CSG and Your Health:

Understand the risks and protect your family

A Report on the Health Impacts of CSG and Shale Gas Mining

&

Self-help Risk Management Tools

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2013

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"Despite the rapid expansion of CSG developments, the health impacts have not been adequately researched, and effective regulations that protect public health are not in place. There is a lack of information on the chemicals used and wastes produced, insufficient data on cumulative health impacts, and a lack of comprehensive environmental monitoring and health impact assessments. In circumstances where there is insufficient evidence to ensure safety, the AMA recommends that the precautionary principle should apply. This is essential given the threat of serious and irreversible harms to human health."
Dr Steve Hambleton, President of the Australian Medical Association, May 2013[1]

Introduction

Gas mining has traditionally used a limited number of wells in unpopulated areas to extract gas from naturally formed underground reservoirs. In contrast, "unconventional" mining for gas from coal seams, shale, and tight sands can involve thousands of wells spread across populated areas, and the horizontal drilling, fracturing and depressurising of gas-bearing strata.[2] All forms of unconventional gas mining share a common technology and involve the use and liberation of similar dangerous substances.

Mining for Coal Seam Gas (CSG) and other forms of unconventional gas is an unprecedented threat to our community. Australians have never before faced the prospect of living and raising children amidst heavily industrialised gas fields in landscapes dominated by gas wells, pipes, flares, busy roads, wastewater ponds, and pumping and compression stations. Entire communities are being exposed to a myriad of psychological and social stresses, and a witch's brew of air, water and soil contaminants.

The fundamental problem with unconventional gas mining is the unmanageable creation of dangerous pollution during production. Liquefied Natural Gas (LNG) burns cleaner than coal, but this benefit is only achieved by polluting air, water and soil and by compromising the health of communities where the gas is mined and processed.

Professor Mary O'Kane[3], the NSW Chief Scientist and Engineer, concluded that "considerable work and research still needs to be conducted by researchers, government and industry to determine the potential risks to health from activities related to CSG extraction". Nonetheless, we already know much about the potential for unconventional gas mining to harm human health, and specific threats are identified and understood.

Protecting Public Health The Role of Baseline Data

Any industry that exposes people to potentially harmful products or processes has an obligation to assess and manage risks to health. Legal responsibilities for duty of care and due diligence require "duty holders" to actively seek out evidence of possible threats, and to think beyond known dangers to consider all risks, "not only those for which regulations and codes of practice exist".[4]

When assessing health risks, a proposed development is not entitled to the presumption of innocence accorded a defendant in a criminal prosecution. The development can not be assumed to be safe (i.e., “innocent”) until it is proved to be harmful (i.e., “guilty”) “beyond a reasonable doubt”.

For instance, new medications are not approved for public use until they have been rigourously tested in controlled studies that look for harmful effects by comparing data taken before and after use of the medication. The “burden of proof” is on the pharmaceutical company, which has to demonstrate that the medication is safe before it can be sold to the public.

Corporations that seek to profit from operating heavily industrialised gas fields in populated areas should be responsible for establishing the safety of their operations. Citizens should not need to prove that gas mining is dangerous.

Baseline health assessments are essential to establish the safety of gas mining operations. Scientific methodology for determining the safety of a product or process requires well designed research that compares data on human health and the presence of potentially harmful substances in water, air, and soil, obtained both before (i.e., the “baseline”) and after development takes place.

Will governments and industry protect community health?

“There is no credible evidence that CSG operations have a negative impact on humans and livestock. CSG operations have operated safely in Australia for over 16 years and following extensive reviews have the support of Australian, Queensland and NSW governments.”
Metgasco CSG Mining Company, 2012[5]

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“*That information (from anti-CSG activists) has gone into the mainstream to such an extent that there is a perception and a view that this is a risky, dangerous, unhealthy industry, which is in fact the furthest from the truth.” AGL has been operating a project in Camden for over 13 years, “where there has been no health impacts, no water contamination taking place, no fugitive emissions of any magnitude have been detected, so therefore the perception they've built up is far from reality, but the perception has driven public sentiment and in turn public policy”.*
Michael Moraza, AGL Upstream Gas Group General Manager, 2013.[6]

The proper assessment and management of risks to human health requires more than CSG companies deciding what constitutes “credible” evidence and simply declaring that their mining operations are in all ways safe.

If CSG companies confidently “know” that their operations are safe, there is a greatly reduced likelihood that they will discharge their duty to the community to properly monitor, investigate, and prevent or mediate health risks associated with operating gas fields in populated areas.

AGL's failure to monitor air emissions at their Camden CSG operation illustrates how vital health risk assessment processes can fail.

In March 2013 the Environment Protection Authority (EPA) fined AGL for not maintaining its emissions monitoring equipment.[7] In the August 2013 "Undertaking to the Environment Protection Authority"[8] signed by AGL Director Michael Moraza, the EPA expressed "concern" that in 2007 AGL's emissions monitoring equipment began to break down, and by 2009 all their monitoring equipment had stopped operating. Monitoring for the single pollutant nitrous oxide only recommenced in July 2012.

AGL provided false information to the EPA in Annual Returns from 2006 to 2011, and its publicly available 2007 to 2011 Annual Environmental Performance Reports included the "false and misleading" statement that, "Full results of the continuous emissions monitoring for the reporting period are kept on file". "AGL advised that the non-reporting was due to oversight combined with a lack of understanding by AGL staff regarding the significance of the equipment breakdown".[9]

What evidence could underpin AGL Manager Mr Moraza's claim that there has been "no health impacts, no water contamination taking place, no fugitive emissions of any magnitude" at their Camden gas field? In this case, the absence of evidence of harm does not mean that there is no harm, only that there is no data. Further, AGL's permitted annual air emissions of 103,000 kg of nitrogen oxides[10] do appear to have some "magnitude", especially given that their CSG emissions include significant amounts of other unmonitored substances.

It is not clear why gas mining companies and regulatory authorities have not obtained the pre-drilling baseline health and environmental data essential for proving the safety of this industry. Only a few politicians have called for proper assessment of health risks prior to approval of unconventional gas mining. Even if the possibility of great harm was small, those promoting gas mining would have a responsibility to properly assess and manage risks to public health. But in this case, evidence to support the claim that gas mining is safe is entirely lacking, while abundant scientific research indicates a high level risk of potentially catastrophic health impacts from operating gas fields in populated areas.

Reports of people being harmed have been dismissed on the perverse grounds that a lack of baseline data makes it impossible to "prove" that their health deteriorated after CSG drilling began. Such arguments demonstrate a disregard for principles of risk assessment and duty of care, and reverse the "burden of proof" that should apply when assessing risks to human health.

If we do not heed the warning that "those who cannot remember the past are condemned to repeat it", unconventional gas mining could become the 21st Century's version of last century's asbestos and tobacco health tragedies, only much worse.

By the 1930s, scientists had linked asbestos to cancer, but in Australia asbestos was not banned until 2003. In the late 1970s, court documents proved that industry executives had known all along that asbestos was dangerous, but had concealed this information as they promoted their business. The 1964 US Surgeon General's Report found that cigarette smoking was the cause of lung and laryngeal cancer, but until court cases in the late 1990s, the tobacco industry lied about the known health impacts of smoking, and claimed that nicotine was not addictive and that there was no "proven" link between cancer and smoking.

The asbestos and tobacco industries thrived while executives denied the known health risks of their products and public regulators did little. Profits harvested over decades were never discounted to reflect the true costs in suffering, illness and death borne by the community.

Nowadays, like asbestos and tobacco in the past, unconventional gas mining is promoted in the absence of proper risk assessment. As before, regulatory authorities appear unwilling or unable to effectively protect public health.

What can we do to protect the health of our communities?

Many people have called for assessment of the health risks from operating gas fields in populated areas, but this is not a straightforward process. Epidemiological studies can take years to complete, and the current threat to health is serious and urgent. Baseline data has to be collected prior to drilling and for many areas that time has passed. Communities are already exposed to dangerous pollutants. In the Northern Rivers, the safety of the existing 60 or so CSG wells cannot be assumed, and no one knows whether people have been exposed to levels of pollution sufficient to cause illness.

In the current circumstances, responsibility for protecting community health falls on individuals. A self-help process of risk assessment and management could make a difference.

A good understanding of how gas mining pollutants can affect health is essential. A potential danger that is not recognised cannot be avoided or mitigated. If you do not know that the fibro you are breaking up contains asbestos, you will have no idea that you are being injured. If you develop lung cancer years later you will have no idea why this has happened to you. People need to understand the risks and how they could be harmed.

Medical professionals need information about CSG health impacts so they can properly diagnose and treat affected patients. Gas field pollutants can cause severe permanent injuries, and for all affected people, but especially for children, it is essential that exposure to harm ends as soon as possible. Unlike asbestos and tobacco-related illnesses, some symptoms of gas poisoning develop quickly, and effective treatment is possible if symptoms are promptly and accurately diagnosed.

This report and the questionnaires are self-help risk management tools which could help people better protect their families from the health impacts of unconventional gas mining.

- The Report on the Health Impacts of CSG and Shale Gas Mining reviews what is known about the dangerous substances and processes, potential pathways to contamination, and health impacts associated with unconventional gas mining.

- The Symptoms List presents symptoms that researchers have associated with exposure to gas field pollutants. If repeated over time, the list can provide either ongoing reassurance of a clean bill of health, or alternatively assist early recognition of a change in health status.

- The Exposure to Gas Mining Questionnaire records information about possible sources of contamination.

- The CSG Concerns Questionnaire records ratings of emotional distress from various dimensions of the CSG experience.

- The Depression Anxiety Stress Scale (DASS-21) □ If repeated over time, responses to this questionnaire could help a person to better recognise changes in symptoms of anxiety or depression.

The Report and the associated questionnaires are educational materials only and are not any form of medical assessment or treatment or legal advice. In all cases, you should discuss any concerns that you have about your mental or physical health with your family doctor. No guarantee is given or implied that the report or the questionnaires carry any legal weight. You should seek professional legal advice for any questions you have regarding gas mining, personal injury, the law, or other legal issue.

The Report on the Health Impacts of CSG and Shale Gas Mining and associated questionnaires are provided free of charge in the interests of community health. You can copy and distribute these documents provided that they are reproduced in full, without alteration and with all citations and references, and no fee is charged. Copies of these materials and many of the referenced publications are available for free download by clicking the links in the attached “Selected References on Gas Mining Health Impacts” on page 41 of this document.

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Risks to worker and public health from unconventional gas mining can arise from political and industrial processes that cause emotional distress and/or create air, water, soil, light, and noise pollution.

Mental Health Impacts of the “CSG Experience”

The rapid transformation of rural communities into industrialised gas fields introduces complex social, psychological and environmental stresses that can undermine health.

The CSG experience is not necessarily stressful in itself – people who profit from gas mining often consider it a good thing. People who feel threatened by, or who suffer losses or injuries as a result of gas mining are most at risk of developing symptoms of emotional distress.

A sense of threat can trigger the “fight or flight” response – a natural coping mechanism which helps us survive dangerous situations. Anxiety signals the presence of danger, and adrenaline and anger prepare us to fight off, or escape from, the threat. If these responses lead to action that successfully removes the danger, then stress will ease. But if the threat cannot be removed, stress reactions can become chronic and result in symptoms such as sleep disturbance, anxiety and depression.

Potentially Distressing Features of the CSG Experience include:

- Loss of control over access to one’s property
- Loss of the right to quiet enjoyment of home and property
- Diminished quality of lifestyle

Every rural landowner subject to a Petroleum Exploration License faces the prospect of unconventional gas companies being legally empowered to forcibly enter their properties, build roads, set up camps, drill multiple wells, dig dams to hold contaminated water, and establish noisy, brightly lit up well sites that run 24 hours a day for years.

- Noise[11] and light pollution
- Disturbed sleep cycles

Grief, emotional shock, and a sense of loss, complicated by disturbed sleep due to noise and light pollution from lighting, traffic, compressors and reverse osmosis plants, can lead to debilitating symptoms of psychopathology.[12]

During sleep, the brain and body repeatedly cycle through stages of dreaming to deep sleep. Deep sleep repairs the body, and dreaming works to resolve emotional issues and consolidate memories. Noise and light pollution disrupt dreaming and deep sleep, impede natural healing and restorative processes, and can trigger anxiety and depressive illnesses.

- Loss of land value
- Lack of adequate compensation
- Compromised livelihood from loss of productive agricultural land

For many farming families, their land is their life's work. For most people, their home is their major asset and legacy for their children. For affected people, the loss of property value and damage to their land feels like a personal injury. The decline in land values can be resented as an unfair transfer of wealth from families to mining companies.

- Denial of an economic "level playing field"
- Politicians' lack of respect, and even contempt for citizens' concerns
- Damage to privately owned assets and small businesses

Respect for Government and the rule of law can be undermined when principles of "a fair go" for all and an economic "level playing field" are seen to be abandoned in favour of powerful mining companies. The perceived violation of individual rights and lack of regard for small businesses can foster unhealthy beliefs that political and legal processes are unfair and that politicians cannot be trusted to protect the community's interests.[13]

- Sense of violation of "Mother Earth"
- Grief over loss of "Nature's gifts of beauty rich and rare"
- Powerlessness to protect one's natural environment
- Negotiating with companies from an inferior position

For some Australians the degradation and pollution of the land can foster a sense of disempowerment and pessimism.[14] Australian psychiatrist Glenn Albrecht (2005)[15] coined the term "Solastalgia" – a loss of solace – to describe the distress that people who are connected to the land feel when their environment is damaged. Affected people can develop unhealthy beliefs that the world is malevolent and uncontrollable.

- Community impacts from rising rents and large numbers of transient workers
- Increased sexual assaults, illicit drugs, and prostitution
- Intimidation by young male mining workers
- The trauma of ill-health

Dubbed the "Boomtown Effect" in the US, for some communities the rapid changes in population, intensive industrialisation, and economic effects due to gas mining result in social ills that can undermine health. There are reports of CSG industrialisation in some Queensland communities leading to: increased rates of crime, drug and alcohol abuse, sexually-transmitted infections and domestic violence; inadequate supply and quality of housing; increased cost of living; increased community dissatisfaction; increased mental health and social services case loads; and increased hospital admissions.[16,17]

In their submission to the NSW Parliamentary CSG Inquiry, the Doctors for the Environment group noted that, "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."[18]

Emotional distress triggered by the CSG experience can undermine health, but exposure to dangerous chemicals and industrial processes can result in serious physical injuries.

Physical Health Impacts of Unconventional Gas Mining

"The fundamental public health issue is the potential for water contamination by chemicals which could seriously affect human health decades after exposure. Health impacts may arise from the use of fracking chemicals or from the release of hydrocarbons and other contaminants from the coal seams."[19]
Professor David Shearman, Emeritus Professor of Medicine, University of Adelaide

Three conditions need to be satisfied for an industrial process to be considered a serious threat to human health. The industry must use dangerous substances. There have to be environmental pathways which potentially bring people into contact with these substances. And it has to be possible for people to be exposed to pollutants in doses sufficient to cause illness. There is abundant evidence that operating CSG gas fields in populated areas satisfies these three criteria.

This report reviews what is known about:

- The identity and health impacts of potentially harmful substances used in gas mining and naturally present in coal and shale gas seams,
- The environmental pathways that make it possible for humans to come in contact with these substances, and
- Cases of illness reasonably attributed to contact with these dangerous substances.

Dangerous Substances

Coal seam and shale seam gases are predominantly methane, but can also contain: other gases such as carbon dioxide, carbon monoxide, and nitrogen; hydrocarbons, including ethane, propane, butane, benzene, toluene, and xylenes; other volatile organic compounds (VOCs), such as carbon disulfide, hexane, cyclohexane, ethylbenzene; toxic non methane hydrocarbons (NMHC); and various particulates.[20]

Coal and shale seams also naturally contain: various salts; heavy metals such as lead, arsenic, mercury; barium, boron and sulphate; and radioactive materials, including radium 226, radium 228, thorium, strontium, uranium and radon.[21]

In addition to dangerous substances naturally present in coal and shale seams, unconventional gas mining also involves the use and production of significant quantities of industrial chemicals, as well as dust, particulates and diesel emissions.

Industrial Chemicals

Gas mining companies argue that only a small percentage of drilling and fracking fluids consists of chemicals, but the volume of fluids used creates a considerable chemical load.

The scale of chemical use in a developed gas mining operation was illustrated by a US House of Representatives Committee finding that over a four year period, 14 companies used more than 2,500 hydraulic fracturing products containing 750 chemicals and other components, to make up (excluding water added at the well site) 780 million gallons of hydraulic fracturing products.[22]

In Australia, in some cases, large quantities of chemical additives are used both at the drilling stage and during hydraulic fracturing. A risk assessment provided to the Queensland Department of Environment and Resource Management (DERM) listed approximately 18,500 kilograms of chemical additive used per well with up to 40% (7,500kg) not recovered.[23]

In Australia, there is no national requirement for public disclosure of all chemicals used in CSG operations, and there is no publicly available comprehensive list of fracking chemicals. The following information regarding the types of chemicals used in unconventional gas mining was compiled from research by the National Toxics Network.[24,25,26]

In Australia, drilling fluid can include:

- Viscosifiers (e.g., bentonite, polyacrylamide)
- Weighting agents (e.g., barium sulphate)
- Bactericides/biocides (e.g., glutaraldehyde)
- Corrosion inhibitors (e.g., zinc carbonate, sodium polyacrylate)
- Defoamers (e.g., glycol blends, light aromatic and aliphatic oil, naptha)
- Emulsifiers and deemulsifiers
- Lubricants (e.g., chlorinated paraffins)
- Scale inhibitors (e.g., anionic polyacrylamide, acrylamide copolymer)
- Polymer stabilisers (e.g., Sodium sulfite)
- Breakers (e.g., diammonium peroxydisulphate, hemicellulase enzyme)
- Salts (e.g., potassium chloride, sodium chloride, calcium chloride)

Hydraulic fracturing fluids usually include:

- Gelling agents (e.g., guar gum, diesel, alkanes/alkenes)
- Gel stabilisers (e.g., sodium thiosulphate)
- Gel breakers (e.g., Ammonium persulfate, sodium persulfate)
- Friction reducers (e.g., polyacrylamide, mixtures of methanol, ethylene glycol)
- Surfactants (e.g., isopropanol, 2-Butoxyethanol /2-BE)
- Biocides (e.g., glutaraldehyde, Tetrakis hydoxymethyl phosphonium sulfate/THPS, 2-Bromo-2-nitro-1,3-propanediol (Bronopol), 2,2-Dibromo-3-nitrilopropionamide
- Clay stabilisers (e.g., tetramethyl ammonium chloride)
- Buffer fluids and cross-linking agents.

Fracking may also use:

- Corrosion inhibitors (e.g., formamide, methanol, naphthalene, naptha, nonyl phenols, acetaldhyde)
- Scale inhibitors (e.g., ethylene glycols)
- Iron control agents (e.g., citric acid, thioglycolic acid)
- pH adjusting agents (sodium or potassium carbonate)
- Diluted acid to dissolve minerals (e.g., hydrochloric acid, muriatic acid)

Dust, Particulates and Diesel Emissions

Dust and particulates are created and mobilised by vehicle and construction activity. Dust is especially hazardous when it contains coal seam and mining chemicals from the spraying of dirt roads with waste water, proppants (i.e., sand/silica and chemicals injected into coal and shale seams to keep fissures open), and diesel fumes and exhaust.

Crystalline silica is a common mineral found in sand, clay and stone. Respirable crystalline silica is the portion of silica that is small enough if inhaled to enter the gas-exchange regions of the lungs. The handling of huge quantities of sand during fracking generates dust containing respirable crystalline silica.

Diesel emissions from vehicles, drills, pumps, compressors, generators, and other equipment are created during all phases of the unconventional gas mining process – from exploration through production, processing and transportation. Diesel fumes and exhaust contain: a mix of fine particles; gases such as carbon monoxide; sulfur oxides and nitrogen oxides; and volatile organic compounds including benzene, toluene, ethylbenzene and xylene.

Unconventional gas mining uses a significant volume of diesel for transport. The New York City Department of Environmental Protection estimated that 800 to 2,000 truck trips are needed for a single-well shale gas pad.[27] A report by the University of Manchester's Tyndall Centre[28] indicated that between 4,300 and 6,600 truck visits occur during pre-production for a six-pad shale gas well arrangement. 10% of the United Kingdom's gas production would require a total of 2 to 4 million truck journeys. Assuming a maximum concentration of 20 wells on one pad, with six frackings over 30 years, there could be between 38,400 to 172,800 tanker truck trips over the life of the well pad.[29,30,31,32]

Risks to Health

Most chemicals used in unconventional gas mining have not been assessed for their toxicity, persistence, or long-term health impacts. There has been no assessment of new compounds that form when mining chemicals interact with other substances or with natural catalysts such as sunlight, water, air, and radioactive elements.

The US House of Representatives Committee on Energy and Commerce[33] identified over 750 chemical products used in gas mining, with 650 containing hazardous substances including carcinogens, neurotoxins, irritants/sensitisers, reproductive toxins and endocrine disruptors. Some of these chemicals are dangerous at concentrations below detection limits.

A UK study[34] of chemicals supplied to New York State for shale gas mining found that 58 of the 260 substances listed were a risk to health: 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.

Colborn, et al.'s (2011)[35] review of chemicals used in US shale gas fracking found that:

> "More than 75% of the chemicals could affect the skin, eyes, and other sensory organs, and the respiratory and gastrointestinal systems. Approximately 40-50% could affect the brain/nervous system, immune and cardiovascular systems, and the kidneys; 37% could affect the endocrine system; and 25% could cause cancer and mutations."

Dr Colborn, et al. (2011)[36] commented that:

> "Numerous systems, most notably the endocrine system, are extremely sensitive to very low levels of chemicals, in parts-per billion or less. The damage may not be evident at the time of exposure but can have unpredictable delayed, life-long effects on the individual and/or their offspring. Health impairments could remain hidden for decades and span generations." [37]

According to Dr Effie Ablett (2013)[38], "A few of these chemicals (used in Australian CSG mining) have been studied and listed as possible carcinogens, but most, including those likely to be the most potent carcinogens, remain untested and therefore are largely not taken into account in assessing potential health risks." Currently legislated "safe" or maximum contamination levels are close to the level of detection for the few known carcinogens listed, and more potent carcinogens such as Poly Aromatic Hydrocarbons "are likely to cause cancer at concentrations that are orders of magnitude below their detectable levels in drinking water".[39]

Law (2013)[40] described how endocrine disrupting chemicals can interfere with hormone action even at very low concentrations, and these effects can be specific to particular stages of a child's physical development.

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.[41] Chemicals used by the Australian unconventional gas industry (e.g., glutaraldehyde, brominated biocides, propargyl alcohol, 2-butoxyethanol and heavy naphtha) have been found to be dangerous at concentrations near or below chemical detection limits by the State University of New York.[42]

Brown (2013)[43] noted that understanding gas field toxicology is complicated because:

- We have incomplete identification of the chemicals present
- Chemicals can interact with other chemicals in complex unknown ways
- The presence of one agent can greatly increase the toxicity of another agent
- Agents have multiple physiological actions on various target organs
- Health effects of exposure to many chemicals is unknown
- How certain chemicals alter the biological processing of other chemicals is unknown
- Substances that inhibit metabolism or excretion magnify the effects of other chemicals
- Some agents can change the physiologic distribution of other chemicals
- Some agents can cause chemicals that would not normally do so to enter the brain
- Medications can affect the impact of toxic substances

Potentially harmful chemicals used in or liberated by unconventional gas mining include:[44,45,46]

- **Volatile Organic Compounds (VOCs)** – Some VOCs are very toxic and bioactive. VOC exposure can cause eye, nose, and throat irritation, headaches, visual disorders, memory impairment, loss of coordination, nausea, and damage to liver, kidneys, and the central nervous system.[47] The US EPA noted that some VOCs can cause cancer and other serious, irreversible health effects, including neurological problems and birth defects.[48]

Some VOCs are known to cause cancer in animals (e.g., methylene chloride), or in humans (e.g., formaldehyde), or are suspected human carcinogens (e.g., chloroform, bromodichloromethane). VOCs are also key ingredients in forming ozone and smog, and fine particle pollution, which is linked to asthma attacks, and other health effects.

- **Benzene, toluene, ethylbenzene, and xylene (BTEX) –** Benzene and toluene are particularly problematic VOCs because they tend to be activated into other substances and impact on certain tissues in unique ways.[49] Short-term health effects of exposure include dizziness, headache, loss of coordination, respiratory distress, and skin, eye, and nose and throat irritation. Long-term health effects of exposure to BTEX chemicals include kidney, liver, and blood system damage. Long term exposure to benzene can affect bone marrow, causing anaemia and increasing the risk of leukaemia and diseases such as non-Hodgkin's lymphoma.[50] Benzene is a health hazard even in minute quantities. The Australian drinking water guidelines for benzene state that "no safe concentration for benzene in drinking water can be confidently set" so the guideline is set below the level of detection at 1ppb (the equivalent of a drop of water in a swimming pool).[51,52,53]

  US researchers have found an association between exposure to benzene and delivery of a child with birth defects.[54] In France, researchers using closeness of residence to a major highway as an approximate measure of exposure to benzene, found a relationship between increased exposure and lighter, smaller children with smaller head circumference.[55]

- **Poly Aromatic Hydrocarbons (PAH)** – PAHs and their derivatives "are among the most potent carcinogens, having structures that resemble the base pair in DNA and readily intercalating and/or covalently bonding to DNA causing mutation."[56] Neuro-developmental disorders and lowered IQ in babies has been associated with the mother's exposure to PAHs during pregnancy.[57]

- **Methanol –** A highly toxic VOC readily absorbed via ingestion, inhalation, and skin exposure. Causes central nervous system depression and degenerative changes in the brain and visual system. In the body methanol is metabolized to formaldehyde and formic acid, and is toxic in very small doses if ingested. Chronic exposure causes headache, insomnia, gastrointestinal problems, and blindness in humans, and hepatic and brain alterations in animals.[58] Methanol is highly mobile in soil. Methanol volatilizes from water and once in the air, exists in the vapor phase with a half-life of over 2 weeks. Methanol reacts with photo-chemically produced smog to produce formaldehyde and can also react with nitrogen dioxide in polluted air to form methyl nitrite.

- **Ethylene Glycol –** A human respiratory toxicant and teratogen (i.e., an agent that causes malformation of an embryo or foetus) in animal tests. Associated with increased risks of spontaneous abortion and sub-fertility in female workers. When ethylene glycol breaks down in the body, it forms chemicals that crystallise, collecting in the kidneys and affecting kidney function. It also forms acidic chemicals in the body, affecting the nervous system, lungs and heart.[59]

- **2-Butoxyethanol –** Readily absorbed and rapidly distributed in the human body. It destroys red blood cells at relatively low levels of exposure; can damage spleen, liver and bone marrow; and cause reproductive problems and birth defects in animals.[60]

- **Ethoxylated 4-nonylphenol –** A persistent, bio-accumulative, endocrine disruptor which is very toxic to aquatic organisms, and has been found to increase the incidence of breast cancer in lab animals. This chemical mimics estrogen, and can cause the feminization of fish, even at concentrations not detected by normal monitoring of the fluid.[61]

- **Isopropanol –** A central nervous system depressant that can cause degenerative changes in the brains of lab animals.

- **Formamide –** A teratogen with the potential to affect the unborn child. Can be absorbed into the body by inhalation and through the skin.

- **Naphthalene –** Causes nasal and lung tumours and is listed as a possible human carcinogen. Readily absorbed via oral dose or inhalation. Chronic exposure of workers reported to cause cataracts and damage to the retina.

- **Ammonium persulfate and Sodium persulfate –** Harmful if swallowed, and inhalation or skin contact can cause sensitization. Can irritate the skin and eyes and cause allergic reactions, rashes and eczema. Long-term exposure can affect lung function leading to disease of the airways and/or asthma.

- **Limonene –** A skin sensitiser and respiratory irritant.

- **Glutaraldehyde –** Highly irritating to the eyes, skin, and respiratory tract. Repeated skin contact can cause allergic reactions.[62]

- **Acetaldehyde (Aldehyde) –** Primary acute effect of inhalation exposure is irritation of the eyes, skin, and respiratory tract in humans. At higher exposure levels, erythema, coughing, pulmonary edema, and necrosis may also occur. Acetaldehyde is considered a probable human carcinogen (Group B2). No information is available on the reproductive or developmental effects of acetaldehyde in humans. Acetaldehyde has been shown, in animals, to cross the placenta to the fetus, and animal studies suggest that acetaldehyde may be a potential developmental toxin.[63]

- **Formaldehyde –** Classified as a known human carcinogen by the International Agency for Research on Cancer (IARC) and as a probable human carcinogen by the US EPA. An association between formaldehyde exposure and several cancers, including nasopharyngeal cancer and leukemia, has been found in exposed workers. Exposure occurs primarily via inhalation of gas or vapour, or by skin absorption.

  When formaldehyde is present in the air at levels exceeding 0.1 ppm, some individuals may experience adverse effects such as watery eyes; burning sensations in the eyes, nose, and throat; coughing and wheezing; nausea; and skin irritation. Some people are very sensitive. Less is known about formaldehyde's potential long-term health effects. The US EPA classified formaldehyde as a probable human carcinogen under conditions of high or prolonged exposure. The IARC classifies formaldehyde as a human carcinogen. Exposure to formaldehyde may cause leukemia, particularly myeloid leukemia, and possibly nasopharyngeal cancer in humans.[64]

- **Tetrakis (hydroxymethyl) phosphonium sulfate (THPS) –** Toxic to microorganisms, and repeated skin exposure to THPS resulted in severe skin reaction and sensitization in guinea pigs. Identified as a severe eye irritant in rabbits.[65] Has mutagenic potential (in vitro) and cancer potential in rats. No exposure information is available for either humans or organisms in the environment.[66] Little is known about the effects of the break down products of THPS.

- **Methylene chloride –** The second most frequently appearing compound in water around gas drilling sites. A central nervous system (CNS) depressant, it decomposes to phosgene, a very toxic substance, and breaks down to carbon monoxide in the body. Linked to reproductive effects. The short-term effects of methylene chloride inhalation in humans consist mainly of nervous system effects including decreased visual, auditory, and motor functions. The effects of long-term exposure suggest that the CNS is a potential target in humans and animals. Human data are inconclusive regarding methylene chloride and cancer. Animal studies found increases in liver and lung cancer and mammary gland tumors following inhalation of methylene chloride.[67]

- **Fumaric acid –** An irritant of skin and mucous membranes.[68]

- **Persistent Organic Pollutants (POPs) –** Perfluorooctane sulfonic acid, permitted in hydraulic fracturing, and chlorinated paraffins used in drilling fluids, are amongst the most dangerous of all man made chemicals.[69]

- **Carbon monoxide –** Released by incomplete combustion of gas and machinery emissions. Cleared from the body slowly. Episodic exposures to high levels, particularly in children, can produce neurological effects due to the blood's decreased ability to carry oxygen.[70]

- **Radium –** A very toxic, water-soluble carcinogen associated with increased incidence of bone, liver and breast cancer. Radon, a decay product of radium, is the leading cause of lung cancer amongst non-smokers and the second leading cause of lung cancer amongst smokers.

  "Radon decay elements deposit as a film on the inner surface of inlet lines, treating units, pumps, and valves principally associated with propylene, ethane, and propane processing streams. Because the radioactive materials become concentrated on gas-field equipment, the highest risk of exposure to radioactive substances is to workers who cut and ream pipe, remove solids from tanks and pits, and refurbish gas processing equipment."[71]

- **Barium, Arsenic, Lead and Fluoride –** Tend to act by replacing normal physiological systems in the body. Consequently, inhibition of calcium is frequently seen, and the substances are likely to be detected in target organs and are difficult to detect in urine. Some compounds of fluoride are not very toxic, but fluorine is a very potent halogen that can cause deep burning of the skin.[72]

- **Dust and Particulates –** Fine particles become hydrated and can absorb soluble toxins present in the surrounding air. When such hydrated fine particles are inhaled, toxic chemicals can be transported deep into the body where they would not otherwise normally penetrate. Particles that fall to the ground can be tracked into the house, where they can be inhaled after vacuuming.[73]

- **Silica –** Inhaling silica is a known cause of lung cancer and a suspected contributor to autoimmune diseases, chronic obstructive pulmonary disease and chronic kidney disease. If inhaled into the deep lung it releases a lysosome that initiates progressive scarring. The effects of silica exposure on children or people with compromised lung function are unknown.[74] Symptoms of chronic silicosis include shortness of breath, fatigue, cough, and, in some cases, respiratory failure.

- **Diesel fumes and particulates –** In 2012 the World Health Organization (WHO) classified diesel engine exhaust as carcinogenic to humans (Group 1) due to an increased risk of lung cancer. Diesel motors emit particles which are very harmful due both to their size and chemical content. If inhaled, fine (PM2.5) particles get into lung tissue and set up inflammatory foci which spread damage throughout the body, including the brain. Ultra-fine particles (PM0.1) can get inside cells and change genetic material. Diesel particles are carried to the brain where they are particularly damaging to young children. Exposure to diesel particles has been associated with lowered IQ in infants and an increase in autistic and antisocial behaviours.[75]

- **Ozone –** Produced from mixing VOCs with nitrogen oxides from diesel exhaust. Gas field ozone has created a previously unseen air pollution problem in rural areas, similar to that found in large urban areas, and can spread up to 200 miles beyond the immediate region where gas is being produced.[76] One highly reactive molecule of ground level ozone can burn the deep alveolar tissue in the lungs, causing premature ageing. Chronic exposure can lead to asthma and emphysema, and is particularly damaging to children, active young adults who spend time outdoors, and the aged. As children's lungs develop in the presence of ozone, alveolar production is reduced, and chronic ozone exposure can result in a child developing brittle lungs like those of an elderly adult.[77]

- **Methane –** Methane toxicity is usually thought of in terms of inhalation and the asphyxiation hazard created by the displacement of oxygen, but "we know virtually nothing about how methane might affect people who ingest it."[78]

There is no doubt that CSG and Shale Gas mining involve the use and liberation of potentially dangerous substances. The following section reviews evidence regarding the potential for humans to come into contact with these hazardous substances via environmental pathways of water, air, and soil contamination.

Pathways to Human Contamination

> *"Under natural conditions, fossil fuels contribute a relatively small volume of PAHs (Poly Aromatic Hydocarbons) to the environment. Because most coal and oil deposits are trapped deep beneath layers of rock, there is little chance to emit PAHs to the surface environment. For the first time, Coal Seam Gas mining will allow large amounts of these chemicals to be solublised from coal seams and leached out into ground water, and fracking chemicals to be released into our atmosphere. This poses a new major health risk for NSW, with a possible increase in cancer cases on par with or greater than asbestos.*
> Dr Effie Ablett, 2013[79]

Dangerous substances used or liberated by unconventional gas mining can escape into air, soil, and water systems during most stages of the gas production process – from exploration drilling, production testing, well completion, processing, venting, flaring and waste water storage, through to transportation and supply of the processed gas.

Human exposure to gas industry contaminants can occur in a variety of ways including through direct skin contact with chemicals or wastes, drinking or bathing in polluted surface or bore water, breathing in vapours and contaminated dust particles, and from ingesting tainted foods.

There are many reported incidents of gas mining contaminants being released into the environment by accidental spillage, leaking pipes, and from legal discharges into the atmosphere during such processes as drilling and flaring, and into rivers to dispose of waste water. But beyond these sources of contamination, it looks as if unconventional gas mining technology is fundamentally flawed and unsafe.

Unconventional gas wells are essentially metal pipes inserted into very deep boreholes – about 1,000m for CSG and 3,000m for Shale Gas. Drilling continues horizontally when the well reaches gas-bearing strata. Gas is extracted after water is pumped from the coal seam aquifer to the surface. The resulting depressurising of coal and shale seams inevitably leads to a drop in aquifer water levels closer to the surface.[80] In the "fracking" process, water, silica compounds, and chemicals are injected under high pressure to further fracture the seam to facilitate the release of gas.

To prevent gases from the coal and shale seams escaping into the atmosphere via the borehole, and to protect aquifers from contamination, for the entire vertical length of the well the space between pipe and rock has to be effectively and permanently sealed. This is purportedly achieved by pumping cement into the gap between pipe and rock – two inches wide at the top and three-quarters of an inch wide hundreds of metres down. Any flaw or deterioration over time in the cement barrier or metal pipe provides a potential pathway for contaminants to escape into the environment.

In July 2013, Metgasco workers had to run for their lives when 200 m of bore pipe was forcibly ejected high into the air during decommissioning of a CSG well in Casino. The well had experienced continuously rising pressure during its lifespan due to a loss of well integrity. The Mine Safety Investigation Unit report on the accident noted that, "Loss of integrity... meant that gas under pressure could migrate between the inside and outside of the (well) casing". Efforts to monitor and control this building pressure had failed in part because there was "insufficient understanding" of the pressure build-up, and the plug used to seal the bore was installed too close to the surface.[81]

Air Pollution

During unconventional gas drilling, the evaporation of "flowback" (i.e., the injected fluid that returns to the surface with substances from the coal and shale seams) can cause severe air pollution.[82] Flaring, the burning off of gases, releases hydrogen sulfide, methane and BTEX chemicals, as well as metals such as mercury, arsenic and chromium, into the air.[83]

In the US, monitoring of air quality at gas drilling sites over a 12 month period[84] detected 44 hazardous pollutants including methane, methylene chloride, ethane, methanol, ethanol, acetone, propane, formaldehyde, acetaldehyde and PAHs/naphthalene.

A multi-year air monitoring program in Utah reported elevated levels of ozone near gas mining activities, and concluded that oil and gas operations were responsible for 98-99% of Volatile Organic Compound (VOC) emissions and 57-61% of nitrogen oxide emissions.[85]

Colborn et. al. (2012)[86] reviewed weekly air sampling results performed 1.1km away from a gas well pad before, during, and after drilling and hydraulic fracturing of 16 wells over the course of a year. Methane, non-methane hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) were detected. As well, methylene chloride, a toxic solvent not reported in products used in drilling or hydraulic fracturing, was detected in 73% of samples, and several times in high concentrations.

In Pennsylvania, a US Health Survey[87] collected 34 air tests at 35 households in 9 counties and found VOCs including 2-butanone acetone, chloromethane, carbon tetrachloride, trichlorofluoromethane, toluene, methylene chloride, dichlorodifluoromethane, n-hexane, benzene, tetrachloroethylene, 1,2,4-trimethylbenzene, ethylbenzene, trichloroethylene, xylene and 1,2-dichloroethane**.** The researchers found a strong association between proximity of residence to gas facilities and severity of symptoms including nasal and throat irritation, sinus problems, eyes burning, shortness of breath, difficulty breathing, severe headaches, sleep disturbance, frequent nausea, skin irritation and rashes, and dizziness.

A 2009 air quality study[88] in Dish, Texas, a town which has no industrial activity other than nearby gas mining, and can therefore be considered informative of the effects of gas mining[89], found “the presence in high concentrations of carcinogenic and neurotoxin compounds in ambient air and/or residential properties.” “Many of these compounds verified in laboratory analysis were metabolites of known human carcinogens and exceeded both short-term and long-term effective screening levels according to TECQ (Texas Commission on Environmental Quality) regulations. Of particular concern are those compounds with potential for disaster as defined by TECQ”.[90]

Queensland Gas Company (QGC) reports to the Australian National Pollutant Inventory indicate that significant quantities of pollutants are being deliberately released into the atmosphere from their CSG operations. These estimates do not include “fugitive” gas emissions that vent into the atmosphere away from company facilities.

Amongst other chemicals and substances, QGC provided the following estimates of air emissions from specific facilities over one year from 2011 to 2012[91]:

- QGC’s Kenya Processing Plant and Compressor Stations in Tara, QLD – Carbon monoxide (520,000kg), Formaldehyde (methyl aldehyde) (47,000kg), Oxides of Nitrogen (840,000kg), Particulate Matter – 10.0 um (2,700kg), Particulate Matter – 2.5 um (2,700kg), Sulfur dioxide (690kg), Volatile Organic Compounds (110,000kg), Fluoride compounds (17,000kg).

- QGC’s Windibri Processing Plant and Compressor Stations in Condamine, QLD – On-site long term waste storage (17,000kg), Carbon monoxide (500,000kg), Formaldehyde (methyl aldehyde) (42,000kg), Oxides of Nitrogen (850,000kg), Particulate Matter – 10.0 um (8,300kg), Particulate Matter – 2.5 um (8,200kg), Sulfur dioxide (640kg), Volatile Organic Compounds (99,000kg).

Australia's National Toxics Network[92] reported that "limited sampling of ambient air undertaken around the Tara estate near CSG activities have detected VOCs, including ethanol, acetone, benzene, toluene, xylene, ethylbenzene, dichlorodifluoromethane, 1,2,4-trimethylbenzene, naphthalene, phenylmaleic anhydride, methyl ethyl ketone, phenol, butane, pentane, hexane."

Toluene, a neurotoxin was found in the air around a number of Tara homes, and the level of toluene measured in the air above a resident's water bore[93] (0.33ppm) was well above the "Chronic Reference Exposure Limits" used for long-term exposure by US states California, Massachusetts and Michigan.

Limited sampling used for a 2013 Queensland Department of Health Report[94] detected a wide range of VOCs in the air around homes in Tara, and concluded that testing "did provide some evidence that might associate some of the (Tara) residents' symptoms to exposures to airborne contaminants arising from CSG activities." In reviewing these findings, Dr Lloyd-Smith[95] noted that "for many of the chemicals assessed the level of detection used by the laboratories was well above the level set for the protection of health". Benzene, a confirmed human carcinogen, was detected at levels above the health criteria.

From July to December 2012, the Queensland Government collected air samples over brief periods in summa canisters from Wieambilla, a residential estate in Tara. Dr Lloyd-Smith commented, "Despite the nature of this testing, many VOCs were again detected in the air. While, most were below relevant guidelines and the criteria used, the number and type of compounds was diverse." [96] Summa canister sampling found the VOCs hexane, propene, chloromethane, dichlorodifluromethane, methylene chloride, ethanol, acetone, methyl ethyl ketone, acrolein, and vinyl acetate (vinyl acetate exceeded the annual criteria in one case). Passive air samplers also detected VOCs including pentane, hexane, heptane, tetradecane, hexadecane, heptadecane, cyclohexane, 2-methylbutane, 3-methylpentane, 3-methylhexane, methylcyclohexane, tetrachloroethylene, 2-ethyl-1-hexanol, ethylacetate, benzene, toluene, xylene, ethylbenzene, 1,2,4-trimethylbenzene, phenol, benzothiazole, naphthalene, and alpha-pinene.[97]

In Australia, many wells in Queensland CSG fields are leaking[98], and the final report of the CSG Well Head Safety Program (April 2011) found that more than 120 wells were reported to be leaking methane.[99] Video of leaking CSG wells in Queensland gas fields and ignitable bores has been shown on the ABC 4 Corners program, "The Gas Rush"[100] and the 60 Minutes program, "Undermined"[101]. In the Four Corners program, Scott Lloyd, a Queensland farmer, reported that QGC wells on his property had been leaking since 2006, and gas that was originally coming from the well head was now "coming straight out of the ground all around the site".[102]

In Australia, a set of observations and research findings suggest that unconventional gas mining involving large numbers of wells with the associated depressurisation of coal seam aquifers could be causing uncontrollable, landscape scale venting of coal seam gases into the atmosphere. These gases potentially escape into the air via natural cracks and fissures in the rock strata, faulty cement bore casings, existing water bores, aquifers, old uncapped drill holes, cracks created by fracking and horizontal drilling, and direct seepage through the soil and rock strata.

In August 2012, a 30-year-old coal mining exploration hole in a CSG field, west of Dalby, was found to be alight with leaking methane.[103] In May 2012, Dayne Pratsky's video[104] recorded the large-scale venting of coal seam gases along a section of the Condamine River.

Leaking around the CSG wells on Scott Lloyd's property and in the Condamine River are only visible because the gases are bubbling through water, and the Dalby CSG leak was only detected because it ignited. There is no reason to expect that leaking coal seam gases are confined to the Condamine River, to puddles, or to old mining shafts. Rather, these observations complement research findings indicating that coal seam gases are venting across the countryside in Queensland gas fields.

Scientists from the Southern Cross University (SCU) reported very high levels of methane, CO2, and radon in the atmosphere across landscapes affected by CSG mining near Tara in Queensland.[105,106] The presence of methane and radon with a "chemical fingerprint" (i.e., methane-CO2 isotope ratio) confirming that they are from coal seams, can reasonably be interpreted as indicating the presence of other coal seam gases and substances. According to Dr Damien Maher, "We are talking about enrichment (levels of methane) over scales of 10, 15, 30 kilometres. So this suggests that we don't have just one leaking well, it suggests that we have got wide scale enrichment of atmospheric methane."[107]

Global atmospheric methane concentration has risen nearly 160% since pre-industrial times, to a current level of 1.8 ppm.[108] Santos and Maher (2012)[109] reported atmospheric methane concentrations in the range of 1.78 ppm to 1.94 ppm along the 500 km they drove travelling to the Tara gas fields. In the Tara area, they recorded methane concentrations three times higher than in surrounding countryside, with hotspot concentrations of methane as high as 6.89 ppm – a new "world record" that exceeded the previous highest reading of 2.89 ppm methane recorded in a Siberian gas field.

The SCU researchers reported that the chemical fingerprint of the atmospheric methane emissions in Tara were coal seam gases. Methane concentrations of 53 ppm were recorded over bubbles in the Condamine River, and chemical analysis confirmed that these were CSG.

The Australian SCU scientists also found atmospheric enrichment of radon gas and carbon dioxide in the Tara coal seam gas fields.[110] Continuous 24 hour air monitoring at sites inside and outside the gas field indicated a 3-fold increase in maximum radon within the field as compared to outside. Levels of both radon and CO2 were more elevated at night, indicating the need for continuous, rather than discrete sampling of air when testing for gas field pollutants. The researchers concluded that their findings pointed to the possibility that emissions in gas fields could be entering the atmosphere from both point sources, such as leaking wells and infrastructure, and from "enhanced diffuse soil gas exchange processes", which allow venting through the soil across the landscape.

Water Pollution

"However, the people of the Central Coast cannot be sacrificed on the altar of economic expediency. Their entitlement to clean, safe water must be paramount."…"It is well-known that in the northern Pilliga forest, massive environmental damage was caused by Eastern Star Gas at its Bohena No. 2 drill site as a result of exploration practices. Experiences in the USA, and in the State of Wyoming especially, clearly demonstrate disastrous problems associated with this industry through groundwater loss, contamination and waste water. Water is used extensively in gas exploration, as it is in gas mining and development…This is in a country that is short of water…Therefore the ground water issue is not an irrelevancy or one to be dismissed in a single rhetorical phrase. It is at the very heart of this debate."

Mr Chris Hartcher, NSW Resources Minister, Parliamentary Speech, 3 May 2005.[111]

"It is critical that any chemicals used in drilling and CSG well stimulation activities do not migrate to the bores of groundwater users. It is critical also that natural occurring chemicals and compounds in coal seams and strata formations are not mobilised to water aquifers tapped by water bores. Many homes use bore water, the livestock we eventually eat as steak, chicken, lamb and pork from supermarkets more often than not drink it, and the plants we grow for grain and vegetables soak up bore water through their roots and foliage systems under irrigation."
Ms A. Bridle's submission to the Senate Standing Committee Inquiry[112]

The lowering of water tables has been described as "a necessary process and an unavoidable impact associated with the depressurisation of the coal seam" by gas mining company Santos[113], and as a "reasonably foreseeable impact" by the Queensland Department of Infrastructure.[114]

In 2011 Bill Heffernan, the chairman of the Commonwealth Government Senate Committee said: "We don't want to look back in 50 years time and regret what we are doing. When the CSIRO tells the committee that we don't really know the long term impacts on the aquifers – it could take 300 years for some aquifers to recharge – these are all things that need to be understood before the industry goes ahead."[115]

But the impacts of coal seam gas mining on water systems involve more than the lowering of water tables and the depletion of bores used for domestic and agricultural purposes.

According to Shenhua Watermark Coal, a CSG company operating in Australia, "Drill holes or fractures may intersect with one or multiple aquifers potentially mixing groundwater from different strata or altering the groundwater chemistry through exposure to the air, gas, fracking chemicals and drilling fluids or the release of natural compounds like BTEX."[116]

As the Australian Government Senate report concluded, "there is a risk that residues of chemicals used in fracking may contaminate groundwater and aquifers used for human or stock consumption or irrigation. There are examples where water has been contaminated. It is acknowledged that in one case in Australia, fracking resulted in damage to the Walloon Coal measures, causing leakage between that and the Springbok aquifer."[117]

Potential pathways for contamination of ground and surface water include: leakage of drilling fluids from the well bore into near surface aquifers; ineffective, damaged or degraded pipe and cement barriers in well casings; contamination from flow back fluid; accidental spills of fluids or solids at the surface; surface and subsurface blow outs; industrial chemicals used in drilling and fracking remaining underground; naturally occurring contaminants finding their way into drinking water aquifers; and discharge of waste water into surface water or underground aquifers.

Accumulation of contaminants in aquifers can have long-term impacts. Studies on the transport and fate of volatile organic compounds have found that they can persist in aquifers for more than 50 years and can travel long distances, exceeding 10 km.[118] "Once a well is drilled, carcinogenic chemicals can leak out for years afterwards, and for wells in the catchment of urban water supplies this poses a huge long-term risk to public health."[119]

There are cases in the US[120,121] and in Australia[122,123] of gas field pollutants contaminating ground and surface water systems.

In the US, Osborn et al., (2011)[124] reported "systematic evidence for methane contamination of drinking water associated with shale gas extraction". In areas with one or more gas wells within 1 km, average (19.2 mg CH4 L^{-1}) and maximum (64 mg CH4 L^{-1}) methane concentrations in drinking-water wells increased with proximity to the nearest gas well, to a level indicating "a potential explosion hazard". In contrast, dissolved methane samples in neighbouring sites with no gas wells within 1 km, and within similar "geologic formations and hydrogeologic regimes", averaged only 1.1 mg L^{-1}.

In 2009, the US EPA sampled drinking water wells in Wyoming and detected chemicals in 11 of 39 wells tested, including 2-butoxyethanol, methane, and diesel range organics used in hydraulic fracturing.[125]

A 2013 US EPA investigation[126] of water contamination in 23 drinking water wells near a natural gas extraction site in Pavillion, Wyoming, concluded that both inorganic and organic compounds associated with hydraulic fracturing have contaminated the aquifer at or below the depths used for domestic water supply.[127,128] These substances included BTEX, isopropanol, diethylene glycol, triethylene glycol, tert-butyl alcohol and tert-butyl hydroperoxide plus diesel and gasoline organics. Detection of high concentrations of benzene, xylenes, gasoline range organics, diesel range organics, and total purgeable hydrocarbons in ground water samples from shallow monitoring wells near pits indicated that they were a source of shallow ground water contamination. Generally higher levels of dissolved methane were found in domestic wells that were in closer proximity to gas production wells. Residents were advised to use alternate sources of water for drinking and cooking, and to have adequate ventilation when showering.[129]

In Pennsylvania, Jackson et al. (2013)[130] found methane in 115 of 141 shallow residential drinking water wells in an area affected by shale gas mining. Methane was detected in 82% of samples, with average concentrations six times higher for homes less than 1 km from gas wells. Ethane was 23 times higher in homes less than 1 km from gas wells, and propane was detected in 10 water wells, all within approximately 1 km distance. The closer that people lived to a well that had been fracked, the more likely it was that their drinking water was contaminated with methane and other shale seam gases. Isotopic analysis indicated that the methane originated in the shale seams being mined.

In Australia, groundwater systems and bores have been contaminated by CSG operations. The Queensland government reported that during the first six months of 2011 there were forty-five CSG compliance-related incidents, including twenty-three spills of CSG water during operations, four uncontrolled discharges of CSG water, three exceedances of discharge limits, three overflows of storage ponds, and other incidents of BTEX contamination.[131]

Testing performed by the Queensland Department of Natural Resources and Mines found toluene and methane in a resident's private water bore.[132] In 2010, BTEX chemicals were found in 5 of 14 monitoring bores in gas fields near Dalby, with benzene being detected at levels between 6 to 15 times the Australian Drinking Water Guidelines (1 ppb).[133,134]

The ABC Four Corners program aired on 21 February 2011 reported an incident in which a bore was contaminated by CSG pollutants. As a result of persistent enquiries by resident Anne Bridle, gas company QGC admitted that it had "unintentionally provided a route for water in the aquifer, as well as the coal measures to enter the well."[135]

In addition to accidental contamination of groundwater, in Australia CSG mining pollutants have also been legally[136] and illegally[137] discharged into surface water systems.

In at least two Queensland CSG projects[138], permits have been given for release of CSG waste water into the Murray Darling river system.

As Lloyd-Smith and Senjen (2011) reported, in a permit for one CSG company,[139]

> "The release of treated water into the Condamine River was authorised for a period of 18 months at a maximum volume of 20 megalitres (ML) per day. Over 80 chemical compounds as well as radionuclides were listed in the permit and included a range of persistent, bioaccumulative toxic substances such as nonylphenols, bisphenol A (BPA), chlorobenzenes, bromides, lead, cadmium, chromium, mercury, BTEX. There was no requirement for an assessment of the cumulative load or the potential to contaminate sediment, plants, aquatic species and/or animals prior to release."[140] "The permits allowed the release of an unquantified and unassessed mixture of persistent toxic chemicals into a river used for irrigation and farming without any prior assessment of the cumulative chemical load or its possible long-term impacts on water quality, sediment, soil, stock and ecosystems."[141]

Lloyd-Smith and Senjen (2011)[142] calculated that for the 18 month period the CSG company was authorised to discharge the following quantities of chemicals and substances into the Condamine River – BPA (2.298 tonnes), bromide (76.65 tonnes), chlorobenzenes (20.148 tonnes), monochloramine (32.85 tonnes), nitrate (5,475 tonnes), uranium (219kg), toluene (8.76 tonnes), xylene (6.57 tonnes), ethylbenzine (3.285 tonnes), benzene (10.95kg), cyanide (876kg) and lead (109.5kg).

Ten thousand litres of CSG waste water leaked into the environment at the Narrabri CSG Project operated by Eastern Star Gas[143] – an incident that gas mining company Santos failed to report.[144] In the Northern Rivers, Metgasco was fined by the NSW EPA[145] after the company over a year illegally dumped at least 1,300,000 litres of CSG water into the Richmond River via the Casino sewerage plant.[146,147] When Metgasco was ordered to draw down an over full CSG dam in Casino they had no option for reducing the level of waste water, so the NSW Government permitted them to discharge a further five million litres into the Richmond River.[148]

Analysis of soil and water contaminated by wastewater spills in the Pilliga CSG operations in NSW found high levels of salts, and a variety of heavy metals including arsenic, lead and chromium, as well as petrochemicals.[149,150] Sampling of CSG released water from Bohena Creek in the Pilliga Forest detected methane at the Eastern Star Gas discharge site at 68 micrograms per litre (ug/l), whereas it was not detected in the upstream control sample."[151]

The CSG industry has touted the use of reverse osmosis filtration technology to render gas mining waste water safe for discharge into the environment, even though this form of filtration cannot remove all dangerous contaminants.[152] Chemicals that are unable to be successfully treated by reverse osmosis filtration include bromoform, chloroform, naphthalene, nonylphenol, octylphenol, dichloroacetic acid, trichloroethylene, tris (2-chloroethyl)-phosphate, and water soluble substances such as the methanol and ethylene glycol are also poorly removed.[153] A 2011 report showed that even after reverse-osmosis treatment, CSG wastewater being released into waterways in Queensland contained a range of toxic substances, including boron and cadmium.[154]

Soil Pollution

Soil contamination by gas mining contaminants can occur accidentally, via spillage or leakage of chemicals and wastewater, and deliberately, by spraying wastewater onto roads and disposing of drilling muds in landfills or by spraying them on agricultural or rural lands.

Morning dew on pastures is an unassessed potential pathway for gas mining air contaminants to pollute soils and to enter the human food chain. Nothing is known about the nature, quantity, or range of distribution of gas mining air pollutants that are dissolved in and transported by dew. Wind can deposit dust containing dried sediments from waste water ponds onto soils.

The transmission of dangerous substances to crops and livestock, and the ultimate potential impacts on the quality of food for human consumption, is unstudied and unknown.

Toxicologist, Dr David Brown (2013)[155] observed that finer particulates transported on the breeze from gas mining activities can be directly inhaled, whereas coarser particulates tend to fall to the ground where they are available for transportation into homes on shoes. Brown (2013) noted that vacuuming of the contaminated floor can mobilise these particulates into the air where they can be breathed in. Dr Brown recommended that people should not be allowed to wear shoes into residences in areas affected by gas mining.

Cases of Human Disease Associated with Gas Mining

Unconventional gas mining pollutants have complex differential health effects on individuals depending on such factors as: the toxicity of the pollutant; the concentration, duration and frequency of exposure; and the vulnerability of exposed people. Continuous monitoring of air quality, rather than discrete sampling, is necessary because weather conditions can affect the concentration of polluted air by a factor of up to 20 times, such that a reading of 2 parts per million (ppm) could be 200 ppm at a different time during the day.[156]

People with existing health problems, gas industry workers, children, and people who tend to be active outdoors are particularly vulnerable. Gas industry workers are at particular risk of exposure to pollutants absorbed through the skin and via inhalation, and their families can be exposed to hazardous substances transported home on clothing. Workers who do not wear appropriate protective clothing or use respirators and dosimeters, are potentially exposed to a greater unassessed risk.

In August 2008, Cathy Behr, an emergency room nurse in Colorado, almost died after treating a gas worker who had been splashed in a fracking fluid spill. A few days after Behr had stripped the man and stuffed his clothes into plastic bags she lay in hospital in critical condition suffering multiple organ failure.[157]

Esswein et al., (2013)[158], from the US National Institute for Occupational Safety and Health, collected 111 personal breathing zone samples at 11 gas drilling sites in 5 states and found that at every site full-shift samples exceeded occupational permissible exposure limits for crystalline silica air pollution, in some cases, by 10 or more times occupational health criteria. The level of exposure was sufficient to overwhelm the maximum use concentration ratings for the air-purifying respirators that workers typically wore.

Children are more at risk from gas mining pollutants than are adults, and due to their higher rates of exposure, children are often the first members of a family to become ill.[159,160] Children living in gas mining affected areas have been likened to "sentinels"[161], because their falling ill is likely to be the first indication of harm to human health. Relative to adults, children are closer to the ground and are more likely to be active outside. Children drink more water, breathe more air, and eat more food per kilo of body weight then do adults. Children have a longer "shelf-life", and their living longer than adults puts them at greater risk from illnesses such as cancer that develop many years after exposure to a pollutant.[162]

As was the case with thalidomide, a child is particularly sensitive to harm when exposed to pollutants during critical stages of physical development. There is little research examining the health impact of exposure to gas mining pollutants during critical developmental periods. A child's health can be affected by its mother's exposure during pregnancy, and even by the exposure of its mother and father prior to the child's conception.[163] Hill (2013)[164] found that infants born to mothers, who during pregnancy lived within 2.5 km of a shale gas well in Pennsylvania, weighed less and were more likely to have a low birth weight. Paulson (2013)[165] noted that children growing up in more polluted environments have smaller lungs at maturity, and this can make them more vulnerable to respiratory illnesses later in life.

Animals tend to suffer more direct exposure to environmental pollutants, and have shorter life and reproductive cycles, than humans. Illness in cows, horses, poultry, and other wildlife can foreshadow impacts to human health.

Bamberger and Oswald (2012) investigated the impact of gas drilling on animal health in six US states, and documented cases of reproductive (e.g., irregular cycles, failure to breed, stillbirths), neurological (e.g., seizures, incoordination, ataxia), gastrointestinal (e.g., vomiting, diarrhea), and dermatological (e.g., hair and feather loss, rashes) problems among livestock exposed to gas mining contaminants.[166] Bamberger[167] described cases of cows that died within one hour after exposure to diluted fracking fluid, while other cattle nearby who were not exposed remained healthy. Bamberger noted that no one is testing the quality of beef and agricultural produce that comes out of gas field affected farming areas, and she queried the safety of feeding pigs and chickens with the rendered flesh of animals that grazed pastures in such areas.

In a case described by Bamberger and Oswald (2012)[168], reports of local animal deaths following gas drilling prompted a doctor to order tests that led to a diagnosis of arsenic poisoning in a child who had been exposed to misted wastewater (misting is used in the US to accelerate evaporation of wastewater). The child, who lived less than 1 mile from a well pad, became unwell with fatigue, severe abdominal pain, sore throat and backache, and after admission to hospital six months later with delirium tested positive for arsenic poisoning. The families of this child and another family 1 mile away were monitored and urine tests revealed high levels of phenol, a metabolite of benzene, which was consistent with their reported symptoms of headaches, fatigue, nosebleeds, rashes, loss of smell and hearing. The affected people were advised to move away. Those who did got better, while those who stayed got worse.

Health researchers are reporting similar symptom clusters across diverse communities that live near unconventional gas operations. US researcher Ronald Bishop (2011)[169] tentatively identified as "down-winder's syndrome", symptoms reported in studies in Texas[170] and Wyoming[171], which included irritated eyes, sore throat, frequent intense headaches, nosebleeds, skin rashes, peripheral neuropathy, lethargy, nausea, reduced appetite and mental confusion.

Steinzor et al (2013)[172] investigated symptoms suffered by people living in proximity to gas facilities in Pennsylvania. The 25 most prevalent individual symptoms among all participants were increased fatigue (62% of respondents), nasal irritation (61%), throat irritation (60%), sinus problems (58%), eyes burning (53%), shortness of breath (52%), joint pain (52%), feeling weak and tired (52%), severe headaches (51%), sleep disturbance (51%), lumbar pain (49%), forgetfulness (48%), muscle aches and pains (44%), difficulty breathing (41%), sleep disorders (41%), frequent irritation (39%), weakness (39%), frequent nausea (39%), skin irritation (38%), skin rashes (37%), depression (37%), memory problems (36%), severe anxiety (35%), tension (35%), and dizziness (34%). Many symptoms showed a strong statistical association between the rate of symptom reporting and how close affected people lived to oil and gas facilities.

Illnesses, including cancer, which can take years to develop, have been associated with exposure to gas mining pollutants. Lefall et al. (2010)[173] compared nationwide cancer mortality statistics with the incidence of cancer in three New York counties that had a distinctively rural character and a history of intensive gas and oil industry activity. Based on nation-wide statistics from 1950 to 1994 for 55 different types of cancer, women in these three counties were consistently in the top bracket for deaths caused by cancer of breast, cervix, colon, endocrine glands, larynx, ovary, rectum, uterus and vagina. Men from the same region were consistently in the highest statistical bracket for deaths caused by bladder, prostate, rectum, stomach and thyroid cancers.[174]

In Texas, emissions from shale gas operations are being checked for contaminants after blood and urine samples taken from household residents near shale wells revealed that toluene was present in 65% of those tested and xylene present in 53%.[175]

In Australia, the residents of estates near Tara on the Western Downs of Queensland have become involuntary subjects in a de facto experiment on the health effects of living amongst CSG gas fields. Gas drilling commenced in the area in 2006, and since 2008 residents have been complaining of symptoms that, as Dr Helen Redmond noted, are similar to the symptoms reported in communities living near US gas fields.[176]

In 2013 medical tests found a high level of hippuric acid, a metabolite produced following exposure to toluene, in the blood of a young boy who lived in the Tara estates.[177] In 2013, Dr Geralyn McCarron obtained information from 113 people (48 younger than 18 years, 65 adults) from 35 households in the Tara residential estates and the Kogan/Montrose region, and from three families who had left the area.[178,179] 58% of surveyed residents reported that their health was definitely adversely affected by CSG mining, and a further 19% were uncertain. The reported symptoms were outside the scope of what would be expected for a small rural community, and resembled the “down-winder’s syndrome” found in overseas communities exposed to gas mining pollutants.

In the McCarron (2013) Tara study, there were reported increases across all age groups in coughing, chest tightness, rashes, difficulty sleeping, joint pains, muscle pains and spasms, and nausea and vomiting. Approximately one third of people over 6 years of age were reported to have spontaneous nose bleeds, and almost three quarters were reported to have skin irritation. Over half the children were reported to suffer eye irritation. A range of symptoms were reported which can be related to neurotoxicity (i.e., damage to the nervous system), including severe fatigue, weakness, headaches, numbness and paraesthesia (i.e., abnormal sensations such as pins and needles, burning or tingling).

The illnesses of children documented in the McCarron (2013) study were cause for particular concern. Approximately a third of all 48 children to age 18 years (15/48) reported symptoms of paraesthesia. Almost all the 31 children aged 6-18 were reported to suffer from headaches, and for over half of these children the headaches were severe. Parents of a number of young children reported twitching or unusual movements, and clumsiness or unsteadiness.

For the 31 children aged 6 to 18 years there was a marked change in reported symptoms following the commencement of CSG mining in the area. Before mining, 90% never and 10% only occasionally suffered nosebleeds, while after mining 32% occasionally and 29% often suffered nosebleeds. Before mining, no child reported constant severe headaches, and only 3% reported often suffering severe headaches. After CSG, 36% reported often and 13% reported constantly suffering severe headaches. Before CSG, no child reported often or constantly suffering skin irritation, but after CSG 19% reported often and 29% reported constantly suffering skin irritation. Before CSG, 97% of children reported that they never experienced symptoms of paraesthesia. After CSG, 22% and 10% of children respectively reported occasionally and often experiencing paraesthesia symptoms. 97% of children reported that they never suffered nausea prior to CSG, and after CSG 23% reported often and 3% reported constant symptoms of nausea.

A before and after CSG mining comparison was not possible for the 17 youngest children in the 0 to 5 age group. The health concerns reported by parents of these children included (with number of children suffering the symptom in parentheses): twitching and unusual movements (6), poor colour/blueness of mouth or limbs (6), blood from the nose (9), headaches (8), tingling/numbness/ pins and needles (5), unusual clumsiness or unsteadiness in children who were walking (5), unexplained inconsolable crying (10), rashes (11), unusual irritability (10), unusual lethargy (7), eye irritation (11), streaming eyes (8), cough (5), difficulty breathing (2), sore limbs (6), muscle spasms (3), and burning nose (7).

Statistics inform thinking about health risks, but they can dull our emotional sensitivity to the suffering borne by real families and their children. Parents' comments about their children's health problems in Tara provide a disturbing glimpse into what life is like for families who have to live among heavily industrialised gas fields.

What peace of mind is possible for parents in a place where children come in from playing outside with nosebleeds if the wind comes from a particular direction, or where an adolescent suffers nosebleeds every day for three months? What is the quality of life for the Tara children and adults who have to avoid going outdoors?

For many of the children surveyed in Tara it is now normal to wake out of sleep with headaches, and an infant was reported to wake screaming, feeling that he has to dip his fingers in water. Some children constantly rub their fingers and complain of ants in their hands. Eye and skin irritation, sometimes so severe that children feel as if they could rip their skin, has become a constant background complaint. Infants, children and adults alike suffer from headaches, some of which are so intense that they have been investigated with CT scans and lumbar puncture. For many residents, extreme fatigue and having difficulty focusing and concentrating are persistent debilitating symptoms. Undiagnosed coughs, repeated diagnosis of "flu", pneumonia, pleurisy and exacerbation of asthma are recurring experiences.

Senses of taste and smell, tuned by evolution, protect us from potentially dangerous foods and substances, and the detection of odours as a potential health issue has been investigated.[180]

In Tara, residents reported that their symptoms were worse when odours were present, and some people could identify distinct individual odours at different times, variously described as "rotten eggs, sickly sweet, like pine tarsal, acetone, creosote, after burn from cigarette lighter." Many people noted an association between their symptoms and the wind blowing from CSG waste water ponds. Some people commented on the link between road spraying and their symptoms. Children and adults complained of a recurring metallic taste which made them nauseous.

The children surveyed in Tara miss a lot of school. Sleep disturbance is endemic within the families surveyed, and many people directly related their sleep problems to the noise and vibrations from CSG traffic, drilling operations, and compressor stations. For others, sleep was disturbed by the constant strain of living and dealing with the impact of CSG on their lives, and the helplessness they felt from being unable to protect their children from illness.

The situation in Tara provides compelling evidence that operating gas fields in populated areas poses a significant risk to human health. It is undeniable that the gas mining industry uses and liberates many dangerous substances from coal seams. In Tara, the potential for humans to come into contact with these dangerous substances via contaminated air, water, and soil is substantial and well documented. In fact, these pathways to contamination are guaranteed by government policies which permit discharges of large quantities of dangerous substances into the environment. The health problems of the Tara residents mirror the "down-winder's syndrome" seen across gas field affected communities in the US, and are consistent with the effects of exposure to pollutants known to be present in the local environment. People who live where unconventional gas is mined and processed pay a high price.

Protecting Your Family's Health

Governments and industry plan to massively expand unconventional gas mining, and protecting your family's health is going to be an ongoing challenge.

Be informed, keep yourself up-to-date regarding local developments, and take action as soon as you can. Keep a written, dated record of observations you make, actions you take, or any other things that might be relevant.

Understand the health risks

To better protect your family's health you need to understand the nature of the risks so that you can recognise potential dangers. You have read the current report, and you can download copies of many of the referenced research papers, videos, and other information. There are also many other avenues to do your own research.

Assess the level of threat – Do you need to be concerned?

Once you understand the nature of the threat, do your own risk assessment. Ask whether there is any real chance that your family's health could be affected by unconventional gas mining now or in the future. Generally, the risk is greater for people who work in the industry and for people who live near to gas mining operations. The level of risk is likely to be highest in areas of intense gas mining activity and minimal where there has been no gas mining and none is planned. In many areas, such as the Northern Rivers which has about 60 capped CSG wells but no current mining, the level of risk needs to be assessed case-by-case.

In assessing risk you might consider the following questions: How near are you to gas mining operations such as wells, processing plants, evaporation ponds, compressor stations, vents or flares? Are any local active or capped wells leaking coal seam gases? (Tip – Look for bubbles around the well when it is raining and the ground is wet) Do you live upstream or downstream from gas fields? Do you ever notice odours when the wind is coming from a gas field?

Remove or avoid dangers

Think about how you can minimise your family's exposure to gas field pollutants and other potentially harmful industrial processes. For example, you might insulate your house against noise, avoid outside odours, use air conditioners during odour events, leave foot wear outside the house, avoid raising dust within the house, use damp cloths for dusting, consider using hepa filters on your vacuum cleaner, test the quality of the water you use for drinking and showering, use first pass filters for collected rain water, filter drinking water, etc.

You might consider writing to your local member of parliament and to the Government to express your concerns and to ask that they require proper risk assessments and health impact studies before approving CSG or Shale Gas developments. If they have not already received this report, perhaps you could send them a copy.

If you are harmed, seek prompt treatment

The current report and many of the referenced resources will be sent to medical practitioners. If your doctor has not received this information, you might pass it onto them.

Nurse/practitioner Ms Denise DeJohn from the South West Pennsylvania Environmental Health Project[181] recommended that individuals keep a health diary in which they record health issues and associated environmental conditions (e.g., wind direction, odours, time of showering etc). Ms DeJohn advised patients not to request from their doctor a battery of tests because it is not possible to know which chemicals are involved, some chemicals have no specific identifying tests, and the half life of many chemicals is too short to catch with testing.

Use the Health Questionnaires

The Health Impacts Report and associated questionnaires are educational materials only, and are not any form of medical or legal advice. You might use these materials to help you assess gas mining risks to health, and to plan how you can better protect your family from possible harm.

You should discuss with your family doctor any concerns that you have about your mental or physical health, including any symptom in the questionnaires or change in your health status. These self-help risk assessment materials are not a substitute for any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community.

No guarantee is given or implied that the completed questionnaires carry any legal weight, and you should seek professional legal advice for any concerns that you have.

If repeated at intervals, should gas development occur, the questionnaires can provide either ongoing reassurance of a clean bill of health, or alternatively early recognition of a significant change in health status.

You might consider reviewing the questionnaires at least once a year, or more frequently if there are changes in gas field activities in your area. You might also consider having your dated completed questionnaires signed and witnessed by someone who could attest to the accuracy of your responses. It is important that you give your doctor any information that might assist diagnosis. Discussing changes in your health status could allow this information to be recorded in your medical files.

The report and associated questionnaires are provided free of charge in the interests of community health. You can copy and distribute this document provided that the materials are reproduced in full, without alteration and with all citations and references, and no fee is charged.

Copies of these materials and many of the referenced publications are available for download by clicking the links on Page 41 “Selected References on Gas Mining Health Impacts”.

Symptom Checklist

The Symptom Checklist is educational material only, and is not any form of medical assessment, advice or treatment. This checklist is intended to be used as a tool for self-directed assessment and management of possible health risks associated with exposure to unconventional gas mining pollutants and processes. The information you record in this checklist could potentially be useful in alerting you to any change in your health status. In all cases, you should discuss any concerns that you have about symptoms or your mental or physical health with your family doctor. It is recommend that you avail yourself of any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community. No guarantee is given or implied that the completed questionnaire carries any legal weight, and you should seek professional legal advice for any concerns that you have regarding legal matters.

The Symptom Checklist is provided free of charge in the interests of community health. You can copy and distribute this checklist provided that it is reproduced in full. Please note that there is no Medicare item for a doctor to review the Symptoms Checklist or any other associated questionnaire or checklist.

The Symptom Checklist consists of symptoms reported in: McCarron, G. (2013) Symptomology of a Gas Field: An Independent Health Survey in the Tara Rural Residential Estates and Environs; and the 25 most commonly reported symptoms in Steinzor, N., et al. (2013) Investigating Links Between Shale Gas Development and Health Impacts Through a Community Survey Project in Pennsylvania, *New Solutions,* Vol. 23(1) 55-83, 2013.

The symptoms in the checklist are grouped in no particular order, and do not represent any comprehensive or characteristic listing of symptoms associated with exposure to gas field pollutants and processes. The full nature and extent of acute and long-term health impacts from operating gas fields in populated areas are uncertain. It is reasonable to assume that exposure to gas field pollutants and processes could result in symptoms of illness that are not represented in this symptom checklist.

	No	**Yes**	**Comment**
Skin rashes			
Pealing skin			
Skin irritation – discomfort, sensitivity, itch, inflammation of skin without visible rash.			
Pins and needles			
Paraesthesia (abnormal sensations such as burning or tingling)			
Chest discomfort			
Chest tightness			
Severe chest pain			
Difficulty breathing			
Cough			
Shortness of breath			
Asthma			
Lethargy			

	No	Yes	Comment
Severe fatigue			
Feeling weak			
Nasal irritation			
Burning nose			
Throat irritation			
Sinus problems			
Eyes burning			
Running or streaming eyes			
Eye irritation			
Joint pain			
Sore limbs			
Mild headaches			
Severe headaches			
Spontaneous nose bleeds			
Disturbed sleep			
Insomnia			
Waking at night in distress			
Depressed mood			
Severe anxiety and tension			
Frequent irritability			
Feelings of helplessness & hopelessness			
Lumbar pain			
Muscle aches and pains			
Muscle spasms			
Joint pain			
Sore limbs			
Numbness			
Nausea			
Memory problems			
Difficulty concentrating			
Dizziness			
Nausea			
Vomiting			
Metallic taste in the mouth			
Twitching & unusual movements			
Poor colour/blueness of mouth or limbs			
Clumsiness or unsteadiness			
Constantly rubbing fingers			
Sensations of ants in hands			

Name: Date of Birth: Date:

Signed by: Name of witness:

Date: Signature of witness:

Exposure to Gas Mining Questionnaire

The exposure to Gas Mining Questionnaire is educational material only, and is not any form of legal advice or medical assessment, advice or treatment. The questionnaire might assist you in self assessing your potential exposure to risks associated with unconventional gas mining activities, and could be useful in the medical diagnosis of any change in your health status.

In all cases, you should discuss any concerns that you have about symptoms or your mental or physical health with your family doctor. It is recommend that you avail yourself of any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community. No guarantee is given or implied that the completed questionnaire carries any legal weight, and you should seek professional legal advice for any concerns that you have regarding legal matters.

The Exposure to Gas Mining questionnaire is provided free of charge in the interests of community health. You can copy and distribute this checklist provided that it is reproduced in full. Please note that there is no Medicare item for a doctor to review this questionnaire or any other associated checklists or materials.

♦

Name: Date of Birth: Date:

Signed by: Name of witness:

Date: Signature of witness:

***

Have you worked in the gas, coal or oil mining industries? (Circle one) **YES / NO**

If YES, when, how long, and what did you do in the mining industry?

Have you worked with toxic substances? (e.g., agricultural or industrial chemicals) **YES / NO**

If YES, please give details:

Do you live near gas drilling activities? **YES / NO**

If YES, approximately how close do you live?

What are the type(s), location(s) or name(s) (if known) of the gas extraction or processing operations you live near? (e.g., drilled wells, capped wells, compressor station, pipeline, waste water pond, refinery):

The approximate date(s) that well drilling activities began near to where you live:

Approximately when did the different stages of drilling activities occur and what stages are they in at present (e.g., seismic testing, drilling, fracking, flaring, well capping etc):

Have there been any incidents such as spills that have occurred near to where you live?

YES / NO

If so, please describe the incident(s) with approximate date(s):

Do you live within 300m of a road used to service a drilling site? **YES / NO**

Do you live near a road that has been sprayed with CSG waste water? **YES / NO**

WATER (Mark with tick √)

Water in my home is from: private bore __ town water __ rainwater tank __ creek/river __

My drinking water is from: private bore __ town water __ rain tank __ creek/river __
filtered tap __ bottled __

My cooking water is from: private bore __ town water __ rain tank __ creek/river __
filtered tap __ bottled __

My water for bathing is from: bore __ rain tank __ town water __ creek/river __ other ___

Water for my animals is from: bore __ rain tank __ town water __ creek/river __ other __

Have you noticed changes in your water? **YES / NO**

If YES, specify visible changes, tastes and odours and when the changes occurred:

Has your water ever been tested by a laboratory? **YES / NO**

If YES: Date(s) Who tested?

AIR

Do you experience unusual odours in the air? **YES / NO**

If YES, when did you notice them the first time?

How frequently do you experience them?

Please describe the odours:

If you know or suspect where or what facility the odours are coming from, please describe:

Have you had any laboratory testing of either your indoor or outdoor air? **YES / NO**

If YES: Date(s): Who tested:

♦

CSG Concerns Questionnaire

The CSG Concerns Questionnaire is educational material only, and is not any form of medical assessment, advice or treatment. The questionnaire could help you to self-assess the level of stress you are experiencing in relation to potential stressors associated with unconventional gas mining activities. The information you record in this questionnaire could potentially be useful in helping you to better understand factors that could be contributing to symptoms of emotional distress. In all cases, you should discuss any concerns that you have about symptoms or your mental or physical health with your family doctor. It is recommend that you avail yourself of any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community. No guarantee is given or implied that the completed questionnaire carries any legal weight, and you should seek professional legal advice for any concerns that you have regarding legal matters.

The CSG Concerns Questionnaire is provided free of charge in the interests of community health. You can copy and distribute this checklist provided that it is reproduced in full. Please note that there is no Medicare item for a doctor to review this or any other associated questionnaire or checklist.

The concerns listed in this checklist are grouped in no particular order, and do not represent any comprehensive or characteristic listing of concerns that people have regarding gas field industrialisation. The acute and long-term mental health impacts associated with operating gas fields in populated areas are uncertain and largely unstudied. It is reasonable to assume that this list of concerns is incomplete and does not represent a typical, or any individual's experience.

Please note that there is no specific Medicare item for a doctor to review this or other related checklist and questionnaires.

Name: Date of Birth: Date:

Signed by: Name of witness:

Date: Signature of witness:

♦

Concerns about CSG and Shale Gas Mining

Please use the following scale to rate the level of stress you feel regarding CSG or Shale Gas activities:

0------------1------------2------------3------------4------------5------------6------------7------------8

0	2	4	6	8
No Problem	Mild Stress	Moderate Stress	Severe Stress	Very Severe Stress

	Stress Rating (0 – 8)
Health symptoms I am experiencing	Stress rating =
Health symptoms that family members or friends are experiencing	Stress rating =
Health of my animals	Stress rating =
Quality of my water	Stress rating =
Quality of the air	Stress rating =
Odours	Stress rating =
Noise	Stress rating =
Traffic	Stress rating =
Personal safety, or safety of family members or friends	Stress rating =
Loss of control over access to property	Stress rating =
Loss of right to quiet enjoyment of property	Stress rating =
Diminished quality of lifestyle	Stress rating =
Noise and light pollution	Stress rating =
Loss of land value	Stress rating =
Lack of adequate compensation	Stress rating =
Compromised livelihood from loss of productive agricultural land	Stress rating =
Politicians’ attitudes	Stress rating =
Damage to privately owned assets and small business	Stress rating =
Sense of violation of “Mother Earth”	Stress rating =

Please use the following scale to rate the level of stress you feel regarding CSG or Shale Gas activities:

0------------1------------2------------3------------4------------5------------6------------7------------8

0	2	4	6	8
No Problem	Mild Stress	Moderate Stress	Severe Stress	Very Severe Stress

Stress Rating (0 – 8)

Sense of powerlessness to protect your natural environment Stress rating =

Grief over loss of “Nature's gifts of beauty rich and rare” Stress rating =

Guilt over inability to avoid harm Stress rating =

Powerlessness from negotiating with powerful companies Stress rating =

Guilt over effects on neighbours from signing access agreements Stress rating =

Further comments:

The DASS-21 Questionnaire

The Depression Anxiety Stress Scale-21 (DASS-21) is a standardised assessment of symptoms of emotional distress used by health professionals.

The DASS may be administered and scored by non-psychologists, but decisions based on particular score profiles should be made only by experienced clinicians or physicians who have carried out an appropriate clinical examination.

As used here, the DASS-21 questionnaire is educational material only, and is not any form of medical assessment, advice or treatment. The questionnaire is to be used as a tool for self-directed assessment and management of possible health risks associated with exposure to unconventional gas mining pollutants and processes. The information you record in this checklist could potentially be useful in alerting you to any change in your emotional functioning. In all cases, you should discuss any concerns that you have about symptoms or your mental or physical health with your family doctor. It is recommend that you avail yourself of any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community. No guarantee is given or implied that the completed questionnaire carries any legal weight, and you should seek professional legal advice for any concerns that you have regarding legal matters. Please note that there is no Medicare item for a doctor to review this or any other associated questionnaire or checklist.

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DASS21

Name: *Date:*

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1	I found it hard to wind down	0	1	2	3
2	I was aware of dryness of my mouth	0	1	2	3
3	I couldn't seem to experience any positive feeling at all	0	1	2	3
4	I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5	I found it difficult to work up the initiative to do things	0	1	2	3
6	I tended to over-react to situations	0	1	2	3
7	I experienced trembling (eg, in the hands)	0	1	2	3
8	I felt that I was using a lot of nervous energy	0	1	2	3
9	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10	I felt that I had nothing to look forward to	0	1	2	3
11	I found myself getting agitated	0	1	2	3
12	I found it difficult to relax	0	1	2	3
13	I felt down-hearted and blue	0	1	2	3
14	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15	I felt I was close to panic	0	1	2	3
16	I was unable to become enthusiastic about anything	0	1	2	3
17	I felt I wasn't worth much as a person	0	1	2	3
18	I felt that I was rather touchy	0	1	2	3
19	I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)	0	1	2	3
20	I felt scared without any good reason	0	1	2	3
21	I felt that life was meaningless	0	1	2	3

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