20profiles/NSW/NSW%20-%20Hunter%20-%20FINAL2.pdf

These statistics demonstrate that visitors are attracted to the natural landscape and the high quality wine and food industries of the Valley. Both the amenity of the natural and rural landscape and the quality and safety of the food and wine produced in the area are under threat from CSG mining. Many jobs in the region depend upon the wine and tourism industries.

An example of how tourism will be eroded with development of the CSG industry in the Hunter Valley can be in found in small tourist towns in Pennsylvania, USA, such as Montrose. There, constant noise from heavy truck movements has completely transformed the main street, turning a quiet rural tourist destination in to an industrial town. *"...members fear narrow rural roadways clogged with the never-ending grind of drilling-related trucks, and landscapes marred with gas wells will be a turnoff to tourists and artisan farmers."*
http://solveclimatenews.com/news/20110517/fracking-pennsylvania-natural-gas-drilling-marcellus-shale

In Pennsylvania, USA, there is mounting concern regarding the environmental impact of the shale gas industry on the forests for which the state is famous and much visited. Even forests that are in state reserves are under threat. Pennsylvania has a total of 4.5 million acres of public lands. Estimates show that as few as 500,000 of these are permanently protected from gas drilling. http://solveclimatenews.com/news/20110422/number-crunching-environmental-footprint-fracking-boom-forests-pennsylvania?page=2

In NSW the Piliga State Forest is being directly impacted by the development of CSG. The Piliga constitutes the largest continuous remnant of semi-arid woodland in temperate NSW. The forest contains 22 endangered animal species including the glossy black cockatoo, the squirrel glider, the koala, the Pilliga mouse and the rufous bettong. Over 60 wells have already been drilled in this conservation area and 1000 more are planned. Reports of leaking gas pipelines, poor management of waste water and dying vegetation around gas wells are of significant concern.

Thus CSG development results in degradation of landscape and industrialization of towns. Both contribute not only to loss of tourism but also to mental health impacts.

- ***RECOMMENDATION 7: There should be wide economic analysis of the benefits versus the costs of the CSG industry in Australia, including health and social costs.***

- ***RECOMMENDATION 8: Agricultural land and landscapes with high conservation values should be protected from CSG exploitation.***

## Mental Health Impacts

Water and air pollution, water shortages, permanent degradation of productive agricultural land and loss of livelihood and landscape...all have mental health consequences for communities living in a gas field.

Solastalgia is a recently developed concept in Australian psychiatry that identifies and describes environmentally induced distress.

*"As opposed to nostalgia the melancholia or homesickness experienced by individuals when separated from a loved home, solastalgia is the distress that is produced by environmental change impacting on people while they are directly connected to their home environment."*
*"...the following responses clearly resonate with the dominant components of solastalgia, the loss of ecosystem health and corresponding sense of place, threats to personal health and wellbeing and a sense of injustice and/or powerlessness."*
http://informahealthcare.com/doi/abs/10.1080/10398560701701288

Nick Higginbotham, Glenn Albrecht and colleagues have studied solastalgia in the context of severe prolonged drought and the Upper Hunter experience of open cut coal mining
http://www.sciencedirect.com/science/article/pii/S1353829209001105

It will be one of the mental health consequences of Coal Seam Gas mining as irreversible change to the landscape occurs over time.
Solastalgia was all too evident in farmers and landowners of Queensland in the 4 Corner's program *"The Gas Rush".* Katie Scott from Chinchilla describes a neighbour who sold up after 77 gas wells were built on their property saying, *"They had to go for sanity*". She also describes being confronted on a daily basis with the infrastructure of a gas field: roads, wells, signs, saying*, "It's a different landscape to what we have always been used to".*
http://www.abc.net.au/4corners/specialeds/20110221/gas/default.htm

Informed consent of landholders is often lacking in the contract process when mining companies first approach landholders about unconventional gas extraction. Lack of full information and disclosure to landholders before leases are signed has contributed to a sense of betrayal and powerlessness. Landowners are not told they have a choice whether to sign a contract with the gas companies or what the implications of a gas field over their property are. They are often told: the resource is there, and you have no rights to stop us obtaining it. The injustice and powerlessness that this engenders contributes to solastalgia and poorer mental health outcomes.

Coal seam gas extraction takes place in rural communities. These are the very same communities who are already at most risk from the adverse health effects of climate change and the degradation of the Murray Darling Basin river systems.
http://www.racgp.org.au/afp/200712/200712Blashki.pdf

We know that extreme weather events linked to climate change have a detrimental effect on mental health and community well-being in rural areas both in the short and longer term.
http://www.climateinstitute.org.au/our-publications/reports/874-a-climate-of-suffering-the-real-costs-of-living-with-inaction-on-climate-change

Coal seam gas will compound these mental health impacts. As described above livelihoods in agriculture, tourism and exports are threatened by CSG. The stress and disruption caused to farmers has already been shown to force some of them to leave a CSG drilling area, allowing once productive lands to lapse into disuse.
http://www.abc.net.au/4corners/specialeds/20110221/gas/default.htm

Elizabeth McGowan eloquently describes solastalgia in US shale gas communities in a series of online articles for *"SolveClimate"* news. Long time residents are moving, unable to bear the changes the gas industry has wrought on their landscape and community.
*"...even those with deep taproots are wrestling with whether they still belong in a place they thought they would never leave"*
*"It feels like you either have to fight the drilling or move...but either choice is*

*difficult. Where do you go anyway? When I think about it though, I just don't know if this is home anymore"*
http://solveclimatenews.com/news/20110517/fracking-marcellus-shale-natural-gas-montrose?page=2

*"They are going to drill to kingdom come and this is breaking my heart. I didn't move here to be embroiled in this. And now, not a day goes by that I don't want to get in my car and get out of here."*
http://solveclimatenews.com/news/20110517/fracking-pennsylvania-natural-gas-drilling-marcellus-shale

In the Hunter Valley a psychiatrist Dr Steve Robinson has written an account of the mental health impacts of CSG extraction he has witnessed in his community. (Appendix 1)

He reports:
*Exploration is when the psychological stresses are first noticed in the community. Exploration maps are placed in the local newspaper but they are difficult to decipher and individual landholders are not notified. This uncertainty starts to generate community anxiety. Some individual landholders are approached and offers are made mostly for access but with agreements that include confidentiality clauses. Individuals don't know if they are being treated fairly.*

*The community starts to divide between the few who see it as an opportunity for an additional income and the larger number who hear the risks and see little in the way of benefits. The local council has a sharp pro-mining v anti-mining divide leading to a spill of one mayor. The letters page in the local newspaper has amply echoed this divide for the past 5 years.*

*Seismic surveys come and go with some damage to paddocks, heavy vehicle traffic ruining country roads, and noise. Drilling occurs with the same complications. The town takes on a different look with mining vehicles being prominent and drilling teams from interstate coming and going. The visual impact is slowly increasing.*

*A few properties are purchased for good prices, other houses close-by cannot be sold and their value drops. Lifetime plans are put on hold or cancelled. Property development in the area declines as a result of the general uncertainty. Rental property is more expensive. The tourism industry is threatened and wealthy prospective city retirees look to other beautiful areas not impacted by mining. The gas company employs very few locals.*

*Exploration wells are fracked to optimize the flow and the wells are flared for months. There is no explanation of the risks and precautions taken in these fracking and flaring operations. There is no publicity given to any air or water testing. There have been at least two separate unpredicted explosions locally due to gas migration known to the community from just a dozen exploration wells and even more dramatic events elsewhere from gas mining. This results in understandable anxiety about safety risks. In Gloucester this first phase has taken 5 years so far and production has yet to commence.*

*The Gloucester Valley is a heritage and very beautiful landscape, which has drawn tourists and retirees to the valley in large numbers. The long time residents have a particularly strong attachment to the landscape and the potential devastation caused by 350 closely sited gas wells sows the seeds for depressive illnesses for many of the 1000 residents of the valley and the 2500 residents of Gloucester town.*

*What are the effects on the individual of this general stress on residents of a town and valley? Stress is cumulative and will highlight the weak link in those already at risk. Those with illnesses of depression, anxiety or paranoia that are currently under control run the risk of having those illnesses reactivated. These were the most numerous group of the disorders I saw in psychiatric practice in this newly mining community. It usually takes a more intense, life-threatening stress to cause PTSD (Post Traumatic Stress Disorder) but stresses that continue for a very long time, involving a powerful opponent and having no apparent solution promote feelings of helplessness and hopelessness. These are hallmarks of depressive illness and I saw a few such cases in individuals with no prior history of mental disorder. Other behaviours included angry outbursts, single episodes of antisocial behaviour, interpersonal disharmony, and 'locking the gate'.*

- ***RECOMMENDATION 9: The mental health impacts of CSG mining should be recognised as part of Health Impacts Assessment prior to any approval of developments***

- ***RECOMMENDATION 10: Landholders and communities should have a say in the approval process for CSG operations and have the right of veto.***

## Growing community and government concern

The US EPA announced in March 2010 that it will conduct a comprehensive research study to investigate the potential adverse impact that hydraulic fracturing may have on water quality and public health.
http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/HFStudyPlanDraft_SAB_020711-08.pdf

This will help to inform the need for federal regulation. Meanwhile, on 6th June 2011 the New York State Assembly passed a one-year moratorium on hydraulic fracturing. This replaces an existing ban on horizontal fracking that was due to expire. The new ban includes all types of fracking and will remain in place until the state Environmental Conservancy Department reports on the environmental and health risks of hydraulic fracturing.

On 25th August 2011 the US state of New Jersey issued a 12 month ban on hydraulic fracturing. The French Canadian province of Quebec has had a moratorium on fracking since March this year.

In South Africa the government has passed a moratorium on all hydraulic fracturing licenses in the Karoo, a large semi-desert region in South Africa.

The French National Assembly in May introduced legislation to ban hydraulic fracturing in shale gas mining.
http://www.connexionfrance.com/Shale-gas-drilling-ban-France-fracking-hydraulic-fracturing-12722-view-article.htmlntamination

A 2011 report from the Tyndall Centre, University of East Anglia, UK, concluded: *"Evidence from the US suggests shale gas extraction brings a significant risk of ground and surface water contamination, and until the evidence base is developed, a precautionary approach to development in the UK and Europe is the only responsible action."*
The report calls for a moratorium on shale gas development until there is a much more thorough understanding of impacts of the extraction process.
http://www.tyndall.ac.uk/sites/default/files/tyndall-coop shale gas report final.pdf

In NSW, Byron Shire Council has joined the other shires of Ballina and Tweed in calling for an immediate moratorium on CGS. The Wingecarribee Shire Council in the Southern Highlands has three times voted to express total opposition to any coal seam gas development.
http://kangaroovalley.nsw.au/news/anti-coal-seam-gas-movement-gathering-steam

**Section (2)**

# INTERNATIONAL HEALTH IMPACTS

## 1. The environmental and health impact of CSG activities including the:

## Effect on greenhouse gases and other emissions

Global warming has a multitude of detrimental effects, many of which are already apparent even at this early stage of the accelerating process. As of now carbon dioxide levels are 40% greater, average global surface temperature 0.8 degrees Celsius higher, the ocean 30% more acidic and the average sea level 20 centimetres higher than in pre-industrial times. Because of the present imbalance between radiant energy gained and energy lost by the earth, due to the greenhouse effect, even if we were to burn no more fossil fuel (coal, oil and gas) temperature and sea level will continue to rise and the most extreme climate events will become more common and more extreme for many decades to come.

Higher air temperatures result in the atmosphere being able to carry more water vapour. The more water vapour the greater the potential for violent storms and flooding rains, for storms are powered by the 'latent heat' released as vapour condenses into cloud. Increasing temperature can also bring drought, ecological change, crop failure and desertification. Rising sea levels and storm surges will inflict increasing damage to low lying states and vulnerable coasts. As the damage accumulates recovery and adaption will become decreasingly affordable and possible.

All governments must be aware that a significant and damaging change is occurring to the world's climate, a change that poses fundamental and worsening risks to human health and survival. According to a 2009 report of the Global Humanitarian Forum, each year climate change leaves over 300,000 people dead and 325 million people seriously affected. A further four billion people are vulnerable, and 500 million people are at extreme risk.
http://www.ghf-ge.org/human-impact-report.pdf
This is the consequence of some 1.1 trillion tonnes of cumulative anthropogenic carbon dioxide that has been emitted since pre-industrial times
http://petrolog.typepad.com/climate_change/2010/01/cumulative-emissions-of-co2.html

These impacts are due to impaired food yields and consequent malnutrition; diarrhoeal diseases associated with freshwater shortages (especially in poorer and unhygienic settings); increased ranges and rates of some infectious diseases; and heightened exposures to storms and floods.

Recognition of Australia's impact on global health, via its contribution to global climate change, has not yet featured in the deliberations of Australian governments. Indeed, if short-term economic considerations continue to be the major political influence on Australia's climate change policies, our

emission record will become increasingly difficult to defend. The world's economic and trading systems are interdependent and assiduously defended, and economic imposts are now likely for those countries that take insufficient action to reduce emissions. As a consequence of Australia not yet having a price on greenhouse gas emissions, Qantas is now penalized by the European Union with a tax on its emissions. Many other such decisions are likely in future.

Although mechanisms may differ between countries, there is universal recognition that global greenhouse gas emissions have to be reduced and that there must be collective responsibility for this. There is a perception that Australia, as a very wealthy country and perhaps the world's highest per capita emitter of greenhouse gases, is not fulfilling its obligations. Indeed, the mining of coal seam gas (CSG) will increase emissions, both here and in other countries that might purchase the gas. Even if CSG produces less greenhouse gas than coal in generating the same amount of electricity (a claim reviewed below) it offers no solution to climate change
http://www.guardian.co.uk/environment/2011/jun/06/natural-gas-climate-change-no-panacea/print.

Natural gas, of which CSG is an example, is regarded by some as an important bridging fuel, a fuel for use during the transition period from high carbon content fossil fuels to low or carbon free fuels. Although the composition of natural gas varies according to its source, in all cases the major component is methane (CH4). On combustion methane releases more thermal energy than other fossil fuels: methane 55.5 MJ/kg, gasoline 47.30 MJ/kg, diesel 44.80 MJ/kg and coal (moist) 13-30 MJ/kg, expressed as higher heating values (HHV)
http://webbook.nist.gov/chemistry &
http://www.railpage.org.au/articles/coal.html.

Natural gas on combustion releases less carbon dioxide (CO2) than other fossil fuels for the same amount of available thermal energy, 52gCO2/MJ for natural gas compared with 67gCO2/MJ for gasoline, 70gCO2/MJ for diesel and 92gCO2/MJ for coal, *(approximate values)*
http://archive.defra.gov.uk/environment/business/reporting/pdf/conversion-factors.pdf
It should be noted that it is impossible to mine, process, store or transport natural gas without the unintended loss of significant amounts of methane and lesser amounts of other greenhouse gases. The warming effect of methane is especially important because on a mass for mass basis it has 25-33 the global warming potential (GWP) of CO2 on a 100 year horizon and a GWP of 72-105 on a 20 year horizon (Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) and Shindell, D.T., Improved Attribution of Climate Forcing to Emissions, Science, 326 no 5953 pp716-718).
Unnecessary fugitive losses caused through cost cutting and negligence must be halted. Fugitive emissions can be minimised by capture during the establishment of wells and by applying high standards of monitoring and maintenance to pipelines and all equipment. Flaring is a common but less satisfactory means of emission reduction than capture. Another source of fugitive emissions, from the clearing of land for wells, pipelines and processing plants should also be minimised. Also there are the greenhouse gases

produced by the industrial equipment used during the extraction, processing, transport and combustion of the fuel to produce useable power. Finally also to be considered are greenhouse gas emissions related to producing the materials used in the needed infrastructure. If the coal seam gas industry is to continue, care should be taken to minimise all greenhouse gas emissions associated with the industry.

A recent US study claimed that on full life cycle analysis, shale gas has a heavier carbon footprint than coal, when used to generate electrical power http://graphics8.nytimes.com/images/blogs/greeninc/Howarth2011.pdf. By extrapolation this raised concerns over the hitherto accepted advantage of coal seam gas over coal. We have now examined the matter and found on the basis of the limited data available that coal seam gas has a lighter carbon footprint than shale gas but either a lighter or heavier impact than coal depending upon the variables and assumptions considered http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&PubId=386 & http://www.springerlink.com/content/b430681263425q64/fulltext.pdf (**see Appendix 2**). Independent good quality Australian data, based on actual monitoring, is needed to establish the true facts.

It should be noted that if the liquefied natural gas and export industry is to be included in our considerations then liquefaction of natural gas uses a further 10% of the natural gas's energy http://what-when-how.com/energy-engineering/liquefied-natural-gas-lng-energy-engineering/.
Thus any possible global warming impact advantage of natural gas over coal is reduced or negated when natural gas is liquefied for export. It should be noted that shipment and re-gasification prior to use contribute further losses in efficiency. On this basis export coal may well have a lighter whole of life cycle greenhouse gas impact than exported natural gas irrespective of its source.

Compared with coal and other fossil fuels, natural gas burns cleanly, producing far less nitrogen oxide and almost no sulphur dioxide, mercury, and particulates. Thus overall, less health and environmentally threatening pollutants enter the atmosphere through its use.

The Queensland government recently commenced leakage testing of coal seam wells near Tara
http://www.dme.qld.gov.au/zone_files/petroleum_pdf/tara_leaking_well_investigation_report.pdf
in response to the airing of a television documentary that was critical of the environmental and ethical standards of the coal seam gas industry http://www.abc.net.au/4corners/content/2011/s3141787.htm.
The investigation found 26 of 58 wells to be leaking, one seriously, and as consequence the government issued compliance orders on all of the Queensland coal seam gas companies. All were directed to inspect their production wells for leaks and to undertake risk assessments in relation to well heads. Despite assurances, based on the industry's subsequent state-wide self audit, 34 (2%) of 2719 CSG wells were found to leak, 5 at a flammable level. Thus public concern persists http://media-newswire.com/release_1151986.html.

Ongoing reports of well blowouts do not assist the industry's reputation. NSW CSG production is currently of the order of 6 PJ (0.108Mt and 3.1% of annual Australian CSG production) with economic demonstrated resources (EDR) estimated at 2466 PJ (44.4Mt and 8.7% of Australian reserves). http://www.accc.gov.au/content/item.phtml?itemId=961581&nodeId=a934a0311336f67b0f7303f344579f82&fn=Chapter 3 Natural gas.pdf

CSG production is proposed to increase dramatically over the next several years to satisfy domestic and international demand. Current NSW originating CSG following combustion to CO2 is calculated to produce 0.297Mt CO2 pa, with EDR potentially producing 122Mt CO2, (equivalent to 0.36% of total global anthropogenic CO2 emissions in 2009) a substantial contribution to global greenhouse gas pollution and sufficient to account for an estimated further 35 or so climate related deaths per year. These figures assume no fugitive losses of gas during the mining, processing, storage and transport of the gas, which as discussed above, is an unrealistic assumption.

The preferred option from the climate change and human health perspectives is discontinuation of the CSG industry, with a rapid transition to renewable and non-carbon energy sources, rather than the current projected expansion. Fugitive emissions from Australian CSG, despite a paucity of data, are projected to increase for at least the next decade http://www.climatechange.gov.au/en/publications/projections/australias-emissions-projections/fugitive-emissions.aspx.

Enhanced monitoring and control of fugitive emissions from all fossil fuel sources and processes needs to be implemented to reduce Australia's greenhouse gas emissions http://www.climatechange.gov.au/en/publications/projections/australias-emissions-projections/fugitive-emissions.aspx.
It is likely that the introduction of an appropriate carbon price could assist the control of fugitive emissions eg. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/343452/Connell_Capture-of-fugitive-emissions-from-open-cut.pdf

The great danger in utilising gas in the transition to non-fossil fuel energy sources is that it delays their introduction. This is occurring with the shale gas industry in the United States http://www.reuters.com/article/2011/06/16/us-energy-summit-costs-idUSTRE75F44D20110616.

In the rush to CSG in Australia we can find no evidence that governments have considered this issue as part of their responsibilities for the long term reductions in emissions. The argument used to develop CSG is that it is cleaner than coal whereas the real issue is that it is a fossil fuel which is retarding renewable energy development. As indicated by International Energy Agency Executive Director, Nobuo Tanaka: *"While natural gas is the cleanest fossil fuel, it is still a fossil fuel. Its increased use could muscle out low-carbon fuels such as renewables and nuclear, particularly in the wake of Fukushima. An expansion of gas use alone is no panacea for climate change"*

http://www.guardian.co.uk/environment/2011/jun/06/natural-gas-climate-change-no-panacea/print.

These words epitomize the message of this submission. Major economic decisions are being made without appropriate consideration of future human health and it is our role to draw attention to them.

- ***RECOMMENDATION 11: Independent Australian full lifecycle comparative analyses of the carbon emissions from the CSG industry, the coal industry and the renewable energy industries are needed. Whatever the findings, stringent regulation and monitoring of fugitive emissions from all fossil fuel industries is necessary. The availability and profitability of coal seam gas must not be used to delay the switch to renewable and non-carbon energy sources.***

## 2. IMPACTS ON WORLD FOOD PRODUCTION

Australia cannot divorce itself from the needs of the world when making decisions in its own financial interests. To forfeit or contaminate good farmland is to reduce the nation's capacity to produce food. There is already a world food crisis www.earth-policy.org/plan_b_updates/2011/update90 with falling yields due to soil erosion and climate change (changes in temperature, rainfall, and seasonal timing), and to steadily rising costs. A State of the World Report indicates that the front-lines of this crisis are occupied by the world's 925 million undernourished people.
http://www.worldwatch.org/sow11

In large parts of South Asia, including almost all of India, and parts of sub-Saharan Africa - chiefly West Africa - there are 369 million food-insecure people living in agriculture-intensive areas that are highly exposed to a potential five percent decrease in the length of the growing period. Such a change over the next 40 years could significantly affect food yields and food access for people -- many of them farmers themselves - already living on the edge.
http://www.ebionews.com/news-center/research-frontiers/ag-bio-a-bio-agriculture/38808-study-maps-global-hotspots-of-climate-induced-food-insecurity.html
A comprehensive review of the literature can be found at
http://www.sciencemag.org/cgi/content/full/327/5967/812

In an increasingly hungry world, Australia has an ethical commitment to produce what it can and to increase horticultural production instead of importing fruit and vegetables for the needs of its own population.
http://www.energybulletin.net/node/52706

Agriculture is a sustainable income-producing industry; CSG is not.

**Section (3)**

# ENVIRONMENTAL IMPACT ASSESSMENT (EIA) AND HEALTH IMPACT ASSESSMENT (HIA)

An Environmental Impact Statement should also detail all human health impacts of CSG development for the subsequent consideration by the State and Federal Ministers. This is clearly not occurring for many of the developments in Australia.

Over many years the medical profession has advocated the need for Health Impact Assessment (HIA) for major projects. In the early 1990's a National Framework for Health Impact Assessment within an Environmental Impact Assessment was developed under the National Better Health Program. In 1993 a Draft National Framework was published. It was apparent that the HIA was a major task and medical opinion was that it should be prosecuted as a process separate to an EIS. In general however, separation has not been pursued by governments most likely for financial reasons. In 2001 Health Impact Assessment Guidelines were issued and it was expected that these would be incorporated fully into all EIS processes.

*"To promote and enhance the incorporation of Health Impact Assessment (HIA) into environmental and planning impact assessment generally, thereby improving the consideration of health issues"*

The responsibilities of proponents are defined within these guidelines (3.3.1), these include *"this process should include the need to explicitly address potential impacts on human health."* The responsibilities of the Public Health authorities are also presented in detail.

Because of the inadequacies of the EIA process and its differing requirements in each state there is a strong case for initiating an independent and National HIA for the CSG industry in its entirety. This would be the optimal solution in our view but is almost certainly unlikely because it would require state and federal agreement. This being so DEA wishes to ensure that both state and federal processes function properly including cooperation between them. At present there are clear omissions in health matters not considered by state or Federal Governments. For example the health implications of green house emissions from coal seam gas developments (see section 2) which are not considered by either jurisdiction

## Commonwealth and State roles in the approval of chemicals in coal seam gas

In Australia contracts worth billions of dollars were signed and mining commenced with the use of chemicals which had not been assessed yet approvals were given. This is confirmed by correspondence below. Some of these chemicals may be carcinogens under certain circumstances.

Doctors for the Environment Australia (DEA) wrote to the Minister of Health and Ageing on 11 May expressing concerns relating to the health impacts of coal seam gas (CSG) developments. On the 5 August the response from the Hon Catherine King, Parliamentary Secretary for Health and Ageing, said

*... If the NICNAS risk assessment identifies adverse health and/or environmental effects, additional controls are recommended to agencies with risk management responsibility for worker safely, public health and environmental risks arising for chemicals.*

*Many chemicals on the AICS (Australian Inventory of Chemical Substances) have not yet been assessed for health and environmental safety and these were 'grandfathered' to the chemical inventory when NICNAS was established. The chemicals used in fracking are listed on the inventory; however, the majority of these chemicals have not been assessed by NICNAS*

The Department of the Environment is involved in the process through the EPBC Act. Their assessment of environmental water issues has been extensive but there is no health input to these deliberations. We have had correspondence with the Environmental Assessment Branch.

In response to a letter from DEA, James Barker, Assistant Acting Secretary, Environmental Assessment Branch, states on 8 August,

*matters relating to the regulation of coal mining and the coal seam gas industry more generally, including health issues, are the responsibility of state and federal governments*

*Coal seam gas proposals that have been approved under the EPBC Act are subject to detailed conditions to minimise or avoid impacts on nationally protected matters. For example strict conditions have been imposed which require the companies to meet water treatment standards, implement appropriate flow regimes and develop management and monitoring plans. The Australian Government will ensure these conditions are implemented so that long term protections remain in place.*

However it is apparent that not all developments have been assessed by the Commonwealth.

*TONY BURKE: What we've done is we've made sure that the impacts have proper safeguards and protections around them. One of the things that I put in place for the approvals that I've dealt with - and mind you, not all of these projects come for Commonwealth approval - but for the ones that have come to me, we've made sure that we've got the scientific oversight happening and that we're testing one aquifer at a time to make sure that as these projects go ahead, we're constantly monitoring and making sure we don't get detrimental impacts on the environment.*
http://www.abc.net.au/lateline/content/2011/s3305181.htm 29.8.2011

Therefore Doctors for the Environment Australia considers the protection of public health displayed by the Commonwealth to be inadequate in relation to water and chemical issues and we consider that in the interests of public health states including NSW should not give approvals to projects until it can be sure that Commonwealth approval is given and the state has regulations to ensure adherence.

In terms of the protection of public health, transparency of process is necessary. In Australia in general, Doctors for the Environment Australia considers that notifications of terms of reference and dates of CSG and coal projects are poorly advertised and response times inadequate. It is relevant to note that in the case of Queensland, we support complaints from the Queensland Environmental Defenders Office on this matter. For the adequate surveillance of public health matters we suggest that there should be a national website that promptly lists submission dates for all coal and CSG developments and we recommend cooperation between NSW and Queensland as an initial step.

**Health impact assessment in New South Wales**

As detailed in this submission, the responsibility for health impact assessment was historically devolved to the states and it is therefore important to ask if the potential health impacts detailed in the DEA submission were assessed in NSW, and when in relation to the approvals given and by whom. Will these assessments be made available so that the medical profession and the public can be assured that health is protected? We note that under WHO principles information on health impact should be available to the public. It is also important that the health processes being used are understood by all and are fully transparent.

If health impacts were not assessed it is assumed that a screening process as defined under Health Impact Guidelines decided that assessment was not necessary. However a screening which reviewed world literature and the health impacts reported to the US EPA would have been expected to lead to a full assessment before projects were approved.

CSG mining presents to the public health physician complex problems with impacts on communities, food production, water and the atmosphere. We ask for example whether the psychiatric and social impacts on local communities detailed so well above were made in the NSW health impact studies. If they were not then there is an important question over an approval in terms of cost to the entire community. Clearly value cannot be equated simply by the royalties paid to government.

From our comprehensive review of the literature on the known and potential medical impacts of coal seam gas mining we have sufficient concerns to say to governments that it is in their long term interests to reform their processes otherwise populations suffering needless consequences will have legal recourse. The cost of prevention is always small compared to that of treatment and there are many examples in the mining industry of consequences that could have been prevented, for example asbestos related disease.

- ***RECOMMENDATION 12: A nationally consistent Health Impact Assessment process should be mandatory for coal seam gas activities.***

# Appendix 1
## Mental Health Impacts of Coal Seam Gas Mining
### (A personal view)

### Introduction

Mining has extensive health impacts at each stage from exploration to rehabilitation. The mental health impacts arise from both the psychosocial stressors (including the visual impact) and also the toxic impacts of chemicals on the brain. In addition Noise has a range of adverse effects on brain functioning that is cumulative with the above effects. Gas mining follows the same principles as coal mining just the details vary.

In a survey into mining problems of 350 residencies in the Gloucester valley in the vicinity of two open cut coal mines the most frequently reported problem was noise. Noise was perceived as a problem up to 10km from a mine at night. Air pollution around coal mines consists of visible dust particles which are not noticed as a problem further than about 3km and a general haze from fine particles which can spread further. The worst health impacts come from the invisible fine particles with increased asthma rates measured up to at least 5km from a mine). The visual impact varies according to how well the mine is screened. Water pollution involves contamination of rivers, bores, pastures and domestic rainwater tanks. Poisons enter the food chain and drinking water. Increased heavy vehicle traffic is a safety hazard as is gas explosions.

Coal seam gas mining involves multiple gas wells about 600 metres apart, a network of gas, power and water pipelines crossing paddocks, water collecting and evaporation ponds, a central processing unit, liquefied gas storage units and either a local power station or a pipeline to export facilities. Gas wells may be drilled and operated to within 200metres of private homes. Large projects will be divided into stages. Stage 1 of the Gloucester Gas Project has been approved for 110 wells spread over 50sq km. The total project will be at least 350 wells over 210sq km of high rainfall good farming land in a heritage valley comparatively densely populated.

Coal Seam Gas Mining by definition occurs in areas where there is coal and by implication coal mining may well be occurring nearby. Coal within 150metres of the surface will be mined by open cut mining and the gas is likely to have escaped into the atmosphere. Deeper seams in the same vicinity will be the primary interest of CSG mining and may not be suitable for underground coal mining. In such an area there are cumulative health impacts of CSG Mining and Coal Mining.

Coal Seam Gas Mining is new and so there are no extensive surveys of impacted populations whose health damage statistics can be quoted. The Gasland film was a dramatic record of social and health impacts of gas mining but it had a drawback. It showed mostly shale gas mining and a little CSG mining but the distinction was not made between the two processes. (Shale

gas mining involves more fracking and can include the injection of BTEX chemicals). In NSW the small Camden Project is the only operational CSG mine. The Gloucester Gas Project has been approved but has not yet commenced operation.

**Exploration Phase and Psychological stress**
***Gas wells are noisy, potentially poisonous and unsightly. No-one would choose them for a neighbour.***

Exploration is when the psychological stresses are first noticed in the community. Exploration maps are placed in the local newspaper but they are difficult to decipher and individual landholders are not notified. This uncertainty starts to generate community anxiety. Some individual landholders are approached and offers are made mostly for access but with agreements that include confidentiality clauses. Individuals don't know if they are being treated fairly. The community starts to divide between the few who see it as an opportunity for an additional income and the larger number who hear the risks and see little in the way of benefits. Seismic surveys come and go with some damage to paddocks, heavy vehicle traffic ruining country roads and noise. Drilling occurs with the same complications. A few properties are purchased for good prices, other houses close-by can not be sold and their value drops. Life time plans are put on hold or cancelled. Property development in the area declines as a result of the general uncertainty. Rental property is more expensive. The town takes on a different look with mining vehicles being prominent and drilling teams from interstate coming and going. The visual impact is slowly increasing.

In order to prove a project is viable the exploration company need to demonstrate a good flow of gas for many months. Exploration wells are fracked to optimize the flow and the wells are flared for months. There is no explanation of the risks and precautions taken in these fracking and flaring operations. There is no publicity given to any air or water testing, which is even lower in the exploration phase than the production phase. Community alarm is generated by Gasland and the seeming inevitability of large areas of land being permanently poisoned ruining the area for food production for generations to come.

There have been at least two separate unpredicted explosions locally due to gas migration known to the community from just a dozen exploration wells and even more dramatic events elsewhere from gas mining. This results in understandable anxiety about safety risks.

***In Gloucester this first phase has taken 5 years so far and production has yet to commence. Wells may have a life of say 10 years. Then Stage 2 and 3.***

The local council reflects the community. It has a sharp pro-mining v anti-mining divide leading to a spill of one mayor and the letters page in the local

newspaper has amply echoed this divide for the past 5 years. The tourism industry is threatened and wealthy prospective city retirees look to other beautiful areas not impacted by mining. Very few locals are employed by the gas miners. The average wage in Gloucester is $32,000 compared with a NSW average of $46,000 despite mining being in the Gloucester valley for 15 years.

The wells closest to town will be adjacent to a new housing development still being promoted and only 3km from the hospital and schools.

## Visual Impact

Glen Albrecht and co investigators described a type of grieving for a lost, loved landscape. He labelled this Solastalgia. The Gloucester Valley is a heritage and very beautiful landscape which has drawn tourists and retirees to the valley in large numbers and features in landscapes of classic Australian artists such as Arthur Streeton. The long time residents have a particularly strong attachment to the landscape and the potential devastation caused by 350 closely sited gas wells sows the seeds for depressive illnesses for many of the 1000 residents of the valley and the 2500 residents of Gloucester town.

## What are the effects on the individual of this general stress on residents of a town and valley?

Reactivation of existing mental disorders: - Stress is cumulative and will highlight the weak link in those already at risk. Those with illnesses of depression, anxiety, paranoia etc that are currently under control run the risk of having those illnesses reactivated. These were the most numerous group of the disorders I saw in psychiatric practice in this newly mining community.

New illnesses: - It usually takes a more intense, life threatening stress to cause PTSD (Post Traumatic Stress Disorder) but stresses that continue for a very long time, involving a powerful opponent and having no apparent solution promote feelings of helplessness and hopelessness. These are hallmarks of depressive illness and I saw a few such cases in individuals with no prior history of mental disorder.

Other Behaviours: - Angry Outbursts, single episodes of antisocial behaviour, interpersonal disharmony, 'locking the gate' and the drive which has led to 200+ activists spending more time fighting mining than is spent running the mining project!

## Chemical Poisons and Particles

The Environmental Assessments of CSG projects say air quality will be impaired by significant emissions of nitrous oxides, formaldehyde, carbon monoxide, volatile organic compounds eg. benzene, and coarse PM10

particles. This list is markedly incomplete. It fails to mention the fugitive methane emissions and with them the other gases eg. propane, butane etc which are part of coal seam gas. It fails to mention drilling fluids and fracking chemicals. Some of these chemicals are powerful endocrine disruptors which in turn disrupt the emotional stability. It fails to mention toxins in the coal which become released into the groundwater and are then either pumped out or pass directly into aquifers that replenish streams etc.

The air particles which are primarily emitted by combustion processes such as flaring and diesel motors are not PM10 particles but the much more harmful fine and ultrafine particles.

Each well needs to be drilled and then a pump installed to extract water and gas. These are permitted as close as 200meters from a private residence. Pipelines have to be installed and all of this maintained. This requires power. The diesel motors and generators emit particles which are very harmful due both to their size and chemical content. Fine (PM2.5) particles are inhaled and get into lung tissue and set up inflammatory foci spreading damage throughout the body including the brain, ultrafine particles (PM0.1) get inside cells causing change to the genetic material of cells ie. cancer and other new diseases all including adverse mental health impacts. This is seen in increased days lost from work typical of mining areas but not yet quantified for CSG mining.

The central processing unit will emit much higher concentrations and for the Gloucester project they have chosen a site only 1.5km from Stratford Primary School.

Diesel particles are carried to the brain where they are particularly damaging to young children.

***Diesel particles have been demonstrated to lower the IQ by up to 5 points in infants and to result in an increase in autistic and antisocial behaviours.***

The chemical emissions of CSG mining will be cumulative with nearby coal mining.

## Noise

Industrial noise legislation has primarily been focused on the avoidance of industrial deafness and has neglected the problems associated with noise of fewer decibels, lower frequency and also ignores the character of noise. Noise can vary from pleasurable when musical to distressing when of a rough mechanical origin. Bird calls of 45 decibels have a very different impact to a diesel motor of the same intensity.

Noise disturbs sleep and impairs concentration and learning. Infrasound and Low frequency noise damage (Vibroacoustic disease) is ignored in noise monitoring legislation but is particularly intrusive because it passes unaffected through insulation and can be of a frequency that will naturally resonate inside a living or bedroom or inside the skull (or chest). Machines may be at their maximum intensity at a low frequency that isn't being measured. It is believed by many that such low frequency energy inside the body will impact on the Autonomic Nervous System which controls many body systems including those involved with anxiety.

Noise monitoring invariably is done outside where these resonance effects are avoided.

If you are sleeping you are likely to be awakened by an increase of 15 decibels over the background noise. Mining consent legislation assumes the minimum night time noise level is 30 decibels. This is probably true for a city. Quiet rural areas can have a normal night time sound level of 20 decibels so that a reading in the high 30's is likely to wake you. The legislators believe that since this is only slightly above their city minimum it will not wake you and is ignored. The more times you are wakened the more likely your REM sleep will be impacted. Sleep is when your memories are laid down and impaired sleep can also be a powerful trigger for manic and depressive illnesses. We have all experienced the irritability that results from just one night of lost sleep. Pity the person with a gas well 200 metres away.

***Recent Australian Early Development Index results and also 'Myschool' results from the mining affected Upper Hunter suggest a community of developmentally damaged and educationally disadvantaged children is being allowed to occur with no interventions taking place. CSG Mining will just add to that damage.***

***Compensation is rarely paid for physical health damage and in my experience is totally unheard of for the more prevalent mental health damage.***

*References*

Mariana Alves-Pereira et al (28.8.2007) 'Public health and noise exposure, the importance of low frequency noise. Paper available on the web from Inter-Noise 2007 Conference.

# Appendix 2
## Critical appraisal of studies relevant to the lifecycle carbon footprints of coal seam gas, shale gas and coal

Coal seam gas *(together with shale gas, tight sands gas and methane hydrates)* is classified as an 'unconventional' natural gas in that its extraction differs from that of conventional natural gas. *(Conventional natural gas is sourced by similar means as crude oil from entrapment within porous rock beneath impermeable geological formations.)*

There are difficulties in making comparison between the merits of 'unconventional' natural gas with coal in regard to total greenhouse gas emissions for a given amount of power generated. This is because of a paucity of data and uncertainty over data quality. It is noteworthy that both the US Environmental Protection Agency
http://www.epa.gov/climatechange/emissions/downloads10/Subpart-W_TSD.pdf
and the US Governmental Accountability Office
http://www.gao.gov/new.items/d1134.pdf
have recently expressed concern that fugitive emissions from unconventional gas may be far greater than reported.

A 2011 Cornell University study has now presented evidence, that on a life cycle basis, greenhouse gas emissions from shale gas *(which is extracted in a somewhat similar manner to CSG)* exceed that of both conventional natural gas and coal, for a similar amount of generated power
http://graphics8.nytimes.com/images/blogs/greeninc/Howarth2011.pdf

This study estimated fugitive methane emissions to be 2.2-4.1% during extraction, 0-0.2% during processing and a further 1.4-3.6% during transport, storage and distribution to end user. Total fugitive methane losses were thus calculated to be between 3.6% and 7.9%. The study concluded that the total global warming effect of shale gas *(including the processes involved in raw material acquisition, raw material transport and combustion)* was 20-100% greater than coal on a 20 year horizon and comparable to coal on a 100 year horizon when expressed on an equivalent energy available during combustion basis.

The Cornell study's findings have been criticised as inaccurate by a number of authors. These criticisms have been partially substantiated by a second study, this time from the National Energy Technology Laboratory (NETL) of the US Department of Energy
http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&PubId=386

The NETL study estimated fugitive losses with shale gas of 1.75% during extraction, 2.4% during processing and a further 0.5% during transport *(storage and distribution excluded)* giving a total methane loss of 4.65% *(with the actual fugitive methane figures presumed lower due to an uncertain amount of flaring)*. Calculations based on the NETL data showed that the lifecycle global warming potential of shale gas was about 690KgCO2e/MWh

(192gCO2e/MJ), 57% of that of coal on a 20 year horizon *(GWP of 72)* and 531KgCO2e/MWh (148gCO2e/MJ), 48% of that of coal on a 100 year horizon *(GWP of 25)* when used to generate the same amount of base-load power. *(These figures are inclusive of raw material acquisition, raw material transport, and energy conversion.)*

Both studies acknowledged major deficiencies in the quality of the available data that could influence the findings. Differences in input data and assumptions were sufficient to account for the differences in findings between the studies.

The first cause of difference between the studies was the consequence of differing assumptions over the amount of fugitive methane emitted at various stages of the natural gas lifecycle. This was due in part to differing assumptions over the amount of emission flaring and an apparent failure of the Cornell study to appreciate that some of the gas unaccounted for between extraction and delivery was used to power equipment.

A second cause of difference was the Cornell study's use of energy available during combustion as its endpoint rather than actual generated electrical power. This is relevant because of the differing efficiencies of gas and coal fired power stations*. (Average coal fired power plants (net plant HHV efficiency 33.0%); average gas fired power plants (net plant HHV efficiency 47.1%)*

The third difference was the use in the first study of justifiably higher global warming potentials *(GWPs)* for methane compared with carbon dioxide at both the 20 year *(105 versus 72)* and 100 year *(33 versus 25)* time horizons (Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) and Shindell, D.T., Improved Attribution of Climate Forcing to Emissions, Science, 326 no 5953 pp716-718). These differences had an added small effect in widening the disparity between studies.

CSG although not considered by the Cornell University study was considered in the NETL study. With coal seam gas, fugitive emissions during extraction were estimated at 0.14% *(as against 1.75% for shale gas and 1.3% for averaged mixed source natural gas)*, other stages having identical emissions to shale gas giving a total emission figure of 3.2% *(with the actual fugitive methane figures presumed lower due to an uncertain amount of flaring)*. Calculations based on the NETL data found that the lifecycle global warming potential of coal seam gas was about 577KgCO2e/MWh (160gCO2e/MJ), 47% of that of coal on a 20 year horizon *(GWP of 72)* and 497KgCO2e/MWh (138gCO2/MJ), 45% of that of coal on a 100 year horizon *(GWP of 25)* when used to generate the same amount of base-load power. *(These figures are inclusive of raw material acquisition, raw material transport, and energy conversion.)*

The lower fugitive emission intensity of coal seam gas production relative to shale gas production is related to the differing geologies and associated extraction complexities

http://www.all-llc.com/publicdownloads/CBMPRIMERFINAL.pdf

Coal seams are generally shallower and more friable than shale gas seams, are accessed by vertical rather than horizontal wells, and require lower pressures and about 2% of the volumes of fracturing fluid *(when used)* to stimulate production
http://www.gwpc.org/e-library/documents/general/Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs.pdf
http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/HFStudyPlanDraft_SAB_020711.pdf

The Queensland Government estimates that 10% to 40% of potential coal seam gas wells may be hydraulically fractured with 8% currently being hydraulically fractured
http://www.derm.qld.gov.au/factsheets/pdf/environment/en10.pdf

In addition coal seam gas *(95-99% methane)* is less contaminated with unwanted impurities than shale gas and thus needs less processing to achieve pipeline quality http://www.climatechange.gov.au/en/publications/projections/australias-emissions-projections/fugitive-emissions.aspx

Citigroup has analysed Australian emissions data from the Environmental Impact Statements for the APLNG and GLNG projects and reviewed a study done for APPEA, which also included data on coal
https://docs.google.com/viewer?a=v&pid=gmail&attid=0.1&thid=13226cd3c81929e7&mt=application/pdf&url=https://mail.google.com/mail/?ui%3D2%26ik%3Ddc344233bf%26view%3Datt%26th%3D13226cd3c81929e7%26attid%3D0.1%26disp%3Dsafe%26zw&sig=AHIEtbTaMaSUicizUHtZvu5ot_F3CfptSQ

They questioned the industry supplied estimates of upstream fugitive CSG emissions (about 0.1%) as these were based on conjecture rather than measurements. Consequently the Citigroup review failed to elucidate the Australian situation.

An even more recent study from the National Centre for Atmospheric Research (NCAR) and the University of Adelaide concluded that natural gas exceeds the carbon footprint of coal once associated fugitive emissions exceed 2% http://www.springerlink.com/content/b430681263425q64/fulltext.pdf

This analysis is holistic in taking into consideration the climatic consequences of reduced air pollution due to reduced coal burning. When coal is burnt it emits a number of air pollutants other than carbon dioxide. The most important of these are black carbon which promotes warming and sulphur dioxide (SO2) which reacts to form aerosols that reflect light (the albedo effect) thus promoting cooling. As the albedo effect of sulphates prevails over that the heat absorbing effect of carbon the overall effect of visible pollution from coal burning is temporary cooling.