Submission to the Select Committee on Unconventional Gas Mining

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Healthy planet, healthy people.

About DEA

Doctors for the Environment Australia (DEA), the organisation making this submission, is a voluntary organisation of medical doctors in all states and territories. We work to address diseases – local, national and global – caused by damage to the earth's environment and emphasise the fact that the natural environment is a major determinant of well-being. DEA has a distinguished board of advisors whose knowledge of medical and public health issues is fully contemporary.

For over 10 years, DEA has been deeply involved in the public discourse on unconventional gas activity, providing input to governmental inquiries in several states and to several Federal committees. These contributions are listed in Appendix (E). Arising from our work, DEA has identified requirements for responsible development of unconventional gas activity.

Recommendations

1. Unconventional gas operations require a national framework of guidelines and regulation.

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

3. A comprehensive Health Impact Assessment process should be instituted promptly by statutory legislation for the industry of unconventional gas operations. The process should ensure:-
    a. Full mandatory disclosure of all chemicals used in fracking and assessment of their potential for short and long term human harm. Mandatory records for each fracking activity- type and volume of chemicals used, and volumes recovered.
    b. Review of all water legislation under drinking water Acts to ensure protection of surface and groundwater.
    c. Air quality monitoring of operations for Volatile Organic Compounds (VOCs), ozone.
    d. Comprehensive water monitoring programs that would provide early warning of potential contamination events.

4. Restriction of Great Artesian Basin water use to human consumption and minimal wastage agricultural practices in recognition of the finite nature and advanced depletion of this resource.

5. Full lifecycle analysis of the carbon emissions of mining unconventional gas in Australian conditions and comparison with coal and renewable energy sources.

6. Wide economic analysis of the benefits versus the costs of the unconventional gas industry in Australia, including health and social costs.

7. Agricultural land should be protected from exploitation. The belated measures to do this by the Queensland government must be expanded and national guidelines instituted.

8. Health Impact Assessment must consider the health implications of greenhouse emissions on both Australian and international communities.

In this submission, DEA responds to the Terms of Reference of the Select Committee on Unconventional Gas Mining with a review of risks and concerns to health and wellbeing posed by the industry to the Australian population. The submission utilises the high level medical and public health knowledge and expertise possessed by DEA to synthesise the current state of evidence and understanding of the intersection between people's health and industrial activities.

The submission cites references from the now substantial peer-reviewed literature and reputable academic and government reports. Our interpretation and recommendations are based on DEA's vision statement *"to utilise the skills of members of the medical profession to address the ill health resulting from damage to the natural environment at local, national and global levels"*[1].

Of the Terms of Reference, quoted here, DEA will submit on the bolded items:

"The adequacy of Australia's legislative, regulatory and policy framework for unconventional gas mining including coal seam gas (unconventional gas operations) and shale gas mining, with reference to:

a. a **national approach** to the conduct of unconventional gas mining in Australia;

b. the **health**, **social**, business, **agricultural**, **environmental**, **landholder** and economic impacts of unconventional gas mining;

c. government and non-Government **services and assistance** for those affected;

d. compensation and insurance arrangements;

e. compliance and penalty arrangements;

f. harmonisation of federal and state/territory government legislation, regulations and policies;

g. legislative and regulatory frameworks for unconventional gas mining in comparable overseas jurisdictions;

h. the unconventional gas industry in Australia as an energy provider; unnecessary renewables

i. the current royalty and taxation arrangements associated with unconventional gas mining; and

j. any related matter."

a. a national approach to the conduct of unconventional gas mining in Australia

f. harmonisation of federal and state/territory government legislation, regulations and policies

DEA is of the view that a national approach is essential to reduce the extensive risks associated with unconventional gas mining. The most (self-)evident reason for this is that sets of unconventional gas operations may take place in regions overlying, and therefore threatening, precious aquifers, aquifers that do *not* recognise state borders. Here we face the actual, absurd situation in which two (or more!) states may take different approaches to exploration and mining licensing, different approaches to aquifer management, different approaches to the approved use of toxic chemicals, different approaches to waste-water management and different Air Quality requirements. We emphasise, this absurd situation almost exists currently: Victoria has an unconventional gas activity moratorium, South Australia does not, yet SA may come to approve unconventional gas activity in the South East of SA extracting gas in relation to the same aquifer that Victoria is protecting.

There are other reasons that require an overarching, national, approach to unconventional gas activity:

1. The potential for harm from this industry needs to be recognised, and all Australians and their critical environmental health assets require non-partisan, apolitical and equitable protection. State-by-state regulation and legislation has been a difficult issue in many areas of human activity (business, law, education), so that diverse legislation on unconventional gas mining will not deliver the safest and most appropriate decisions for all Australians, especially as equity in health is a value Australians hold highly. In this regard, and given the many steps in unconventional gas operations (from exploration to commercial gas production) that have health relevance, DEA particularly asks the Committee to include consideration of the health impacts from all steps in the unconventional gas chain. Indeed the health deliberations in existing reports by the states have not been thorough and health experts have not been involved.

2. DEA asks the Committee to be aware that medical and health research literature on unconventional gas is rapidly expanding. Much published research comes from the United States where an estimated 15 million people live within 1.6km of gas or oil wells. As a result, there has been a large increase in the number of published papers addressing unconventional gas activity and health: there are now over 400 peer-reviewed articles, most appearing between 2013 and 2015, on air pollution, water pollution/water security, soil pollution/food security and public health. More-than-ever, it is clear that a strong emphasis on health and well-being is required in any over-arching framework for the unconventional gas industry and that the principle of proof-of-safety from the regulated industry is required rather than absence of proof-of-harm.

3. Whilst individual states might design effective frameworks, for the reasons of the multi-component nature of the unconventional gas industry and the rapidly evolving evidence of risks to health, it is clear that state-by-state frameworks would have a high likelihood of being inadequate in many ways, notwithstanding the key fact that aquifers threatened by unconventional gas activity cross state boundaries. From the viewpoint of efficiency (at best) and from the viewpoint of inadequacy (at worst), DEA asks the Select Committee to find in favour of a national framework for the unconventional gas industry.

4. Even so, DEA is of the view that local communities are entitled to accept or *decline* unconventional gas activity in their region even if all requirements for health, safety, profitability, and community benefit are met. The possibility of community objection, does mean that an additional layer of local decision-making about the industry, based on well-informed community consensus, is the only way forward.

b. The health, social, business, agricultural, environmental, landholder impacts of unconventional gas mining

In this section we deal with health-related issues. Health-related items in this Term of Reference relate to human activities of individuals, families, communities and populations. Further, they apply to those directly involved in unconventional gas activity (the workers), those living nearby unconventional gas activity (within the ranges of sight, sound or smell), the population centres providing for unconventional gas activity (those dependent on regional food, air and water) and, finally, the global population (those affected by climate change).

The Health Literature

Because the development and spread of unconventional gas activity is relatively recent, long-term impacts are yet to be reported. However, an increasing number of current observational studies associate adverse health outcomes with unconventional gas activity. In mid-2015, the Physicians, Scientists and Engineers for Healthy Energy in the United States identified 555 peer-reviewed publications on unconventional gas activity, with 437 (79%) being published after 2013[2]. While there are differences in many aspects of unconventional gas activity between countries, the literature and experiences in the United States are extremely important in anticipating potential impacts in Australia. This is because comprehensive risk assessments and epidemiological studies cannot occur until substantial numbers of wells are drilled and people are exposed to potential risks for sufficient time. A good example of such a risk would be cancer[3]. Therefore, DEA emphasises that we cannot rely solely on Australian health experience in determining suitable over-arching frameworks for unconventional gas activity if we are to protect health.

Health Impact of Chemicals

A central concern related to unconventional gas activity is the impact on health of chemicals escaping from mining processes. In fact, the possibility of escaping chemicals underlies nearly all concerns to do with personal and public health, agriculture and the natural environment. Large quantities of chemicals are injected up to several kilometres into the earth during drilling and during fracking. Hundreds of chemicals are available for use in drilling and fracking, although the number injected in any fracking event may not be large. Unquestionably, however, some of them are toxic (see Appendices A and B) and it is evident from the multiple organ diseases and mechanisms listed, why people have a right to be concerned. Note also that some chemicals are not identified by the user and, therefore, have no toxicity information. Others may have not been assessed for toxicity to humans or the environment[4,5]. Chemicals are also found naturally in fossil fuel or shale seams, and emerge into the environment with the water from productive wells. Because some of these are, as yet, unknown they may become the most serious.

Transparency on Chemicals

Not only are some of the chemicals from gas-bearing strata unknown, some of the chemicals used in the fracking process are ‘commercial in confidence’ products and, therefore, also unknown. Lloyd-Smith 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[6] [7]. 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. Although NICNAS is currently in the process of assessing many thousands of chemicals, some of which are used in fracking, this process is occurring over years and there is no publicly available comprehensive list of fracking chemicals[8]. Facing this situation, in Western Australia the Standing Committee on Environment and Public Affairs recommended that the Department of Mines and Petroleum’s policy of public disclosure of chemicals used in any hydraulic fracturing activity be formalised[9].

Water Usage

Additional concerns relate to the loss of available water through its requirement for fracking and to the loss of treasured agricultural or natural environment through the industrialization brought about by the unconventional gas activity.

Unconventional gas activity – processes (in brief)

Hydraulic fracturing requires the drilling of directional wells (vertical and horizontal) and then the pressurised injection into the wells of fluids comprising large quantities of locally-sourced water together with chemical additives, and sand, to open up or enlarge fractures, so-called 'propping agents'. A proportion of the drilling and fracturing fluids returns to the surface and needs to be treated or disposed of safely because some returned fluids contain chemicals. The extraction of gas from coal seams may also require coal seams to be de-pressurised through the withdrawal of (even more) water. This water may also contain chemicals from the shales that also produce the gas, some of which are similar to fracking chemicals (see Appendix A), as well as heavy metals such as mercury, lead and arsenic, and radioactive elements such as radium, thorium and uranium. When contaminated water returns to the surface, it has the potential to mix into the environment in numerous ways: in watercourses, open ponds, closed tanks, evaporation or trucked away to waste dumps. All of these provide opportunities for 'escape' into the environment. The final disposition of these chemicals varies – some evaporate into the atmosphere, some are left in exposed mud ponds to concentrate for burial, some are re-injected into other fracking wells or into non-potable aquifers, and some are sprayed on roads.

Local risks – chemical contamination

Contamination of the environment around unconventional gas activity will occur with accidents and/or spills during drilling and fracking or during the processing of contaminated water. A US EPA document notes: "Hydraulic fracturing operations require large quantities of chemical additives, equipment, water, and vehicles, which may create risks of accidental releases, such as spills or leaks. Surface spills or releases can occur as a result of events such as tank ruptures, equipment or surface impoundment failures, overfills, vandalism, accidents, ground fires, or improper operations. Released fluids might flow into nearby surface water bodies or infiltrate into the soil and near-surface ground water, potentially reaching drinking water aquifers."[10]

Contamination of aquifers by chemicals in fracking fluids may also occur, non-accidentally, if fractures provide an underground path from the fracked well to the aquifers, evidence for which is becoming more certain. We quote: "The ability to delineate methane sources and thus the distinction between natural flux [local biological sources] and anthropogenic [from unconventional gas activity] contamination is based on the different isotopic (δ13 C-CH4 ; δ2 H-CH4) and geochemical (propane/methane ratios) compositions of thermogenic [gas/oil/coal] relative to biogenic methane sources." Findings "indicate that the high levels of methane exceeding the hazard level of 10 mg/L are indeed related to stray gas contamination directly linked to shale gas operation"[11,12].

Accumulation of contaminants in aquifers might have long-term impacts. Studies on the transport and fate of volatile organic compounds have found they can persist in aquifers for more than 50 years and can travel long distances, exceeding 10 km[13]. The Australian Interim Senate report noted "there is a risk that residues of chemicals used in fraccing may contaminate groundwater and aquifers used for human or stock consumption or irrigation. It is acknowledged that in one case in Australia, fraccing resulted in damage to the Walloon Coal measures, causing leakage between that and the Springbok aquifer."[14] An additional long-term concern of considerable significance because of their effects at miniscule concentrations, are the so-called "endocrine disrupting chemicals" – with potential impacts on fertility, growth and development. The tiniest quantities of agents are damaging – billionths to trillionths of a gram per ml. These levels are much lower than deemed to be safe by any Material Safety Data Sheet and these agents have been identified in regions of unconventional gas activity[15].

Australia is not immune from accidents or spills. Sixty-one environmental incidents were reported to the peak industry body APPEA in the 2011–12 year, and it was noted that "the Australian industry still has some way to go to match safety performance in other parts of the world"[16].

Recently 10,000 litres of saline water leaked at the Narrabri unconventional gas operations project, operated by Eastern Star Gas. The incident was not reported at the time despite an obligation to do so under the conditions of the petroleum exploration licence[17].

It is clearly a matter of chance (type and concentration of chemical in the spill fluid and the proximity of workers or those living nearby) whether people experience adverse health as a consequence. So far, as judged by scientific publications, unconventional gas activity workers themselves, appear to have avoided ill-health as an occupational risk, but long-term impacts remain to be investigated. However the mining industry has the highest injury and fatality incidence rate reported to WorkCover in NSW[18]. Information from overseas also indicates cause for concern. In the USA, the annual fatality rate of workers in the oil and gas industry during 2003—2006 was estimated to be 6-7 times the rate for all US workers[19]. Instances of worker chemical contamination do occur, even if not frequently reported: in 2008 a nurse in the US became very ill from chemical exposure after treating a gas-field worker who presented to hospital soaked in chemicals[20].

Regional and remote risks – present and future

1. Present: during extraction

    a. While initially the focus of most public health concern was on risks of contamination of water, the US experience to date has indicated that health risks associated with **air pollution** are at least as serious to the health of people living nearby[21],[22],[23]. People may be exposed to air-borne pollutants directly, e.g. through diesel exhaust from the extensive truck movements, drilling, compressors and other machinery used in the process and from gases from the coal seam or shale deposits released during well completion and other phases, so-called "fugitive emissions"[24,25,26]. Some of these gases mix and react in the atmosphere to form secondary pollutants, such as ground level ozone. Other exposure pathways, involving inhalation of potentially harmful substances, occur through the movement of volatile compounds from contaminated water into the air.

       Observational studies from here and overseas provide concerning pointers to health impacts of unconventional gas activity on the adjacent population. In a recent report on the health of communities living around established gas wells in the USA (Colorado), there was an association between the density and proximity of gas wells near where mothers lived, and the prevalence of birth defects of the heart in children born in that region. There was a less prominent, but also concerning association with defects of the spinal cord.[27]

       Indeed, atmospheric research in a variety of circumstances has revealed significant underestimations in emissions of methane and other hydrocarbons based on ground level measurements and modeled predictions[28,29,30]. A new approach in examining air quality and symptoms was taken by Macey et al (2014)[31] in four US states where substantial oil and gas production activities had occurred. This involved community members receiving training and utilizing a "grab air" sampling procedure when individuals felt normal, and at times when they felt sick or sensed pollution from the nearby gas operations through taste or smell. This novel method enabled the community to identify numerous excursions above federal guidelines and above health-based risk levels, that were particularly frequent for air-borne toxins, notably formaldehyde, 1,3-butadiene, hydrogen sulfide, mixed xylenes and n-hexane. Importantly these measured exceedances had not been detected and/or reported in routine air monitoring, raising questions about the sensitivity of existing data in ensuring protection of health. This paper suggested that community involvement clearly enhances the accuracy of risk determinations above and beyond routine sampling. It also provided a series of warnings that may be important for coal seam gas as well as shale gas extraction: "The mixtures that we identified are related to sources commonly used in well pad preparation, drilling, well completion, and production, such as produced water tanks, glycol dehydrators, phase separators, compressors, pipelines, and diesel trucks. They can be released during normal operating conditions and persist near ground level, especially in regions where topography encourages air inversions. The toxicity of some constituents is well known, while others have little or no toxicity information available. Our findings of chemical mixtures are of clinical significance, even absent spikes in chemicals of concern. The chemical mixtures that we identified should be further investigated for their primary emissions sources as well as their potential cumulative and synergistic effects. Clinical and subclinical effects of hydrocarbons such as benzene are increasingly found at low doses. Chronic and subchronic exposure to chemical mixtures is of particular concern to vulnerable subpopulations, including children, pregnant women, and senior citizens".

Other surveys of self-reported health symptoms indicate that upper respiratory (nose and throat) or skin complaints are also more frequent the nearer people live to gas wells[32]. These findings are entirely consistent with a health survey conducted in a Queensland gas field by Dr Geralyn McCarron[33].

b. Unconventional gas activity not infrequently has general negative **impacts on emotional well-being**. Reaching gas in fossil deposits requires significant vehicular access and clearing of vegetation for well-pads, roads and pipes. Families depend on the use of prime agricultural land or treasured natural habitat, for livelihood and enjoyment. Communities nearby are exposed to the sight, sounds, and smells of unconventional gas activity, sometimes against their will. Thus, negative impacts on living environments are a certain consequence of unconventional gas exploration on landscape, with many people experiencing a reduced state of well-being known as solastalgia[34].

c. **Loss of water** due to aquifer draw-down in coal seams, or from competition for local resources of water that would otherwise be available to agriculture for stock and crops, has implications for food production and its quality and for the well-being of farmers. This is an issue because of the large volumes of water required for the fracking process, such that the rate of use of water may not match its rate of accumulation from rain or flow through aquifers. Such issues have been recognised already in the interim Senate report, including the impact on rural communities and the environment[35].

2. Future: after gas extraction
There are two aspects to consider, here, the fate of wells no longer in production, and the fate of the unconventional gas exported to the world for energy.

a. A troubling challenge relates to well-deterioration after gas extraction is completed, so-called '**wear-out failures**'. Older and aging wells experience wear-out failures due to rusting, electrolytic corrosion and dissolution of metals and concrete by acids. Failure in the integrity of the wells leads to long-term low-level fugitive emissions. The level of concern can be seen in statements in industry publications, GasTips, World Oil, Oilfield Review: "between 7% and 19% of more than 1000 wells drilled from 2005 to 2007 in western Canada had gas migration along the casing annulus, and 9% to 28% of them had gas leakage through surface casing vents"[36]. Unintended natural gas migration along production wellbores, even for conventional gas, has been a "chronic problem for the oil and gas industry ... as a result of poor primary cement jobs, particularly in gas wells"[37]. Brufatto et al. (2003)[38] cite U.S. Mineral Management Service data from the Gulf of Mexico indicating that "by the time a well is 15 years old, there is a 50% probability that it will have measurable gas build up in one or more of its casing annuli". Schlumberger, one of the world's largest companies specializing in fracking, published in its magazine as long ago as 1994: "Older fields will continue to benefit from the expertise of the corrosion engineer and the constant monitoring required to prevent disaster"[39]. We emphasise: these words are from the industry itself. They point to the possibility of wear-out-failures that permit movement of contaminated water in the subterranean environment and into aquifers and of continuing fugitive gas emissions.

b. There is a global health problem related to the fact that gas is simply another fossil fuel which, when burnt, inexorably will add to the **green-house gas burden** of our planet and inflict distress on populations world-wide. Methane released by unconventional gas activity is a potent greenhouse gas with many times the global warming impact of carbon dioxide on the time-scale of decades and when fugitive emissions and other leaks are considered there is doubt whether unconventional gas has any carbon advantage over coal. It is well known that it will not be possible to burn all the fossil fuels we have identified if we are to hold climate change to less than 2 degrees of warming[40]. Climate change is already affecting our health with the increased risk of bushfires, hotter, longer and more frequent heat waves, deteriorating air quality, changes in disease patterns and other serious impacts.

b. The economic impacts of unconventional gas mining

In this section we raise several of the financial aspects of unconventional gas activity that have relevance to health.

Firstly, unconventional gas when used commercially or domestically releases toxic materials and $PM_{2.5}$ particles leading to respiratory, cardiovascular and cerebral arterial diseases. Societal use of unconventional gas therefore brings with it societal health costs. These costs are usually not considered when the costs of different forms of energy are being estimated and DEA urges that they should be. North American studies suggest that these 'external' costs amount to multiples of the cost of energy from coal and oil and, while very small for gas, some accounting adjustment should be made[41].

Secondly, unconventional gas activity sometimes produces water contaminated with mercury, lead and arsenic, and radioactive elements such as radium, thorium and uranium, that requires specific treatments before being released into the environment or re-used in some way. Here we draw attention to the potential costs of this by quoting Hamawand and colleagues: "The different types of treatment of unconventional gas operations associated water such as membrane, ion exchange, reverse osmosis and other similar types often require large and specialized industrial equipment that have high energy consumption and capital expenses. Processes with high energy consumption are economically and environmentally unfavourable"[42]. DEA sees this as significant factor that might motivate against necessary treatment of returned water and therefore a risk to health, if the water is contaminated.

There are already examples of where produced coal seam gas water has been (unwisely but legally) discharged into waterways with contaminants of concern to the environment; for example, into the Condamine River south of Chinchilla where 22 chemicals were discharged in excess of ANZECC freshwater environmental guidelines, including boron, silver, chlorine, copper, cadmium cyanide and zinc, which at the limits approved are toxic to aquatic organisms[43]. Contaminated waste water needs to be stored in tanks or pits at the well site and then may be recycled for future use in fracking, injected into underground storage wells, or transported to wastewater treatment facilities for precipitation treatment, reverse osmosis or other measures. The amount of water contaminant can be impressive: modelling suggests the industry could produce 31 million tonnes of waste salt over the next 30 years. The industry has not yet come up with a solution for disposal of all this waste salt and it is likely that much of it will end up in landfill, it being too expensive than to do otherwise.

c. Government and non-Government services and assistance for those affected

Apart from emphasizing personal anxiety and distress related to chemical contamination of the environment, this section requires a brief summary of other, non-chemical-related, impacts on people and communities by unconventional gas activity. Challenges include chronic stress in the face of excessive noises, intermittent smells and the industrialisation of their environment. For those living close to well activities, as well as to the roads that cater to the well pads, there will be machinery noise or thousands of truck movements transporting chemicals or waste-water or gas. The level of involuntary adaptation to that will be required by residents of these areas, and the emotional and financial distress among families as to whether they will leave or continue to live in affected areas, are just some of the factors that will contribute to anxiety levels. Persistent challenges of this nature are strongly linked to cardiovascular disease, possibly through the chronic stimulation of neuroendocrine stress responses.

The CSIRO recently published an important study on four communities in the Western Downs of Queensland where many CSG wells have been operating for some years[44]. This study found that about 50% of residents reported that their communities were only just coping, not coping or resisting the industry. In contrast a very small percentage, (well under 10% of each community), saw their community "changing to something different but better". Similarly, 69% of respondents were resisting, tolerating or accepting the industry, while only one in five (21%) approved or embraced the industry. While these concerns are acknowledged in the Chief Scientist's report, there is little recognition that the responses point to psychological distress associated with unconventional gas activity in rural communities[45]. People living in rural areas with anxiety and depression, are already a serious contributor to Australia's burden of disease, and they will be at higher risk[46]. Hence risks to mental health linked to this industry should not be sidelined in any assessment and protection of mental health should feature prominently in the NSW Gas Plan[47].

People strongly feel that their health and wellbeing should be valued and protected by their government. If the industry does proceed, a firm commitment to public health research would help to ensure a commitment to the protection of people's health and wellbeing. Such research might find reassuring results, but could also reveal previously unexpected links between unconventional gas activity and impaired health and well-being.

DEA can identify many distressing situations that will affect people living in the region of unconventional gas activity. Given the ubiquitous concerns about chemicals, it would be expected that robust information about the uses, the amounts, the fate, the environmental concentrations and the toxicology would be a clear starting point for dialogue. Virtually none of this essential information is available because of lack of continuous monitoring of water, air and land, lack of knowledge of injected chemicals when these are 'proprietary' formulations, and lack of toxicological studies of many chemicals.

There is no kind of support, service or compensation that can over-come issues of this nature.

No therapies are available for those whose land and livelihoods have been usurped by the unconventional gas industry: compensation might have a beneficial effect on the health of those affected, but compensation would need to be impressively generous to succeed. In the meantime, issues to do with the social impacts of serious community divisions, the uneven way in which the beneficial and the negative impacts are very likely to be experienced, and likely further amplification of differences between the 'haves' and the 'have nots' will increase the level of psychological disturbance at the community level. Clearly there will be additional costs in supporting affected communities: they will be direct medical costs, social service costs and possibly crime-related costs.

High occupational health and safety standards would be expected to apply in all unconventional gas activities. Provided workplace safety is maintained, only accidents and spills may attract the need for medical support and later services. Given that existing accidents and injury to personnel appear to be infrequent, little additional support may be needed. Local medical services, however, are entitled to be aware of the chemicals likely to be involved in incidents and to have an opportunity to prepare their emergency strategies. Additional costs cannot reliably be predicted.

There are existential issues wrapped up in the unconventional gas industry: individuals are concerned about vigorous chemical contamination of their environment, fearing for the future of their country, its animals and plants. Individuals are also distressed by the continuing utilisation of fossil fuels for energy locally (and world-wide). No form of reassurance, or support is available for those who see these existential threats. What is required is concerted action by society to undertake measures of mitigation against polluting industries and green-house gas production: the direct contrary of the aims of the unconventional gas industry.

Appendix A

Table: Toxic Effects of Chemicals Used in Hydraulic Fracturing

Modified from http://www.cbu.ca/wp-content/uploads/2015/10/Toxic-Effects-of-Chemicals-Used-in-Hydraulic-Fracturing-Lorna-Williamson.pdf

Code:

S	Suspected of causing an adverse health effect

Chemical	Number of Products	Skin, eye and sensory organ	Respiratory	Gastrointestinal and liver	Brain and nervous system	Immune	Kidney	Cardiovascular and blood	Cancer	Mutagen	Developmental	Reproductive	Endocrine disruptors
(2-BE) Ethylene glycol monobutyl ether	23	S	S	S	S	S	S	S	S	S	S	S	S
2-Ethylhexanol	7	S	S	S	S	S	S	S		S	S	S	S
2,2-Dibromo-3-nitrilopropionamide (DBNPA)	4	S	S	S	S	S		S			S		
Acetic acid	7	S	S	S	S	S	S	S					
Acrylamide (2-Propenamide)	6	S	S	S	S	S	S	S	S	S	S	S	S
Ammonium bisulfite	7	S	S	S			S						
Ammonium persulfate	5	S	S	S		S		S					
Aromatic naphtha, Type I (light) (Light aromatic solvent)	4	S	S	S	S						S		
Asphaltite (Gilsonite, Hydrocarbon black solid)	7	S	S	S		S							
Boric acid	4	S	S	S	S	S	S	S			S	S	S
Butanol (N-butyl alcohol, Butan-1-OL, 1-Butanol)	8	S	S	S	S		S	S					
Chromium III	4	S	S	S	S	S	S				S	S	
Diesel 2	20	S	S	S	S		S	S	S	S			
Diethanolamine	5	S	S	S	S	S	S	S	S	S	S	S	S
Ethanol (Acetylenic alcohol)	8	S	S	S	S	S	S	S	S	S	S	S	S
Ethoxylated nonylphenol	7	S	S	S		S		S			S	S	S
Ethylene glycol	18	S	S	S	S	S	S	S			S	S	S
Formaldehyde	4	S	S	S	S	S	S	S	S	S	S	S	
Formic acid	8	S	S	S	S	S	S	S		S	S		
Fuel oil #2	9	S	S	S	S	S	S	S	S	S			
Glutaraldehyde	11	S	S	S	S	S	S	S		S	S	S	S
Heavy aromatic petroleum naphtha (aromatic solvent)	15	S	S	S	S								
Hydrochloric acid (HCl)	13	S	S	S		S		S					
Hydrotreated heavy petroleum naphtha	9	S	S	S	S		S	S					
Isopropanol (Propan-2-OL)	50	S	S	S	S	S	S	S			S		
Methanol	76	S	S	S	S	S	S	S		S	S	S	S
Monoethanolamine	5	S	S	S	S	S	S	S		S	S		S
Naphtha, petroleum, heavy catalytic reformed	4	S	S	S	S			S				S	
Naphthalene	19	S	S	S	S	S	S	S	S	S	S		S
Petroleum distillate hydrotreated light	24	S	S	S	S								
Petroleum distillate naphtha	7	S	S	S	S	S	S	S	S	S	S	S	S
Phenolic resin (Phenoformaldehyde resin)	5	S	S	S	S	S	S			S	S	S	
Polyacrylamide	4	S	S	S	S								
Polyacrylamide/polyacrylate copolymer	7	S	S										
Propane-1,2-diol	6	S	S	S	S	S	S	S				S	S
Propargyl alcohol (Prop-2-YN-1-OL)	7	S	S	S	S		S	S		S			
Proprietary	34												
Sodium acid pyrophosphate	4	S	S	S		S							
Sodium hydroxide	17	S	S	S									
Tetramethyl ammonium chloride	7	S	S	S	S			S				S	
Trisodium nitrilotriacetate	4	S		S			S	S	S				
Unknown	45												
Xylene	12	S	S	S	S	S	S	S			S	S	S

Appendix B
Further comments on chemical toxicity

Benzene: Long-term exposure to benzene can affect the bone marrow, causing anaemia, increase the risk of leukaemia, and can affect unborn children[48]. 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)[49].

Toluene and Ethylbenzene can damage the nervous system, liver and kidneys, and ethylbenzene is a possible carcinogen[50,51].

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.[52]

Glutaraldehyde is irritating to skin, eye, throat and lungs. Repeated skin contact can cause allergic reactions.[53]

Fumaric acid is an irritant of skin and mucous membranes.[54]

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.[55]

Methanol is readily absorbed after oral, inhalation, or dermal exposure. It is metabolised to formaldehyde and formic acid in the body and is toxic in very small doses if ingested. Death can be caused by ingestion of only 80 ml. Chronic exposure to methanol can cause headache, insomnia, gastrointestinal problems, and blindness in humans and hepatic and brain alterations in animals.[56]

Appendix C
DEA position statement on unconventional gas:

http://dea.org.au/images/general/DEA_Position_Statement_-_Unconventional_Gas_Development_-_April_2015.pdf

Appendix D

DEA community brochure on unconventional gas:

http://dea.org.au/images/general/DEA_Unconventional_Gas_Brochure_v04_Dec_2014_Office_Print.pdf

Appendix E

DEA submissions and official statements on unconventional gas:

Victoria:
http://dea.org.au/images/uploads/submissions/Unconventional_Gas_-_VIC_submission_07-15.pdf

New South Wales:
Submitted to the Parliament of NSW coal seam gas (Inquiry) submission 412:
http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/0/29AE48525CFAEA7CCA2578E3001ABD1C

http://parliament.nsw.gov.au/prod/parlment/committee.nsf/0/f96d076732225603ca25791b00102098/$FILE/Submission%200412.pdf

http://dea.org.au/images/uploads/submissions/DEAs_Opening_Statement_NSW_unconventioal_gas_operations_Inquiry.pdf

http://dea.org.au/images/uploads/submissions/NSW_SEPP_Amendment-CSG_2013_11-13_.pdf

http://dea.org.au/images/uploads/submissions/NSW_Mining_SEPP_Submission_08-13_.pdf

South Australia:
DEA Submission to the Inquiry into Unconventional Gas (Fracking) – South Australia. January 2015.
http://dea.org.au/images/uploads/submissions/Inquiry_into_Unconventional_Gas_SA_-__01-15.pdf

Tasmania:
DEA Submission to the Review of Hydraulic Fracturing (Fracking) in Tasmania. December 2014.
http://dea.org.au/images/uploads/submissions/Review_of_Hydraulic_Fracturing_%28Fracking%29_in_Tasmania_12-14.pdf

Northern Territory:
DEA Submission to the Hydraulic Fracturing Inquiry Northern Territory. May 2014.
http://dea.org.au/images/uploads/submissions/DEA_Hydraulic_fracturing_in_NT_inquiry_final.pdf

Western Australia:
DEA Submission to the Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas. September 2013.
http://dea.org.au/images/uploads/submissions/WA_Inquiry_into_Hydraulic_Fracturing_-__UG_Submission_09-13.pdf

National
Murray Darling Basin
http://dea.org.au/images/uploads/submissions/MDB_unconventioal gas operations_Senate_submission_June_2011.pdf

http://dea.org.au/images/uploads/submissions/CSG_and_large_coal_mining_impacts_on_water_resources_submission_07-13.pdf

http://dea.org.au/images/uploads/submissions/NICAS_08-12.pdf

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