Limestone Coast Protection Alliance Inc.

Save our water, soil and air from invasive mining & industrial gasfields

www.protectlimestonecoast.org.au

Email: secretary@protectlimestonecoast.org.au

Senate

Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

May, 2015

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Senate
Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

The private senator's bill proposes to make gas or coal mining activities undertaken without prior written authorisation from landholders unlawful and would ban constitutional corporations from engaging in hydraulic fracturing operations (fracking) for coal seam gas, shale gas and tight gas

The Limestone Coast Protection Alliance offer our submission into this inquiry divided in the following sections.

Contributors:

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Prime Agricultural land covers only 4% of Australia's land area and is essential to our long term survival.

We believe that this Bill, which proposes to make gas or coal mining activities undertaken without prior written authorisation from landholders unlawful, will ensure that prime agricultural land is protected for food production.

Furthermore, this Bill which places a ban on constitutional corporations from engaging in hydraulic fracturing operations (fracking) for coal seam gas, shale gas and tight gas, will ensure that our landscapes, water, soil, air quality and the health of people and animals is protected.

Hydraulic fracturing and coal mining are industrial processes with a massive environmental footprint and significant potential to contaminate our air, soil and water and have an impact on our landscape. In view of the potential, long term and serious risks of hydraulic fracturing we support this Bill.

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About us:

In 2013, a group of Kingston & Robe residents & ratepayers' re-formed Limestone Coast Strike Out Alliance Incorporated (LCSOA). The primary objective of the group was to raise awareness amongst the local community of the potential risks that Strike Energy mining activities may pose to the Limestone Coast region. Strike Energy at that time had a licence over the lignite coal deposit north of Kingston, and if this mine went ahead it could have put Kingston's water supply at risk, potentially drying up bores of surrounding farms and houses, leading to salt water intrusion and contamination of groundwater.

In 2014, the LCSOA recognised that the whole of the Limestone Coast is covered by Petroleum Exploration Licenses (PEL) and we changed the name to Limestone Coast Protection Alliance Inc (LCPA) although the goal continues to be to raise awareness of the potential risk gasfields and invasive mining projects have for the region which is only 2.2% of the State's land area, but contains over 40% of the state's prime agricultural land.

In 12 months, LCPA has built up a solid reputation and membership has risen from 11 to over 400. We have worked with our seven local councils, as well as the South East Local Government Association (SELGA) to raise awareness of the potential losses gas mining projects would pose for our groundwater, land, air quality and health. In June 2014, SELGA formally passed a motion asking for a moratorium on unconventional gas and fracking in the Limestone Coast and each individual council has passed similar motions either asking the State government for a moratorium or an Inquiry for further information.

In September, LCPA presented a petition to the Legislative Council containing 2795 signatures asking for 'landholders to have the rights to say no to gas and mining projects on their land'. This has seen overwhelming majority support from the community, both rural and city.

In October 2014, the District Council of Robe was the first SA council to be presented with Gasfield Free community declarations. On Australia day, 2015, the LCPA was awarded the Mayoral community event of the year – for this declaration day ceremony – by the District Council of Robe.

In May 2015, the Limestone Coast has 25 communities self-declared Gasfield Free. Over all, in these local communities 96% of people are opposing gas fields and mining projects.

LCPA statement "Our concern is Australia has very little prime agricultural land to grow clean and green food. If these coal and gas projects went ahead potentially it will have detrimental effects on our ground water, land, businesses, tourism & health (people, livestock, pets, wildlife)."

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Senate

Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

SECTION 1: Summary

Limestone Coast Protection Alliance Inc.

THE PRIVATE SENATOR'S BILL PROPOSES TO MAKE GAS OR COAL MINING ACTIVITIES UNDERTAKEN WITHOUT PRIOR WRITTEN AUTHORISATION FROM THE LANDHOLDERS UNLAWFUL.

The Limestone Coast Protection Alliance Incorporated welcomes the opportunity to place a submission for the Inquiry into the Landholders' Rights to Refuse (Gas and Coal) "The private senator's bill proposes to make gas or coal mining activities undertaken without prior written authorisation from landholders unlawful and would ban constitutional corporations from engaging in hydraulic fracturing operations (fracking) for coal seam gas, shale gas and tight gas."

Our submission is written regarding the South East of South Australia as this is the area in which we reside and are familiar with. The Limestone Coast consists of 2.2% of the state but contains over 40% of the state's prime agricultural land.

The South East of South Australia is a highly productive "food bowl". Much of the area has very fertile soils involving a vast array of agricultural activities. Where the soil is lighter it is still very productive due largely to the availability of ground water.

Almost all of the South East of South Australia is covered in mining or gas licences.

The majority of the agricultural land in the South East of South Australia, if not all of it, is privately owned freehold. These farms have often been owned by the same family for generations. The ability of the area to sustain this generational family farming has meant the local communities generally thrive.

These farms are not only a source of income to the families that own them, they also supply employment to many others. Some are employed on the farms themselves others are contractors such as shearing and fencing teams, and harvesters. Others are employed due to the farming properties of the region such as veterinarians, stock agents, rural merchandise agents, machinery dealers, mechanics, fuel depots, livestock and general transport. This in turn enables a whole range of other businesses to operate in these rural communities which then allows schools & hospitals & emergency services to remain open in the general area. Agriculture generates entire communities to prosper sustainably.

To allow one industry to effectively step in over another industry as mining and gas have been doing to agriculture is completely wrong and generally not accepted as a lawful dealing usually. However in Australia it is considered irrelevant that a landowner has paid a considerable amount of money for land, has often invested countless hours of time and energy maintaining and improving that land or even that the land is the family home. This occurs because the Crown owns the mineral and petroleum rights, therefore with little regard to the fertile top part of the land, mining companies can move in on privately owned land and basically dig it up and place any infrastructure on that property they please with very little compensation to the landowner and very little regard for the disruption this may cause the existing business. It makes a mockery of freehold land.

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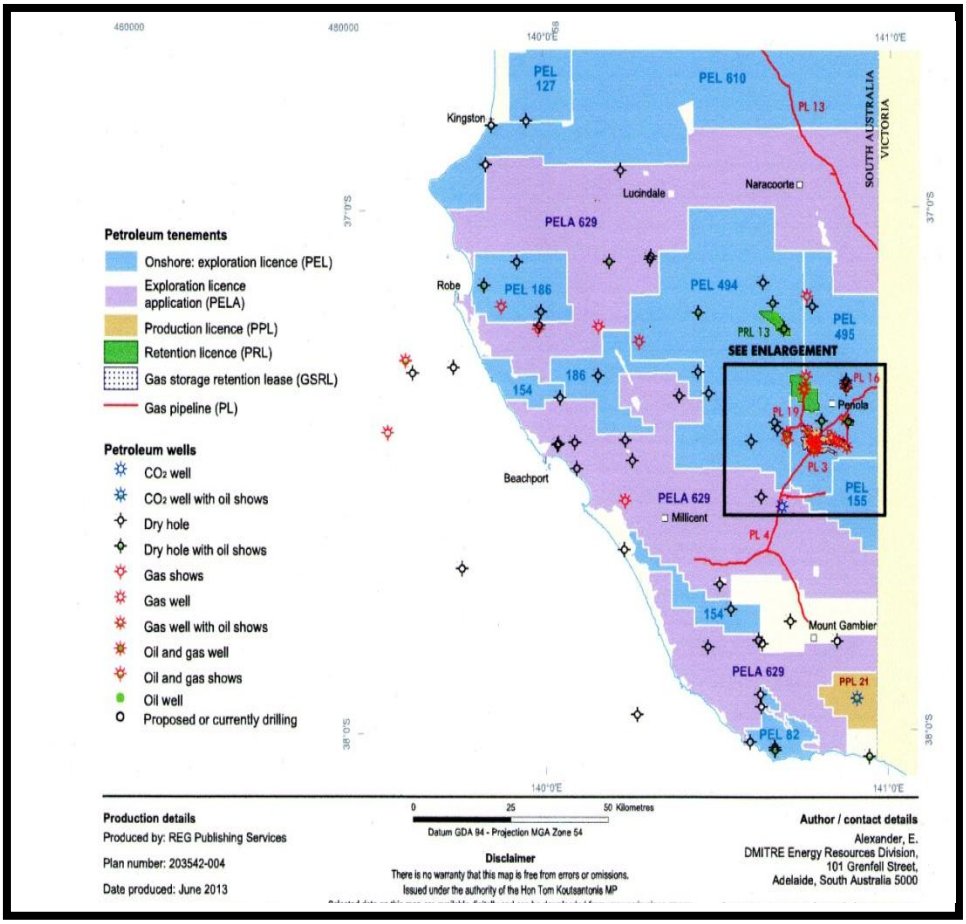
Map of PELs in SE of SA



This causes great angst and anxiety amongst the farming communities. It is not only the people that own the land that are affected by gas and mining companies taking over farming property but also the entire community in which the property owners live.

Doubt lingers as to whether this property now competing for the land and water with a gas or mining company can continue as a thriving business. If there is to be any soil, air or water contamination the farming business cannot survive as it was. Land prices devalue, the property possibly is no longer a saleable item. Insurance companies and banks may also have concerns about being involved with a property now exposed to a gas or mining company's activities.

Compensation could never be adequate. For a gas or mining company to purchase land at its current market value, even if some more is paid, it goes nowhere near compensating the value of that property if it had been left as a farming property for generations. True monetary compensation should cover the market value of that property and the income it would have generated for the current owners for the term of its natural life. It goes nowhere near compensating the community that has families move away, no longer able to afford to live in the area or gain employment. It goes nowhere near compensating the people of Australia for losing their skilled and knowledgeable farmers. It goes nowhere near

compensating the people of Australia for the food, wine, seeds and fibre once grown in abundance in their own country.

It simply is not sustainable to have productive farming land taken over and become gasfields or coal mines. This land is unlikely to be rehabilitated sufficiently to produce food again. The soil structure is too often changed to a degree that won't allow it to be fertile again. The water of the region may be over allocated or contaminated. Healthy soil and water are basic requirements of food production. Food and clean water are basic requirements of human survival and yet Australia seems willing to risk these basic requirements in a rush to sell the country's resources.

We need to show greater respect for the land, river systems and ground water to protect agriculture, rural communities and existing rural businesses for Australia to be able to sustain or increase food production for the future. We need to value healthy soil and water to continue producing food. Australia cannot afford to allow invasive mining or unconventional gas practices to encroach upon productive agricultural regions any further than they have already.

The agricultural industry has to abide many regulations to ensure the environments health. There are strict penalties for landholders that clear vegetation without written authorisation. Water is available through allocation processes so it is a sustainable resource. Gas and mining companies often appear to be exempt from similar rules and regulations, even though they may be on the same land where these rules exist for the landholder. This gives them unfair advantages over agriculture and other land users.

Livestock producers are required by law to complete a National Vendor Declaration (NVD) whenever a livestock sale is to take place. The NVD form must state amongst other things that the livestock have no unacceptable residues after consuming conventional stock feeds including pasture and stubble. Signing the NVD as a livestock transaction takes place has legal significance, regulatory authorities may take legal action and purchasers may seek damages if any information is found to be incorrect. How is a landholder who has effectively lost control of what occurs upon his or her land to a gas or mining company able to comply with this legal requirement of livestock sales?

Gas and mining companies are often reported to have not followed due process and are responsible for clearing trees and vegetation, spreading weeds and disease over properties by not following wash down procedures on vehicles and machinery as they move between properties.

The additional traffic caused by gas and mining activities upon properties can create soil erosion problems. Damage can be caused to crops and pastures. The increased traffic, noise, lights, infrastructure and general activity on a property can interfere with necessary farm life such as movement of livestock and successful birthing.

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Existing legislation and regulation does not protect the interests of landholders, the environment or sustainable development.

Landholders should definitely have the right to refuse gas and coal mining activities upon their properties. It is in Australia's national best interest that they do so.

Health Risks

The common health threats recognised in such circumstances have included:

1. The psychological threat to farmers (not to mention other local stakeholders like local towns) that their previously very pure water supply - a previous 'given' on which they have built their lives and their livelihood - is under threat, both in quantity and quality.

    a. In the Limestone Coast, the water that six towns, and about 20,000 people rely on (for stock, irrigation, drinking, washing) comes from a 'confined aquifer' about 70m below ground. This is old water, which has filtered over thousands of years through limestone, originating in Victoria and flowing ultimately into the sea; it is not replenished from surface run-off. There are also 'surface aquifers' that are only about 6-10m below the surface and are replenished by local rain.

    b. Added to this has been the perception that the gas companies are all-powerful and that the farmers feel powerless; additionally, they have felt their government was supporting the threat against them, to the extent of giving the threat itself an exemption from the protective laws with which they themselves have always had to comply.

2. The health hazards associated with contamination. Such health hazards may be present soon or later, indefinitely into the future; they may include both known and unknown hazards, due to both known and unknown toxins and physical hazards, with known and unknown effects. They can include the effects of heavy metals, radioactive materials, petrochemicals, and of the large number of toxic chemicals used by the gas companies in preparing and using 'slick-water'. Effects on people in Australia and other parts of the world, that have been reported have included respiratory, endocrine, haematological, immunological, dermatological, neurological, and psychiatric illnesses, together with many malignancies.

3. Physical hazards, including noise and light emanating from well-pads, cause significant nuisance 24 hours a day and 7 days a week from before drilling starts, for the life of the well. During the exploration stage of Jolly 1 near Penola, the neighbours complained of nuisance issues with the noise, smell of the drilling muds and diesel, and the lights at night.

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4. Hazards associated with the macro-changes that occur in the region, in terms of industries, employment, regional infrastructure, appearance/aesthetics and challenges to indigenous connection to land. These may result in significant demographic change to a previously very quiet, largely conservative and fairly homogeneous population. There will be increased truck traffic, resulting in congestion on narrow rural roads which will be damaged by the increased traffic, increased diesel exhaust fumes and traffic accidents.

5. Hazards associated with a change to the demography, with fly-in – fly-out (FIFO) or drive-in-drive-out (DIDO) workers. Elsewhere this has commonly resulted in increased crime and increased sexually transmitted diseases (STDs).

6. Despite the low risks quoted by the resources industry, accidents occur within all industries – and it is too late once contamination has occurred."

Legal issues

At the moment there is a great deal of confusion regarding many aspects of the type and length of time this current hydraulic fracture stimulation (fracking) has been used and this needs to be clarified.

The Act should be amended to protect Prime Agricultural Land, Water Resources, Farmers and Rural Communities.

Key outcomes should be:

1. No licences should be issued on Prime Agricultural land.

2. Water resources should be protected, at all costs

3. Farmers to have the right to farm, productively and efficiently without interruptions.

4. Health, wellbeing and prosperity of rural communities should be a priority.

5. Climate Change should be addressed.

Conclusion

Short-term gas well extraction life cycles of 15 to 30 years and coal mining should not outweigh risking centuries of guaranteed high quality and high volume agricultural produce from this region.

Gas well integrity and cement lifetime at a US shale basin is being questioned. This type of uncertainty in the technology must be addressed by the inquiry, particularly given the SE's

history of geothermal and volcanic activity which could provide conditions conducive to rapid cement failure.

This issue may be a legacy for South East farmers, and farmers around Australia, local residents and government to resolve 20 to 50 years in the future, once the gas companies have long departed and are not even required by current legislation to ameliorate any damage caused. Gas resources will still be present in decades to come at which point we will have had time to reassess the technology's viability via the impact shale gas extraction has had worldwide.

Landholders should definitely have the right to refuse gas and coal mining activities upon their properties. It is in Australia's national best interest that they do so.

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SECTION 2: RISKS OF GROUNDWATER CONTAMINATION

PART 1

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Author

Of Part 1 and Part 2 on Risks of Groundwater Contamination.

Anne Daw, grew up out of Kingston SE on her parent's sheep and cattle station. The family still retains some of the property which is pristine natural vegetation. Although living in Adelaide, Anne still spends quite a lot of time with the community in the South East. She trained as a registered nurse at the Royal Adelaide Hospital, gaining a gold medal at completion of studies. Anne has been advocating for the protection of high yielding agricultural land for the past 8 years, when she discovered that the Kingston lignite next door to her property had been re-granted for exploration. During this time, Anne has been working voluntarily at a state, national and international level. She is a member of the Round Table for the Roadmap of Unconventional Gas Projects in South Australia since 2012, when she first became aware of planned unconventional gas in the SE, and has also served on the Round Table for Health and Energy Policy in Canberra. Anne was a joint winner for the Jill Hudson state award for environmental work from the Conservation Council in 2013. Her main concerns are fresh water and a sustainable food bowl for now and for the future and health issues.

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SUMMARY

There is much information here under the topic of water, addressing the serious contamination risks and impacts on water, soil and air, thus with the potential to wreak havoc on export markets, communities and Australia's precious food bowl. Here-in lies many substantiated reasons why fracking (coal seam gas, shale gas or tight gas, or coal mining activities should not be undertaken on high yielding sustainable agricultural land, let alone any activities without prior written authorisation from land owners. This should apply whether a single entity company, companies in joint venture or partnership companies.

Although much of this submission is directed at the South East of South Australia, the information supports most of Australia's high yielding sustainable agricultural land as far as hydraulic fracture stimulation and coal mining are concerned. By basing the submission on the state of South Australia, this should enable the Senate Inquiry to gain a better understanding, that not only the Eastern States are being impacted, where there has been much information made available publically already, but agricultural land in South Australia and all other states are impacted negatively by hydraulic fracture stimulation and coal mining (to a lesser degree in South Australia) as well. The same should apply, whether it is a single entity company, companies in joint venture or partnership companies.

Clean, potable water is our most valuable resource on earth. Without it, we cannot survive. Adult bodies are made up of about 60% of water. Without it, we cannot grow food. Already, there are 700 million people in 43 countries of the world that are suffering from water stress and scarcity. This is only going to increase, particularly as salinity increases, rainfall decreases, we face a hotter climate, the population grows and precious lakes, streams, rivers and aquifers continue to be polluted, much at the expense of big industry, including mining and petroleum industries. Even our own state government acknowledges water shortages ahead.

Lack of water also affects the economy. Polluted water and soil means that we lose our 'clean, green image' for our wonderful food bowl and wines that our state premier holds in high esteem and sells to the world. Polluted water and soil means that we would face losing our local, national and international trade and export. Polluted water and soil would have a major impact on our tourism. After all, who really wants to holiday in a gas field? Who wants to live next door to a gas field? Who wants to buy property or a house next to a gas field? We ask the committee to ponder these questions. Would you like your grandchildren to live in a gas field area? This is the question the Mayor of New York asked himself and replied in the negative.

South Australia is the driest state in the driest inhabited continent in the world. In 2006 there was no recharge of any aquifer in the entire South East region. We continue to have bushfires. Aquifers in the SE are already in decline. By permitting highly water intensive hydraulic fracture stimulation to proceed, declining aquifer water levels may continue to fall

at a much quicker rate. Over a life time a "fracked" shale gas well may require up to 34 million litres of water. A document by Frogtech on shale gas commissioned by Vic. and SA government departments, including DEWNR, PIRSA AND SA water, estimated that there will be 3446 shale gas wells in the Otway Basin, most on the South Australian side. The South East people do not want water brought to the surface from deep aquifers, that may possibly be extremely saline as well as containing heavy metals, radionuclides, volatile organic compounds and other pollutants. When any substance, whether it is fluid or solid, is removed from under the ground, a void is left. What is going to fill that void? Voids may lead to compaction, creating an unwanted chain of events.

Even our own state government acknowledges water shortages ahead. The government released a report on CONSERVING NATURE. "***Drought conditions are likely to increase in frequency across many parts of South Australia, as a consequence of climate change, particularly in agricultural areas.*** *To this end, Australia's strategy for the National Reserve System recognizes and gives priority to increasing protection for areas that support reliable surface waters and accessible ground water'.*
Currently, the world population is a bit over **7 billion.** It is estimated at the current growth patterns that by 2050, the population may be around 9.3 billion people. The United Nations Food and Agricultural Organization has estimated that to be able to meet the needs, food production will need to increase by 2050, 70%. China is looking to Australia for its food bowl security. Most people in Australia have already seen the impacts on air pollution in China, often caught on TV. If our water and soil become polluted, where are we going to source our food? Certainly, we cannot rely on overseas markets in a world where the demand is already exceeding production.

The Limestone Coast of South Australia consists of 2.2% of the state. Australia only has 4% high yielding sustainable agricultural land. This is not a lot of land to have exempted from mining and petroleum activities, in one of the most important food bowl and wine regions in the state. **The geological science is already in**. The South East is built on limestone. Other states, such as Victoria, Tasmania and Western Australia also have limestone areas. Limestone is very porous and can be very brittle. Already, there is much subsidence and 100's of sinkholes in the South East. Drilling and fracking in limestone areas exacerbates subsidence and the formation of sinkholes. Normally, under natural conditions, subsidence and sinkhole formations may take scores of years to occur. Man-made causes, such as drilling, mining, fracking, buildings, heavy equipment and dams hasten the time span for subsidence and sinkholes to occur. What also needs to be taken into account is that when pressure through weight is exerted on land, such as dams and heavy equipment, this may also trigger subsidence.

There has been pollution of aquifers through toxic holding ponds in other states, such as the Pilliga area in New South Wales and Kingaroy area in Queensland, through underground coal gasification. Mines have filled with water during flooding rains on the East coast, with

the issue of toxic water ending up in rivers. In the South East of South Australia, near Penola, the shale gas exploration waste water pond known as Jolly 1 holding pond analysis revealed salinity up to **¾ as salty as seawater**, high barium levels, some heavy metals and toxic chemicals such as **phenanthrene, fluroanthrene, pyrene and chrysene**. Beach Energy plans to let the holding pond water settle and spray this waste - water on the agricultural land near Penola. This is simply absurd. Even treated reverse osmosis water does not remove all contaminants.

Well integrity failure is a real issue. There is already evidence of this occurring in the South East. A drill hole is a drill hole, whether for mining exploration or shale gas exploration and production. It goes through aquifers and geological formations, regardless of the depth. The deeper the drill hole, the more there is to be concerned about. The famous "Nulty hydrology observation drill hole" was commissioned by WMC in 1982 in limestone country. 30 years later, there was subsidence along side of the casing down 20 metres to the unconfined aquifer. As the water levels dropped in the aquifer, the limestone roof became exposed, leaving a weak spot allowing subsidence to occur. SA has only 2 logging trucks in operation to audit drill holes and wells. How are they possibly going to keep track of **ALL** previous drill holes and wells from the past, let alone new ones?

Caves and sinkholes have connectivity to each other. The Naracoorte Caves is UNESCO listed. The Petroleum Exploration Licences border the park. Fracking activities may have unwanted consequences on caves including damage to these fragile structures or movement of gases into them.
The South East also had problems with seawater intrusion, particularly in the Donovans area south of Mount Gambier. Here there was over allocation of bore water that allowed seawater intrusion to occur. Bores had to be capped to stop this. Imagine what may happen with the multiplication effect of 100's or even 1000's of wells**.** Who is going to foot the bill for 1000's of hydrology holes to observe if seawater intrusion is occurring due to fracking activities? How do you get seawater out of an aquifer once it gets in?

There is considerable and unknown vertical leakage between the unconfined and confined Dilwyn aquifers. At a SELGA meeting in April 2014, the question was asked to the EPA representative of how to clean up an aquifer once it is contaminated. He stated that it is impossible to clean up a large contamination area. He also stated that smaller contaminated areas are cleaned up by removing the contaminated water from the aquifer. The question begs, what is done with the contaminated water once it is above ground? The highly toxic wastewater is stored in holding ponds that usually have high-density polyethylene (HDPE) plastic liners that are meant to protect the environment from seepage. As evidenced with photos in this document with the Salamander 1 holding ponds in the SE, these liners did not last 4 years in the South East. There is also no safe way of disposing of toxic waste - water and drilling muds. Reinjection causes earthquakes and potential contamination.

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The South East has numerous fault lines. What is appalling is that Beach Energy Ltd. has already been drilling through vertical fault lines that rise upwards and in some cases, to the confined and unconfined aquifers. As you will see by documented evidence in this submission, that hydraulic fracture stimulation should never be allowed near faults. Earthquakes are triggered by both the fracturing itself and waste water re-injection. This in turn causes contaminant pathways**.** How do you plug up a contaminant pathway forever? Is it possible to even find all contaminated pathways underground? It is impossible.

There are numerous sources of potential contamination to our water through fracking activities. Chemical spills occur on the surface that may reach the unconfined aquifer. Flow-back water is full of contaminants and may be spilled or leak. Holding pond wastewater overflows have occurred due to heavy rains. Well integrity is a huge problem. No well can be guaranteed 100% integrity. Six (6) % usually fail in the first year. Once a well is put down, it is there forever. Eventually, all wells will fail. It does not matter how many layers of casings and cement there are. They break down even from the inside layers because of hydrogen sulfide and anaerobic bacteria. Also, when cement is being poured down the drill hole it may hit methane under pressure, causing cement channelling, not allowing sealing between the rock matrix and the outer layer of cement. All causes are too numerous to list in this summary.

Health impacts on animals and humans through contamination of water resources, as the result of fracking is a major and serious problem. This is covered in depth in the sections on health and chemicals. The industry is not as “clean” as it claims. At the back of this part of the submission, you will see the incidents that have been occurring in South Australia, which backs up what is written in the rest of this submission. There was an incident with a leaking wellhead in the South East at Salamander 1. There is no way that the state can afford to have fracking in their food bowl, among the wineries of Penola, or in the holiday hotspots of Robe and Penola. The Limestone Coast Protection Alliance has not included incidents from other states, as those writing submissions from their own states will no doubt include those.

NO ONE CAN CONTROL WHAT IS HAPPENING UNDER THE GROUND. How do we stop subsidence and earthquakes from occurring? Who is going to foot the bill for problems in the future, which may occur long after the companies have gone?

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1.0 WATER SCARCITY

For human survival, we need clean water, clean air and a clean green food supply. This means maintaining and keeping our precious aquifers, surface water, soil and air and food protected from pollution. South Australia is the driest state in the driest inhabited continent in the world.

According to Elizabeth Hameeteman, of The Global Water Institute, in her paper entitled "Future Water (In)security: Facts, Figures, and Predictions", 2013, she is quoted as *saying "More than 2.8 billion people in 48 countries will face water stress or conditions of scarcity by 2025. By the middle of this century, this will have reached almost 7 billion. …* ***Approximately 700 million people in 43 countries are currently suffering from water stress and scarcity.*** *It is projected that by 2025 water withdrawals will have increased by 50%, mainly in low-income nations or in countries and regions with absolute water scarcity. Two-thirds of the world population is at risk of being stained by water scarcity."*
In 2012, a document by the South Australian Government was released entitled 'CONSERVING NATURE 2012 – 2020. Page 20 '***Drought conditions are likely to increase in frequency across many parts of South Australia, as a consequence of climate change, particularly in agricultural areas.*** *To this end, Australia's strategy for the National Reserve System recognizes and gives priority to increasing protection for areas that support reliable surface waters and accessible ground water'.*

http://www.environment.sa.gov.au/managing-natural-resources/Park_management

Water is very precious in South Australia, and is already under severe stress as prolonged dry periods persist in Southern Australia. There is sufficient credible documentation sounding the warning bells that potable water sustainability is a problem both at state level, through to a worldwide problem. Taking into account the figures on water security in the quotes by Hameeteman, it would be astute to assume that the potable water problems around the world are not going to improve, and in fact get worse. Australia will not be able to source much food from overseas. Therefore, it is of the utmost urgency that our potable water resources in the SE are protected forever, and are never exposed to the risks of unconventional gas production. Our precious food and water resources should be **preserved for generations to come.** Currently, the world population is a bit over **7 billion.** It is estimated at the current growth patterns that by 2050, the population may be around 9.3 billion people. The **United Nations Food and Agricultural Organization** has estimated that to be able to meet the needs, food production will need to increase by 2050, 70%.

2.0 AUSTRALIAN GOVERNMENT BUREAU OF METEOROLOGY (BOM) ANNUAL CLIMATE STATEMENT 2014

http://www.bom.gov.au/climate/current/annual/aus/

The Australian Government Bureau of Meteorology (BOM) released the ANNUAL CLIMATE STATEMENT for 2014 on 6th January 2015. Data collected and analysed by the BOM showed

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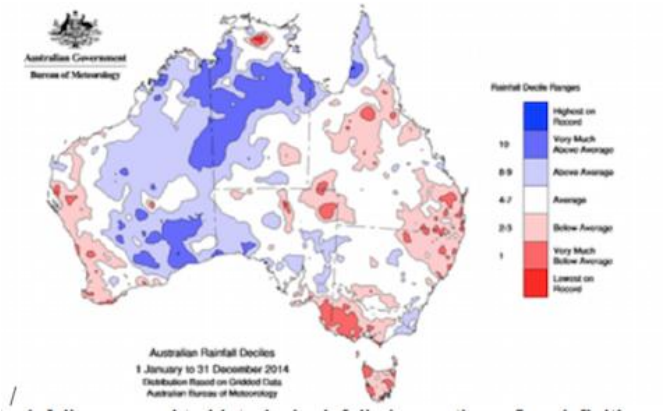
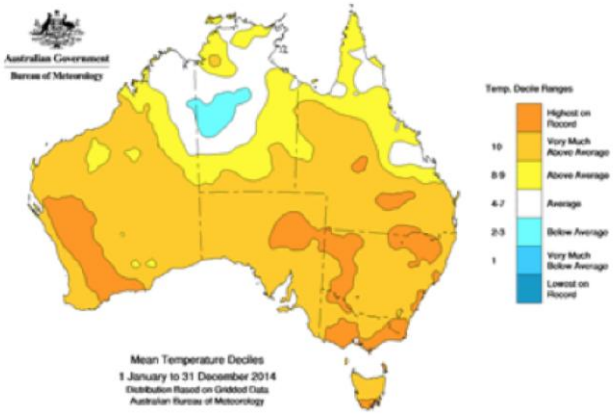
overall that 2014 was Australia's third-warmest year on record. The average temperature was +0.91 °C above average. Rainfall was below to very much below average across the majority of Victoria, southeast South Australia, and other areas of Australia. The map is in the BOM annual climate statement 2014. Most of the SE of SA is covered in dark pink, which shows below average rainfall from 1st January until 31st December 2014. There are predictions from the CSIRO that dry hot spells are going to continue.



The next map from the BOM annual climate statement for 2014 shows that the SE of SA temperatures from 1st January to 31st December 2014 were very much above average, and in the north of the state, the temperatures in the dark orange were the highest on record.



3.0 SOUTH EAST UNCONFINED AND CONFINED DILWYN AQUIFERS

According to the Australian Bureau of Statistics data in 2013, data indicates the SE NRM region supported approximately $1.0 billion of South Australia's $5.6 billion gross value agricultural industry – notably dryland and irrigated agriculture and horticulture, dairy, and forestry.

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Most detail regarding the unconfined and confined Dilwyn aquifers in the South East is covered in the section on the Lower Limestone Coast Water Allocation Plan, other than a few key points. There are two underground water systems – the upper unconfined Tertiary Limestone Aquifer consisting of calcareous sandstone and limestone, and the lower Tertiary Confined Sand Aquifer. The aquifers are a finite resource, that require to be managed properly to be sustained for now and future generations to enjoy social, economic and environmental benefits. Underground water is extracted from both aquifers. The confined Dilwyn aquifer contains around 30% of the state's water.

4.0 SOUTH EAST GEOLOGICAL, WATER, DRILL HOLE, WELL AND POND ISSUES

4.1 NO RECHARGE IN 2006

In 2006, there was no recharge of any aquifer in the whole of the South East. Please see the under the heading Lower Limestone Water Allocation plan that explains in full, policy and also notes concerns in relation to hydraulic fracture stimulation.

4.2 PAST PROOF OF HOW SENSITIVE THE SE AQUIFERS ARE

Already there is proof of the sensitivities of the South East aquifers. In 1979, Western Mining Corporation (WMC) discovered lignite north east of Kingston SE, covering an area 30 km x 5 km. The lignite is between the unconfined aquifer and the Dilwyn confined aquifer. In 1982, pumping tests performed by W.M.C. were found to significantly interfere with the artesian water in the area, particularly with the potable Dilwyn confined aquifer. The Watchdog committee found serious errors in modelling mine dewatering and associated impacts on underground water resources. Serious issues that occurred which included a large drop in pressure heads of bores several km away that ceased flowing and very slow pressure head recovery. One bore had to be pumped for a number of weeks before regaining pressure. During the trial, the loss of pressure and downward water leakage from the unconfined aquifer was evident. There was an immediate revelation of a direct interconnection between the Mepunga and Dilwyn aquifers, with evidence at one bore site that there was an absence of separating clays between the aquifers. If the project had proceeded, Kingston's town water supply would have been at great risk.

'A submission to THE HONOURABLE THE MINISTER OF ENVIRONMENT AND PLANNING By the Kingston Branch of the United Farmers and Stockowners of South Australia on The Kingston Lignite Project Draft Environmental Impact Statement Researched by the Kingston UF & S Watchdog Committee' 1983

4.3 VERTICAL LEAKAGE BETWEEN THE UNCONFINED AQUIFER AND THE CONFINED AQUIFER

I understand it is impossible to measure 'artificial leakage' from one aquifer to another. According to the government document 'South Australia – Victoria Border Zone Ground Water Investigation: Results of Pumping Test Program' 2011/23, page 1 – **"Extensive faulting occurs through the South East and across the border between South Australia and**

Victoria. Although faulting has a significant impact on lateral flow in both unconfined and confined aquifers, its impact has not been determined. Vertical flow between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer is likely to be significant, however this is not well understood." On page 2, in 2000, DFW carried out an investigation to examine the hydraulic relationship between the two aquifers and estimated recharge rates of the confined aquifer (Brown et al., 2001). The study inferred that recharge to the TCSA is occurring via preferential flow paths (fractures, faults or sinkholes), **however the rate of vertical recharge could not quantified.**

Therefore, in any situation, regardless of where hydraulic fracture stimulation takes place in high yielding agricultural and cropping areas, how can any modelling for water be accurate? Given these facts, it is impossible to clean up an aquifer once it is contaminated, as the contamination may spread quickly through the vertical leakage to the other aquifer, with the potential to affect agriculture.

4.4 FIVE ($5) MILLION TO REHABILITATE LEAKING CONFINED AQUIFER WELLS IN POOR CONDITION

As far as well integrity problems, there is already plenty of evidence in the South East to support that casings and cement for wells do break down. On page 37/196, 3.5 of the Lower Limestone Coast Water Allocation plan done for the Natural Resources Management in the SE, it states

"**Prior to 2010, direct leakage of pressure water from the confined aquifer into the overlying unconfined aquifer occurred via a large number of confined aquifer wells in poor condition due to age and construction techniques. During 2001 to 2010, 120 leaking confined aquifer wells in the Kingston-Greenways area were either replaced or back-filled using specialist techniques, as part of the South East Confined Aquifer Well Rehabilitation Scheme. Expenditure on the scheme was estimated to be $5.5 million over nine years, including $1.3 million funding from the Natural Heritage Trust, $1.1 million from State investment and a financial commitment from landowners of up to $3.1 million.**

Imagine the costs of in time of repairing every drill hole for unconventional gas in the SE that are in the ground down to around 4 km and extending horizontally, with the casing and cement that does not last forever'. Who will foot the bill in 30 – 50 years if these companies are no longer around?

4.5 SEA WATER INTRUSION

There is evidence of a direct hydraulic connection of the Dilwyn aquifer to the sea. in the form of tidal pressure effects. In recent years, bores had to be capped in the Donavan's area near Mount Gambier, because of over-allocation of water and seawater intrusion.

A document recently released is called "Preliminary Investigation of Seawater Intrusion into a Freshwater Coastal Aquifer: Lower South-East, September 2012" This was also a

concern 32 years ago, and is today with the proposed Kingston lignite protect. In the summary - "This fresh groundwater aquifer is vulnerable to salinisation by seawater intrusion due to over exploitation of the resource and climatic changes, which may respectively cause the lowering of the groundwater hydraulic head, and reduced recharge into the unconfined aquifer." "Evidence of a dynamic freshwater-saltwater interface occurs in the Eight Mile Creek area, where groundwater salinities are slowly increasing and salinity profiles show seasonal changes."

Page 2 "Fresh groundwater in coastal aquifers is vulnerable to salinisation by seawater intrusion due to increasing extraction of the resource and climatic changes, which causes the lowering of the groundwater hydraulic head and reduced recharge into the unconfined aquifer. The threat of sea level rise, which could increase the risk of inland salt water migration into the aquifer, is a potential threat to coastal groundwater resources. Saline groundwater intrusion has the potential to result in significant economic and environmental impacts. "Reduced recharge due to climate change may further exacerbate this process**. Recent years with below-average annual rainfall has resulted in reduced recharge to the unconfined aquifer and also increased extraction."**

The following government document "LOWER LIMESTONE COAST PRESCRIBED WELLS AREA UNCONFINED AQUIFER GROUND WATER LEVEL AND SALINITY STATUS REPORT, 2012 reported the two sobering paragraphs –

Page 1 - Analysis of climatic trends in the South East has revealed a general drying trend since the early 1950s. This is reflected in most groundwater hydrographs and a strong relationship has been demonstrated between decreases in average annual rainfall and declining water levels measured in observation wells for both the confined and unconfined aquifers over the last 40 years.

Page 2 - Declines in groundwater levels predominantly occurred along the eastern border of the PWA, with the largest declines recorded between Naracoorte and Penola. The Donovans Management Area remains at risk of seawater intrusion due to an overall decline in groundwater levels in the area. The overall decline in groundwater levels across the Lower Limestone Coast PWA is the likely result of the increase in extractions and below-average rainfall.

https://www.waterconnect.sa.gov.au/Content/Publications/DEWNR/Lower_Limestone_Coast_PWA_Unconfined_Aquifer_GSR_2012.pdf

What will replace the SE water supplies, if hydraulic fracturing stimulation proposed projects go head and sea -water intrusion does occur as fracture stimulation activities? How much would it cost the state to put in hundreds of hydrology observation points along the coast and monitor them daily? How do you collect the salt from the aquifers, once seawater intrusion has taken place? How do you clean up not only one but 2 aquifers if contamination occurs?

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4.6 SALT MOBILISATION

The Qld. study on Healthy Headwaters was done in 2012. The study refers to the fact that it is impossible to predict the amount of salt that will be mobilized as the result of coal seam gas activities in the headwaters of the Murray River, and therefore it is impossible to know the impacts in the future, on the Murray Darling Basin and river systems, which, I believe, without a doubt, will impact the River Murray in South Australia. **What studies have been done into possible salt mobilization as the result of unconventional gas extraction in the South East? It is believed that not doing impacts on salt mobilization before any exploration drilling is irresponsible.**

https://www.dnrm.qld.gov.au/water/catchments-planning/healthy-headwaters/coal-seam-gas-water-feasibility-study

4.7 LIMESTONE AND SUBSIDENCE

Subsidence causes cracking, ground movement, damage to buildings, pipes, roads and railways, groundwater system changes, flooding, sinkholes, coastal impacts, increases in seawater intrusion, and can reactivate faults. Land subsidence on the coast is cumulative to climate change effects with sea level rises and future coastal erosion. Beach Energy Ltd. have plans for a shale exploration gas well near Robe, and Rawson Resources plan to drill a shale gas exploration well 16 km west of Mount Gambier and 18 km south east of Robe. Given the evidence in Gippsland, this is concern in regard to possible coastal subsidence.

4.8 NULTY OBSERVATION HYDROLOGY DRILL HOLE SUBSIDANCE 31 YEARS AFTER WMC COMMISSIONED IT

NULTY SUBSIDED HYDROLOGY OBSERVATION DRILL HOLE PUT DOWN IN 1982 BY WMC

This drill hole, pictured above, is on the property of the Nulty family. It was commissioned by Western Mining Inc. to be drilled in 1982. The drill had never been inspected since, and it is highly likely that none of the drill holes or hydrology observation holes in the Kingston

SE area (950 of them) have never been audited since 1982. Please note the hole at the side of the casing. The hole was around 30 x 46 cm at the top and went down for 20 meters to the unconfined aquifer. As the water levels in the aquifer drops, the limestone roof may be exposed. There may be a weakness in the roof, which allows the subsidence to occur. This is the most likely scenario of why the earth around the casing collapsed. This is in limestone country. The rest of the South East has limestone. There is no proof that inspections have been done of the other 950 drill holes including 92 that were cored.

4.9 SEISMIC SURVEYING BY BEACH PETROLEUM IN THE 1960'S

Beach Petroleum, now Beach Energy, as I understand, was involved with seismic surveys in the SE in the 1960's that covered extensive distances. I recently visited a property near Robe. A number of holes, set distances apart and approximately 15 metres deep were drilled and left uncased. I was able to observe one of these old drill holes. Detonator wire left on the property, was used to connect the holes and place down 5 pounds of explosive geofex. Please see attached specimen of original detonator wire with the hard copy of the submission.

4.10 AQUIFER BARRIER FRACTURED

Questions have been raised if there was any damage to the aquifer barrier that may have been caused by these seismic activities. Rosemary Brojatsch has written a testimony of her family experience back in the 1960's. At that time Beach Petroleum was searching for oil on properties in the Beachport area. Her father, the late Mr. Bert Bowman, moved the family to a property on the Beachport-Penola road in 1958. There was good underground water supplied from a windmill near the house. After the area was tested 'anywhere and everywhere' by the mining company on a quest for oil, drill holes were put down in lines, as explained above, and detonation took place for a seismic read out. No thought was given about any damage that may occur to the underground water. Two wells were also drilled on the property near Lake George, which is in the vicinity of the state's biggest earthquake in 1897. There are numerous fault lines in this area. As it is a fragile area, it is Rosemary's belief that damage was done as the connectivity between the aquifers were shaken and fractured, causing salt water to infiltrate the freshwater confined aquifer. To this very day, the underground water in this area has never recovered and still remains saline.

Fresh bore water cannot be found in the area today. As the result of this occurring, there was no compensation. After drilling ceased, Mr. Bowman approached Beach Petroleum to cap the well at artesian level, which was done. Water was then piped across to their house at the family expense. At that stage, people did not voice out their opinions and were too trusting of the powers in charge.

4.11 SINKHOLES AROUND THE SOUTH EAST

One of the major geological scientific reasons that hydraulic fracture stimulation should not be allowed in the South East, or any major mineral mining for that matter, is because

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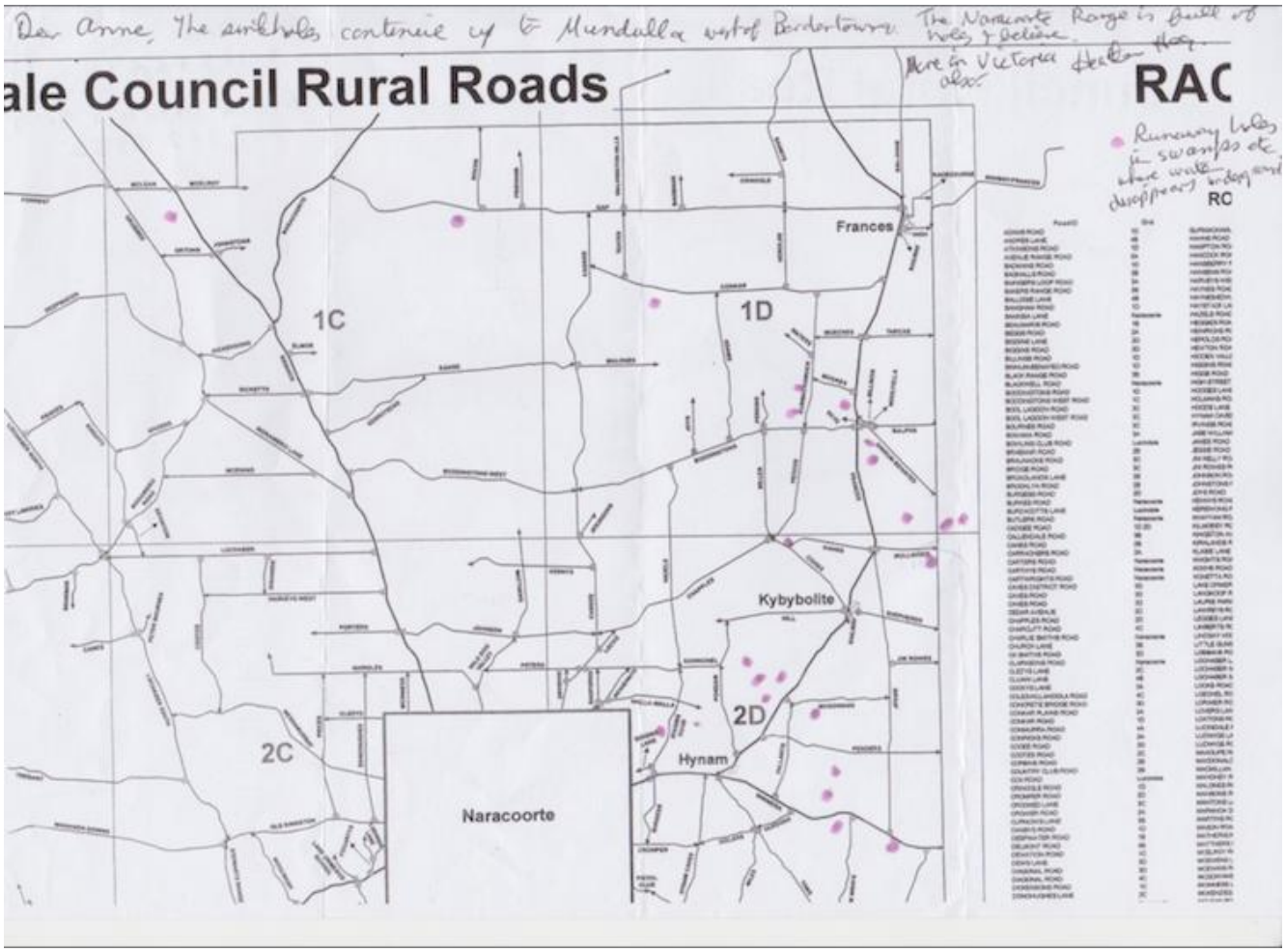
the South East is built on limestone. Limestone is very brittle in its nature, and does not lend itself to be drilled, mined or fracked without the risk of exacerbating subsidence and sinkholes. There are various reports of 100's of sinkholes around the South East of South Australia. One property owner has stated there is one on her property "about 70 feet deep and opens out at the bottom with water, and there is a windmill over it.

Another property owner from the Kybybolite area has reported that he has lost count of subsidence holes on his property. They range in size from 1 metre to 3-4 metres across. These sinkholes have been happening for over 70 years. The property owner has observed that a lot more have appeared in the last 6 years. There are many sinkholes around Wrattonbully and Comaum, north east of Penola. There are around 350 known sinkholes in the Mount Gambier area alone.

PINK DOTS SHOW KNOWN SINKHOLES IN NARACOORTE AREA TO THE EAST.

THERE ARE HUNDRED'S MORE



4.11.1 HATHERLEIGH STORY

In March 2014, there was a report in the SE TIMES regarding a Hatherleigh farmer who narrowly escaped being buried alive when the ground collapsed under his tractor to form a 1.5 metre deep sinkhole on his property. The sinkhole opened up suddenly without

warning. It subsided down another 0 .5 metres and had 10 cm of water in the bottom. According to the owner of the property, Mr. Lance Skeer, sinkholes occur all the time around the Mount Gambier and Glencoe area all the time. Kevin Mott of the South Australia Cave Exploration Group said that it was a normal occurrence in the geological limestone-based form of the South East. He stated the following "Limestone in the region has been formed under stress and there's a lot of cracks and faults in the stone" "Often if you get a little water or acid from the soil into the crack, it slowly erodes the rock. Over time, the stuff in between of the rocks opens them up and sometimes it can be sitting there for years. All it takes is a little pressure to collapse. There have been similar tubes in the forest that have done the same thing, extra weight from a tractor puts pressure on the already stressed formation and suddenly you drop your wheels into a hole." Ian Lewis, geologist, said that the pressure caused by the machinery may have formed the sinkhole. Lewis thought it sounded like a type of cavity referred to as a solution tube. These are found everywhere in limestone, and there are thousands of them around the South East.

This is a major reason why hydraulic fracture stimulation should not go ahead in the South East. Aside from the drilling and the hydraulic fracture stimulation itself, the waste - water re-injection can exacerbate subsidence and sinkholes in limestone. This is a clear example that the shear pressure of heavy machinery can also be a major issue. The weight of the waste - water in the holding pond would also be putting a considerable amount of pressure on geology system.

4.11.2 CHANNEL 7 STORY ON SINKHOLES INCLUDED MOUNT GAMBIER

In 2014, Channel 7 had a program on sinkholes, which included footage in USA and Mount Gambier in the SE. The link is still active –

https://au.news.yahoo.com/sunday-night/features/a/22907841/the-truth-about-sinkholes/

The gas industry is mentioned and blamed for sink holes at around 10 minutes and 30 seconds from the beginning. The end of the film shows the Mt. Gambier sinkholes, 11 minutes 40 seconds along.

4.11.3 BEACHPORT EAST 1 DRILL HOLE PUT DOWN IN 1983 NOT DECOMMISSONED AND LEAKING NOW

Below is a picture of the leaking well. It is Beachport East 1. It was drilled to 1428m on 25 Aug 1973 but only cased to 610m so the production zone would be in the confined aquifer. The well had been abandoned, not backfilled. It is presumed the leaking is a result of the pressure from the confined aquifer. The valve is open and should be shut off. This may be difficult with the current infrastructure as it has been left open for a number of years and would be hard to operate.

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BEACHPORT EAST 1 ABANDONED WELL

4.12 EARTHQUAKES IN THE SOUTH EAST OF SOUTH AUSTRALIA

Earthquakes may appear to be an odd subject under the topic of water, but the reason it is here, is because contaminant pathways between the aquifers and the faults as the result of fracture stimulation activities possibly exposing radionuclides, volatile organic compounds and heavy metals to impact the aquifers. Below is a map of South Australia showing the major seismic zones. Please note the South East area**. What is very important to realize is that we have no control over what is happening underground. We cannot control earthquakes, and we cannot control impacts on wells under the ground. We cannot say that wells or pipes won't bend or rupture during an earthquake that occurs naturally or is seismically induced as the result of hydraulic fracture stimulation activities**. We cannot say that bacteria attacking the casings and cement will not happen. It is as simple as this – it does.

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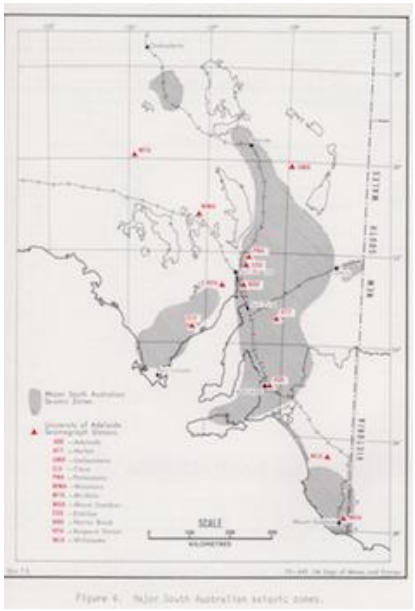
Map of the 4 most seismic areas in South Australia – The Mining Department



The epi-centre of South Australia's biggest earthquake between Kingston SE and Beachport occurred in 1897, magnitude 6.5, intensity 9. It was felt in Port Augusta and Melbourne, toppled chimneys in Adelaide and there was massive damage around Beachport, Kingston and Robe and liquefaction occurred. Another 5.6 magnitude earthquake occurred in the same area in 1949. Other numerous earthquakes have occurred in the South East including in recent years. The lower South East is 4th most seismically active in the state. This is another major reason why there should be no unconventional or unconventional gas, or mining exploration and projects in the lower SE. With many fault lines already existing in the Lower South East, if hydraulic fracture stimulation took place, naturally occurring earthquakes or those stimulated by hydraulic fracture stimulation activity, may result in contaminant pathways opening up as fault lines may then join up which reach the aquifers. The picture below is of slumping just outside of Robe (1897).

Slumping possibly due to liquefaction. (Photo 44184)

http://www.pir.sa.gov.au/__data/assets/pdf_file/0020/10829/rb1995_047_earthquakes.pdf
(copy and paste)

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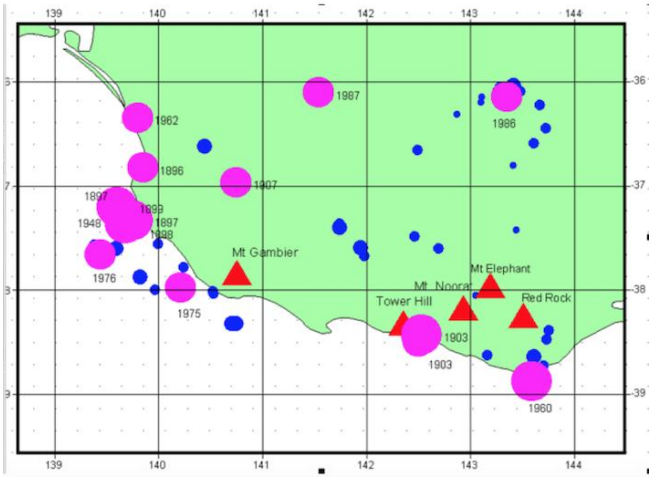
The University of Western Australia compiled a report on volcanoes and earthquakes in the SE of SA. Although there have been numerous other earthquakes in the SE, earthquakes of magnitude 5 or more were May 1897 SA's biggest earthquake 6.5 between Beachport and Robe, May 1899 5.3 magnitude Robe, July 1903 5.3 magnitude over the border at Warrnambool, Vic., August 1948 Robe and December 1960 Cape Otway. **Concerns have also been raised for the community for current offshore exploration for oil and gas a few km off of Robe, given the highly fractured area under the sea.**

Map of volcanoes (red triangles) major earthquakes (purple) and other earthquakes (blue) from University of Western Australia.



http://www.seismicity.see.uwa.edu.au/welcome/seismicity_in_australia/volcanoes_and_earthquakes_in_southeastern_australia

4.13 VOLCANOES IN THE SOUTH EAST OF SOUTH AUSTRALIA

South West Victoria and South East SA were both active volcanic areas in relatively recent times. The latest eruption in the Mount Gambier area occurred around 4000 years ago. With disturbance to the underground system as the result of hydraulic fracture stimulation activities, triggering an eruption may never occur to people, but should never be discounted. We cannot control what happens under the ground.

4.14 MR SPRIGG – FOUNDER OF BEACH PETROLEUM RECORDED COASTAL BITUMENT STRANDINGS

Mr. Sprigg founder of Beach Petroleum (now Beach Energy Ltd.) and others recorded stranding of coastal bitumen in the SE of SA and Western Victoria following offshore earthquakes. IN A DOCUMENT BY D. PADLEY, 1995, he states under the heading of 1.3.4.5 Hydrocarbon Surveys, page 11, that in the Western Otway Basin, **submarine gas seeps are commonly associated with major faults that pierce the Tertiary cover sequence. Therefore, it appears that these fault zones may be acting as pathways for the escape of gas from deeply buried Cretaceous rocks.**

https://digital.library.adelaide.edu.au/dspace/bitstream/2440/48539/10/02chapter1.pdf

4.15 UNFAVOURABLY ORIENTATED FAULTS IN THE SE

In a government document "PETROLEUM GEOLOGY OF SOUTH AUSTRALIA VOLUME 1: OTWAY BASIN" IN CHAPTER 5 - STRUCTURAL AND TECTONIC SETTING BY JENSEN-SCHMIDT, CD COCKSHELL AND PJ BOULT, Page 7 it is stated 'The influence of this event on structures and fault planes is very important for hydrocarbon **exploration with unfavourably oriented faults being prone to reactivation and leakage.** Continuity of this stress field to the present day is validated by the persistence of significant earthquake activity, particularly in the Beachport High area, the site of the most intense structural inversion mapped in the SA border of the basin.' Under the title on Volcanism, I quote 'This tectonic phase **represents a risk to petroleum exploration** by introducing magmatic CO2 into the sedimentary sequence….

http://www.misa.net.au/__data/assets/pdf_file/0013/40432/pgsa1_v2_chapter_5.pdf

4.16 TOO MANY FAULTS IN THE SE FOR HYDRAULIC FRACKING STIMULATION

Although Carbon Capture and Storage (CCS) is not part of the enquiry, it is important to note that according to the http://www.co2crc.com.au/aboutccs/safety COOPERATIVE RESEARCH CENTRE FOR GREENHOUSE GAS TECHNOLOGIES

"Sites will also be chosen to minimise any possibility of triggering seismic i.e. (earthquake) activity or reactivating any fault."

One of the members of LCPA received the following email from Barry Goldstein, Executive Director, Energy Resources DMITRE regarding the fault lines and CCS in the South East.

"It remains my personal view as an experienced geologist that the nature of faulting in this location is interpretable to be less than perfect geologic circumstance for lowest cost and highly extensive CCS. Others may reach an alternative conclusion, but I was unsurprised no bids were lodged.' **Barry A Goldstein**

If the faults are a problem for CCS, then surely they are a bigger problem for invasive, high volume, high pressure, multi - stage' slick water fracture stimulation.

4.17 BEACH ENERGY DRILLS THROUGH FAULT LINES NEAR PENOLA

The South East of South Australia is heavily faulted. Beach Energy has been intersecting faults according to their own information.

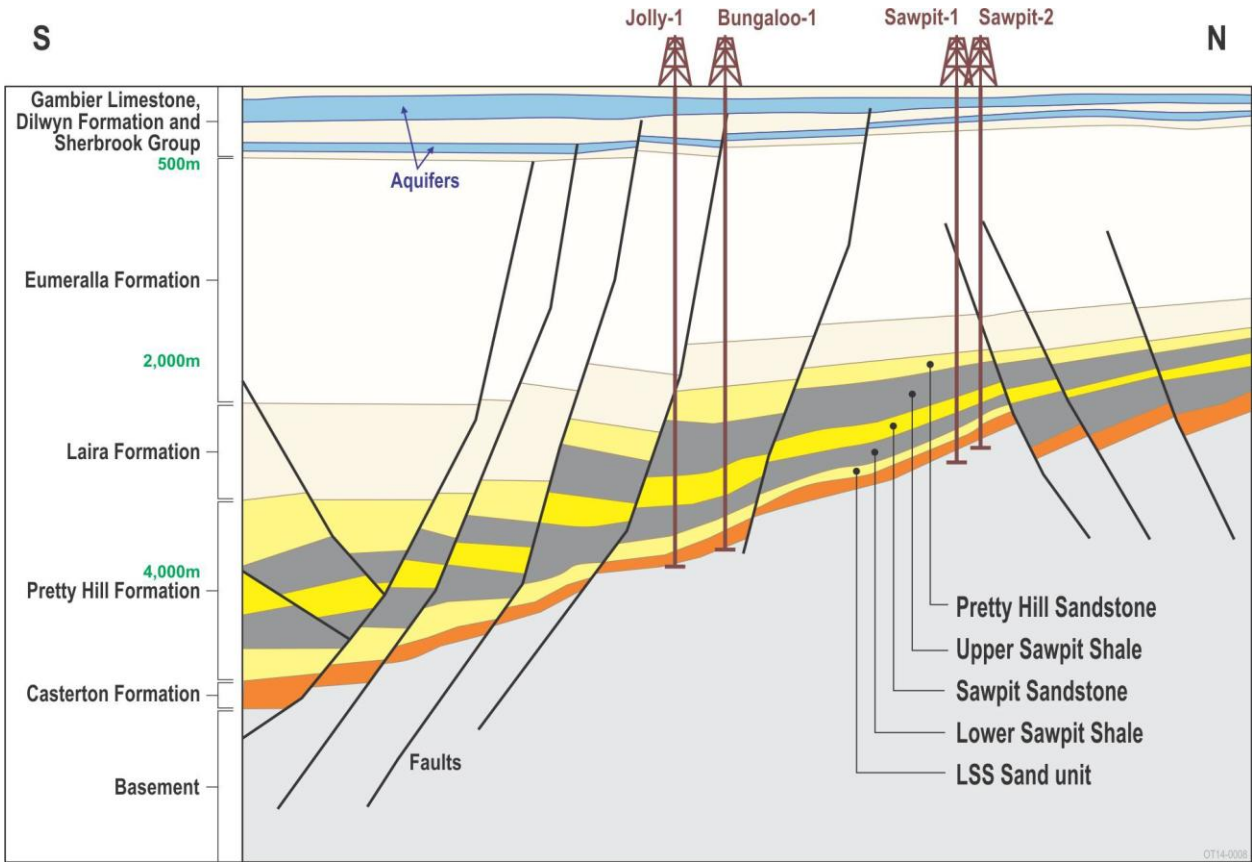
http://bpt2.live.irmau.com/IRM/Company/ShowPage.aspx/PDFs/3297-41383964/MonthlyDrillingReportJanuary2014 (copy and paste)

There was a mechanical drill problem, described by locals as 'the drill head getting stuck', which was not disputed when mentioned to Beach Energy Ltd at the SELGA day at Penola,

and as a result, a side track around the problem had to be drilled. This occurred at 2,406 metres, and on the drawing showing the intersecting of faults, this appears to be right where the drill intersects a fault.

The fractures in the shale caused by HFS are only meant to extend for around 100 metres. However, this is not always the case**. This may result in contaminant pathways up to aquifers if drilling too close to fault lines. This is of particular concern in the SE, with so many faults, and the fact that Beach Energy Ltd. has been drilling through fault lines and that these fault lines are vertical, and in some cases, extend into both the confined and unconfined aquifers.**

ILLUSTRATION FROM BEACH ENERGY NON DEAL ROADSHOW 23RD – 27TH JUNE 2014,PAGE 46



http://www.beachenergy.com.au/IRM/Company/ShowPage.aspx/PDFs/3461-28940747/NondealRoadshowPresentation (copy and paste)

4.18 ROADMAP OF UNCONVENTIONAL GAS PROJECTS IN SA

According to the Roadmap for Unconventional Gas Projects in South Australia, under the heading of 'Shale Gas Play in the Otway Basin', there are principal targets for shale in the onshore Otway Basin. The Otway Basin extends into Victoria. These areas include the Robe Trough, Penola Trough, and the St. Clair Trough, which are expected to be gas prone with liquids potential The prospective for shale oil for the Robe, Penola, Rivoli and St. Clair troughs is between 2.3 km and 3.8 km. Targets depths are up to 4 km. Tight gas potential is

in the deeper areas of the Robe and Penola Troughs. Tight gas still requires hydraulic fracture stimulation.

It is stated in The Roadmap ***"complex faulting from rift tectonics could be advantageous for unconventional gas through enhancement of natural fracture networks that would improve connection with, and drainage of the rock matrix."*** Given the evidence on risks of hydraulic fracture stimulation in regard to earthquakes, and migration of methane and other highly toxic substances into aquifers, this should be of major concern that the Department of State Development and the industry's attitude is that faults are seen as an advantage for the petroleum industry.

http://www.petroleum.dmitre.sa.gov.au/__data/assets/pdf_file/0008/179621/Roadmap_Unconventional_Gas_Projects_SA_12-12-12_web.pdf

4.19 PELS BACK ONTO NARACOORTE CAVES NATIONAL PARK (UNESCO LISTED)

The Naracoorte Caves National Park is world famous and a wonderful draw card for international and national tourists. **It is South Australia's only United Nations Educational Scientific and Cultural Organisation UNESCO listed national park.** The Naracoorte Caves National Park is listed as UNESCO because of the importance of fossils in the caves. The park is home to 100 known fossil deposits and for preservation of bones of mega - fauna that became extinct roughly 60,000 years ago. The caves acted as pitfall traps, collecting animals for at least 500,000 years, **preserving the most complete fossil record we have.** It covers several ice ages and arrival of humans. Bones include those of the Marsupial Lion, Thylacine and Zygomaturus and Sthenurine Kangaroos.

PEL 495, and PEL 629 have longitudes and latitudes that appear to be very close to the caves. See the purple and green cross on the map. As the Naracoorte Caves are UNESCO listed, petroleum and mining licences should not be allowed anywhere near the Naracoorte Caves. Contaminant pathways are a major issue with hydraulic fracture stimulation activities. There are numerous fault lines, subsidence, caves and sinkholes that are in the South East that are part of the limestone. Hydraulic fracture stimulation, mining and drilling in limestone exacerbates subsidence and sinkholes. If contaminant pathways open up to the caves, carbon dioxide and methane could pose a problem. Potentially this could be a problem with caves right across the Lower South East. Often caves are also connected by pathways, as are areas of subsidence.

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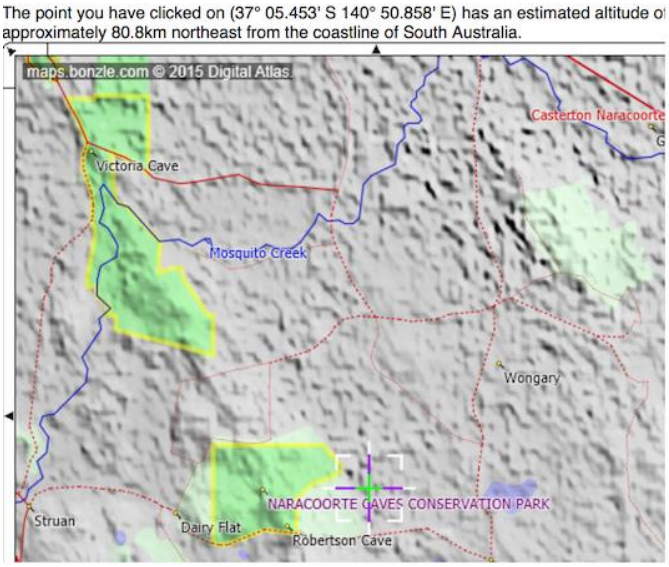
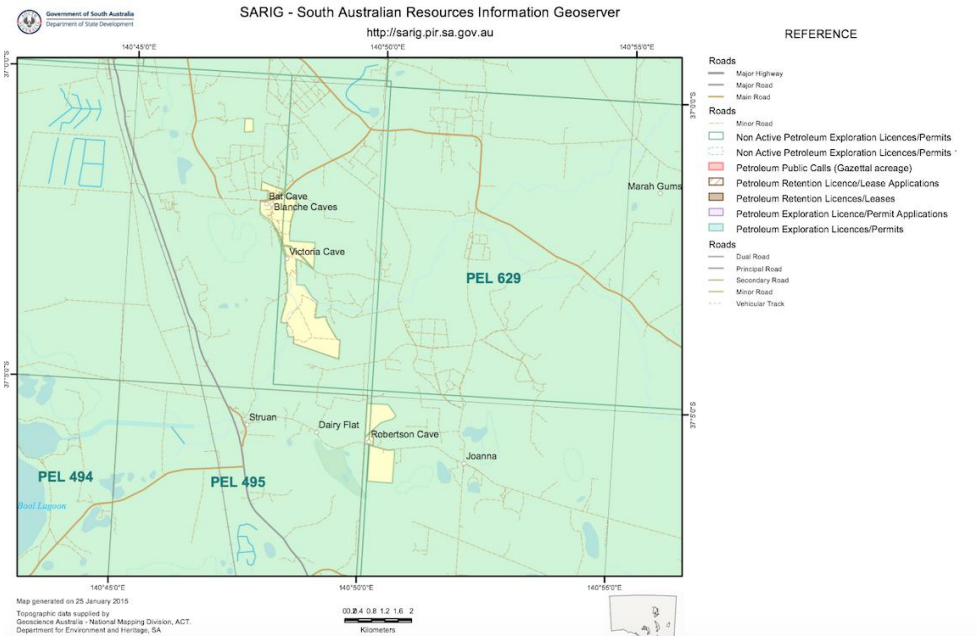
Cross showing PEL 495 in extremely close vicinity of UNESCO Naracoorte Caves National Park



SARIG showing PEL 495. The boundary runs up the west side of the reserve then turns west till it meets PEL 494. PEL 629 covers the rest of the map.



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4.20 PANAX GEOTHERMAL – HDPE LINERS DON'T LAST 4 YEARS FOR HOLDING PONDS

Salamander-1 well was drilled in the Otway Basin near Nangwarry in the SE of SA in 2010 by Panax Geothermal (RAYA Limestone Coast Project). The well was intended to be drilled to 4,000 metres. The project halted, because the rocks were not impervious. Left behind was a drilling mud area and 2 holding ponds**. One holding pond contained a severe algae bloom, and the HDPE plastic liner, less than 4 years old, contained large holes and tears**. The Stock Journal published a story on 30th January 2014, with a photo of SE local identity in front of the muddy tailings. It appeared that the same day, DMITRE liaised with the RAYA group to clean this up as reported in the ASX Raya report – see link.

The pond with the algae bloom was pumped dry. The thick layer of dried drilling mud, was taken to an EPA landfill known as Telford's Quarry. The landfill operator kept the waste separate and it is not known whether the drilling mud has been disposed of properly yet. Concerns were raised about how much contaminant dust may have been blown over the district during transportation. The question is how much and what chemicals have leached down through the soil from the holding ponds themselves because of the plastic liner breaking down.

http://www.asx.com.au/asxpdf/20140131/pdf/42mfs60t5v6tdn.pdf (copy and paste)

January 2014 ; This picture shows holding ponds at site of Salamander 1 near Nangwarry.

Right side shows algae bloom. Left side note hose in right hand corner pumping out the last of the pond water. Please note the same tears in the HDPE plastic liner with before and after photos.

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4.21 JOLLY 1 WASTE WATER HOLDING POND ANALYSIS

The exploration well at Penola (Jolly 1) produced about 1,000,000 litres of highly saline water and this has been stored in holding ponds at the well site. Water quality testing data has shown that this water is **half to three quarters as salty as seawater with high levels of potassium and virtually no calcium and magnesium.** There are **elevated levels of metals above the recommended drinking water guidelines for arsenic, barium, chromium, manganese, nickel and lead. The water also contains trace amounts of organic substances including phenol, phenanthrene, fluroanthrene, pyrene and chrysene**. Many of these substances and all of the metals are persistent pollutants and some are **known to cause cancer as well as other human health effects.**

The amount of Barium is 20 times recommended amount, high levels of barium can cause low potassium, increasing risk of heart arrhythmias and death in some people. **Page 2 of the analysis report states that there was a poor matrix spike recovery due to the presence of high contaminants.**

Page 2 of Jolly 1 wastewater analysis – 2nd from bottom – presence of high-level contaminants

Page	: 2 of 7
Work Order	: EM1404169
Client	: BEACH ENERGY LIMITED
Project	: Jolly

ALS

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EG035T: Sample EM1404169 #1 and #2 has been diluted for mercury analysis due to sample matrix. LOR's have been raised accordingly.**
- **EP071: Poor matrix spike recovery due to sample (EM1404169_001) heterogeneity. Insufficient sample remains to confirm by re-extraction and re-analysis.**
- **EP071: Sample (EM1404169_001,002) shows poor duplicate precision due to sample heterogeneity. Insufficient sample remains to confirm by re-extraction and re-analysis.**
- **EP075(SIM): Sample EM1404169-002 shows poor matrix spike recovery due to the presence of high level contaminants.**
- **Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.**

4.22 TOXIC WASTE WATER HOLDING PONDS IN THE SOUTH EAST

According to a letter written from Beach Energy on 22nd August 2014, to at the Wattle Range Council, regarding the Katnook Gas Facility, acquired by Beach Energy Ltd, raw gas, free condensate and produced water are separated at the front end of the plant in a High Pressure Separator, produced water from the plant inlet High Pressure Separator is then directed to the liquids handling tank to enable hydrocarbon gas and liquids to be

separated from the water under atmospheric condition. The water from the liquids handling tank then gravity flows to the Evaporation Pond 1 via the Katnook interceptor tank as a final hydrocarbon reduction measure. Water from Evaporation Pond 1 is transferred to Evaporation Pond 2 as required.

During times of the year when water production and gas processing and rainfall exceed the evaporation capacity, excess water is disposed of to an EPA licensed facility on a batching disposal basis.

Given the contamination of produced water, the Limestone Coast Protection Alliance would like to know exactly how this water is disposed of, including the concentrated high saline brine, heavy metals, etc. The letter goes on to say that due to the time of the year, the drill sump contents associated with some of these wells has not yet evaporated and given current and predicted rainfall rates, it was considered a risk to keep the drilling sump waste water in situ. To avoid over topping, Beach Energy Ltd (under the name of Adelaide Energy acquired EPA emergency authorization 45682 to enable Katnook Gas Facility to receive and temporarily store up to 1 ML of drilling sump waste water from the Bungaloo 1 and Jolly 1 exploratory drilling well sumps. Beach Energy Ltd now seek to amend the EPA licence 23644 associated with the existing gas production facility at Katnook to include the receipt of fluids from their other licensed operations in the area.

4.23 WASTE WATER FROM HOLDING PONDS REMOVED TO KATNOOK

In September 2014 Beach Energy Limited had moved the toxic and highly water from the holding ponds to the Katnook gas storage facility pond. How can there be any confidence in the regulatory system and "world's best practice", when estimating the correct size of a holding pond cannot be determined properly? The ridiculous part is that then the water, according to the information above may have to be sent off to an EPA facility. The more contaminated water is handled, the more likely it is to be spilt.

http://www.naracoortelucindale.sa.gov.au/webdata/resources/minutesAgendas/September 2014 Attachments Items 11 to 14.pdf

4.24 JOLLY 1 HOLDING POND WASTE – WATER TO BE SPRAYED ON AGRICULTURAL LAND IN SE

The LCPA understand **that the holding ponds waste - water is being allowed to settle the drilling muds and then the water will be used for irrigation on agricultural land in the area.** This is absurd, given the holding ponds analysis, shows high salinity and other contaminants. The CSG industry 'treats its water' for use. Despite this, the treated CSG water flowed into the Condamine River, still releasing 13 contaminants. Treated water for shale gas would not be any different as the same contaminants are usually present.

No one has answered the question on how disposal in the South East of SA, of shale gas produced water (concentrated brine, heavy metals, radionuclides, salt, etc. in the water left

behind after water treatment) was going to be dealt with, as the result of exploration or during the process of hydraulic fracture stimulation. There isn't any environmentally acceptable solution. At a meeting of international hydrologists on "Fracking, Friend or Foe", it was confirmed re-injection causes earthquakes. There were 3 members of LCPA present at this meeting.

4.25 WHAT HAPPENED IN NEW ZEALAND WHEN DRILLING MUDS WERE LAND FARMED

In the Taranaki area of New Zealand, where fracture stimulation is taking place on prime agricultural land, a process called 'land farming' of oil and gas-drilling waste is spread across farming land where it is covered and pastured. It was costing Fonterra $80,000 per year to test the milk from these areas for contaminants. Fonterra no longer accept milk from these areas.

http://www.stuff.co.nz/taranaki-daily-news/business/8817459/Fonterra-to-halt-future-landfarm-collections

4.26 NO ACCEPTABLE ANSWER FOR TOXIC DRILLING MUDS AND WASTE WATER IN THE SOUTH EAST

Injection wells are also a major problem. Hence, what do they do with the disposal of drilling muds and waste - water in the South East? This illustrates the point that drilling muds and waste - water should not be disposed of through re-injection, nor should the waste water with high saline levels be used to be sprayed on agricultural land or roads. Casings and cement also break down over time, so there is simply no way to dispose of drilling muds or waste - water in any acceptable manner. Spills or leaks can also occur during mixing and storage of the water and flowback, transportation, overflowing waste water ponds, damaged plastic liners that break down in less than 4 years e.g. Salamander 1 in the SE of SA. Between 2008 and 2010, there were 1435 violations served to Marcellus Shale gas drillers, including 952 that were considered 'likely' to be detrimental to the environment. (Gilliland 2012)

http://na.unep.net/geas/archive/pdfs/GEAS_Nov2012_Fracking.pdf (copy and paste)

4.26.1 DRILLING WASTE

The **American Petroleum Institute (API)** estimates that approximately 1.21 barrels of total drilling waste are generated for every foot drilled in the United States. Of this total drilling waste, nearly 50% is solid drilling waste. The accumulated volume of solid drilling waste generated yearly is approximately 139,961,305 barrels, which is equivalent to 29,097,984 cubic yards of solid drilling waste -- enough generated waste to fill almost 9000 Olympic swimming pools. This is a sobering thought, considering that people were initially told in USA that there would only be a few drill pads.

http://www.oilandgasbmps.org/resources/solidwaste.php

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4.26.2 RADIONUCLIDES

Shale may contain very high levels of Radioactive Radium 226. Once removed from its source deep within the earth and exposed to water and air, radium decays rapidly, becoming radon gas. Radium is over one million times more radioactive than the same mass of uranium and has a half - life of 1600 years.

4.27 CLEANING UP LARGE CONTAMINATION IN AQUIFERS MAY BE IMPOSSIBLE – EPA AT PENOLA MEETING

The question of cleaning up aquifers was raised at a public meeting in Penola in April 2014. As recalled, the EPA representative admitted that small contaminations can be cleaned up, but not large contaminated areas. What was perplexing was the explanation of how contamination of aquifers was dealt with. According to the EPA representative, as recalled by attendees, the water and contamination is pumped out of the aquifer. **The question is, what is then done to dispose of the contaminated water once at the surface? Even with the water being treated, there is always a second lot of residue water in a concentrated form that will always remain.**

4.28 ROTTEN EGG SMELL COMING FROM AREA OF JOLLY 1 WELL

During the drilling of Jolly 1 well near Penola, there was a strong rotten egg smell coming from the holding pond and extending across the paddocks of the property next to the drilling rig. The holding pond was located about 3 metres from the neighbour's fence. DMITRE said it was from polymers. Upon further investigation it appears that the answer given was not logical, and more than likely it was stemming from hydrogen sulfide. This toxic air pollution did not come under the regulation of the Environmental Protection Authority, but DMITRE while at the exploration stage.

4.29 LETTER TO THE BORDER WATCH SUMARIZING HEALTH IMPACTS SOUTH EAST MAY FACE

Health issues will be under the heading of HEALTH IMPACTS, but I will include a quote from a letter to the editor of The Border Watch from Dr. Michelle Sherriff of Portland, which provides a great summary. LCPA has had access to the documents quoted to establish that the facts in the letter are correct. The letter was refuting statements made by Stedman Ellis, a paid representative of the Petroleum industry, regarding health and environmental concerns. In Sept. 2014, a study by Yale University found that people living near gas wells had a higher prevalence of skin conditions and upper respiratory conditions that lived closer to the wells. In Jan. 2014, a study published in the Environmental Health Perspectives showing an association between congenital heart defects and possible neural tube defects of newborn babies increasing with density and proximity of gas wells of the mother's home. At the same time, preliminary data from Princeton University, Columbia University and MIT showed low birth weight in the same circumstances. October 2013 Cornell University also found decreased birth weight and premature birth.

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4.30 WHO IS GOING TO LOSE OUT ON WATER ALLOCATION - GROUNDWATER (BORDER AGREEMENT) ACT 1985

Confined and unconfined aquifers in the LLC PWA areas are under the jurisdiction of the Groundwater (Border Agreement) Act 1985. No new allocations should be granted or temporary allocations renewed, where the limit to the volume of water to be extracted from licensed wells in the relevant Zone of the Designated area would be exceeded, under the Groundwater (Border Agreement) Act 1985. **If this is the case, who will lose their water allocation to provide the petroleum companies with their requirements if fracking is allowed?**

4.31 PREDICTION OF 3,446 SHALE GAS WELLS AND THE RED QUEEN AFFECT

According to a study done by FROGTECH, "Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013", Council of Learned Academics, which states **3,446 SHALE GAS** wells are estimated for the Otway Basin. Most of the wells would be on the South Australian side of the border. This report was commissioned by Dept. of Sustainability and Environment, Vic, PIRSA, VIC DPI, Geoscience Australia, DEWNR, and SA Water. Therefore this is a credible government document. This, without a doubt, will have huge impacts on the ground water, with levels of water within the aquifers dropping.

http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks Jan2013.pdf

From a site geology.com, a credible geoscience news and information site, I quote the following.

"Imagine that an oil and gas company drills fifty wells during their first year in a new shale play. They contract with a pipeline company who will transmit that gas to market. One year after these wells are drilled their production rate has fallen by 60 to 80%. So, to meet the amount of gas promised to the pipeline the oil and gas company must drill at least 30 to 40 new wells to make up for the drop in production. At the end of the second year the company has first year production drops on all of its new wells and second year production drops on all of the wells drilled in the first year. This forces the oil and gas company to drill, drill, drill to keep up with its promise to the pipeline. Many people in the oil and gas industry call this the "Red Queen Effect".

http://geology.com/royalty/production-decline.shtml

It would be assumed, based on the 'Red Queen Effect', this is why FROGTECH has come up with this figure.

According to THE NEW INTERNATIONALIST magazine, page 5, they confirm the "Red Queen Effect". As Fracked shale gas and oil wells don't appear to be productive for long, as extraction levels drop swiftly –new wells have to be dug continually just to try to maintain levels. In the US, 30-50% of shale gas production needs to be replaced each year that equals around 7,000 new wells. In a report by the Energy Policy Forum, it is scathing about the US

Energy Information Administration. The EPF conclude that the US shale oil and gas reserves have been over stated by between 100% and 500% of what is really there.

4.32 WOULD THE SE ALSO EXPERIENCE UP TO 82% DECLINE IN PRODUCTIVITY IN 3 YEARS

David Hughes is a geoscientist who has studied the energy resources of Canada for forty years. He was also with the Geological Survey of Canada as a scientist and research manager and served as Team Leader for Unconventional Gas on the Canadian Gas Potential Committee. David has a large CV that also incudes a current board member of Physicians, Scientists & Engineers for Healthy Energy (PSE Healthy Energy). He has written a report on '"DRILLING DEEPER – A REALITY CHECK ON US GOVERNMENT FORECASTES FOR A LASTING TIGHT OIL AND SHALE GAS BOOM". Each shale production area in USA has well decline areas. Hughes reports on each shale area separately and the results are similar. According to his report, vertical and directional wells have much lower productivity than horizontal wells and are being phased out. (page 263). Decline rates occur the quickest in the first year**. Over the first three years, between 74% and 82% is the amount of decline that takes place for an average well life**. **Why would Beach Energy then be considering using directional drilling?**

http://www.postcarbon.org/wp-content/uploads/2014/10/Drilling-Deeper_PART-3-Shale-Gas.pdf

5.0 CONVENTIONAL AND UNCONVENTIONAL GAS BOTH CAN HAVE HYDRAULIC FRACTURE STIMULATION

Below is an illustration out of an ASX report from Beach Energy Ltd. It clearly shows the shale is either side of the sandstone and in the Casterton Formation. It would require little effort to become a horizontal well. The drill head just needs to be lifted up or down very little. **Hydraulic fracture stimulation is also done in conventional wells.**

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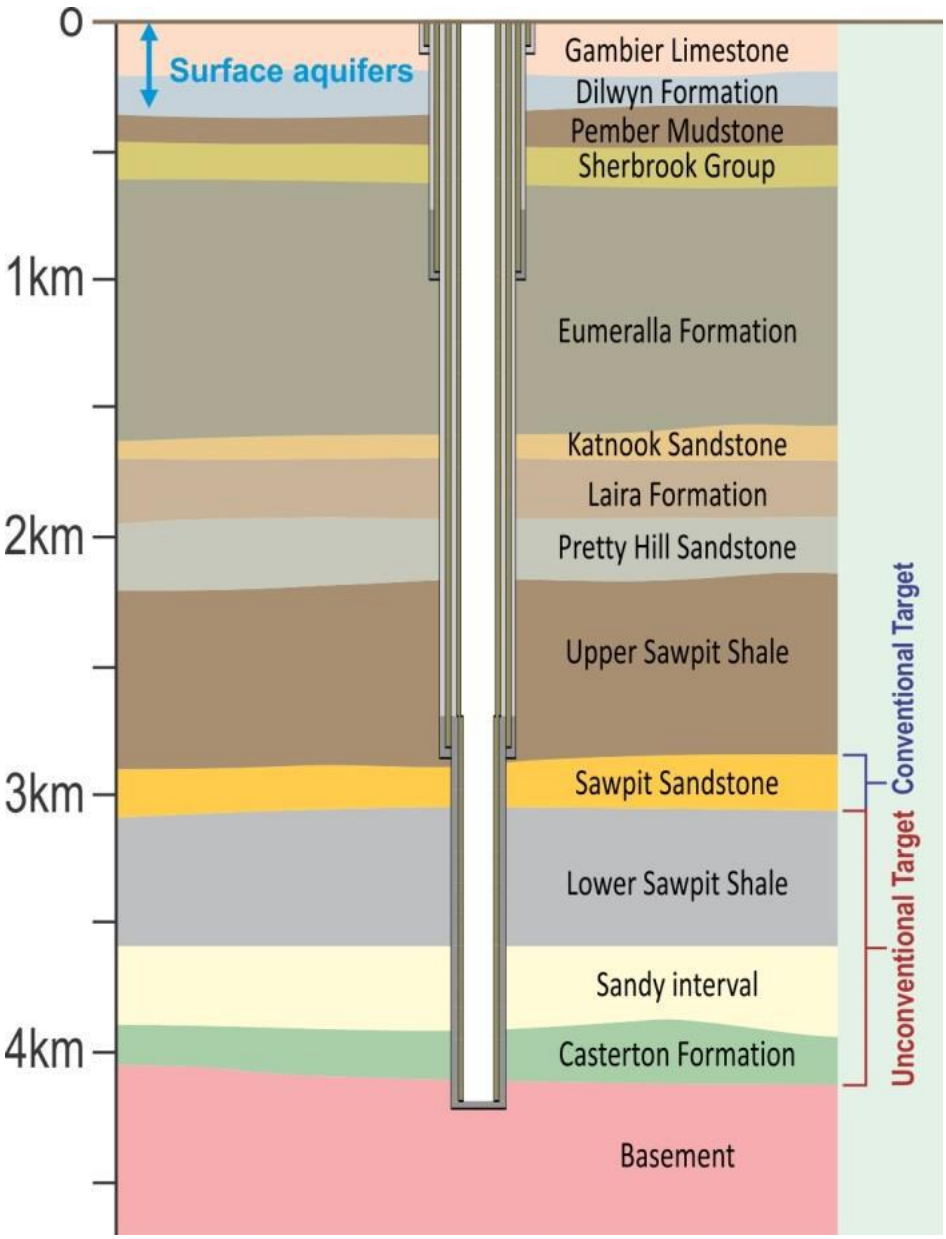
http://www.beachenergy.com.au/IRM/Company/ShowPage.aspx/PDFs/3451-56505461/PromisingresultsfromOtwayBasinExplorationDrilling (copy and paste)



6.0 REPORT FOR THE CHIEF SCIENTIST OF NEW SOUTH WALES – DIRECTIONAL DRILLING

According to the NSW Chief Scientist report, "INDEPENDENT REVIEW OF CSG ACTIVITIES IN NSW – FRACTURE STIMULATION ACTIVITIES" Sept. 2014 'Horizontal drilling' is a form of 'directional drilling' in which the well being drilled is deviated onto a horizontal plane (Carter, 2013). Usually beginning as a vertical bore, the well can extend hundreds to thousands of metres underground, bending until it runs parallel with the gas seams. From the point of deviation from the vertical, multiple radials can branch out, tapping multiple seams, or can be directed and drilled within a single seam, providing greater exposure to the target reservoir and maximising the gas extracted which can decrease the need to use fracture stimulation (Carter, 2013; Pinczewski, 2012).

http://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0008/56924/140930-Final-Fracture-Stimulation.pdf (copy and paste)

7.0 HORIZONTAL ARMS MAY BE DRILLED 1000 METRES IN SE

According to "THE ENVIRONMENTAL IMPACT REPORT, OTWAY BASIN DRILLING" for Beach Energy Ltd., page 11, a well may be **drilled horizontally for up to 1000 metres** before being cased and cemented.

8.0 NATIONAL VENDORS DECLARATION (NVD) AND NATIONAL ANIMAL HEALTH STATEMENT (NHS)

When farmers and graziers sell their stock in Australia they are required to fill out and sign the Livestock Production Assurance National Vendors Declaration (LPA NVD), accompanied by the National Animal Health Statement. The LPA NVD is the main document behind the livestock food safety reputation for Australia. It also shows movement of stock i.e. to processors, sale yards or between properties. Any contamination is required to be stated on the NVD.

How will farmers feel, if their stock becomes contaminated as the result of hydraulic fracture stimulation activities, stating their stock has been contaminated as the result of drinking contaminated water or contaminated pasture? This would affect their income and also put at risk our national and international export market.

9.0 SOUTH EAST INDUSTRY AND AGRICULTURE ALREADY DEPENDENT ON UNDERGROUND WATER

According to the South Australian Centre for Economic Studies, Regional Development Australia – Limestone Coast, the Limestone Coast covers an area of 21,330 square km, which accounts for ONLY 2.2% of the state's land mass. This is a very small area that should be exempt from unconventional gas, for protection of prime agricultural land, being one of the most diverse and productive areas in South Australia. Industry and agriculture that are dependent on these aquifers include irrigation of crops, pastures, vineyards, beef cattle, sheep (meat and wool), organic crops, trees and vineyards, dairy industry, fruit and vegetables, aquaculture, forestry, tourism and domestic and town water. Water for fire fighting should also be taken into account. Already by 13th January 2015, the South East of SA has experienced a number of bushfires for the year. There is a considerable amount of peat soil in the South East. Peat soil is highly flammable and often fires around the world have burnt underground in peat soil. With venting and flaring and the chance of explosions happening in the gas industry, which have happened overseas, these operations may be putting the SE at further risk with fire. Oils, grains, wines, spirits and wood products also contribute to the South East economy. The combined gross regional product for the South East is around $1,438,200,000.

http://www.pir.sa.gov.au/__data/assets/pdf_file/0005/181454/Limestone_Coast_Economic_Diversification_Report_Full_-_Final_14_11_2012.pdf (copy and paste)

9.1 ECOCIDE

Ecocide is a legal term meaning the extensive damage to, destruction of or loss of ecosystem(s) of a given territory, whether by human agency or by other causes, to such an extent that peaceful enjoyment by the inhabitants of that territory has been or will be severely diminished. This is how many people view the possibility of hydraulic fracture stimulation in the South East.

9.2 IF RATES OF FLOW ARE ALTERED IN THE SOUTH EAST

Where the rate of flow in an aquifer is increased, such as removal for hydraulic fracture stimulation, this can increase the risk of subsidence, as I understand from one of my engineering colleagues. I have spoken to a geophysicist in regard to this, and he has stated to me the following *"there is no question in my mind that anything that weakens Earth structure, e.g., fracking, will increase rate of events where they are already prevalent."*

10.0 KEEPING OUR NATIONAL AND INTERNATIONAL EXPORTS MARKET IN PLACE

The state government produced a document on food and wine, entitled 'ECONOMIC PRIORITY 2: PREMIUM FOOD AND WINE PRODUCED IN OUR CLEAN ENVIRONMENT AND EXPORTED TO THE WORLD".

The document states that there is a world demand for high quality food and wine and we have a strong reputation for food safety, biosecurity and product integrity. There is a focus on Asia.

http://www.foodwine.sa.gov.au/2014/12/economic-priority-2-premium-food-and-wine-produced-in-our-clean-environment-and-exported-to-the-world/

Premier Jay Weatherill is quoted as saying "*The growing world demand for high quality food and wine, combined with our strong reputation for food safety, biosecurity and product integrity, creates significant opportunities for South Australia."" The food and wine industry currently generates $17.1 billion in revenue, employs one in five working South Australians and accounts for over 40 per cent of the state's merchandise exports. Agriculture, forestry and fishing have been the fastest growing segments in the South Australian economy".*

If we are to maintain this reputation and our export markets are to continue to grow, we must keep our image as 'clean and green'. Credible, scientific peer evaluated papers showing serious concerns and effects on health, water, soil, air and agricultural issues must be heeded as warning bells.

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11.0 FOUR HUNDRED PEER-REVIEWED PAPERS SHOWING FRACKING ISSUES ARE OF THE MOST SERIOUS NATURE

There are now around 400 peer-reviewed papers that have been evaluated in USA regarding unconventional gas and fracking issues that are of the most serious nature. These can be found at the following link.

http://www.ernstversusencana.ca/state-of-science-on-harms-by-fracking-to-public-health-and-water-health-professionals-scientists-release-analysis-of-400-peer-reviewed-studies-on-fracking-along-with-major-scientific-compendium

73% of all available scientific peer-reviewed papers have been published in the past 24 months. The credible scientific report is available now to prove that hydraulic fracture stimulation is having massive detrimental effects. Not only that, the geological science in the SE is established as well in relation to limestone, faults and seawater intrusion.

12.0 HYDRAULIC FRACTURE STIMULATION CAN NOT CO-EXIST WITH AGRICULTURE

Hydraulic fracture stimulation and unconventional gas projects cannot successfully co-exist with farming and agriculture. We have a choice – either an industrialized gas field over time, or having a pristine agricultural food bowl and wonderful tourism destination for ourselves and for the rest of the world to enjoy. It is as simple as this – one or the other.

Provided that the precious South East water, soil and air is not exposed to contamination through unconventional gas projects, agricultural industry should be allowed to continue to provide an extremely important food bowl for Australia and the world for now many years to come. Gas projects using hydraulic fracture stimulation are generally expected to have a short - term life for usually around 15 - 30 years at most. South Australia must have a long-term vision, which prioritizes providing for food and water security. Without good food and water, human life cannot be sustained.

13.0 PROMINENT SOUTH AUSTRALIAN INVOLVED IN SHEEP GENETICS DISCOVERS DEAD SHEEP BY WELL IN CHILE

Brian Jefferies, AM, well known in the sheep industry in South Australia, nationally and internationally, visited a property in Chile in 2012. The owner and Brian visited an area of the property where gas was being extracted. 12 dead pregnant ewes were found 200 metres from contaminated water. Brian attended the autopsy and the blood was extremely pale and stank of hydrogen sulfide.

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The Editor of the Stock Journal,
123 Greenhill Road,
Unley SA 5061

23/9/12

Dear Deanna, TOXIC WATER

On Landline on Sunday 23/9/12, the 94 year old inventor and entrepreneur, Roy Eykamp, from Quirindi,NSW, on the rich Liverpool Plains, stated that he fears for the future of Agriculture, Irrigation and Livestock production on these rich soils. Here he could make an excellent income from a 600 acre farm.
He said that the proposal of 'Frakking for coal gas' is likely to contaminate the whole aquifer of underground water in this prime agricultural region.
Now, I have just returned from a trip to South America when I flew down to Southern Chile to assess the genetic progress in the three new sheep breeds that I established there between 1995 and 2007 I handed this project over to Andrew Michael from Leahcim, Snowtown.
While there we drove to my former client's Eastern Property, Canadon Grande (74,000 hectares with 32,000 sheep) which runs along the Southern border between Argentina and Chile. Chile's gas supply is dwindling rapidly so ENAP are extracting all the gas that they can find. They have pumps to extract the gas and then separate the mud and water from the gas. The water then runs into settling ponds.
However, we were confronted with 12 dead pregnant ewes, . close together and only 200 metres from one of these ponds of contaminated water. These 12 Patagonian Meat Merinos were part of a flock of 7000 ewes in this large paddock. A veterinarian could not find any pathological cause for their death and some were blown up with gas.. All organs were normal but I have never seen blood of such a light crimson colour and it smelt of gas. This was due to the sheep drinking contamimated water. ENAP immediately fenced off the contaminated water from the sheep.
Miners beware! You could start something that you cannot control! Stop Frakking on good Agricultural land!!.

Yours sincerely,"
Brian C. Jefferies, A.M.

14.0 COW LOST ITS TAIL AS RESULT OF FRACKING IN NORTH DAKOTA

Schilke ranch cow that has lost its tail, one of many ailments found in cattle following hydrofracturing of the Bakken Shale in North Dakota. There is now evidence showing stock dying in vicinity of gas wells. The picture is self - explanatory.
http://www.thenation.com/article/171504/fracking-our-food-supply

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15.0 IMPACTS ON HUMANS AND ANIMALS

IMPACTS OF GAS DRILLLING ON HUMAN AND ANIMAL HEALTH - A Report has been done by Dr. Michelle Bamberger, a veterinarian, and Robert Oswald, Professor of Molecular Medicine at Cornell College of Veterinary Medicine. They both have documented cases of animals and their owners with health problems that have potential links to gas drilling. Many cases are in litigation. They found that conventional wells also had faulty well casings and failure of blowout preventers, leading to contaminated water. They also included horizontal wells. The wells were both deep and shallow. Wastewater had been **spread on agricultural land** and dumped in creeks, wells and spring water. There was also surface contamination through drilling fluid spills. Humans, deer, cows, horses, fish, dogs, poultry and birds were all affected. Sudden deaths occurred in birds and poultry. Body condition, reproduction, milk production, neurological, gastrointestinal, dermatological and immunological health disorders were found. More on health impacts is found under that topic in the submission.

http://www.psehealthyenergy.org/data/Bamberger_Oswald_NS22_in_press.pdf (copy and paste)

16.0 HEALTH RESEARCH IN THE KOGAN, MONTROSE AND TARA RESIDENTIAL ESTATES AREAS

DSD (formerly DMITRE) cite a flawed draft health report based on environment as assurance there are no problems. The Queensland government report was based on minimal non-systematic sampling, relying on the inadequate industry commissioned data (subsidiary of Metgasco as understood by LCPA). This investigation was very underfunded and understaffed, and no medical staff actually visited the site. Only 15 people were examined clinically. Volatile chemical findings were dismissed even though they cause major health impacts.

Dr. Geralyn McCarron did her own independent research on patients around the Tara rural residential estates. Her report 'SYMPTOMATOLOGY OF A GAS FIELD' showed that the Queensland Health Report had no credibility at all. 35 households in the Tara residential estates and the Kogan/Montrose region were surveyed in person and telephone interviews were conducted with 3 families who had left the area. 82.58% of residents surveyed reported that their health was definitely adversely affected by CSG, whilst a further 19% were uncertain. This included adults and children. All groups "reported increases in cough, chest tightness, rashes, difficulty sleeping, joint pains, muscle pains and spasms, nausea and vomiting." A number of children complained of spontaneous nose - bleeds, skin and eye irritation. Other symptoms could be related to neurotoxicity - severe fatigue, weakness, headaches, numbness, pins and needles, burning or tingling were reported. Severe headaches, severe fatigue, difficulty concentrating, twitching, unusual movements, clumsiness or unsteadiness were also reported.

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As reported in peer reviewed papers from the USA, there are just as many or maybe even more health issues with shale gas production as there is with coal seam gas production. Quoting the draft Queensland Health Report by DSD is insidious as to what the real effects on health area. More is covered in this submission under health and chemicals.

http://www.ntn.org.au/wp/wp-content/uploads/2013/05/Symptomatology-of-a-gas-field-An-independent-health-survey-in-the-Tara-rural-residential-estates-and-environs-April-2013.pdf

17.0 REPORT FOR THE CHIEF SCIENTIST OF NEW SOUTH WALES – POTENTIAL IMPACTS

It has been quoted by the industry, that because the shale is located much deeper than coal seam gas, and further away from aquifers, there are not the problems associated with shale gas. To say that there are not serious problems with shale gas production is simply a myth. The following quotes in italic are from the "LIFE CYCLE OF CSG PROJECTS: TECHNOLOGIES AND POTENTIAL IMPACTS" June 2013 for the "Report For The New South Wales Office Of The Chief Scientist And Engineer", prepared by Professor Peter J Cook CBE, FTSE June 2013**". This document alludes to the fact, that there may even be more problems associated with shale gas production.** There are some statements regarding coal seam gas that are quoted, but upon examining these quotes, it is easy to also apply them to shale gas. This comes under the topic of 'Cumulative Impacts'.

Page 70 - "Many parts of eastern Australia are being subjected to a range of developmental issues and cumulative impacts relating to urban growth, transport, increased water needs, mining, agriculture, tourism and forestry. These activities impact on biodiversity, vegetation, flora and fauna species, soils and local water supplies for ecosystems, on people and other industries. CSG developments add to these cumulative impacts through surface activities (roads, drill pads, storage areas, water storage and use, pipeline installation, processing plants) and subsurface activities (production of CSG, production of water, disposal of water, fracking). Therefore it is important to extract CSG in a manner and in locations that do not unduly compromise agriculture, water resources, alternative land uses, and landscape function (O'Neill, et al., 1997; Tongway, 2005) using knowledge of Australian landscape processes, together with specific landscape, geological and hydrological data. These and other elements are all components of a highly connected and complex landscape system and it is important to take account of the cumulative impacts on this connected landscape that are important."

*Page 44 - "A site with complex hydrogeology is likely to be avoided because of the difficulties in aquifer management that might be encountered during the dewatering process**. A major fault zone will almost always be avoided because of the difficulties in predicting the subsurface conditions of the site and the prospect of this leading to increased risk and uncertainty.** There is also the possibility that hydraulic fracturing or disposal of waste water at such a site could lead to induced seismicity."*

Page 54 - *"Hydraulic fracturing does not have the significance for CSG production* ***that it has for shale gas production."***

Page 72 - ***All shale gas plays need to be hydraulically fractured (fracked) to stimulate gas production. Many of these wells need to be fracked multiple times. ….shale gas wells often require many phases of fracking." "The pressure required to frack shale is high due to the depth of the rock (2-3000m), the relative strength of the shale rock and the need to maximise the reach of the hydraulic fractures. In contrast, the fracking pressure used for CSG is low due to the rock being shallower (less than 1000m), the comparative weakness of coal and the need to restrict the reach of the hydraulic fractures because the coals are generally much thinner than the shales.***

Page 73 - ***It is also possible for fractures to propagate towards an aquifer along a pre-existing transmissive fault.*** *This possibility can be minimised by undertaking geomechanical modelling to predict fault orientation behaviour and avoid fracking in the vicinity of faults using high resolution seismic surveys to accurately map faults."*

http://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0010/31321/Life-Cycle-of-Coal-Seam-Gas-Report_FINAL_PJC.pdf (copy and paste)

18.0 SANTOS CONTAMINATES AQUIFER

A $1500 fine was issued to SANTOS when its joint venture partner, Eastern Star Gas allowed water to seep from one of its CSG water holding ponds into a shallow aquifer. The EPA chief environmental regulator Mark Gifford, confirmed the contamination included uranium levels 20 times higher than safe drinking water guidelines, lead, aluminium, arsenic, barium, boron and nickel, all at elevated levels above livestock, irrigation and health guidelines.

http://www.smh.com.au/environment/santos-coal-seam-gas-project-contaminates-aquifer-20140307-34csb.html

19.0 HIGH RISK INCIDENT WITH JETISONNED DRILL PIPES FLYING OUT THE GROUND

A high-risk incident occurred on 14th July, 2013. 18 drill pipes were ejected from a conventional gas well, over 2000 metres deep, (Kingfisher E01) near Casino, NSW. The well was being de-commissioned at the time. The incident occurred due to an unplanned release of gas at high pressure. There was significant damage to equipment. There was loss of integrity that had occurred during the working life of the well that resulted in gas under pressure migrating up between the inside and outside of the casing.

20.0 BASIC EXPLANATION OF HYDRAULIC FRACKING STIMULATION (FRACKING, FRACCING)

Although 'fracking' has been around for many years, the industry fails to be up front about the type of hydraulic fracture stimulation used now. Multi stage slick water, horizontal, invasive, high volume, high pressure, fracture stimulation has only been used

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since 2002, and not 60 years. Multi well pads have only been in use since 2007. According to a United Nations Environment Programme document, between 15 and 30 million litres of highly pressured water used per fracked well.
http://na.unep.net/geas/archive/pdfs/GEAS_Nov2012_Fracking.pdf

The extremely low permeability (how easily fluid can flow through a rock of the rock – low means very hard to flow through) means that shales must be artificially stimulated (fractured) to enable the extraction of natural gas. An individual well pad may typically have 6 to 10 wells, although 20 wells have been reported as being on one drill pad.

Without going into all the technical detail, a basic explanation is as follows. The well is drilled down through many geological layers including the aquifers, limestone and sand stone to reach the shale. Drill cuttings are brought to the surface as drilling is done. My question is what is in these drill cuttings – are there contaminants, heavy metals or radio-nuclides and how are they disposed of in the South East. 3 layers of casings are usually put down, then cement poured down between the casings and surrounding rock. The horizontal bore is drilled through the shale. This report states that there is no casing for the horizontal section. Other reports state there is. On report states that shaped charges are pushed down the pipe to perforated holes at various locations. Another report states that a perorating gun is inserted into casing. An electric charge is sent by wire to detonate a charge in the perforating gun, which in turn, blasts small holes through the casing and cement into the shale. At this stage, large volumes of water, chemicals and sand acting as proppant (to keep the shale fissures open) are pumped down the well under very high pressure. Sinitered bauxite or ceramic beads may also be used as a proppant. The fractures allow natural gas and oil to flow from the rock into the well. A wellhead is then installed. Please see section under health relating to chemicals. Some of the above information is from Methodology on Hydraulic Fracking Stimulation- **Report for European Commission DG Environment AEA/R/ED57281 Issue Number 11 Date 28/05/2012**

21.0 FRACTURES CAN EXTEND 600 - 900 METRES

In the report "SUPPORT TO THE IDENTIFICATION OF POTENTIAL RISKS FOR THE ENVIRONMENT AND HUMAN HEALTH ARISING FROM HYDROCARBON OPERATIONS INVOLVING HYDRAULIC FRACTURING IN EUROPE" done for the European Commission DG Environment, 2012, on Page 6 states that the "toe" of the horizontal leg can be up to 3 km from the vertical leg (Zoback et al., 2010 NPR). This suggests that a typical horizontal section can be expected to be 1200 to 3000 metres in length. This document also states that in a report by Fisher and Warpinski, 2012, a vertical fracture extended around 600 metres.

http://ec.europa.eu/environment/integration/energy/pdf/fracking study.pdf

RJ Davies prepared a document "MARINE AND PETROLEUM GEOLOGY". Page 3 – Unintentional hydraulic stimulated fractures can occur, such as an underground blowout (e.g. Tingay 2003), or through injection of waste - water at high enough rates to generate

pore pressures which exceed pressure required for hydraulic fracturing (e.g. Loseth et al., 2011). Page 5 – A petroleum company in the Tordis field offshore from Norway injected produced wastewater from oil production 900 metres below the surface. **This caused hydraulic fractures to extend 900 metres to the seabed.** This caused fracturing of the overburden. As the result the injection only lasted 5 ½ months and leakage to the seabed may have occurred for up to 77 days. One of the concerns is that if hydraulic fracture stimulation is allowed

in the SE, then there is nothing to say that drilling down vertically onshore and then horizontally drilling under the sea will not occur in the future. **(NB fractures may extend to existing fractures creating pathways to SE aquifers)**

http://www.shale-gas-information-platform.org/fileadmin/ship/bilder/news/Davies_uncorr_proof_2.pdf (copy and paste)

22.0 DEEPEST AND LONGEST HORIZONTAL WELL IN THE WORLD

It is interesting to note that the deepest and longest horizontal well is the Odoptu OP-11 well is NE of Sakhalin Island, part of Russia. It was drilled down 12.3 km. on shore and then horizontally drilled 11.5 km under the sea.

Exxon Mobile has this project. It is interesting to note that this is just above Japan where earthquakes occur frequently, the biggest being magnitude 9 on March 11th, 2011.

http://news.exxonmobil.com/press-release/sakhalin-1-project-drills-worlds-longest-extended-reach-well

Odoptu 11 deepest and horizontally longest gas hole in the world, just above earthquake prone Japan.

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23.0 UNDERSTANDING THE GEOLOGY OF SUBSIDENCE AND SINKHOLES

Sinkholes are depressions in the ground formed when Earth surface layers collapse into caverns below. They usually form without warning. According to the Pennsylvania Department of Environment Protection sinkholes are all about water. Water dissolves minerals in the rock, leaving a residue and open spaces within the rock, known as weathering. Lowering of ground water levels also is another cause, causing loss of support for the soft material in the rock spaces that lead to collapse. It is believed that this is what happened in the case of the Nulty drill hole – the aquifer dropped, exposing the limestone roof leading to the collapse of soil down the side of the casing into the aquifer. If the groundwater gradient is changed because of removing or introducing water to the system, this can also cause loose material to flush out quicker from the voids and result in surface collapse. Putting more water in or taking it may lead to instability of the hydrologic system, leading to sinkholes. Sinkholes can result from season to season changes in the groundwater table, drought and heavy rain. Karst landscapes develop naturally through the weathering process so a sinkhole can be considered a natural occurrence. **But, human influence causes sinkholes to occur where they might not naturally have happened**.

Typical activities that can lead to sinkholes are:

- Decline of water levels - drought, groundwater pumping (wells, quarries, mines)
- Disturbance of the soil - digging through soil layers, soil removal, drilling
- Point-source of water - leaking water/sewer pipes, injection of water
- Concentration of water flow – storm water drains, swales, etc.
- Water impoundments - basins, ponds, dams
- Heavy loads on the surface - structures, equipment
- Vibration - traffic, blasting

All of these activities are part of the activities of hydraulic fracture stimulation, including waste - water - holding ponds. **A sinkhole is not a hole in the rock.** Sinkholes that have collapsed and subsided that are seen on the ground surface are because of the hole in the rock below. Often, you can only see soil in the hole and not the actual hole in the rock itself because the rock is too far below.

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Sinkhole Formation

Pennsylvania Department of Environmental Protection

http://www.portal.state.pa.us/portal/server.pt/community/sinkholes/21708/what_causes_a_sinkhole_/1744210

It is clearly evidenced that a mass volume be it groundwater, oil or gas, cannot be removed without there being a degree of subsidence. It is to the weight of the compaction layer, formation of subsurface and time frame of extraction that determines the severity of subsidence. This will impact the South East of South Australia. The more a government then sources (imports) extra freshwater supplies from alternative sources that contributes to compaction weight.

A document "DEVELOPMENT OF SINKHOLES RESULTING FROM MANS' ACTIVITIES IN THE EASTERN UNITED STATES" by John G Newton, states that **induced sinkholes result in water pollution.** Millions of dollars may be required to repair sinkhole damage i.e. houses, roads, bridges etc. **As well as loss of buoyant support from water – level declines, increase in velocity of water movement, water – level fluctuations and induced recharge result in sinkholes.** Newton says on page 1, "The most predictable development results from dewatering by wells, quarries, and mines." Sinkholes occur in soluble carbonate rocks such as limestone and dolomite (sedimentary rocks), and marble (metamorphic rock). "A natural collapse is a product of a process that can span many thousands of years. This time - frame, can be reduced to hours or days by man's activities.

According to SINKHOLES IN PENNSYLVANIA: PENNSYLVANIA GEOLOGICAL SURVEY, W F Kochanov limestone can be thick or thin, laminated, folded, faulted, fractured, or it can have various combinations of these characteristics. In addition, layers of limestone can alternate with layers of dolomite or other rock types. It is mostly calcium carbonate, we can deduce that the more calcium carbonate in a rock, the greater its reaction will be with certain acids. This is a concern with fracking chemical spills with acid. One of the chemicals used for drilling is hydrochloric acid. **Hydrochloric acid dissolves the sediments and mud solids that inhibit the permeability of the rock, to enlarge the natural pores and stimulate the flow of hydrocarbons. As it etches and dissolves limestone**, this is also another concern in the

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South East because if spilt at the surface, this may cause a problem with unintentional dissolving of limestone).

https://www.rigzone.com/training/insight.asp?insight_id=320&c_id=4

The BRITISH GEOLOGICAL SURVEY confirms that when there is drought or groundwater abstraction, this can cause **sinkholes because of the level of the water – table changing**. They also confirm that mining can be a factor causing sinkholes from dewatering (i.e. for mining or gas) or intercepting clay filled voids, which then collapse. **As with the likely event of what happened with the Nulty drill hole, the buoyant water support is no longer there for the cavity.** Draining the cavities will cause collapse.

http://www.bgs.ac.uk/caves/sinkholes/home.html

23.1 BAYOU CORNE SINKHOLE

NASA RADAR DEMONSTRATES ABILITY TO FORESEE SINKHOLES by Staff Writers Pasadena CA (JPL) Mar 11, 2014

Data was collected as part of an ongoing NASA campaign to monitor sinking of the ground along the Louisiana Gulf Coast. The Bayou Corne sinkhole formed unexpectedly Aug. 3, 2012. There had been weeks of minor earthquakes and bubbling natural gas. Investigations **concluded it was caused by the collapse of a sidewall of an underground storage cavity connected to a nearby well operated by Texas Brine and owned by Occidental Petroleum.** The investigation revealed the storage cavity, located more than 3,000 feet (914 meters) underground, had been mined closer to the edge of the subterranean Napoleonville salt dome than thought. The sinkhole, which filled with slurry -- a fluid mixture of water and pulverized solids -- has gradually expanded and now measures about 25 acres (10.1 hectares) and is at least 750 feet (229 meters) deep. It is still growing.

Aerial photo of a 25-acre sinkhole that formed unexpectedly near Bayou Corne, La

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The sinkhole formed near Bayou Corne, La., in Aug. 2012. New analyses of NASA airborne radar data collected in 2012 reveal the radar-detected indications of the sinkhole before it collapsed and forced evacuations. Such data may someday help foresee sinkholes. Image courtesy On Wings of Care

http://www.spacedaily.com/reports/NASA_Radar_Demonstrates_Ability_to_Foresee_Sinkholes_999.html

23.2 GIPPSLAND SUBSIDENCE

The 2008 Gippsland Coastal Board reported that land subsidence has occurred over 40 years because of the **extraction of underground water, oil and natural gas resulting in a relatively rapid collapse (compaction) of underlying strata**.

Pages 4 and 32 - COASTAL SUBSIDENCE ALONG THE GIPPSLAND COAST.
There is now an increase in seismic activity in Gippsland. Land subsidence along the Gippsland coast will exacerbate the effect of sea level rise and future coastal erosion. Questions are being asked if depletion of the Latrobe Aquifer combined with land subsidence is causing seismic reactions. According to a CSIRO document "SIMULATION OF COASTAL SUBSIDENCE AND STORM WAVE INUNDATION RISK IN THE GIPPSLAND BASIN" Falling water levels in the Gippsland region have been observed since the late 1960's. There have been **associated impacts on irrigators and the wider community through potential land subsidence**. The Hatton Report concluded that fluid extraction activities have geographically variable impacts on the Latrobe Aquifer water levels.

23.3 SUBSIDENCE IN CALIFORNIA

LAND SUBSIDENCE ALONG THE DELTA-MENDOTA CANAL IN THE NORTHERN PART OF THE SAN JOAQUIN VALLEY, CALIFORNIA, SCIENTIFIC INVESTIGATIONS REPORT 2013–5142 By Michelle Sneed, Justin Brandt, and Mike Solt Page 7 - Large-scale groundwater development started around 1860 for urban and agricultural use in the northern part of the San Joaquin Valley. As the result, groundwater levels and flow patterns prior to 1860 have altered throughout the Central Valley. Groundwater levels have declined. Page 47 – Because of the extensive withdrawal of ground water in the valley, this has resulted in widespread land subsidence. The subsidence from groundwater pumping started in the mid 1920's. By 1970, subsidence had exceeded 8.8 metres, reaching 9 metres by 1981. A Canal and aqueduct as well as the associated decrease in the groundwater accounted for subsidence. Page 48 - There was a steady recovery of water levels in some areas. However during the drought periods of increased groundwater pumping resulted in declining water levels. Subsidence has affected irrigation channels.
http://pubs.usgs.gov/sir/2013/5142/pdf/sir2013-5142.pdf

In a recent agricultural magazine, an article entitled MERCED COUNTY IS SINKING; RESEARCHERS BLAME OVER-PUMPING OF GROUNDWATER by J.N. SBRANTI in 2014, the report confirms the article above. Locals are concerned with impacts of subsidence on

roads, dams, railway lines, pipes and bridges. According to Michelle Sneed, the USGS hydrologist, there is a 12" of subsidence a year. USGS officials said they fear sinking ground levels will **wreak havoc on economically vital man-made structures** like the Delta-Mendota Canal, the California Aqueduct and irrigation canals that serve Merced and Madera counties. The sinking soil – called subsidence – also could **damage dams, roads, railroads, pipes and bridges.**

"Is there any concern about such undersea aquifers subsiding or collapsing when water is pumped out? A news story in Modesto, California, reported that the USGS found the ground levels above that farming region is now sinking almost a foot a year in some areas! The USGS hydrologist states that pumping apparently has increased so much that groundwater levels have fallen to new lows in Merced County. ***Sneed said that's causing layers of clay to collapse beneath the surface, which is compressing the land above. Once that happens, the aquifers can never be refilled."*** *Considering also that water weight is about the same as soil, the beginning depth of drilling would be added to the feet underneath the seabed. If part of the aquifer collapsed to allow saltier water to mix, whoever relied on that water could suddenly have serious problems."* ***"The subsidence is permanent,"*** **Sneed warned.**

http://www.modbee.com/news/business/agriculture/article3156994.html

24.0 UNDERSTANDING THE RISKS OF HYDRAULIC FRACTURE STIMULATION AND EARTHQUAKES

24.1 CHIEF SCIENTIST OF NSW WARNS THAT MAJOR FAULT LINES WILL ALMOST ALWAYS BE AVOIDED

According to "Life Cycle of Coal Seam Gas Projects: Technologies and Potential Impacts. Report for the New South Wales Office of the Chief Scientist and Engineer" prepared by Professor Peter J Cook CBE, FTSE June 2013, Cook states ***"It is also possible for fractures to propagate towards an aquifer along a pre-existing transmissive fault."*** Cook also states ***"A site may be preferred because it is geologically simple; extensive folding or faulting may add considerably to the cost of development or limit the volume of gas-bearing coal that can be easily accessed. A site with complex hydrogeology is likely to be avoided because of the difficulties in aquifer management that might be encountered during the dewatering process. A major fault zone will almost always be avoided*** *because of the difficulties in predicting the subsurface conditions of the site and the prospect of this leading to increased risk and uncertainty. There is also the possibility that hydraulic fracturing or disposal of waste water at such a site could lead to induced seismicity."* **The question needs to be asked, why are licences given out in the SE that has so many faults?**

http://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0008/56924/140930-Final-Fracture-Stimulation.pdf

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24.2 DEEP INJECTION RISKY DUE TO FAULT LINES

There will be effects on the landscape. As previously stated, there is no adequate disposal method for brine and contaminated drilling mud. Deep injection is not acceptable, due to existing fault lines. HDPE liners in holding ponds do not last long, as demonstrated by the holding pond liners at the Panax Geothermal well of Salamander 1 – not lasting 4 years. As well as infrastructure, drilling pads, holding ponds, transport corridors will take up inappropriate areas. No well can be guaranteed 100% integrity, or be guaranteed to last 100 years or more.

24.3 SEISMOLOGICAL SOCIETY OF AMERICA – HYDRAULIC FRACTURING ITSELF ALSO CAUSES EARTHQUAKES

In January 5th 2015, a document released by the Seismological Society of America **showed that the fracking process itself, and not water re-injection, was responsible for a series of earthquakes occurring near Poland Township in Ohio.** One had a magnitude of 3 and occurred within 1 km of a group of oil and gas well where hydraulic fracturing was taking place at the time. There were pre - existing faults in the area. The activity did not create a new fault, but reactivated an existing fault. **This should serve as a warning bell with all the faults in the SE of SA.** 77 earthquakes with magnitudes from 1.0 to 3.0 occurred between March 4th and 12th 2014. The earthquakes coincided temporally and spatially with hydraulic fracturing at specific stages of stimulation.

http://www.seismosoc.org/society/press_releases/BSSA_1051_Skoumal_et_al_Press_Release.pdf

24.4 EARTHQUAKES OVERSEAS BLAMED ON FRACKING ACTIVITIES

In the "COMPENDIUM OF SCIENTIFIC, MEDICAL, AND MEDIA FINDINGS DEMONSTRATING RISKS AND HARMS OF FRACKING (UNCONVENTIONAL GAS AND OIL EXTRACTION)" December 2014, it is stated that "A growing body of evidence, from Ohio, Arkansas, Texas, Oklahoma and Colorado, links hydraulic fracture stimulation wastewater injection (disposal) wells to earthquakes of magnitudes as high as 5.7, in addition to "swarms" of minor earthquakes and fault slipping."
http://concernedhealthny.org/wp-content/uploads/2014/07/CHPNY-Fracking-Compendium.pdf

There are reports of hydraulic fracture stimulation leading to earthquakes in Canada and across the Atlantic in the United Kingdom. Since 2008, when hydraulic fracture stimulation has been taking place for shale, earthquakes have spiked in central and eastern United States. Before 2008 Oklahoma averaged just one earthquake greater than magnitude 3.0 a year. So far this year there have been 430 of them, Holland said. (2014)

http://phys.org/news/2014-11-scientists-fracking-earthquakes-heartland.html - jCp

In an article "INJECTION INDUCED EARTHQUAKES by Dr. William L Ellsworth, of the

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Earthquake Science Centre, Ellsworth reports that injection into deep wells can induce large earthquakes as is a higher risk and causes larger earthquakes. There was a 5.6 magnitude earthquake in central Oklahoma that destroyed 14 homes, along with other earthquakes in 2011 and 2012. This was blamed on injection wells. This activity appeared to weaken a pre-existing fault by elevating the fluid pressure. If the deeper aquifer system is under-pressured with the right circumstances, this can cause fault failure by raising the water table and the pore pressure acts on the faults**. Beach Energy Ltd. has indicated that the waste - water may be re-used. Even if this is so, the used waste - water has to go somewhere eventually.**

50 earthquakes were recorded in Oklahoma in 2009. The following year, there were over 1000 but most were not felt in 2013 there were 253. According to seismologist Austin Holland of the Oklahoma Geological Survey told Reuters: "We have had almost as many magnitude 3 and greater already in 2014 than we did for all of 2013… We have already crushed last year's record for number of earthquakes."

There have been 1562 earthquakes in past year in Oklahoma. According to the Washington Post, there were 183 earthquakes with a magnitude over 3 between October 2013 and October 2014. These have all been blamed on fracking. According to the Journal of Geophysical Research, Prague, 44 km from Oklahoma City had a 5.6 magnitude earthquake blamed on fracking activities.

http://earthquaketrack.com/p/united-states/oklahoma/recent

A 2011 fracking operation in the Bowland Shale near Blackpool, England set off 50 minor earthquakes.

In British Columbia, the industry, which uses three times more water and often at higher pressures than other shale gas formations, set off more than 200 quakes in the Horn River Basin between April 2009 and Dec. 2011.

At least 19 of the quakes ranged between a magnitude of two and three, and one reached a magnitude of 3.8, an event that surprised most scientists.

In Azle, Texas and other shale fractured landscapes, scientists suspect the culprit may not be fracking but its companion industry: dirty water disposal. A 2012 study by Cliff Frohlich, a senior researcher at the University of Texas in Austin, noted that a swarm of tremors in the Barnett Shale near Dallas were all located near deep well disposal sites. "You can't prove that any one earthquake was caused by an injection well," said Frohlich. "But it's obvious that wells are enhancing the probability that earthquakes will occur." William Ellsworth, a geophysicist with the USGS, argues that several of the largest earthquakes in the U.S. Mid-continent in 2011 and 2012 were probably triggered by the practice of disposing of salt and drilling fluids more than 10,000 feet underground in disposal wells.

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24.5 HYPO-CENTRES OF EARTHQUAKES OCCUR WITHIN DISPOSAL FORMATIONS BETWEEN 2 AND 5 KM IN DEPTH

A paper "EARTHQUAKES BLAMED ON FRACKING ACTIVITIES SINCE 2008" by Keranen, Weingarten, Abers, Benkins and Ge, from the following institutions respectively - Department of Earth and Atmospheric Sciences, Cornell

University, Department of Geological Sciences, University of Colorado and Lamont-Doherty Earth Observatory of Columbia University **it is stated that earthquake hypo-centres occur within disposal formations and upper basement, between 2 and 5 km depth.**

According to seismologist Dave Wolney**: "If you are doing deep well injection, you are altering the stress on the underlying rocks and at some point, (it) will be relieved by generating an earthquake."**

24.6 SCHLUMBERGER AND THE RUSSIAN ACADEMY OF SCIENCES DO STUDY ON PRODUCTION AND SEISMICITY

SEISMICITY IN THE OIL FIELD – by Vitaly Adushkin, Vladimir Rodionov and Sergey Turuntaev, Institute of Dynamics of Geospheres, Russian Academy of Sciences Moscow, Russia – it is stated that in some regions, hydrocarbon production can induce seismic activity. To help understand how production affects seismicity, a recording network was installed in a producing field in Russia. In a cooperative project between Schlumberger and the Institute of Dynamics of Geospheres at the Russian Academy the findings on page 16 were "**Few will deny that there is a relationship between hydrocarbon recovery and seismic activity, but exactly how strong a relationship exists has yet to be determined. Furthermore, what can or should be done about it sparks another debate."**

In regions of high tectonic potential energy, hydrocarbon production can cause severe increases in seismic activity and trigger strong earthquakes, as in Gazli, Uzbekistan (magnitude 7.3). In regions of lower tectonic stress, earthquakes of that magnitude are less likely, but relatively weak earth- quakes could occur and damage surface structures."

When the industry is prepared to admit, as the result of scientific testing, that there is a relationship between hydrocarbon recovery, which includes shale gas, then all activities relating to shale gas and tight gas in the SE of SA must cease.

http://www.slb.com/~/media/Files/resources/oilfield_review/ors00/sum00/p2_17.ashx

There are a number of other earthquakes around the world that have also been blamed on fracking activities, including Holland but too much to include here.

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24.7 LOSS OF WELL INTEGRITY

The industry likes to reassure the public that there are no problems with well integrity, because there are 'three layers of casing and three layers of cement'. In fact, the opposite can be said. While cement is being poured down during construction of the well, it may hit methane under pressure. This in turn can cause cement channelling to occur, and prevents proper sealing of the annulus, as the **outside layer of cement does not adhere to the rock matrix**. According to the McGraw-Hill Dictionary of Scientific and Technical Terms, the cement slurry does not rise uniformly, leaving open spaces and thus preventing a strong bond.

25.0 REPORT FOR EUROPEAN COMMISSION ON METHODOLOGY OF HYDRAULIC FRACTURING STIMULATION

This is a quote from Methodology on Hydraulic Fracking Stimulation- **Report for European Commission DG Environment AEA/R/ED57281 Issue Number 11 Date 28/05/2012**

Page 36 – "Poor well construction can have important environmental consequences due to the effect that inadequate design or execution can have on the risks associated with hydraulic fracturing. The causes of groundwater contamination associated with the well design, drilling, casing and cementing stage generally relate to the quality of the well structure. **(NB added in - deterioration and age of the wells need to be also taken into account, as well as earthquake activity that can affect well integrity).** Poor casing quality can thus lead to pollution of groundwater during subsequent well development stages, such as hydraulic fracturing, flowback or gas production activities. **(NB added in - age, bacteria and hydrogen sulfide also play a role in well integrity)** The risks to groundwater posed by well construction for HVHF during the well construction stage are similar to those posed by well construction for conventional natural gas extraction."

Page 62 –" methane may have leaked from leaky gas casings at depths of up to hundreds of metres below ground, followed by migration of the methane both laterally and vertically towards the water wells." According to Considine, there were **2,988 violation notices issued between 2008 and 2011 by the Pennsylvania Department for Environmental Protection. There were 845 environmental issues.**

25.1 LOST CIRCULATION

In a document entitled "A SAFETY NET FOR CONTROLLING LOST CIRCULATION" by various authors in the petroleum industry prepared for Schlumberger, on page 20, lost circulation is defined as reduced or total absence of fluid flow up the formation casing, or casing – tubing annulus when fluid is pumped down drill pipe or casing. **This is a familiar hazard when drilling and cementing in highly permeable reservoirs, depleted zones and in weak or naturally fractured vugular (small cavity in rock) or cavernous formations.** <u>This should sound warning bells for the SE of SA, which is limestone and is very cavernous.</u> Lost

circulation is also referred to as seepage. Page 21 "If the borehole does not remain full of fluid, then the vertical height of the fluid drops and the pressure exerted on exposed formations decreases. As the result, another formation can flow into the well bore while the primary loss zone is taking fluid. **A catastrophic loss of well control can occur.** During cementing operations lost circulation commonly leads to inefficient cement fill in the annulus, either because of leak-off during the pumping stage or cement fall back after the pumps are shut down. When this happens, the final cement level is below the planned placement level. Lost circulation during cementing may lead to drilling difficulties in subsequent sections of the borehole or to inadequate zonal isolation. Fluid leakage or corrosion caused by poor cement placement around the casing **might not be evident for years by which time these problems become impossible to fix**. **Total lost circulation can result in a blow out.**

https://www.slb.com/~/media/Files/resources/oilfield_review/ors03/win03/p20_27.pdf

25.2 SOME DAMAGE MAY NOT BE EVIDENT FOR YEARS

"THE COSTS OF FRACKING – THE PRICE TAG OF DIRTY DRILLING'S ENVIRONMENTAL DAMAGE" – prepared for Environment Maryland Research and Policy Centre. Page 31 highlights that harm may not be detected straight away. Polluted water can often be detected early. Other damages, including health and ecosystems may not become evident for years, even decades, long after the companies and responsible individuals have left the scene. This is very serious and the Natural Resources Committee need to be very aware of this. Who will pay down the track for damage that may not become evident for many years? We could be leaving future generations with an enormous burden, not only on health, but reliable clean water and food sources.

http://www.pennenvironment.org/sites/environment/files/reports/The Costs of Fracking vPA_0.pdf

25.3 BAD CEMENT BEHAVIOR AND LONG TERM CONSEQENCES

"WHY OIL WELLS LEAK: CEMENT BEHAVIOUR AND LONG TERM CONSEQUENCES" – by Dusseault, Gray and Nawrocki and prepared for the Society of Petroleum Engineers International. This paper also explains on page 1 that oil and gas wells can develop gas leaks along the casing years after production has stopped and the well has been abandoned and plugged. Reasons included are poor cake removal, channelling, high cement permeability and cement shrinkage. Cement leakage leads to surrounding fractures that are extended upward by the slow accumulation of gas under pressure behind the casing.

The following facts are very concerning, and please note that this paper has been written for the petroleum industry. There are literally tens of thousands of abandoned, inactive or active oil and gas wells including gas wells that leak gas to the surface in North America. This is as the result of cement shrinkage. Whilst North America is the other side of the

world, what needs to be considered are the 120 artesian wells that were in a poor state in the SE of SA and had to be rehabilitated. The SE cannot be thought of as exempt from the problem of cement shrinkage over time. According to this petroleum paper, much of the gas enters the atmosphere directly, contributing to greenhouse effects. Some of the gas gets into shallow aquifers where traces of sulfurous compounds cause the water to be non-potable. The methane can generate unpleasant effects such as gas locking of household bores, or gas entering household systems and coming through the taps. Because of the nature of the mechanism, according to this paper, the problem is unlikely to decrease and in fact the gas **RISKS** concentration in the shallow aquifers will increase with time.

25.4 SCHLUMBERGER REPORT – PROBLEMS EVEN AFTER A FLAWLESS CEMENT JOB

According to an OILFIELD REVIEW for Schlumberger, Autumn 2003, page 65, "even after a flawless cement job, the cement can still be damaged by the routine operation of the well. Also the mechanical properties of casing and cement vary over time. Differential expansion and contraction due to temperature, pressure or vibration can cause the bond between casing and cement to fail."

25.5 COOPER BASIN PROBLEMS – VERY MISLEADING TO SAY THERE HAVE BEEN NO PROBLEMS

There have been problems in the Cooper Basin. Please refer to the list at the end of this topic. A document "DOWNHOLE ENVIRONMENTAL RISKS ASSOCIATED WITH DRILLING AND WELL COMPLETION PRACTICES IN THE COOPER/EROMANGA BASINS" by Damien Mavroudis was written in 2001. **To say that there have never been problems in the Cooper Basins is misleading.** Although written in 2001, from other up to date reports, I understand **these problems still exist today.**

On page 7, drilling fluids was seen as a problem because of the potential to infiltrate fresh water aquifers, particularly the Great Artesian Basin. Other issues, as highlighted by recent documents included microbial contamination in aquifers, biocide contamination and poor mud cake removal.

Page 8 - **effectiveness of cements in achieving long-term isolation in the well bore is a major concern.** Failure mechanisms that were identified included potential mechanisms of cement failure. Other mechanisms identified included **cement carbonation due to chemical reactions, high cement permeability, sour and sweet conditions, high temperature, cement shrinkage, and formation damage**. Uncontrolled drilling fluid invasion into reservoirs penetrated by the well is another concern.

On page 19, Damien states that it is **difficult to put a time limit on the life of cement.** The cement is what provides the hydraulic seal between the formations penetrated in the well bore.

On page 23 - Casing corrosion as the result of cement failure occurred as the result of

exposure of the casing to corrosion mechanisms**. A blowout occurred on Della 1 in 1987. Page 25, "External corrosion of the surface casing by groundwater was thought to be the most likely** cause for the Della 1 failure. Recovered casing from Della 15 indicated that corrosion of the surface casing was from the inside and that the attack on the production casing was much more severe than that on the surface casing." Corrosive chemicals in the drilling mud that were left in the well at the time of completion were thought to be the likely cause of the corrosion**. Formation waters containing corrosive compounds were also a possible reason for failure, particularly lignosulphates in the mud, which, as they decompose, release carbon dioxide and hydrogen sulfide.**

Page 30, Damien discusses **poor mud displacement** resulting in a primary cement job failing. Voids, pockets or channels are left behind in the casing for a failed primary cementing job is poor mud displacement, which resulting insufficient hydraulic isolation between the various permeable zones.

Page 45, **carbon dioxide can cause leaching of the cement.** It also causes a corrosive environment, when it reduces the ph. of water to below 7.

Page 48, **The Della 15 well started to fail 15 years after the cement had been put in place.** Deterioration is thought to have occurred long before this time. **"Absolute favourable conditions would need to be present to ensure that cement integrity is maintained for an infinite time after well abandonment. This is never likely to occur since wellbore cement is exposed to dynamic conditions and streams of potential corrosive compounds.**

This needs to be taken into account with 4 km drill holes in the SE, as a big question remains unanswered over the length of time casings and cement will last before inevitable well integrity failure.

25.6 INDUSTRY ADMITS ANAEROBIC BACTERIA AND HYDROGEN SULFIDE CAUSING PROBLEMS FOR WELLS

According to the document "BACTERIA IN THE OIL FIELD – THE TECHNICAL REVIEW" by Schlumberger pages 48, 49, **anaerobic (free of oxygen) sulphate reducing bacteria are common and troublesome organisms.** Anaerobic bacterial metabolism has 3 main products – hydrogenase, acetic acid and hydrogen sulfide. Hydrogenase is an enzyme that causes oxidation of hydrogen in even an oxygen free environment. This converts iron from a metallic state to an ionic state that forms corrosion. **Stainless steel (used for casings) is an iron alloy with 10.5% chromium. Acetic acid forms pockets of corrosion when interfaced with iron sulfide and metallic iron. Hydrogen converts metallic iron to iron sulfide flocs. Most bacterial corrosion detected by the casing evaluation tool is caused by anaerobic bacteria. Aerobic bacteria oxidise iron causing rust. Corrosion is hastened by oxygen concentrating beneath aerobic biofilms covering metal surfaces.** As well as causing corrosion, bacteria can plug rock pores by releasing hydrogen sulfide that causes precipitation of iron sulfide flocs and by creation of **bacterial slimes.**

http://www.slb.com/~/media/Files/resources/oilfield_review/ors89/jan89/4_bacteria.pdf

Schlumberger are also responsible for another document – 'CORROSION IN THE OIL INDUSTRY". This document also covers gas. The following is quoted from the document, page 1, **'Corrosion, the deterioration of its metals and its properties – attacks every component at every stage in the life of every oil and gas field.** From casing strings to production platforms, from drilling through to abandonment, corrosion is an adversary worthy of all the high technology and research we can throw at it…..Drilling muds left untreated will not only corrode the well casing, but also drilling equipment, pipelines and mud handling equipment. **Water and carbon dioxide – produced or injected for secondary recovery – can cause severe corrosion of completion strings. Acid – used to reduce formation damage around the well or to remove scale - readily attacks metal. Completions and surface pipelines can be eroded away by high production velocities or blasted by formation sand.'**

Page 7, 'While a well is being drilled, stress is applied not only to the rig structure, but also to the drilling equipment. **Drill pipe is probably the most harshly treated of all equipment. It is exposed to formation fluids and drilling mud, subjected to stress corrosion and erosion by cuttings. Joints of drill pipe are made from hardened high strength steel and are likely to suffer from fatigue failures started by deep corrosion pits caused by oxygen, either from the mud itself or from being stacked wet.** Drill pipe is sometimes coated internally with baked resins or fusion bonded epoxies, to counteract corrosion. Once this coating has disappeared, corrosion can be rapid.

http://www.slb.com/~/media/Files/resources/oilfield_review/ors94/0494/composite.pdf

25.7 EFSA SCIENTIFIC REPORT – BIOCIDES AFFECT AQUATIC HABITATS AND ECOSYSTEMS

The adverse effects on aquatic habitats and ecosystems is a major concern. In a peer reviewed *Summary of the EFSA Scientific Report* (2008) 214, 1-54 Conclusion on the pesticide peer review of didecyldimethylammonium chloride (DDCA) prepared by Michael Morrison for the European Food Safety Authority, after testing, he found that higher concentrations of all biocides, except didecyldimethylammonium chloride, were required to kill planktonic cells of G20 that were exposed to humic acid. These results clearly indicate that biofilm formation by sulfate-reducing bacteria, as well as organic loading rates, negatively impact the desired result of biocides. DDCA was found very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment"). This subject will be discussed further under the topic Holding Ponds.

http://www.efsa.europa.eu/fr/scdocs/doc/s214r.pdf

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25.8 ACCORDING TO DEPT. ENVIRONMENTAL PROTECTION, PENNSYLVANNIA 6% OF WELLS FAIL IN THE FIRST YEAR

According to a survey on leaking wells in the Pennsylvania Marcellus shale play based on violations issued by the DEP (Dept. Environmental Protection), 6% of wells fail in the first year and the numbers climb as the wells age each year.

http://www.marcellus-shale.us/pdf/Violations_Jan-to-6-18-10_DEP.pdf

25.9 INSIGHTS FROM PROFESSOR ANTHONY INGRAFFEA

INSIGHTS ON UNCONVENTIONAL NATURAL GAS DEVELOPMENT FROM SHALE: AN INTERVIEW WITH ANTHONY R. INGRAFFEA: Professor Ingraffea is a founding board member of Physicians, Scientists, and Engineers for Healthy Energy (PSE). This board was established to have all kinds of technical expertise to observe, determine cause and prove effect. He is the Dwight C. Baum Professor of Engineering at Cornell University, and has taught structural mechanics, finite element methods, and fracture mechanics at Cornell for 33 years.

Page 204, People can be exposed to the toxic chemicals in the slick water, drilling muds, flow-back water or emissions a number of ways – from deep underground, the surface and the air. On the surface, chemicals are transported to the well pad and way from the well pad with other waste products from the well pad. This involves transportation and storage. This risks spills of hazardous materials. It will involve lots of trucks and pipelines. Other contaminants come out along with the methane, and not all of it goes into the pipeline. The wells and their ancillary infrastructure, such as pipelines, storage units, compressor stations and processing stations leak. This all contributes to climate change. Page 205 - **Professor Ingraffea believes that most wells will fail eventually, during the life time of a human, leaving behind tens of thousands of leaky gaskets. Which means that everything [that] was down there sequestered now (under the earth) has a pathway upwards into an underground source of drinking water or all the way to the surface.**

http://courses.washington.edu/envir300/papers/Law_and_Hays_2013.pdf

FLUID MIGRATION MECHANISMS DUE TO FAULTY WELL DESIGN AND/OR CONSTRUCTION: AN OVERVIEW AND RECENT EXPERIENCES IN THE PENNSYLVANIA MARCELLUS PLAY BY ANTHONY R. INGRAFFEA, PH.D., P.E. JANUARY, 2013 – page 2, **"Failure to isolate sources of hydrocarbon either early in the well construction process or long after production begins has resulted in abnormally pressurized casing strings and leaks of gas into zones that would otherwise not be gas bearing.**

According to page 8, violations issued by the Department of Environmental Protection and well inspector comments, 1609 wells were drilled in the Marcellus Shale in 2010, there were 111 well failures and 6.9% rate of failure. 1979 wells were drilled in the Marcellus Shale in 2011. There were 142 well failures and 7.2% well failure. **1346 wells were drilled in the Marcellus Shale in 2012. There were 120 well failures that resulted in 8.9% rate of failure**.

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Violations included gas and fluids from lower formations entering fresh ground water, failure to cement and case properly through storage reservoir or storage horizon, incorrect diameter of bore hole, excessive casing seat pressure, improper casing to protect fresh ground water, improper coal protection casing and cement procedures, inadequate, insufficient and or properly installed cement, failure to report defective, insufficient or improperly cemented casing, failure to case and cement to prevent migrations into fresh ground water.

More wells had failed cement jobs that reported in the above violations. Page 8 – All inspection reports as of January 2013, for more than 6000 wells drilled in the Marcellus Shale in Pennsylvania were reviewed. Many failed wells were not issued violations. They received a 'violation pending' indicated that a 'squeezing' cement repair procedure would be or was done if there was leaking on the outside of well's production casing, or comments that repairs were underway for a perforated casing, or comments that gas was detected at the well head or above the lower explosive limit**. It cannot be assumed that because the well looks okay at the well head, that everything is okay that can't be seen underground. Fluid migration can occur a significant distance away from the wellhead of the well that appears, when inspecting the wellhead, that there is structural integrity.**

Key factors found by researches as having a negative influence on well integrity included rapid development of a field, disturbance of young cement due to adjacent drilling activities on the same well pad, presence of 'shallow' high-pressure gas horizons and the need for deviated wells. Please note Beach Energy Limited have stated the <u>possibility of deviated wells in the South East of South Australia.</u>

According to a report 'DOES THE NATURAL GAS INDUSTRY NEED A NEW MESSENGER" CBN news, 29th Nov. 2011 (NB in USA all gas including shale gas is referred to as natural gas) interviewing Professor Anthony Ingraffea, the industry's PR is built on myths. Myths have at least a kernel of truth. Many highly qualified people in different fields, including the former head of the EPA, Lisa Jackson, want questions answered. **Fluid migration is not rare.**

In 2009, 352,000 Canadian wells were examined, according to A SOCIETY OF PETROLEUM ENGINEERS PAPER, 2009 by Watson and Bachu. There was sustained casing pressure and gas migration. Watson and Bachu found about **12% of newer wells leaked** (even more than older wells). These industry researchers found that a substantial amount of wells leak initially, an even higher amount of wells leak eventually, and now more wells are leaking than in the past, with the problem increasing.

According to Professor Ingraffea, clustered multi-well drill pad sites are now taking up **to 10 acres or more. Some sites in Canada are taking up to 50 acres.** Drew Shindell, a NASA climate scientist shows that **methane – natural gas is 105 times more powerful than carbon dioxide as a global warming contributor over a 20 year time line, and 33 times more powerful over 100 years.** Unconventional gas drilling techniques leak MORE methane than conventional techniques. The leaks occur during drilling, fracking and flowback operations,

liquid unloading, processing, and along pipelines and at storage facilities.

The leakage rate varies **between 3.6% to 7.9% during the lifetime of production of a shale gas well.** This means that from 3 to 200% greater leakage rate than from conventional gas wells. Production of shale gas creates a greater problem of global warming than coal or oil.

FLUID MIGRATION MECHANISMS DUE TO FAULTY WELL DESIGN AND/OR CONSTRUCTION: AN OVERVIEW AND RECENT EXPERIENCES IN THE PENNSYLVANIA MARCELLUS PLAY BY ANTHONY R. INGRAFFEA, PH.D., P.E. JANUARY, 2013 – page 5, Duke University published a paper (Warner *et al.,* 2012) that documented geochemical evidence possible for natural migration of Marcellus formation brine to shallow aquifers in Pennsylvania. In 2011, the US Environmental Protection Agency released a report on Pavilion, Wyoming, showing substances used in hydraulic fracture stimulation might migrate into adjacent water-bearing strata. Methane from gas wells to nearby drinking water wells was clearly evidenced. This was caused by inadequate well construction, deficient cement work, and spills have been implicated in various states in a large number of cases of migration of drilling related substances into nearby drinking water. According to the Department of Environment on 30th June 2010, there were 565 violations for the first 6 months of June.
http://www.marcellus-shale.us/pdf/Violations_Jan-to-6-18-10_DEP.pdf

On January 9th, 2015, the latest interview from Professor Ingraffea was released on the following link. He discusses the relationship with earthquakes.

https://www.youtube.com/watch?v=fU-9_NUWyxk

26.0 REPORT FROM FROGTECH ON RISKS – COMMISSIONED BY SA AND VIC GOVERNMENT DEPARTMENTS

This report was commissioned by This report was commissioned by Dept. of Sustainability and Environment, Vic, PIRSA, VIC DPI, Geoscience Australia, DEWNR, and SA Water.

The document "POTENTIAL GEOLOGICAL RISKS ASSOCIATED WITH SHALE GAS PRODUCTION IN AUSTRALIA, JANUARY 2013", page 2, " There are potential parallels with the coal seam gas industry but there are also important differences as well. However, much of the work developed for the Bioregional Assessment process for assessing the impact of CSG by the Office of Water Science may also be applicable for shale gas." The document goes on to say that 100% of shale wells need to be fracked, and that shale gas wells produce much smaller volumes of produced water (water that comes back out with contaminants etc. AED) Although it may be very saline (greater than three times seawater) and the water may contain a range of harmful chemicals which will limit treatment and reuse possibilities.

Page 18, states "The stimulated fractures may extend up to several hundred meters into the rock (Royal Society and Royal Academy of Engineering, 2012), as demonstrated by Davies et al., (2012) who reported maximum upward propagation of fractures of ~588m and ~536m in the Barnett and Marcellus Shales in the US, respectively." "Because of the

potential health and environmental risks due to induced seismicity from fracking, a blanket ban on hydraulic fracturing has been imposed in France and Bulgaria.

http://www.theguardian.com/world/2012/feb/14/bulgaria-bans-shale-gas-exploration

On page 30, of the report is the following "Shales naturally have inherent low permeability and will generally act as aquitards or aquicludes limiting ground water flow. However, faults, fractures and lithological heterogeneities in the **shale and overlying and underlying units may act as preferential ground water pathways** (Myers 2012).

In the document "SUPPORT TO THE IDENTIFICATION OF POTENTIAL RISKS FOR THE ENVIRONMENT AND HUMAN HEALTH ARISING FROM HYDROCARBONS OPERATIONS INVOLVING HYDRAULIC FRACTURING IN EUROPE" 2012 REPORT FOR EUROPEAN COMMISSION DG ENVIRONMENT on page ix, is the following quote –"However, the potential of natural and manmade geological features to increase hydraulic connectivity between deep strata and more shallow formations and to constitute a risk of migration or seepage needs to be duly considered."
Also included in the report on page 62, "the fracturing process could create new fracture pathways from the shale to the aquifer and methane gas being released to solution due to pressure reduction during extraction. This could then allow gas phase methane to migrate through the fissure network…and where the overlying formations are naturally highly fractured, and faulted.
http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks_Jan2013.pdf

27.0 REPORT BY TOM MYERS, HYDROLOGIST

In the document "GROUNDWATER – POTENTIAL CONTAMINANT PATHWAYS FROM HYDRAULICALLY FRACTURED SHALE TO AQUIFERS" By Tom Myers, hydrologic consultant, quotes on page 3 that Osborn (2011) found systematic circumstantial evidence for higher methane concentrations in wells within 1 km of the Marcellus shale gas wells. Advective transport through sedimentary rock, faults and fractures, open boreholes and abandoned wells form potential pathways. Gas movement through fractures depends on the width of the fractures and is also a concern for carbon capture and storage. (Annunziatellis 2008 and Natural Gas storage Breen 2007). Improperly sealed water and gas wells as well as open boreholes can be highly conductive pathways. He says "Pathways for gas suggest pathways for fluids and contaminants, if there is a gradient". **Please note natural gas is the term used in USA that also covers shale gas.**

http://www.scribd.com/doc/90528680/Fracking-Aquifers

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28.0 PICTURE OF A DRILLING PAD FROM A DISTANCE OF 5,000 FEET

Drilling pad from a distance of 5,000 feet. Permission for use – Sarita Rose Upadhyay, Cornell University

[The following shows the aerial impact of a drilling pad from a distance of 5,000 feet.

29.0 REPORT FOR EUROPEAN COMMISSION DG ENVIRONMENT AEA/R/ED57281 ISSUE NUMBER 11 DATE 28/05/2012

The document "SUPPORT TO THE IDENTIFICATION OF POTENTIAL RISKS FOR THE ENVIRONMENT AND HUMAN HEALTH ARISING FROM HYDROCARBONS OPERATIONS INVOLVING HYDRAULIC FRACTURING IN EUROPE" - **Report for European Commission DG Environment AEA/R/ED57281 Issue Number 11 Date 28/05/2012** prepared for the European Commission DG Environment states the following –

Page 29, "shale gas installations have greater scope for habitat impacts directly associated with stormwater runoff, through the impact this has on the erosion of streams, sediment build-up, water quality degradation and potentially flooding."

Page 36, During the well construction and development phase there is a risk of subsurface groundwater contamination due to drilling muds, additives and naturally occurring chemicals in well cuttings. New York State DEC (2011 PR p6-40) identifies these risks as: suspension of solids within the water supply arising from aquifer penetration, flow of fluids into or from rock formations and natural gas migration to water supplies poses a hazard because it is combustible and an asphyxiant. The root cause lies in well integrity. . New York State DEC 2011 PR cites the preceding GEIS (New York State 1992 PR)

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Page 37, "During the drilling stage, contamination can arise as a result of failure to maintain stormwater controls (potentially leading to site-contaminated runoff), ineffective site management, inadequate surface and subsurface containment, poor casing construction or more generally well blowout or component failure events (New York State 2011 PR page 6-15)."

Page 43, "Hydraulic fracturing can also affect the mobility of naturally occurring substances in the subsurface, particularly in the hydrocarbon-containing formation (EPA 2011a PR). The substances of potential concern include the chemical additives in hydraulic fracturing fluid, produced water, gases, trace elements, naturally occurring radioactive material and organic material. Some of these substances may be liberated from the formation via complex biogeochemical reactions with chemical additives found in fracturing fluid (Falk et al., 2006 PR; Long and Angino, 1982 PR quoted in EPA 2011a PR). If fractures extend beyond the target formation and reach aquifers, or if the casing around a Page 44 - wellbore is inadequate in extent or fails under the pressure exerted during hydraulic fracturing, contaminants could potentially migrate into drinking water supplies.

Page 46, "Besides leakage through artificial pathways, Warner et al (2012 PR) show that there is also a possibility of leakage of fluids or gases through natural geological structures, cracks, fissures or interconnected pore spaces."

Page 48, " New York State DEC 2011 PR (page 6-15) highlights that other spillage events could arise from tank ruptures, piping failures, equipment or surface impoundment failures, overfills, vandalism, accidents, fires, drilling and production equipment defects or improper operations." Spills of water and flowback water are also risks.

Page 49, 'The hydraulic fracturing process is water-intensive and therefore the risk of significant effects due to water abstraction could be high where there are multiple installations. A proportion of the water used is not recovered.

Page 50 - If water usage is excessive, this can result in a decrease in the availability of public water supply; adverse effects on aquatic habitats and ecosystems from water degradation, reduced water quantity and quality; changes to water temperature; and erosion. Areas already experiencing water scarcity may be affected especially if the long - term climate change impacts of water supply and demand are taken into account. Reduced water levels may also lead to chemical changes in the water aquifer resulting in bacterial growth causing taste and odour problems with drinking water. The underlying geology may also become destabilised due to upwelling of lower quality water or other substances. Water withdrawal licences for hydraulic fracturing have recently been suspended in some areas of the United States.'

http://na.unep.net/geas/archive/pdfs/GEAS_Nov2012_Fracking.pdf

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30.0 ENGINEERING REPORT ON AMOUNT OF CHEMICALS REQUIRED FOR HYDRAULIC FRACTURE STIMULATION

According to a New York City Environment Protection document Final Impact Assessment Report, December 2009 by Hazen and Sawyer, Environmental Engineers and Scientists, a variety of chemical additives are added to fracking fluid to control fluid properties. Chemicals are often cited as making up 0.5 to 2.0 percent of the fracking fluid. For a four million gallon (15,142,000 litres) fracture operation, this translates to 80 to 330 tons (160,000 to 660,000 lbs.) (72,574.8 – 299,371 kilograms) of chemicals per well**.**

With this type of fracture stimulation, there has been insufficient time to conduct scientific investigations of impacts due to the process itself and unforeseeable accidents.

The exact chemical composition of many additives is not known. This is because the chemicals are listed as proprietary. As one of the LCPA members recall, this discussion came up at one of the Round Tables that she attended. As far as public knowledge, one of the companies represented on a panel was happy to have the ingredients declared to DSD, then known as DMITRE, but not for public knowledge!!

http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/12_23_2009_final_assessment_report.pdf

31.0 PICTURE OF SHALE GAS HOLDING POND

Shale gas holding pond in USA – permission for use Sarita Rose Upadhyay, Cornell University, New York State – please note that this picture was taken from 3 miles away.

32.0 WHERE HYDRAULIC FRACTURE STIMULATION HAS BEEN BANNED

THE NEW INTERNATIONALIST magazine, December 2013 on page 5 points out that as people are becoming more knowledgeable about the true facts on fracking and are not prepared to stand back. Resistance to this activity is in almost every country where fracking has been launched. The unconventional gas industry has painted success stories, when in fact, there are countless stories and documents now arising in the public arena on the shocking impacts that are being left behind. Bans or moratoriums are currently in place in France, Ireland, Romania, Bulgaria and parts of Canada, Spain, Argentina, and the USA. New York State has banned any potentially gas drilling for several years as data becomes available. Denton in Texas, the birth - place of fracking, has a ban. Victoria in Australia has a moratorium. The Victorian moratorium will remain in place until the state inquiry brings back its findings at the end of this year. It is a suspension on the issuing of licenses, on the process of fracking and now the issuing of works plans for unconventional gas drilling. Tasmania has a 12month moratorium until 16th December 2014, to enable a review on fracking. Fracking has been blamed for a number of earthquakes around the world, including Holland, the USA and other countries. It is interesting to note that in 2012 Western Australia government put a freeze on coal mining in the Margaret River area, because of concerns of aquifer and soil contamination.

http://rt.com/usa/fracking-texas-activists-concerned-510/

33.0 INSTITUTIONAL FAILURE IN SOUTH AUSTRALIA

Although not related to unconventional gas, it is important to mention that there are problems state wide. The LCPA understand that only two government logging trucks operating in South Australia. There are thousands of drill holes around the state, including mineral exploration and hydrology observation drill holes. All auditing for both Mineral and Petroleum drill holes comes under the Department of State Development. This shows an inadequacy of auditing previous drill and hydrology observation holes, let alone hundreds more, including gas drill holes and wells in the future including for generations to come.

On Eyre Peninsula, farmers forced DMITRE to do an audit on Eyre Iron. They only looked at 136 of the 406 drill holes. 109 were non compliant. As far as LCPA are aware the remaining 270 drill holes were never audited. DSD is the regulator of licences, the promoter and the regulator. This is clearly a conflict of interest.

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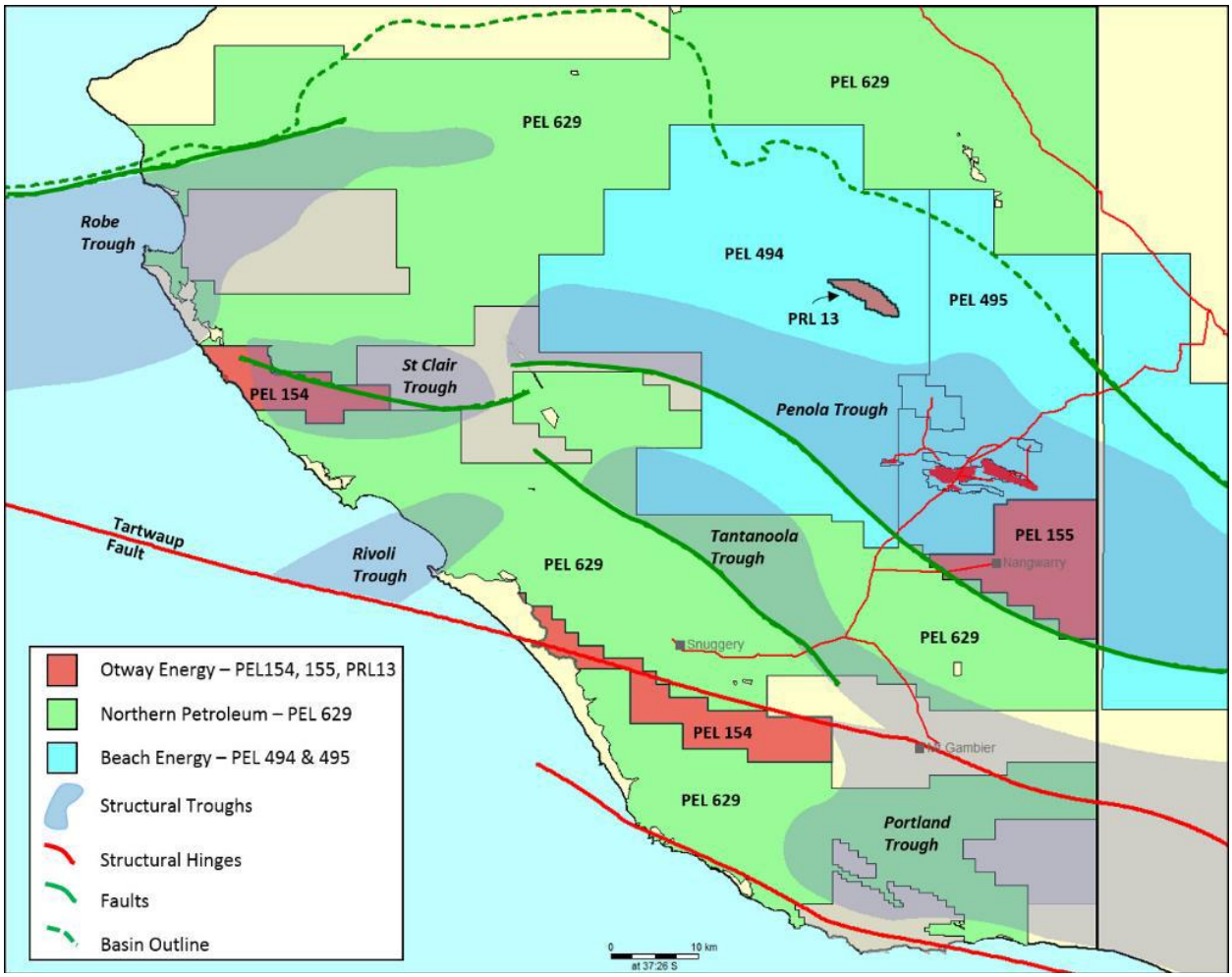
34.0 MAP OF PELS IN SOUTH EAST OF SOUTH AUSTRALIA

Map of Petroleum Exploration Licences that cover nearly all of Lower South East South Australia. (Image taken from Rawson Resources Investor Presentation March 2014)



35.0 THE DIRTY INCIDENTS IN SOUTH AUSTRALIA THAT THE INDUSTRY DOES NOT WANT US TO KNOW ABOUT

35.1 PETROLEUM AND GEOTHERMAL ENERGY ACT COMPLIANCE REPORT 2011

January – (SANTOS) Separated hydrocarbon in groundwater 22 m below ground level and dissolved phase hydrocarbons in the groundwater. These were detected beneath a decommissioned burn pit adjacent to the Toolachee gas processing facility in PPL 14 in the Cooper Basin. Discovered when SANTOS was carrying out internal rehabilitation process on decommissioned sites. Root cause was because of absence of impermeable liner not installed in pit as not required in 1980's.

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PICTURE OF SUMP WASTE WATER POND IN COOPER BASIN USED IN BEACH ENERGY SLIDE SHOW DECEMBER 2014

Since the late 1980s the main preventive action taken to prevent the reoccurrence of contamination incidents is that all interceptor and sludge storage pits and ponds must have installed a UV-stabilised reinforced polyethylene liner. One of the members contacted DSD regarding the picture of the sump waste - water pond in the Cooper Basin that has no HDPE plastic liner. Part of the reply is as follows **"**Egis Consulting (2001) undertook a risk based study into the potential for the bioaccumulation of contaminants in the meat of cattle to detectable levels following exposure to drilling fluids, cuttings and other materials associated with well completion activities for Santos Ltd. The results of the study indicated the following.

·Constituents from which drilling muds are formulated are generally nontoxic or have a low effective chronic toxicity at the concentrations present in the drilling mud. They also have chemical properties, which indicate that they are unlikely to bioaccumulate in the meat of cattle. **WHAT THE PICTURE DEPICTS, ACCORDING TO THE COMPLIANCE REPORT MEANS THAT THIS IS ILLEGAL, ESPECIALLY GIVEN THAT IN THE COMPLIANCE AUDIT REPORT THAT SINCE THE LATE 1980'S ALL INTERCEPTOR AND SLUDGE STORAGE PITS MUST HAVE INSTALLED A UV-STABLISED REINFORCED POLYETHYLENE LINER.**

http://www.beachenergy.com.au/IRM/Company/ShowPage.aspx/PDFs/3719-10000000/BeachEnergyInvestorPresentation25November2014

In February – (SANTOS) Phase separated hydrocarbon was in groundwater 16 m below ground level adjacent to the fire water tank in the Moomba crude oil tank farm area. The contamination was attributed to a failure that occurred in November 2009 of a crude return line that connected the storage tank 1000 to the Crude Stabilisation Plant within the

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Moomba plant. Because of heavy rain throughout 2010, the site was inaccessible to ascertain the depth of contamination.

In March - (SANTOS) Corrosion leak on its Tantanna to Gidgealpa oil trunk line at a location 3 km from the Gidgealpa oil satellite.

In May – (SANTOS) Phase separated hydrocarbon in groundwater underneath decommissioned oily sludge storage pit – Moomba plant facility. The Moomba plant had leaked during operation. Vertical migration of contaminants through the soil profile seeped into the underlying aquifer.

In September - SANTOS reported a similar incident to the February incident in the vicinity of storage tank 1000. Then in October it was reported that 1.2 m of phase separated hydrocarbon was in the groundwater in the vicinity beneath this next leak.

In May - LINC ENERGY reported an observed uncontrolled flow of water to surface from its hydrogeological monitoring piezometer well, Orroroo 5 P2, in the Walloway Basin (within PEL 120). The source of the leak to surface was identified to be from a failed joint in the PVC casing below the surface and the primary root cause of this failure was attributed to a design flaw in well construction.

In June - LINC ENERGY reported an uncontrolled water flow to surface from 13⅜ ” and 20” casing annulus during the drilling of Hayack 1 in PEL 121. The flow rate was estimated to be ~12 L/h. The cause was identified to be a small hole in cement between 13⅜ ” and 20” casing rings.

In June - LINC ENERGY reported an uncontrolled discharge of formation water from a lined sump at Hayack 1 in PEL 121 into an area beyond the well site that had not been culturally cleared and into an adjacent mud flat. The primary cause of the discharge was inadequate design of the sump coupled with an unexpected large flow of water from Hayack 1 when drilling out the 13⅜ ” casing shoe into an unidentified aquifer.

In September - LINC ENERGY reported an uncontrolled formation water flow through the 7” and 4ó” annulus during the cementing operation of the 4ó” casing at its Wirrangulla 1A well in PEL 122. The cause of the uncontrolled flow was identified as a breakdown of formation at a weak zone below the 7” casing shoe causing the level of cement in the 4ó” and 7” annulus to drop. The subsequent drop in annulus pressure as a result of this is believed to have then allowed formation water higher up the annulus and not covered by cement to flow to surface.

In October - the APA Group identified a weeping crack on the Moomba to Sydney gas pipeline (PL 7), 91.1 km from Moomba (in SA).

In September - SANTOS reported a leak adjacent to crude oil storage tank 1000 on a separate buried crude line to that which failed in November 2009. In addition, on 9 December Santos reported a failure detected on its 10” buried crude run down line from the

crude stabilisation plant to tank 3000. In the case of the 9 December crude line failure, the pipeline was immediately hydrostatically tested after the clamp was installed. Subsequent hydrostatic testing revealed another two leak locations along the line that were excavated and repaired. The primary root cause of these buried pipeline incidents was attributed to the absence of cathodic protection on the buried sections of these lines and defects in the corrosion protective polyethylene wrap at the locations where the pipes failed. Furthermore, another cause was the fact that the ongoing inspection of these lines was limited to assessments of the condition of the above ground sections with inspections of the buried sections restricted to planned excavations.

On 19 March SANTOS reported a corrosion leak on its Tantanna to Gidgealpa oil trunk line at a location 3 km from the Gidgealpa oil satellite.

On 21 April BEACH ENERGY was issued with a formal notice of noncompliance for the commencement of construction of water storage ponds at the Holdfast 1 well site without an activity notification having been submitted to DMITRE, thereby breaching section 74(3) and regulation 18 under the Act.

On 4 May BEACH ENERGY was re-issued with a formal notice of noncompliance in relation to the commencement of earthworks in the establishment of a contractors camp in PEL 92 without an activity notification having been submitted to DMITRE, thereby breaching section 74(3) and regulation 18 under the Act.

On 6 May SENEX ENERGY was issued a formal notice of noncompliance for the commencement of earthwork activities at its Growler 9 well site within Petroleum Retention Licence 15 prior to receiving written approval from the Minister, thereby breaching section 74(3) and regulation 19 under the Act.

On 6 June ORIGIN ENERGY was issued a formal notice of noncompliance for the inappropriate disposal of wastewater at Celcius 1 well site.

On 8 July AHAVA ENERGY was issued with a formal notice of noncompliance when a DMITRE inspection at the Trainor Echo 1 well site (PEL 138) identified that an animal had become trapped in an open container of sump oil and subsequently died. The findings highlighted a breakdown in Ahava's management system resulting in the fauna mortality which is a clear breach of Objective 3 of the APY Lands Exploration Drilling Activities SEO.

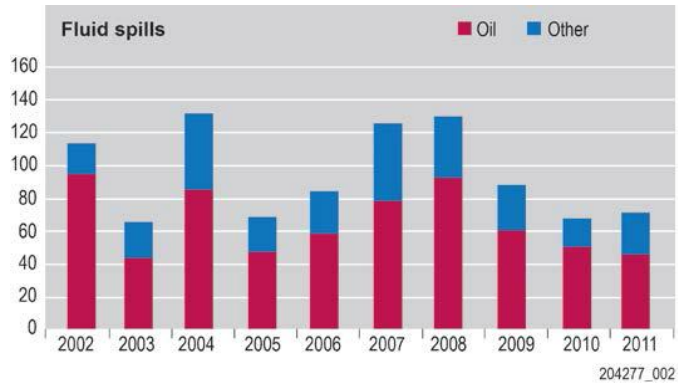
On 18 July BEACH ENERGY was issued with a formal notice of noncompliance for extracting water from the Cooper Creek without submitting an activity notification, thereby breaching section 74(3) and regulation 18 under the Act. The incident involved four tanker loads of water being extracted from the Cooper Creek near Beach Energy's Butlers oil facility due to operational problems with the reverse osmosis plant.

On 8 August ADELAIDE ENERGY was issued with a formal show-cause letter requesting why Adelaide Energy should not be directed by DMITRE to appoint an independent and

competent third party to undertake a comprehensive review of the company's management systems to demonstrate that they are fit for purpose.

On 16 September EPIC ENERGY was issued with a formal notice of noncompliance for the extraction of five tanker loads of water from the Cooper Creek near the Innamincka causeway by one of Epic's contractors without an activity notification having been submitted to DMITRE, thereby breaching section 74(3) and regulation 18 under the Act. This extraction of water from the Cooper Creek was for use during construction of the QSN3 pipeline project under PL 18.Figure 10 is a graph of all fluid spills reported since 2002 to end 2011 for the onshore petroleum and geothermal industries in South Australia. The graph shows the portion of these spills that are oil as opposed to other contaminates. The relative frequency of types of fluids spilled in 2011 is shown in Figure 11.

RED IS OIL SPILLS AND BLUE IS OTHER SPILLS



There were higher percentages of oil spills in 2001 and 2002 with two major spill incidents that occurred in those years – a pipeline leak in 2001 released 500 m3 and a breach in an oil interceptor pond wall in 2002 released 200 m3 of oil. Between 2001 and 2008 only one incident was deemed as having the potential to cause serious environmental harm and was hence treated as a serious incident under the Act.

Gas release incidents relate to uncontrolled and unintended gas releases at processing facilities and pipelines. Such incidents may be indications of equipment integrity issues that may have security of supply and/or safety implications. Eight incidents were reported during 2011, the risks associated with these releases were considered to be tolerable and hence did not warrant concern and further investigation by DMITRE.

During 2011 the four OHS&W incidents related to two small fires, a dangerous occurrence on a drilling rig and failure of a fan on a condensing unit in a gas plant. In all these cases no injuries were sustained.

Other incidents relate to all other incidents not specific to the other categories but which have the potential to adversely affect the environment and third parties (workforce, public and landowners) if no action is taken. Examples include landowner complaints, road incidents and heritage disturbance. In 2011 these included the heritage disturbance and

uncontrolled flow and discharge incidents detailed in Sections 4.2 and 4.3.

35.2 PETROLEUM AND GEOTHERMAL ENERGY ACT COMPLIANCE REPORT 2012

During 2012 a number of serious incidents were reported under the *Petroleum and Geothermal Energy Act 2000*, and details of these incidents are provided in Section 4. These included potential aquifer contamination, potential cultural heritage disturbance, uncontrolled flow and pipeline integrity incidents.

There were failures that occurred on Santos' glass reinforced epoxy pipelines.

In August 2012 Santos had commenced the construction of the Cook (Qld) to Merrimelia (SA) pipeline (PL 20) in the Cooper Basin. This pipeline was of interest to DMITRE due to the increased inherent risk associated with the environmental sensitivity of the route and the relatively new construction material (spoolable composite pipe) used.

Santos and its joint venture partners, as licensees of the now expired PELs 5 and 6, have set aside funds to offset the residual environmental effects of their seismic exploration activities in the Merninie Range, to the north of Innamincka.

During 2012 Beach Energy separately reported two cultural heritage incidents. On 21 June 2012, during the final phase of the Boston 1 well lease construction within PEL 218, sump spoil was pushed over a cultural heritage exclusion zone while the flare pit was being excavated. − _On 13 August 2012, during the construction of the Marble 1 well lease access within PEL 218, a cultural heritage exclusion zone was disturbed. A 6.5 m wide access track was constructed where a condition exists for a width restriction of 3 m access.

On 3rd July 2012 DMITRE inspected Panax Geothermal Salamander 1 well site and detected a gas leak from the wellhead. A subsequent inspection showed a second smaller leak. Gas sampling found the gas methane rich. The cause of the leak was due to a short un - cemented section behind the 9 . 5/8" casing below the 13.3/8" shoe and failure of the 9.5/8" liner packer resulting in a loss of pressure containment.

On 9 January 2012 Santos reported a leak on the Carmina 1 flow line, made of glass-reinforced epoxy.

In 2012 Santos reported 17 flow line failures (pinhole leaks) on their 5000 km steel flow line network in the Cooper Basin. Such failures are defined as serious incidents under the currently gazetted Cooper Basin Processing and Production SEO. The failure mechanisms related to internal and external corrosion, with the primary root cause being inadequate monitoring and maintenance.

On 18 and 20 November 2012 Beach Energy reported two pipeline failures during the commissioning of the Lycium to Moomba pipeline.

In September 2011, Santos reported a leak adjacent to crude oil storage Tank 1000 on a

separate buried crude line

to that which failed in November 2009. December 2011 Santos reported a failure detected on its 10" buried crude run down line from the crude stabilization plant to Tank 3000. These incidents were attributed to the absence of cathodic protection on the buried sections of these lines and defects in the corrosion protective polyethylene wrap at the locations where the pipes failed.

On 12 January 2011 Santos reported that phase separated hydrocarbon on groundwater at ~22 m below ground level and dissolved phase hydrocarbons in the groundwater had been detected beneath a decommissioned burn pit adjacent to the Toolachee gas processing facility within Petroleum Production Licence 14 in the Cooper Basin.

May 2011 Santos reported phase separated hydrocarbon on groundwater underneath another decommissioned pit – the oily sludge storage pit at the Moomba plant facility.

The primary root cause for the Toolachee incident was the absence of impermeable liners in the pit, as this was not a design requirement at the time the pit was constructed in the early 1980s. The oily sludge pit at the Moomba plant is lined but leaked during operation. This allowed for vertical migration of contaminants through the soil profile and hence seepage into the underlying shallow aquifer. **The main preventive action taken to prevent the recurrence of such incidents is the requirement since the late 1980s that all interceptor and sludge storage pits and ponds must have a UV stabilised reinforced polyethylene liner installed.**

On 12 September 2011 Santos reported a second buried line leak adjacent to crude oil storage Tank 1000 on a separate crude line to that which failed in November 2009. As a result of this line failure, on 17 October Santos reported that 1.2 m of phase-separated hydrocarbon was detected on groundwater in the vicinity beneath the location of this leak.

On 28 November 2012 Santos was issued with a formal notice of noncompliance for undertaking an activity, the partial replacement of 2 km of the Moomba to Port Bonython liquids pipeline, **without distributing formal notice of entry letters to relevant landowners, thereby breaching section 61 of the Act.**

On 15 November 2012 Acer Energy was issued a formal notice of noncompliance for the construction of Cypress 1 well lease within PEL 103 **without issuing relevant notice of entry letters to landholders**. A notice of entry letter issued did not reference Cypress 1 well lease or illustrate the location of the well lease. This is a breach of section 61 of the Act and regulation 22 detailing the required contents of written notice of entry on land.

On 15 November 2012 Senex Energy was issued a formal notice of noncompliance for the construction of Tomcat A well lease within PEL 111 without written approval by the Minister, thereby breaching section 74(3) of the Act and regulation 19. Senex Energy had been given approval to construct a different well lease, Tomcat 1.

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On 19 March 2011 Santos reported a corrosion leak on its Tantanna to Gidgealpa oil trunk line at a location 3 km from the Gidgealpa oil satellite.

Gas release incidents relate to uncontrolled and unintended gas releases at processing facilities and pipelines. Such incidents may be indications of equipment integrity issues that may have security of supply and/or safety implications. In the case of the 15 incidents reported during 2012.

35.3 PETROLEUM AND GEOTHERMAL ENERGY ACT COMPLIANCE REPORT 2009

On the 24th April 2009, the Habanero 3 well within Geothermal Retention Licence (GRL) 3 near Innamincka in the north east of South Australia operated by Geodynamics Ltd experienced a serious failure at the surface and intermediate casing strings just below the well head. This resulted in an uncontrolled flow (blow-out) of steam and 14 ML of produced water to the surface, hence constituting a serious incident under the Petroleum and Geothermal Energy Act. Subsequent investigation into the incident revealed that the principal cause of the failure was hydrogen embrittlement of the 9 5/8 and 13 3/8 inch casing strings within the well. It was found that two factors most contributed to material failure of the casing deployed in Habanero 3; the high carbon steel casing composition combined with the operating conditions (and in particular heat flux) in the well made the casing susceptible to hydrogen embrittlement.

In April 2009, through routine monitoring, a minor uncontrolled water leak to surface was detected and reported to PIRSA by Santos at its abandoned Tirrawarra 3 well site. The source and location water leak was due to a lack of isolation integrity of existing perforations below 5400 feet.

In August and September 2009 two spills of bore water from storage ponds into adjacent salt lake areas from the Chiton and Murninnie exploration well sites operated by Beach Energy Ltd within its PEL 91 and 92 exploration areas respectively in the Cooper Basin were reported. In both cases the spills constituted a serious incident mainly as a result of the spills encroaching onto areas that were outside the area specifically cleared for the well lease.

On the 4th October 2009, a leak was detected followed by an investigation and analysis concluding that the Habanero 3 well had a leaking annulus and the gas contained 98% methane. The manifestation of the leak was benign and small (less than 0.0012 Million standard cubic feet per day) with a low flowing pressure. The gas was making its way up through the annulus between the 9-5/8 inch and 13-3/8 inch casing strings.

35.4 PETROLEUM AND GEOTHERMAL ENERGY ACT COMPLIANCE REPORT 2008

Drilling rig PDI 709 fatality, 27 January. On 27 January 2008 a fatality occurred on drilling rig PDI 709 while contracted to Santos for drilling Mudera 12 in the Cooper Basin.

Moomba Plant gas supply outage, 18 August. At 1 pm on 18 August 2008 gas supply from

the Moomba Plant into the Adelaide and Sydney pipelines ceased as a result of a detected gas leak in the main sales gas line immediately upstream from the Adelaide (MAP) and Sydney (MSP) pipelines' flow control valves. The leak was a result of a crack on a weld connecting a small bore gas-sampling line to the sales gas line.

Victoria Petroleum NL (Victoria Oil Exploration (1977) Pty Ltd) — Tigershark 1 abandonment noncompliance. Victoria Petroleum was noncompliant with the 'South Australian Cooper Basin drilling and well operations SEO' (November 2003) during the abandonment of Tigershark 1 (PEL 104) by not setting a plug isolating the Birkhead–Hutton–Poolowanna units from the basement (Warburton Basin). PIRSA issued a letter of noncompliance on 21 November.

There were other incidents as well for 2008, 2007 and 2006 including the leaking wellhead at Salamander 1 well in the South East. Do the residents of the South East want to risk contamination in their water and on the land and have similar incidents happening as listed in this submission? The answer is a clear no. Even in South Australia there is clear evidence, from the government's own site, to show the flaws in the system and contamination that should have never happened. For other evidence found in government annual compliance reports, please click on the following link –

http://www.pir.sa.gov.au/petroleum/legislation/compliance/petroleum_act_annual_compliance_report

CONCLUSION

Clean, potable water is our most valuable resource on earth. Without it, we cannot survive. It is necessary to sustain us for food and drinking. Already there are 700 million people in 43 countries of the world that are suffering from water stress and scarcity. This will increase, particularly as salinity increases, rainfall decreases, we face a hotter climate, the population grows and precious lakes, streams, rivers and aquifers continue to be polluted, much at the expense of big industry, including mining and petroleum industries. Even our own state government acknowledges water shortages ahead.

South Australia is the driest state in the driest inhabited continent in the world. In 2006 there was no recharge of any aquifer in the entire South East (SE) region. We continue to have bushfires. According to the Lower Limestone Coast Water Allocation Plan, aquifers in the SE are already in decline. No one can give a guarantee that there won't eventually be 1000's of wells. The government commissioned document by Frogtech points out that there may be 3446 shale wells in the Otway Basin, mostly on the South Australian side. While Beach Energy Ltd. claim there won't be many wells, a truth yet to be proved, they may on sell their licence to the next petroleum company which intends to put in 100's or 1000's of gas wells.

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As the science is already in on scarcity of water, and predicted climate change with increasing temperatures and forecasts of declining rainfall, the government in South Australia needs put preservation of water resources at the top of its agenda. Lack of water also affects the economy. The South East people do not want to risk losing the "clean green image" which would impact local, national and international trade. The South East has a myriad of wonderful tourist destinations. This includes the UNESCO listed Naracoorte Caves National Park, where Petroleum Exploration Licences run along the boundaries of the park. This is not just a local issue, but also of international concern, and would come under the United Nations jurisdiction. Many caves are interconnected. Most people do not want to holiday in gas fields. Most people don't like to live in a gas field.

The South East or the rest of Australia should not be regarded as "a gas field". Already the South East people are disturbed that the government is permitting the irrigation of Jolly 1 holding ponds wastewater on agricultural land. The Jolly 1 holding pond analysis revealed salinity up to **¾ as salty as seawater**, high barium levels, some heavy metals and toxic chemicals such as **phenanthrene, fluroanthrene, pyrene and chrysene**. There have been serious incidents in the South East, including high-density polyethylene pond liners breaking down at the Salamander 1 well site. The Salamander 1 wellhead leaked. There has been subsidence of the hydrology drill hole in limestone country.

No one can control what is happening under the ground anywhere in Australia or the world. Who is going to foot the bill for problems in the future, which may occur long after the companies are gone? Where do we get water from once it is contaminated? We must have a vision for now and future generations to come which includes a clean and green food bowl and clean water. The choice is a gas field or agriculture. It cannot be both. A gas field and agriculture in the South East or anywhere else in Australia simply cannot co-exist.

There is much evidence in this section to show that any gas or mining activities should not be undertaken without prior written authorisation from landowners. There is much evidence in this section to show that constitutional corporations should be banned from engaging in hydraulic fracturing operations for coal seam gas, tight gas and shale gas.

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Senate
Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

SECTION 3: RISKS OF GROUNDWATER CONTAMINATION
PART 2

Limestone Coast Protection Alliance Inc.

SOUTH EAST WATER ALLOCATION PLAN

WATER ALLOCATION PLAN FOR THE LOWER LIMESTONE COAST PRESCRIBED WELLS AREA (LLC Water Allocation Plan) November 2013. Prepared by the Natural Resources Management Board

http://www.naturalresources.sa.gov.au/southeast/water-and-coast/water-allocation-plans/lower-limestone-coast

Introduction

This is intended to be a brief précis of the LLC Water Allocation Plan to highlight issues with the water management in the South East of South Australia (SE) and to support the argument for exempting the South East from hydraulic fracture stimulation. Parts of the policy are highlighted, and in some cases, comments added in brackets. Much of this would apply to other areas of Australia as far as water allocation.

There are 2 aquifers – the unconfined and confined Dilwyn – they are a finite resource.

For the last decade underground and surface water hydrology of the SE region has changed with reduced water inflows. The SE Water Science Review states that the SE is experiencing prolonged dry conditions and increasing salinity. There are dropping groundwater levels – the SE does not need intensive water use from hydraulic fracture stimulation to add to this burden.

This resource needs to be managed properly for future generations.

A study done by FROGTECH, commissioned by PIRSA, DEWNR, SA Water and other departments estimates there may be 3,446 shale gas wells in the Otway Basin, mainly on the SA side.

There are many faults in the SE. Hydraulic fracture stimulation should not be near any faults – there is risk to contaminant pathways and activating earthquakes.

There are numerous sink holes in the SE. The SE is on limestone which is prone to subsidence and sink holes and exacerbated with mining, drilling and hydraulic fracture stimulation.

Much water in the confined aquifer is 25,000 years old.

Near Tarpeena and Nangwarry, vertical underground water recharge to the confined aquifer is via fractures, faults or sink holes. There would be other areas as well. Hence these should not be put at risk for hydraulic fracture stimulation that may cause contaminant pathways.

Aquifers below 4000 metres increase salinity with depth. This water should not be brought to the surface for hydraulic fracture stimulation activities, risking contamination of potable surface and aquifer water and soil. It would most certainly contain heavy metals,

radionuclides, volatile organic compounds and be very high in salinity. Underground water in the confined aquifer is under pressure.

Declines of water levels are occurring in both the unconfined and confined aquifers due to less rainfall, underground water extraction and interception of recharge.

There is moderate to good hydraulic connection between the two aquifers – if one gets contaminated it is very likely both will become contaminated.

Livestock, cropping, commercial forests, irrigation, dairy, beef, sheep, horses, grapes, lucerne, fruit and vegetables, seed crops and cereals, olives, the organic sector, domestic and town water supplies, tourism, flora, fauna, and eco-systems as well as fire fighting water all rely on the water resource from both aquifers.

Hell's Hole, Ewens Pond and Piccaninnie Ponds are on the Register of the National Estate.

Piccaninnie Ponds, Hacks Lagoon and Bool Lagoon are on the list of Wetlands of International Importance (RAMSAR).

During 2001 to 2010, there were 120 leaking aquifer wells in the SE that had rehabilitation costing $5.5 million.

(Please note, imagine the costs of in time of repairing every drill hole for unconventional gas in the SE that are in the ground down to around 4 km and extending horizontally, with the casing and cement that does not last forever). Who will foot the bill in 30 – 50 years if these companies are no longer around?

There are issues with sea water intrusion and the unconfined aquifer South of Mount Gambier. Fresh underground water in coastal aquifers is vulnerable to salinisation by seawater intrusion due to increasing underground water extraction and climate changes, which can cause the lowering of the underground water hydraulic head and reduced recharge to the unconfined aquifer.

"Is there the potential that current levels of allocation and extraction in management areas in the Lower Limestone Coast will lead to (further) declines in water tables and resource quality, which could detrimentally impact the community and industries dependent on the groundwater?" (note this exact question should be asked of unconventional gas projects.)

Over the last 10 years, rainfall has been lower than longer-term averages, with a noticeable decline in groundwater tables compared to the previous three decades".

'THE WATER ALLOCATION PLAN FOR LOWER LIMESTONE COAST PRESCRIBED WELLS AREA'. (WAP)

Below are important points in relation to the Lower Limestone Coast taken from the WAP.
Please note these points are highlighted , and comments are in bold text.

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Not only is the underground and surface water important for agriculture and agricultural industry for all South Australians, and Australians, but also for ecology, bio-diversity, which in turn is important for the South Australian and Australian Tourism industry. There is no copy right on the LLC WAP document.

Background to the Water Allocation Plan - page 8/196

"The aquifers of the Lower Limestone Coast (LLC) Prescribed Wells Area (PWA), located in the South East of South Australia, provide the region with large volumes of high quality water. **However, this finite resource requires careful management to ensure that future generations can enjoy."**

"The LLC contains significant, often high quality, underground water resources in the form of unconfined and confined aquifers. A core objective of the Plan is to manage these resources for the **continued social, economic and environmental benefit of current and future generations."**

The Prescribed Wells Area - page 9/196

"The LLC PWA covers an area of approximately 1,450,000 hectares. The PWA is bordered to the north by the Padthaway and Tatiara PWAs, and to the east by the state border with Victoria. It incorporates the city of Mount Gambier (population ~ 23,000), and the major townships of Naracoorte and Millicent (population ~ 5,000 each) ." (as of November 2013)

Confined and unconfined aquifers in the LLC PWA areas are under the jurisdiction of the **Groundwater (Border Agreement) Act 1985. No new allocations should be granted or temporary allocations renewed, where the limit to the volume of water to be extracted from licensed wells in the relevant Zone of the Designated area would be exceeded,** under the Groundwater (Border Agreement) Act 1985**. (note – with the 'red queen effect, explained in other documentation of the submission, according to a study done by FROGTECH, "Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013", Council of Learned Academics, which states 3,446 SHALE GAS wells are estimated for the Otway Basin. This report was commissioned by Dept. of Sustainability and Environment, Vic, PIRSA, VIC DPI, Geoscience Australia, DEWNR, and SA Water. Therefore this is a credible government document.)**

http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks Jan2013.pdf

There are two underground water systems – the upper unconfined Tertiary Limestone Aquifer consisting of mainly calcareous sandstone and limestone, and the lower Tertiary Confined Sand Aquifer. Underground water is extracted from both aquifers within the Murray Basin (NE) and the Gambier Basin of the Otway Basin. There are different formations, both in higher inland plains and low-lying flats. There are also remnant sand dune ridges.

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1.3.1 Unconfined Aquifer - page 9/196

The unconfined aquifer consists mainly of calcareous sandstone and limestone. It incorporates the Gambier and Murray Group Limestones in the higher inland plains in the east of the region, and the younger Coomandook, Bridgewater and Padthaway Formations in the low-lying flats, which are interspersed with a series of northwest-trending remnant sand dune ridges. **In the NE of the PWS, the flow of underground water in the confined aquifer generally goes from east to west. Underground water flow in the unconfined aquifer in the north east of the PWA is generally from east to west.** Underground water flow radiates out from the Nangwarry/Tarpeena area in a northerly, westerly and southerly direction, that is, water flows approximately east to west throughout the northern three quarters of the PWA and from north to south in the lower South East. **There are a number of major faults in the area** which impact on underground water flow and gradient. Two prominent faults are the Kanawinka Fault and the Tartwaup Fault, referred to as the Tartwaup Hinge. **(I understand based on evidence document in the submission, that fracture stimulation should not occur near faults).**

The thickness of the unconfined aquifer varies from ~10 metres thick north west of Mount Gambier, increasing to more than 300 metres thick south of Mount Gambier. The depth to water varies throughout the PWA relative to topography. Generally the depth to water is less than five metres on the plains, up to 20 metres in the ranges and more than 40 metres in the Mount Burr Range (Figure 12, Appendix of Figures and Tables). **In the southern portion of the PWA there are numerous karst (dissolution) limestone features, of which Ewens Ponds, Piccaninnie Ponds and Hell's Hole are examples. (please note that most of the South East is on limestone. Limestone is prone to subsidence and sinkholes and exacerbated by drilling, mining and fracking.)**

Confined Aquifer - page 10/196

The confined aquifers are separated from the unconfined aquifers by **a low permeability aquitard (or confining layer)**, comprised mainly of glauconitic marl and dark brown carbonaceous clay. The combined thickness of the aquitard is generally more than 20 metres. The confined aquifer consists of non-calcareous quartz sands, interbedded with dark brown carbonaceous clays. Together these units make up the Dilwyn Formation, which was deposited during the early part of the Tertiary Period (approximately 50 million years ago). **Much of the water in the confined aquifer is over 25,000 years old.** For management purposes, the confined aquifer is treated regionally as one aquifer, but is actually a complex multi-aquifer underground water system (Cobb and Brown 2000).

Recharge to the confined aquifer occurs largely via lateral through-flow, with the main recharge area thought to be the Dundas Plateau in Western Victoria (Cobb and Brown 2000). A 2001 study by the former South Australian Department for Water Resources into **vertical underground water recharge to the confined aquifer concluded that at the study sites near Tarpeena and Nangwarry, recharge occurred via preferential flow (fractures,**

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faults or sinkholes) rather than via diffuse recharge processes through the soil and overlying clay aquitard (Brown et al. 2001).

Beneath the Dilwyn Formation is a number of deeper aquifers from the Late Jurassic, Early and Later Cretaceous and Tertiary ages of variable water quality and lateral extent down to 4000+ metres, **which demonstrate increasing salinity with depth.** These aquifers are not used for irrigation, industrial or town water supplies due to their depth and **generally high salinity.**

The aquifers within these deeper formations are of potential value as targets for petroleum and geothermal exploration and production**. (please note that the SE land owners are not happy about this highly saline water coming to the surface, or being used in any activities for drilling or fracking. This water would most certainly contain heavy metals, volatile organic compounds and radionuclides.)**

The Tertiary and Late Cretaceous formation aquifers below the Tertiary Dilwyn formation for alternative water supplies has not been investigated and evaluated**. As well as salinity issues, there may be a risk of depressurization associated with extractions from these aquifers.**

Underground water flow for the confined aquifer systems originates from the Dundas Plateau located in Western Victoria. From there, underground water flows radially southwest to the coast and into the marine environment, and northwards to the Murray Darling Basin. Due to the confining layer, the **underground water in the confined aquifer is under pressure**, and in some parts of the South East is artesian (i.e. flows to the surface without pumping) (Cobb and Brown 2000).

Aquifer interaction - page 11/196

Declines in the unconfined aquifer water level have been observed along the border between South Australia and Victoria. **These declines have been attributed to a combination of reduced rainfall, underground water extraction and interception of recharge to the aquifer.** Although there is little water extracted from the deeper, underlying confined aquifer, similar declines to those in the unconfined aquifer have been observed. Funding support was sought from the National Water Commission by the former DFW in South Australia and the Department of Sustainability and Environment in Victoria to study the interaction between the unconfined and confined aquifers. The study involved the drilling of eight sites into the confined aquifer to carry out pumping tests from the aquifer, while monitoring drawdown of water levels in the unconfined aquifer, to determine the degree of connection between the two aquifers. The project resulted in a three dimensional model and revealed that there **is moderate to good hydraulic connection between the two aquifers. (please note, if there is contamination of one aquifer, both aquifers may be contaminated)** The results indicate that the two aquifers are **more highly connected** than assumed in previous models.

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1.6 Water and land use - page 12/196

The total area of the Limestone Coast Region is 2,345,937 hectares, which extends beyond Keith, according to PIRSA 2010. Land use in the Limestone Coast- livestock grazing of modified pastures, cropping, commercial forests both hardwoods and softwoods, irrigated crops for pasture for dairy, beef, prime lamb production, wine grapes, lucerne pasture/hay, potatoes, lucerne seed, and cereals. Industry and public water supply are other major users.

1.7 Surface Water Resources - page 12/196

Apart from an extensive drainage system, there are surface water resources. These consist of a number of ephemeral (seasonally flowing) creeks including Glenroy Creek, Mosquito Creek, Naracoorte Creek and Morambo Creek. 4 km of the Glenelg River flows through the SE. South of Mount Gambier, there are a number of drains and coastal springs, fed by discharge from the unconfined aquifer. These include Piccaninnie Ponds **(an important tourism area)**, Deep Creek, and Eight Mile Creek.

Other important surface water areas are Reedy Creek, Bakers Range, West Avenue, Taratap and Marcollat watercourses, which consist of a series of wetland complexes and floodplains. Coastal lakes extend from Port MacDonnell in the south through to the Coorong. There has been an indication of increasing interest in surface water for consumptive uses.

2. Assessment of the needs of water dependent ecosystems - page 13/196

NRM Act 2004 Section 76(4)(a)(i) (amended in 2013) of the Act provides that a water allocation plan must include an assessment of the quantity and quality of water and times or period needed by the ecosystems that depend on the water resource.

NRM Act 2004 Section 76(4)(aab) of the Act also requires a water allocation plan to include:

(i) an assessment of the capacity of the water resource to meet environmental water requirements;

(ii) information about the water that is to be set aside for the environment including, insofar as is reasonably practicable, information about the quantity and quality, the time when that water is expected to be made available, and the type and extent of the ecosystems to which it is to be provided; and

(iii) a statement of the environmental outcomes expected to be delivered on account of the provision of environmental water under the plan. Environmental water requirements and environmental provisions for the PWA are described in Sections 2.2.1 and 2.2.2, respectively. The environmental water provisions for the PWA do not aim to return water-dependent ecosystems to a pristine condition, but to keep them at an acceptable level of risk. This is achieved by setting aside a portion of recharge for through flow purposes, the

maintenance of water tables and underground water salinity and the reduction of allocations in management areas at high or very high risk from current allocation and extraction, as well as reducing the impact of any further development in the vicinity of high ecological value underground water dependent ecosystems by means of setback distances for new water use activities."

2.1 Ecosystems dependent upon underground water in the Lower Limestone Coast PWA - page 13/196

As well as the hydrological component, underground water contains physio-chemical properties and dissolved nutrients that are important for ecosystem processes. There are five types of underground water dependent ecosystems which **include Karst, streams/watercourses, wetlands, phreatrophytic vegetation and marine environment.**

2.1.1 Karst

Karst (aquifer) ecosystems occur within the voids (solution features) that have developed within the carbonate rocks making up the unconfined aquifer of parts of the South East. The **limestone** units of the LLC PWA geology **have numerous sinkholes, cenotes, caves** and other karst features, **many of which intersect the underground water table. (please note, limestone is prone to subsidence and sink holes and exacerbated by mining, drilling and fracture stimulation, according to Pennsylvania Department of Environmental Protection).**

The underground water dependent ecosystems present within the volcanic crater lakes (e.g. the Blue Lake and Valley Lake) around Mount Gambier bear many similarities to those found within the limestone karst systems **found elsewhere throughout the region. Karsts in the vicinity** of Mount Gambier include Bottlebrush Sinkhole, the Valley Lake, Grundy's Woodland, Caverton Park Estate Cave, the Blue Lake, Sheathers Cave, Engelbrecht Cave and Hells Hole.

The underground water contained in these systems supports aquatic stygobites that are endemic to the South East, including syncarids, amphipods and stromatolite communities. In a number of features, including the Blue Lake, the surface opening is substantial and provides a **lake** habitat which supports benthic algae, phytoplankton, invertebrates, fish and birds**. Hell's Hole is listed on the Register of the National Estate for its biological significance, due in part to the presence of the endangered fern Pteris tremula , which may be dependent on the underground water fed lake environment.**

Page 15/196 - Toward the coast, further **south** from Mount Gambier are **other caves and sinkholes** which have underground water on which ecosystems and stygobite communities are dependant on. These include Fossil Cave, Gum Road Cave, The Pines Cave, Tea Tree Sinkhole, Horse and Cart Sinkhole, Mushroom Cave, The Shaft, Hereford Stream Cave, Allendale Sinkhole, Gouldens Hole and Morgans Cave. Hereford Stream Cave extends for over 250 metres and has **eight permanent pools.** At the southern end of the system, water flows out through a permanent underground stream that is up to one metre deep.

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Sinkholes and Karsts of significance west of Mount Gambier include Bullock Hole, One Tree Sinkhole, Ten Eighty Sinkhole, Benara Sinkhole, Alleyn's Cave (Death Cave), Little Blue Lake, Green Lake, Woolwash Cave, The Sisters, The Black Hole, Mud Hole and Tank Cave. Many of these systems feature wetland habitats at their surface,

Page 18/196 - South of Mount Gambier in the **coastal region, the Karst** features fall into two categories – **caves – and sink holes which lie inland and rising springs along the coast** which provide discharge points for the water table. The cavities themselves support important and well preserved habitats and also form underground water dependent surface habitats generally comprising a permanent lake, fringing wetland vegetation and a stream draining to the sea. **Underground water is the most important source of water in these ecosystems,** and small local catchments provide limited and intermittent surface runoff. **Sinkholes** in this area include Pretty Pond, Stratmans Pond, Fifty Four Foot Pond, Unnamed pond, Fel Pot Pond, Bugga Bush Pond, Piccaninnie Ponds, Tadpole Pond, Crescent Pond, Bones Pond, and Ewens Pond. Some of these ponds discharge into creeks or drains.

Karst ecosystems which include the Shaft, Allendale Sinkhole and Black Fellows Cave. Ewens Ponds, Piccaninnie Ponds, Crescent Pond and Hammerhead Pond are found within Conservation Parks and provide well preserved **examples of an integrated surface and subsurface underground water dependent ecosystem. Other karst ecosystems** include the Shaft, Allendale Sinkhole and Black Fellows Cave. Ewens Ponds, Piccaninnie Ponds, Crescent Pond and Hammerhead Pond are found within Conservation Parks and provide well preserved examples of an integrated surface and subsurface underground water dependent ecosystem. **Both Ewens and Piccaninnie Ponds are listed on the Register of the National Estate for their biological significance. In addition Piccaninnie Ponds was included on the List of Wetlands of International Importance (Ramsar List) in 2013. The Ramsar list also includes the Hacks and Bool Lagoons in the LLC PWA**. The Ramsar Convention of Wetlands is an inter-governmental treaty that provides a framework for national action and international cooperation for the conservation and wise use of wetlands and their resources**. (please note these areas are all recognized as very important tourism areas)**

The permanent discharge of underground water to the surface supports reed and sedge vegetation (Phragmites australis/Typha domingensis) on the fringes of pools and tea-tree fen closed scrub (Leptospermum lanigerum/Melaleuca squarrosa) in the wetland areas. The open water of the ponds supports aquatic biota including vascular plants (e.g. Triglochin procerum), algae and mosses and a variety of fauna including fish, tortoises, water birds and crustaceans. The endangered marsupial mouse, Swamp Antechinus (Antechinus minimus), has been recorded in Piccaninnie Ponds Conservation Park, as well as the nationally listed fish Dwarf Galaxias (vulnerable) and nationally listed Spiny Crayfish (endangered), while the Maroon Leek-orchid Prasophyllum frenchii (endangered) is found on the wetland margins. Ewens Ponds provides habitat for vulnerable fish species, including the endemic Ewens Pygmy Perch (Nannoperca varigata) and the Australian Grayling (Prototroctes maraena).

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Karst faunal communities can be impacted by groundwater level decline, which may cause stranding if the decline occurs at a rate greater than that with which the animals are able to move downwards; **loss of connectivity** between cavities; and an increase in the distance between the aquifer ecosystem and the source of carbon, reducing the amount of organic matter available to aquifer food webs.

2.1.2 Streams, watercourses and drains - Page 19/196

Streams, watercourses and drains are dependent on underground water where the discharge contributes to the flow of the stream, watercourse or drain, or to permanent pools or water quality. The stream and permanent pools support threatened fish communities.

2.1.3 Wetlands - Page 19/196

Wetlands can be supported by the discharge of underground water to the surface (or near surface) by creating a damp, saturated or inundated soil environment. Surface runoff also contributes to the water in wetlands, but underground water influences the timing, duration and extent of wet conditions during dry periods. Wetlands support particular plants and animals, such as frogs, invertebrates and water birds. **Since European settlement, there has been a reduction from 44% to less than 6% of wetlands** in the South East because of drainage and land clearance. This is in the SE NRM region. **Less than 10% of these remaining wetlands are intact.** The majority of **remaining wetlands have some dependence on the unconfined aquifer.** The South East Water Science Review (DFW 2010) reports that the majority of wetlands in the South East **(77% of wetlands by number and 96% of wetlands by area) are highly likely to be dependent on underground water.** This relationship is consistent for the LLC Prescribed Wells Area. Since the introduction of the **Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), the inclusion of a wetland on the Ramsar List entails specific management obligations, namely the maintenance of the ecological character of the site and the wise use of resources.**

Wetlands supported by underground water within the PWA contain populations of EPBC Act listed threatened species, including the nationally vulnerable Southern Bell Frog (Litoria raniformis) in Bool and Hacks Lagoons, Lake Ormerod, and Rocky Swamp in the north and north east of the PWA. Populations of nationally vulnerable native fish species Yarra Pygmy Perch (Nannoperca obscura) also occur within Bool and Hacks Lagoons. In the region of the PWA adjacent to the border of South Australia and Victoria, a large number of wetlands are semi-permanent and interact with the water table by forming underground water mounds or by receiving underground water discharge in springs. Penola Conservation Park, which includes Green Swamp, has representative wetland vegetation containing Prickly Tea-tree (Leptospermum continentale) and Swamp Gum (Eucalyptus ovata).

There is much more information in the Water Allocation Plan document in regard to wetlands, threatened plant and animal species and ecosystems which all rely on

underground water, either directly or indirectly through other plant associations that are directly dependent on underground water. They are not all included here.

In the last decade, the underground and surface water hydrology of the South East region has **changed, with reduced water inflows.** This has resulted in a change in the floristic composition of wetlands, with salt sensitive species present pre-2000 being lost and salt tolerant species now occurring.

Phreatophytic vegetation – Page 21/196

Phreatophytic vegetation is vegetation which exists specifically due to the presence of underground water which sustains deep-rooted plants in an otherwise dry environment. Phreatophytic vegetation is often closely associated with wetlands. Eucalyptus camaldulensis (in the northern area) is the dominant tree species in many wetlands, depressions and water courses where the underground water table is less than 10 metres below the surface. These trees are likely to be dependent on underground water in many areas, varying from permanent use to temporary dependence during dry periods. Remnants of Eucalyptus camaldulensis woodland are also present, along with other communities which are likely to be underground water dependent including Melaleuca halmaturorum tall shrubland, Typha domingensis closed sedgeland, Eucalyptus ovata / E.viminalis woodland and Pteridium esculentum closed fernland with emergent Eucalyptus species. In the region of the PWA adjacent to the South Australian and Victorian border, there are substantial remnants of vegetation that are likely to be dependent on underground water, including Eucalyptus ovata, E. viminalis woodland, Xanthorrhoea caespitosa, Leptospermum continentale open shrubland, Melaleuca brevifolia low shrubland and Eucalyptus camaldulensis var. camaldulensis woodland. **(please note trees are necessary for stock weather shelter)**

2.1.5 Marine environment – Page 21/196

The marine environment receives a significant quantity of underground water from aquifer discharge and through baseflow discharging to watercourses which then flow to the ocean. The influx of fresh water will affect the marine habitat along the coast **and may support particular species or communities.** Some of these freshwater beach springs and ecosystems that are supported by underground water derived surface water flows are south and south west of Mount Gambier**. (please note, the aquifers extend under the sea, so in the likelihood of contamination of aquifers occurring on the land, then this also may impact the ocean as well).**

2.2 Assessment of the quantity and quality of water needed by water dependent ecosystems Page 22/196

NRM Act 2004

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Section 76(4)(a)(i) of the Act requires a water allocation plan to provide an assessment of the underground water quantity and quality needed by the ecosystems that depend on the water resource and the times at which, or periods during which, those ecosystems will need that water. **(please note, how can this assessment accurately occur in the event that there are thousands of unconventional gas wells in the SE, as predicted in a document "Potential Geological Risks Associated With Shale Gas Production in Australia", January 2013, Project Code AA S801, by FROGTECH, commissioned by PIRSA, VIC DPI, Goescience Australia, DEWNR, SA Water and DSE. It is stated that 3,446 SHALE GAS wells are estimated for the Otway Basin, most being on the South Australian side.**

The Act defines 'environmental water requirements' to mean: "those water requirements that must be met in order to sustain the ecological values of ecosystems that depend on the water resource, including their processes and biodiversity, at a low level of risk". The exact environmental water requirements of groundwater **has not been fully studied for wetlands in the South East of South Australia,** however, the South East Water Science Review (DFW 2010) states that wetlands in the **South East are experiencing prolonged dry conditions and increasing salinity. These ecosystems are at risk due to dropping groundwater levels and/or increases in underground water salinity. An increase in depth to the water table of 1.5 metres past current** levels is expected to result in total loss of a wetland. **(please note, this should be a wakeup call not to allow fracture stimulation and unconventional gas projects to go ahead, because of the high water requirements and the extreme likelihood of contamination occurring, given the limestone properties and numerous faults in the SE)**

2.2.2 Environmental water provisions – Page 23/196

NRM Act 2004 Section 76(4)(b)(i) of the Act provides that a water allocation plan must achieve an equitable balance between environmental, social and economic needs for water. For the purposes of the Plan 'environmental water provisions' mean those parts of environmental water requirements that **can be met at any given time,** with consideration of existing users' rights and social and economic impacts. Despite the above studies, the exact level of dependence solely on underground water of ecosystems in the LLC PWA has not been fully studied. As a result, the Plan proceeds on the basis that to conserve ecosystems dependent upon underground water**, the current quality and quantity of that underground water must be conserved.**

The Plan accordingly sets principles for water management that aim to maintain the current quantity and quality of underground water available for these ecosystems by virtue of:

- **no further declines and, where possible, recovery in underground water table levels, to ensure underground water dependent ecosystems can continue to access this resource;**

- **no significant increases in underground water salinity, to ensure no detrimental impact on species that are sensitive to salinity levels; and**

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- **the maintenance of lateral through-flow of underground water, in order to prevent recycling of irrigation water (which can lead to increases in salinity), and to ensure that salts are flushed from the region.**

Assessment of effects on other water resources – Page 33/196

As required by the **NRM Act 2004 section 76(4)(a)(ii)** of the Act, this section provides an assessment as to **whether the taking or use of water from the resource will have a detrimental effect on the quantity or quality of water that is available from any other water resource.** This section looks at the potential detrimental impacts of taking or using water from the LLC PWA upon the quantity or quality of water from other water resources in the LLC PWA and adjacent PWAs. Within the PWA, it considers the potential for impacts upon streams, springs, rivers, wetlands, drains and other surface water bodies, and the possibility of impacts arising from the relationship between the two aquifers.

Science has shown that plantation forestry expansion can significantly impact surface water catchment yield and underground water recharge and that, under some circumstances, plantation species can extract water directly from shallow water tables (Benyon and Doody 2004, Benyon et al. 2006, Benyon et al. 2008). The impacts of this on dependent environmental ecosystems are not yet known but will be considered during the implementation of the Plan**. (please note, invasive, high water usage, high pressure multi-well slick water fracture stimulation may possibly cause declining aquifer levels)** There are a number of wetlands, springs, streams, drains ,other surface water bodies and the Glenelg River that are reliant on water from the LLC PWA.

Springs and Wetlands- Page 33/196

Wetlands in the LLC PWA vary in terms of their relationship with, and reliance on, underground water. It is likely that the taking and use of underground water will have a detrimental effect on these wetlands. Where springs and wetlands (known to be dependent on underground water) exist in close proximity to water affecting activities, such as underground water pumping or forestry, it is likely that these activities will affect the quantity and quality of water available to these ecosystems. The extent to which it will detrimentally affect these systems is unknown.

Currently, **little information is available for identifying the relationship between underground water extraction and impact on wetlands and drains in the LLC PWA**. **(please note, how can accurate assessments be made in relation to unconventional gas projects going ahead, when it is clear that knowledge is already lacking, before unconventional gas projects even come into the picture).**

There has been **a long term decline in water levels** in the area surrounding Mount Gambier. The primary influences on the underground water level are assumed to be climate (e.g. rainfall amount and timing) and the rate of extraction of underground water from the aquifer. A slight decline in water levels has been noted within the southern coastal region.

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This slight decline can also be largely attributed to **a period of consecutive dry years. Underground water extraction may be a contributing factor to this slight decline, but the extent of this contribution is unknown. (please note unconventional gas projects should not be allowed to add to problems of already declining water levels).**

The Blue Lake and Other Surface Water Bodies – Page 35/196

The Blue Lake, located in the centre of Mount Gambier, is a source of water for the city's population of approximately 23,000 people. Underground water from the unconfined aquifer provides the inflow to the Blue Lake. The lake level reflects the underground water table of the unconfined aquifer. Water levels in the Blue Lake and the surrounding Mount Gambier area have been in long term decline since 1925 and hydrographs show that the water levels **have declined approximately 3.5 metres since 1972** (South Australian-Victorian Border Groundwaters Agreement Review Committee 2008). The downward trend in Blue Lake water level since the early 1990s **can be linked to a long term declining rainfall trend.**

3.5. Unconfined Aquifer – Page 37/196

Prior to 2010, direct leakage of pressure water from the confined aquifer into the overlying unconfined aquifer occurred via a large number of confined aquifer wells in poor condition due to age and construction techniques. During 2001 to 2010, 120 leaking confined aquifer wells in the Kingston-Greenways area were either replaced or back-filled using specialist techniques, as part of the South East Confined Aquifer Well Rehabilitation Scheme.

Expenditure on the scheme was estimated to be $5.5 million over nine years, including $1.3 million funding from the Natural Heritage Trust, $1.1 million from State investment and a financial commitment from landowners of up to $3.1 million. (please note, imagine **the costs of in time of repairing every drill hole for unconventional gas in the SE that are in the ground down to around 4 km and extending horizontally, with the casing and cement that does not last forever'. Who will foot the bill in 30 – 50 years if these companies are no longer around. An audit should be done on EVERY existing drill hole and hydrology drill hole associated with past mining and petroleum exploration or production in the SE now. Until this is done, one cannot say that every drill hole and hydrology observation hole is in order. Judging from a DMITRE spread sheet on drill holes in the SE, there are a number that appear missing. I question the records storage system)**

4.1 Unconfined Aquifer - Page 40/196

In the majority of the management areas, a declining trend in depth to water has also been observed in the last five years. There are three principal factors affecting the extensive underground water level decline in the LLC PWA:

- **underground water extraction;**
- **reduced rainfall and hence recharge; and**

- **the effects of land use change, particularly the establishment of commercial forests.**

In the Mount Gambier area the underground water levels have been in long-term decline since 1925, as observed by the water level in the Blue Lake**. Impacts from forestry, variability of rainfall and its incidence, and increased underground water extraction have contributed to this decline. In addition, the level of stock and domestic water use around Mount Gambier is estimated to be high.**

<u>On page 41/196</u>, The South East Water Science Review (DFW 2010) that states that the water table has been declining approximately **0.5 metres/year (Figure 5, to the underground water table has been increasing by approximately 0.5 metres/year.**

Risk of seawater intrusion south of Mount Gambier – Page 43/196

The coastal area south of Mount Gambier includes sites of underground water discharge such as Piccaninnie Ponds. The water levels in the coastal area were relatively stable up until 1997 with negligible seasonal fluctuation. Since 1997 underground water levels have fluctuated seasonally. **The South East Water Science Review (DFW 2010) identified the area south of Mount Gambier as an area subject to specific risks. A seawater-freshwater interface in the unconfined aquifer has been detected about 1.5 kilometres inland and 150 metres below the surface, indicating the potential for seawater intrusion in the Donovans management area. Fresh underground water in coastal aquifers is vulnerable to salinisation by seawater intrusion due to increasing underground water extraction and climate changes, which can cause the lowering of the underground water hydraulic head and reduced recharge to the unconfined aquifer.**

Saline underground water intrusion has the potential to result in significant economic and environmental impacts. It is estimated that approximately 2,527 hectares of agriculture may be at risk, equating to a potential current regional economic impact of $31 million (Department of Planning and Local Government 2011). Underground water dependent ecosystems such as the internationally important karst wetland system Piccaninnie Ponds, and the nationally important karst wetland system, Ewens Ponds, may also be at risk.

A recently completed study into the risk of seawater intrusion into the unconfined aquifer in the LLC (Mustafa et al.2012) was recently completed. Coastal monitoring wells reveal salinity levels exceeding 25,000 mg/L, with the highest risk for seawater intrusion considered to be irrigation extraction which could cause a reversal of underground water movement (currently towards the coast). **The freshwater-saltwater interface has been detected at four locations:** Eight Mile Creek, Port MacDonnell, Piccaninnie Ponds/Pick Swamp complex and the area west of the township of Port MacDonnell.

4.1.3 Present and future needs of needs of water users – Page 44/196

NRM Act 2004 Section 76(4)(c) of the Act requires that a WAP must take into account the present and future needs of the occupiers of the land in relation to existing requirements

and future capacity of the land, and the likely effect of those provisions on the value of the land. In terms of providing for future expansion in water use, the Plan provides for **limited new allocations** from the Crown from the unconfined aquifer, including to some existing section 128 authorisations and temporary allocations for mining purposes**, (please note how can water use for unconventional gas projects be classed as temporary)** subject to a number of conditions.

Mining – 44/196

Action 48 of the Water for Good Plan (Government of South Australia 2010) relates to water used for mining and **requires "mining ventures to provide their own water supplies within the sustainable framework of natural resources management planning and regional water demand and supply plans". (please note the SE land owners do not want water brought up from deep below that will be contaminated with heavy metals, radionuclides etc. and exposing it to the landscape i.e. holding ponds and movement on holding ponds water if accidents happen, or drill holes to get to this water that will have to go through the potable aquifers. Casings and cement do not last forever).**

There are a number of extractive mineral mines in the LLC PWA, extracting limestone, sand, and/or gravel. Additionally, a lignite (coal) mine is proposed for an area northeast of Kingston SE. **(Please note this exploration licence should have never been allocated to Strike Energy Ltd. In 1982, pumping tests were performed over 8 days for Western Mining Corporation, with serious consequences. Several bores lost pressure and one had to be pumped to regain pressure for many weeks. A direct connection through the breach of the wall between the Dilwyn confined aquifer and the Mepunga confined aquifer from where Kingston SE gets its water, was discovered. The EIS was found to be fundamentally flawed as proven by the United Farmers and Stockowners of South Australia Watchdog Committee of Kingston S.E.).**

The Plan allows for allocation of water for the purpose of mining provided that an equivalent volume to that allocated above the TML (if any), is returned to the source aquifer from which the water was originally extracted, with no detrimental change to the quality of the water in the source aquifer, and subject to a number of other conditions**. (please note the analysis of Jolly 1 holding pond in the submission, therefore there will be changes in the quality of the water).**

There is currently a Ministerial authorisation under section 128 of the Act (South Australian Government Gazette, 30 August 2001, page 3442) for the taking of water in relation to a hydrocarbon exploration well under the **Petroleum Act 2000 (now Petroleum and Geothermal Energy Act 2000**).

A hydrocarbon includes petroleum, natural gas and coal seam gas. Water extracted during the drilling process comes from the unconfined aquifer. Petroleum and carbon dioxide is sourced from the deeper confined aquifer(s) which may result in co-produced water (water taken as a by-product of petroleum or carbon dioxide extraction), being extracted during

the production process. (**Please note Jolly 1 holding pond analysis – this water should not be returned anywhere)**

Indigenous and cultural needs – Page 62/196

Access to, and use of, water from prescribed water resources by Aboriginal people is exempt from licensing for the purpose of social, cultural or spiritual use, provided that the taking does not involve stopping, impeding or diverting the flow of water for the purpose of collecting the water or diverting the flow of water from water resources. The Minister has issued a state-wide authorisation (under section 128 of the Act) to take water for Native Title purposes.

The traditional owners of the land that is now the LLC PWA are the Tanganekald, Meintangk, Bungandiji, Potaruwutj and Marditjali people. A number of culturally significant underground water-dependent ecosystems have been identified through members of this Group, including the Crater Lakes (Blue Lake, Valley Lake, Leg of Mutton Lake and Browns Lake), Little Blue Lake, Bool and Hacks Lagoons, the Coastal Lakes (including Lake George) and the wetlands of the upper northwest of the LLC including the management areas of Duffield, Landseer, Peacock and Marcollat.

4.5 Limestone Coast Groundwater Risk Assessment - confined aquifer – Page 76/196

The risk assessment was done for the confined aquifer resource in regard to what is considered at risk of degradation from the current level of demand. In regard to the confined aquifer, the LLC PWA risk assessment poses the following question for each management area: **“Is there the potential that current levels of allocation and extraction in management areas in the Lower Limestone Coast will lead to (further) declines in water tables and resource quality, which could detrimentally impact the community and industries dependent on the groundwater?”(note this exact question should be asked of unconventional gas projects)** Sources of risk which could lead to adverse impacts on the confined aquifer resource, and therefore its users (water dependent industries, stock and domestic water users), were identified as: groundwater extraction and interception, climate variability, drought, and climate change.

4.7 Climate change – Page 78/196

Climate change presents a **significant challenge** to South Australia and all of Australia. While the water policy decisions included in the Plan were based on the most recent meteorological, hydrological and hydrogeological information and trends, **the effects of climate change are not yet clearly yet clearly understood and therefore knowing the consequences for future water allocation demand is difficult. (please note, again why allow fracture stimulation which requires vast amounts of water, when already it is difficult to ascertain the consequences for future water allocation demand)**

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Climate modelling in the South East region has indicated a significant variation from the current weather pattern. A continuation of the increasing temperature trend and an overall decreasing annual rainfall trend, most significantly in the spring is predicted. **Annual decreases in rainfall of one to10% are predicted for 2030 and two to 30% by 2070 in the South East NRM region** (Suppiah et al. 2006).

The close relationship between climate and underground water levels in the unconfined aquifer, will in-turn, continue to have a negative impact on the underground water resources in the LLC PWA.

The South East Water Science Review (DFW 2010) examined the historical rainfall record for evidence of climate change in the South East. They found that "**Over the last 10 years, rainfall has been lower than longer-term averages, with a noticeable decline in groundwater tables compared to the previous three decades"**.

While the CSIRO has tried to make an assessment of declines in rainfall by downscaling the global climate models**, there is still a high degree of uncertainty.**

7. Transfer Criteria – Unconfined Aquifer – page 124/196

7.1 Objectives

The objectives of the unconfined aquifer transfer criteria are:

a) To manage the underground water resource of the unconfined aquifer so that it may continue to be available for the social, economic and **environmental needs of current and future generations.**

b) To protect the environment generally by ensuring that the taking and use of underground water from the unconfined aquifer **does not cause significant degradation of any other resource such as soils or other water resources.**

c) To maintain and/or improve the availability of underground water for ecosystems dependent on underground water.

d) To provide flexibility and equity in access to the underground water resource of the unconfined aquifer.

e) To minimise constraints on transfers of water allocations so that these are available to sustain economic development.

f) To ensure that allocations resulting from transfers remain within the sustainable limits of the unconfined aquifer in the relevant management area.

g) To provide for the transfer of volumetric allocations from the unconfined aquifer.

147. In management areas subject to reductions in allocations, if a licensee applies in

writing to the Minister, the Minister may transfer in an allocation from the same management area exempt from principles 58-65 (Hydrogeological effects and assessment) and principles 2-5 **(Protection of ecosystems dependent on underground water – extraction from licensed wells). (please note how can what is happening under the ground be observed EVERYWHERE for contamination at the same time? Usually when contamination occurs it is found some time after the contamination first began.)**

8. Allocation Criteria – Confined Aquifer page 132/196

8.1 Objectives

The objectives of the confined aquifer allocation criteria are:

a) To cautiously manage the confined aquifer so that it may continue to be available for the social, economic and environmental needs of current and future generations.

b) To protect the resource locally, throughout each management area, and throughout the entire PWA.

c) To provide flexibility and equity in access to the underground water resource of the confined aquifer.

d) **To protect the environment generally by ensuring that the taking and use of underground water from the confined aquifer does not cause significant degradation of any other resource and other water resources.**

e) To bring at-risk and/or over-allocated management areas back to environmentally sustainable levels of allocation.

f) To provide for the implementation of the volumetric conversion of confined aquifer allocations.

Allocations for the purpose of mining page 139/196

214. Water from the confined aquifer may be allocated upon application in writing to the Minister, for the purpose of mining, subject to the following:

c) all water extracted is returned to the same source aquifer from which water was originally taken pursuant to a permit in accordance with section 10.5 (Managed Aquifer Recharge: Draining or discharging of water into a well) of the Plan, with no detrimental change to the quality of water in the source aquifer**; (note how can this be done given the analysis of the Jolly 1 holding pond)**

d) **no weakening or fracture** of the confining layer between the unconfined and confined aquifers **(given the nature of fracking and seismicity produced, there is no proof that this can be safely done without weakening or fracturing the confining layer)**

e) water allocated under this principle is exempt from principles 220 - 222

Allocation for the purpose of petroleum or carbon dioxide production

215. Water from the confined aquifer may be allocated above the TML for the purpose of water taken as a by-product of petroleum or carbon dioxide production (known as coproduced water), including allocation to water users producing co-produced water as a by-product of petroleum or carbon dioxide production in existence at the date of adoption. **(please see attached Jolly 1 holding ponds analysis).**

217. Allocations made in accordance with principle 215 shall be exempt from principles 220-222 (Hydrogeological effects and assessment) and shall expire on the 30 June following the cessation of the activity authorised under the Petroleum and Geothermal Energy Act 2000 .

Hydrogeological effects and assessment page 140/196

220. No allocation of water from the confined aquifer shall be made which appears, in the opinion of the Minister, to have potential to:

a) **adversely affect the quality of water in the confined aquifer** to a significant extent, and in **particular shall not cause or contribute to an increase in salinity;**

b) cause or contribute to a long term decline in the potentiometric level of the confined aquifer by causing or being likely to cause a mean (arithmetic) decrease in the potentiometric level of the confined aquifer: **(note this is questionable with fracking activities)**

i. within the vicinity of the point of taking (including neighbouring properties and the nearest potentiometric level monitoring wells**), (please note fracking activities usually do affect neighbouring properties – there are a number of examples)**

ii. within the relevant confined aquifer management area; of greater than 0.1 metres per year (measured over the preceding five years);

c) adversely affect to a significant extent, or have the potential to adversely affect to a significant extent, the structural integrity of the aquifer;

d) adversely affect to a significant extent any other water resource inside or outside of the PWA;

f) adversely affect to a significant extent ecosystems dependent on underground water.

Page 140/197

221. In areas where the existing confined aquifer potentiometric level is greater than the unconfined aquifer potentiometric level, the allocation of water from the confined aquifer shall not occur if it has, in the opinion of the Minister, the potential to cause the confined aquifer potentiometric level to permanently fall below the unconfined aquifer

potentiometric level.

222. The allocation of any water from the confined aquifer shall not, in the opinion of the Minister, have the potential to cause a seasonal drawdown at any point beyond the two kilometre radius from the point(s) **(please note – a number of wells with multi-drill pads have the potential of causing aquifer problems. This is all unknown as to the full potential risks)**

Restrictions on use - page 141/196

226. Water shall not be allocated from the confined aquifer for a purpose that produces tail water unless: **(please note could tail water also be interpreted as co-produced or produced water as the result of unconventional gas activities)**

c) the disposal of tail water will not cause:

i. an acceleration in salinity increase in either aquifer; or **(please see Jolly 1 holding pond analysis)**

ii. pollution of either aquifer by the tail water; or

iii. pollution of either aquifer by any other substance; and

d) the ponds, tanks, vessels, or other places for the keeping of any water for that purpose have no significant hydraulic connection with either aquifer.

227. For the purpose of principle 226, tail water is water that flows out of a system once it has flowed through any ponds, tanks, vessels or other places, including places for the keeping of farmed aquatic species.

10.5. Managed Aquifer Recharge: Draining or discharging of water into a well - page 151/196

The following objectives and principles apply to permits required for the draining or discharging of water directly or indirectly into a well ("artificial recharge") **(section 127(3)(c) of the Act).** These objectives are additional to those expressed for all water affecting activities. In addition to any permit required to drain or discharge water directly or indirectly into a well, additional authorisations may be required under the **Environment Protection Act 1993**.

Water drained or discharged into a well must comply with the Environment Protection Act 1993 and any associated policy. **(please note, is re-injection into the ground regarded as down a well, as this toxic water is re-injected through a purpose built well – the industry admits re-injection causes earthquakes)**

10.5.1 Objectives – Page 151/196

a) To protect the underground water resource **from waste or pollutants** (as defined in the

Environment Protection (Water Quality) Policy 2009 under the Environment Protection Act 1993) to the receiving underground water resource during the draining or discharging of water into a well. **(please note there are many issues with well integrity, casings and cement breaking down e.g. as the result of hydrogen sulphide, contaminant pathways opened up through fracture stimulation with existing or new faults)**

b) To provide for the draining or discharging (artificial recharge) of water directly or indirectly into a well in a manner that does not have the potential to adversely affect:

i. the quality of surface water and underground water resources;

ii. the integrity of the relevant aquifer (including, but not limited to, the ability of the aquifer to transmit water);

iii. water tables (particularly where the adverse effect might include water logging, land salinisation or damage to infrastructure (roads, buildings, foundations, etc.)

iv. any water-dependent ecosystem or ecologically sensitive area that depends on the underground water resource;

v. the ability of other persons to lawfully take from that underground water; **(please note what has happened in Australia with coal seam gas, and with shale gas – aquifers have become contaminated in Australia and overseas and petroleum companies overseas are now being sued because of this)**

266. The relevant authority will not grant a permit if the salinity of the drained or discharged water exceeds:

a) 1500 mg/L TDS; or

b) where the ambient background underground water salinity levels are less than 1500 mg/L TDS - the ambient background underground water salinity level.

267. A permit to drain or discharge water into a well will not be issued unless a risk assessment is undertaken to the satisfaction of the Minister. **(note – re-injection is proven to cause earthquakes, other documentation will be supplied).**

268. This risk assessment must be consistent with the National Water Quality Management Strategy – Australian Guidelines for Water Recycling: Managing Health & Environmental Risks, Phase 1 2006, and must include:

a) an investigation into the suitability of the draining or discharging site, including but not limited to tests for transmissivity, effective porosity and storage coefficient, maximum injection pressures and calculated likely impacts on the integrity of the well and confining layers, and impacts of potentiometric head changes to other underground water users;

11.5 Identification of knowledge gaps and further research required - Page 159/196

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Current knowledge gaps with respect to the needs of water dependent ecosystems include: **(please note with current knowledge gaps the government should take the precautionary principal and not allow fracture stimulation in the SE)**

1. Intrinsic knowledge of underground water dependent ecosystems underground water/surface water interaction and dependency including:

a) water level and quality thresholds; and

b) long term implications of climate change.

3. Definition of the threatening processes, the risks they pose and the consequences of not addressing them including:

a) development of shallow and deep drains; and

b) land use change (including cross-border issues).

4. Intrinsic knowledge of cause-and-effect relationships and the development of effective management tools to address the following issues:

a) declining underground water discharge due to interception of recharge in inland areas by high water use crops and commercial forests;

b) **declining underground water discharge due to lowering of the water table as a result of climatic trends;**

c) increasing salinity due to landward migration of the boundary between fresh underground water (associated with declining water table elevations in the unconfined regional aquifer); and

d) contamination of the aquifer, particularly with nitrates.

5. The development of environmental response functions for individual ecosystems dependent on underground water is required to better inform the determination of environmental protection policy. Environmental response functions describe the relationship between ecosystem function and water regimes in which the ecosystems exist (e.g. depth to water table fluctuations, soil water content, soil water and underground water salinity).

Conclusion

In regards to protection of water resources and rights of landowners, the Limestone Coast Protection Alliance recommends to the Senate Inquiry that no gas or coal mining activities are undertaken without prior written authorisation from land owners.

The regulations of the South East Water Allocation Plan (South Australia) are in place to protect our water resources in the South East for all users in South Australia. Some of the

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important components of the Lower Limestone Coast Water Allocation Plan have been highlighted to show that gas drilling and hydraulic fracturing is not compatible with the purpose, goals and legislation of the Water Allocation Plan. The same should be said for other states of Australia. The impacts on surface water and ground water as the result of hydraulic fracture stimulation and gas activities are very real. In view of both short term and long term consequences, there are too many serious risks with the potential for contamination of air, soil and water. There is the added burden of the costs of health to both humans and animals as the result of any contamination. Once aquifers are contaminated, it is difficult or impossible to clean them up. No one can control what happens under the ground. No one can control earthquakes.

Therefore, regarding the subject of potable water, essential for agriculture, the Limestone Coast Protection Alliance recommends to the Senate Inquiry that constitutional corporations should be banned from engaging in hydraulic fracturing operations for coal seam gas, shale gas and tight gas.

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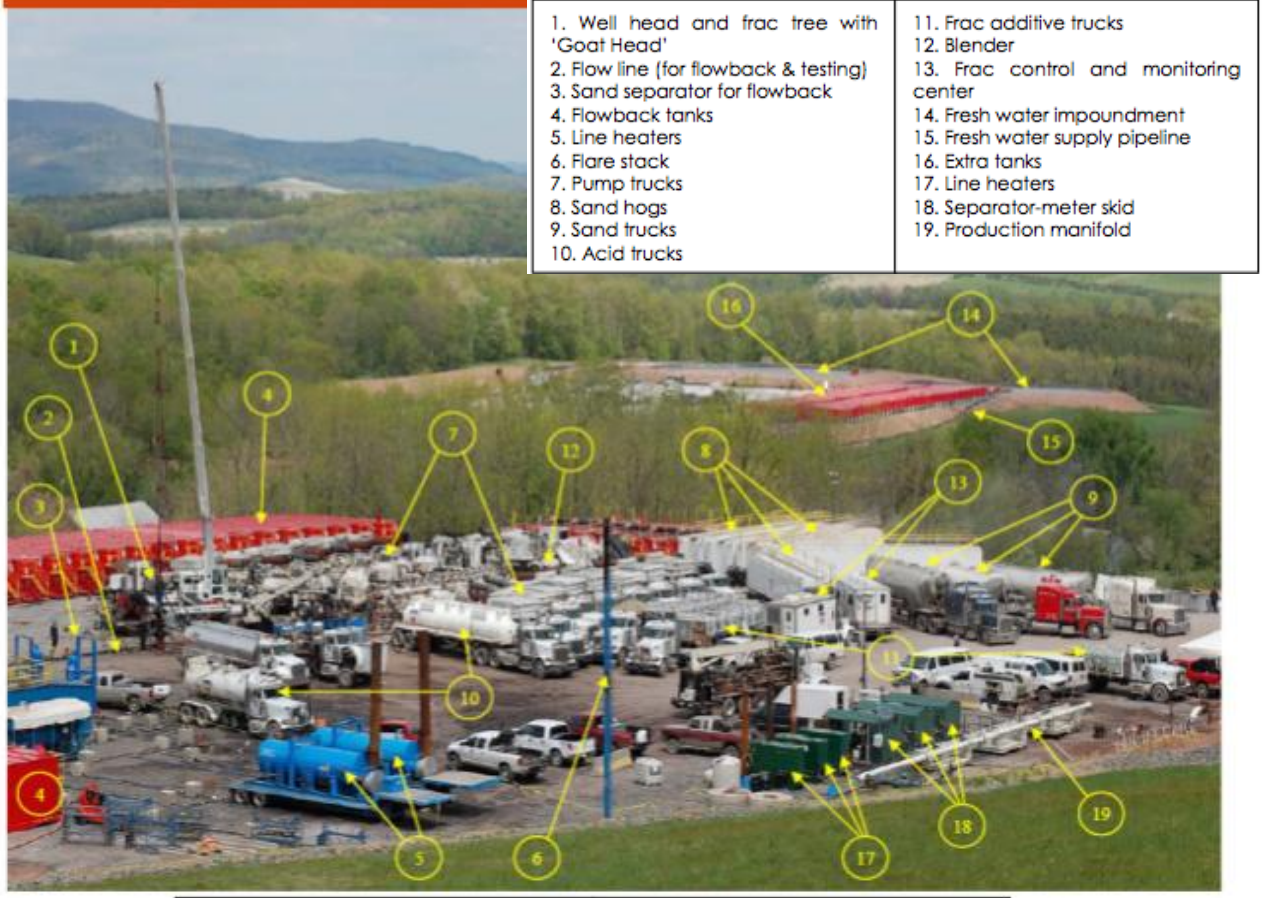
Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

SECTION 4: CHEMICALS

Figure 2.5: A well site during a single hydraulic fracturing operation (New York State, 2009)



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1 Summary

This section on chemicals raises the following issues in relation to chemical use in the gas & fracking industry for Australia:

- there are chemicals used by industry and chemicals produced by the process itself.
- there are multiple pathways for exposure (more on this is covered in section on health).
- disclosure of chemical substance or additive by name,
- disclosure of amount and concentration of chemical substance or additive,
- the number of chemicals used by industry and produced by the process itself and released into our land, water and air
- the type of chemicals used by industry and produced by the process itself by type
    - volatile organic chemicals,
    - polyaromatic hydrocarbons,
    - carcinogens,
    - endocrine disruptive chemicals,
    - persistent organic pollutants,
    - other compounds,
    - heavy metals,
    - radioactive elements.
- the many unknowns including; what new compounds form, incomplete toxicology assessments, length of chemical persistence and detection limits for chemicals.
- reducing our exposure to unnecessary and excessive chemical use is better for our health, our children's health and our environment’s health.
- the increasing importance of regulation and testing of all these chemical substances and additives.

2 Introduction

In Australia, both conventional and unconventional gas wells have been drilled and hydraulically fractured (fracked). In SA, over 700 wells in the Cooper Basin have been fracked. Extraction of coal seam gas (CSG), which is being produced in the Eastern States, requires drilling and may require hydraulic fracturing up to 40% of the time. In the South

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East of SA, we have tight and shale gas, the production of which requires drilling and hydraulic fracturing (fracking) 100% of the time. In the U.S.A., most of the investigations and studies have related to shale and tight gas which is applicable to what we have in the South East. CSIRO have stated that the exact nature of fracking mixtures used by gas companies varies from well to well.[1] We understand that the exact chemicals used depend on the geology and local environment.

Drilling and hydraulic fracturing for gas extraction uses a huge range of chemical products that contain a similarly huge range of chemical substances. Many of these products are known to be toxic while others have not been assessed for their health or environmental impact, either as the product itself or through their potential interaction with other products or naturally occurring substances. New products, or variations of extant ones, are continually introduced by the industry with little or no regulation. In some cases the chemical constituents of these products is not known due to the industry claiming they are trade secrets. A US House of Representatives hearing in 2011[2] on **Chemicals used in Hydraulic Fracturing** identified more than 750 chemical products containing 650 hazardous substances, with 279 products of unknown composition due to trade secrets.

The use of these chemicals in the U.S.A. has largely been unregulated due to loopholes in US law which excluded these chemicals from assessment under the Safe Drinking Water Act. This has led to widespread community distrust and concern and increased the risk of harm to the land, water and air.

In Australia, careful use of the statistics is required to comprehend the amount of toxic chemicals that are used in drilling and hydraulic fracturing (fracking). For example, the Australian Petroleum Production & Exploration Association, which is the peak national body representing Australia's oil and gas exploration and production industry, state [3],

Water and sand comprise more than 99 per cent of the volume of fraccing fluid.

However, the volume of fracking fluids used is so large that this 1% of fraccing fluids amounts to, according to CSIRO, an estimated 75 tonnes of chemicals used in each well.

The Australian Petroleum Production & Exploration Association (APPEA) produce a handout [4] which lists chemicals used by the coal seam gas industry and next to each one a common

[1] CSIRO (2012) 'What is Hydraulic Fracturing?', Factsheet, CSIRO website.

[2] US House of Rep. C'tee on Energy & Commerce, April 2011 Chemicals Used In Hydraulic Fracturing. http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf

[3] http://www.appea.com.au/oil-gas-explained/mythbusting/

[4] Australian Petroleum Production & Exploration Association (2013) 'Chemicals & Compounds Used in CSG Fraccing', Natural Coal Seam Gas. Retrieved Jan 2015, http://www.appea.com.au/wp-content/uploads/2014/08/CSG-fraccing-chemicals.pdf

usage, claiming that some of the chemicals are household ones that we use every day. Whilst it may be true that some of these chemicals are used in homes, many are not and none are used in such enormous quantities or as part of poorly understood chemical cocktails. Many ordinary chemicals are okay at home, because of the small quantities in which they are used, the finite area in which they are used, or because of the way the waste is safely handled. In larger amounts, in an open environment, and when poor disposal methods these same chemicals become unsafe.

For example, sea water (salt water) is safe and useful in the sea, but highly toxic flooding agricultural land. Seawater is great for swimming and catching fish, but no good to drink and it kills fruit and vegetable crops.

The question is not just which chemicals are used, but where, how much and for how long.

An unregulated, or poorly regulated industry removes this choice.

It is vitally important that we have good regulation to protect our health and keep our land, water and air clean. In the following chapters we make recommendations to tighten up our regulations. However, the oil and gas industry is constantly changing, with many new advances that a clear enforceable mechanism will be required for regulations to keep up.

"Without rigorous scientific studies, the gas drilling boom sweeping the world will remain an uncontrolled health experiment on an enormous scale."

Dr Michelle Bamberger and Professor Robert Oswald.[5]

3 Chemicals used in drilling and hydraulic fracturing (fracking)

The sheer number of chemicals used in drilling and hydraulic fracturing is cause for concern. The following lists are compiled from National Toxic Network documents.[6]

Hydraulic fracturing fluids usually include:

- Gelling agents to hold the proppant in suspension (e.g. mixtures of industrial guar gum, diesel, alkanes/alkenes);
- Gel stabilisers (e.g. sodium thiosulphate) and gel breakers (e.g. Ammonium persulfate, sodium persulfate);
- Crosslink agents (e.g. Borate salts, MEA borate, disodium octaborate tetrahydrate);
- Friction reducers to ease pumping and evacuation of fluid (e.g. polyacrylamide, mixtures of methanol, ethylene glycol, surfactants /fluorocarbon surfactants);

[5] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

[6] Lloyd-Smith 2013. Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources National Toxics Network

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- Surfactants to affect fluid viscosity (e.g. isopropanol, 2-Butoxyethanol /2-BE);
- Biocides to prevent bacterial action underground (e.g. glutaraldehyde, Tetrakis hydoxymethyl phosphonium sulfate / THPS, 2-Bromo-2-nitro-1,3-propanediol (Bronopol), 2,2-Dibromo-3-nitrilopropionamide (DBNPA, tributyl tetradecyl phosphonium chloride);
- Clay stabilisers to prevent clay expanding on contact with water and plugging the reservoir (e.g. tetramethyl ammonium chloride);
- Buffer fluids (e.g. sodium hydroxide, acetic acid, hydrochloric acid, sodium or potassium carbonate, sodium acetate).

They may also use:

- Corrosion inhibitors (e.g. formamide, methanol, naphthalene, naptha, nonyl phenols, acetaldehyde);
- Scale inhibitors (e.g. ethylene glycols);
- Iron control (e.g. citric acid, thioglycolic acid);
- Diluted acid to dissolve minerals (e.g. hydrochloric acid, muriatic acid).

Drilling fluid components include:

- Viscosifiers to increase viscosity of mud to suspend cuttings (e.g. bentonite, polyacrylamide);
- Weighting agent (e.g. barium sulphate);
- Bactericides/biocides to prevent biodegradation of organic additives (e.g. glutaraldehyde);
- Corrosion inhibitors to prevent corrosion of drill string by acids and acid gases (e.g. zinc carbonate, sodium polyacrylate, and ammonium bisulphate);
- Defoamers to reduce mud foaming (e.g. glycol blends, light aromatic and aliphatic oil, naptha);
- Emulsifiers and de-emulsifiers to help the formation of stable dispersion of insoluble liquids in water phase of mud;
- Lubricants to reduce torque and drag on the drill string (e.g. chlorinated paraffins);
- Shale control inhibitors to control hydration of shales that causes swelling and dispersion of shale, collapsing the wellbore wall (e.g. anionic polyacrylamide, acrylamide copolymer, petroleum distillates);
- Polymer stabilisers to prevent degradation of polymers to maintain fluid properties (e.g. Sodium sulfite);
- Breakers to reduce the viscosity of the drilling mud by breaking down long chain emulsifier molecules into shorter molecules (e.g. diammonium peroxydisulphate, hemicellulase enzyme);
- Salts (e.g. potassium chloride, sodium chloride, calcium chloride).

3.1 Numbers of chemicals

A US paper, Colborn *et al.* (2011), considered chemicals used in gas operations. They compiled a list of 944 products, containing a total of 632 chemicals. They noted that more than 75% of the chemicals could adversely affect the skin, eyes, respiratory and gastrointestinal systems. Approximately 40-50% could adversely affect the brain and nervous system, immune and cardiovascular systems and kidneys. Over a third could adversely affect the endocrine (hormonal) system and a quarter could lead to cancer and mutations. [7]

A US House of Rep. Committee on Energy and Commerce Inquiry (2011) identified more than 750 chemical products containing 650 hazardous substances plus 279 unknown products with trade secrets. These included twenty nine carcinogens (e.g. naphthalene), plus neurotoxins (e.g. isopropanol), irritants/sensitisers (e.g. sodium persulfate), reproductive toxins (e.g. ethylene glycol) and endocrine disruptors (e.g. nonylphenol). Some of the chemicals were found to be dangerous at concentrations near or below chemical detection limits, (e.g. glutaraldehyde, brominated biocides (DBNPA, DBAN), propargyl alcohol). [8]

There have been many studies and reviews trying to identify the chemicals used in drilling and hydraulic fracturing, each with differing numbers and variations, but all with a common theme that there are numerous chemicals including carcinogens, and other harmful or potentially harmful chemicals used by, or produced by, drilling and hydraulic fracturing in search of gas.

3.2 Amount and concentration of chemicals

This is essential information that needs to be disclosed in SA. In WA the *maximum ingredient concentration in product* and *maximum ingredient concentration in total fluid used* is required to be disclosed. [9]

Beach Energy [10] estimates that in a Cooper Basin well, 0.5% of the fluid injected will be chemicals and 2.3% proppants. Proppants may be sand or ceramic beads. As estimated by CSIRO about 5-40ML of water is injected for hydraulic fracturing which means that 0.5% of

[7] Colborn T, Kwiatkowski C, Schultz K, and Bachran M. 2011. Natural gas operations from a public health perspective. Hum Ecol Risk Assess, 17(5):1039-56

[8] US House of Rep. C'tee on Energy & Commerce, April 2011 Chemicals Used In Hydraulic Fracturing. http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf

[9] Government of Western Australia Department of Mines and Petroleum. Information Sheet Chemicals and Other Substance Disclosure Details. 2012. www.dmp.wa.gov.au

[10] Beach Energy (2012). Environmental Impact Report Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia.

this by percentage is approximately 25 - 200 tonnes of chemicals and 115 - 920 tonnes of proppant per well.

CSIRO estimates 75,000 litres of chemicals and 1000 tonnes of proppants are needed to hydraulically fracture stimulate one well in Australia.

In 2011 a study for the European Parliament [11] estimated that 16 tonnes of acute toxic substances were used to frack one well for tight gas in Lower Saxony, Germany. This is despite the fact that the chemical additives were reported as being only 1.5% of the total amount of fluid used,

> *The fractions fluid contains 0.25% of toxic substances, 1.02% of substances which are harmful or toxic to human health and 0.19% substances which are harmful to the environment. At the well 'Goldenstedt Z23' in Lower Saxony in Germany, a total of about 65 m³ (more than the equivalent of two road tankers with a gross weight of 40 t and a net payload of 26 t) of substances which are harmful to human health have been applied, thereof about 16 t of acute toxic substances.*

The nature of shale geology in Australia makes it likely that Australian wells will require 'more fracture stimulations' [12] to extract the gas than those overseas and this will mean more water, sand and chemicals per well.

In the Otway Basin it is estimated that over 3446 wells will be drilled so this means that billions of litres of chemicals will be injected underground.[13]

3.3 Toxicity and persistence

- Many of the chemical compounds used in the process lack scientifically based maximum contaminant levels (MCLs), which makes assessment of their public health risks more difficult; [14]
- Eco-toxicity, bioaccumulation and persistence in our environment is unknown for many chemicals;
- Chemical interactions may enhance chemical toxicity;

[11] Lechtenböhmer, S et al (2011). Impacts of Shale Gas and Shale Oil Extraction on the Environment and Human Health. European Parliament, Policy Department Economic and Scientific Policy, Environment, Public Health and Food Safety.

[12] Cooke, D. 2012. A Brief Review of GeoScience Issues associated with Shale Gas development in Australia. University of Adelaide/ Australian School of Petroleum, and ZDAC Geophysical Technologies. For the ACOLA/ Unconventional Gas Production Working Group

[13] Frogtech 2013, Potential Geological Risks Associated with Shale Gas Production in Australia for Australian Council of Learned Academies (ACOLA) Project Code: AAS801 http://www.acola.org.au/

[14] Colborn T, Kwiatkowski C, Schultz K, and Bachran M. 2011. Natural Gas from a Human Health Perspective, Human and Ecological Risk Assessment: An International Journal, 17(5), 1039-1056.

- An early study on the transport and fate of more than fifty volatile organic compounds (VOCs) evidenced their long persistence (>50 years) and the long distances reached (>10 km). [15]

3.4 Water

Water is the major component of fracking fluid and has a Chemical Abstract Service (CAS) number. In the USA, as stated by the U.S. Department of Energy report, [16]

> *disclosure does not require any information about the chemistry of the make-up water that is traditionally 90% by weight of the fracturing fluid. The water used to mix the fracturing fluid is normally fresh water taken from water wells, lakes or rivers. However, during the past few years, it is becoming increasingly common to recycle fracture fluid that is produced from wells that have recently experienced physical or chemical fracture treatment. In either case, the chemicals that are part of the make-up water are not always measured.*

In Australia, legislation in WA states that,

> *Water should also be listed as a chemical whether it is used as a base fluid or as an additive within a product.*

One company in the SE (Beach Energy) is reported to be considering taking water from a deep saline aquifer in which case the composition of this water needs to be fully disclosed as it may contain salts, heavy metals and other substances.

4 Disclosure

4.1 USA disclosure

FracFocus started as a voluntary measure for gas companies to disclose the chemicals being used in the USA. As of November 2013, over 20 states have adopted some level of regulation and disclosure requirements, and 14 states require the use of FracFocus.

- It was found that 84% of the wells registered on FracFocus invoked a trade secret exemption for at least one chemical.

A U.S. Energy Department Task Force Report [17] in March 2014 outlined some of the regulation issues that have arisen in the oil and gas industry such as,

[15] Barber, L.B., Thurman, E.M., Schroeder, M.P., 1988. Long-term fate of organic micropollutants in sewage contaminated ground water. Environ. Sci. Technol. 22, 205–211.

[16] U.S. Department of Energy (March 2014) Secretary of Energy Advisory Board Task Force Report on FracFocus 2.0 March 28, 2014 U.S. Department of Energy

- The chemicals disclosed were too narrow in focus
    - Chemicals reported are only those that have Material Safety Data Sheets (MSDS).
    - MSDS reporting includes those chemicals that are believed to be hazardous to workers in an occupational setting, but reporting needs to also include other chemicals that might be hazardous to humans and the natural environment due to prolonged, intensive or extensive exposure.
- Multiple exposures occur in environmental settings as compared to workplace settings (e.g. a small amount of salt water at work is harmless, but large quantities can destroy drinking water and crops).
- Exposure to a mixture of compounds rather than a single compound at a time is common, plus simultaneous exposure to complex mixtures occurs such as to multiple carcinogens.
- Full disclosure of all known constituents added to fracturing fluid must include both chemicals ***and*** additives.
- Protection of trade secrets could be managed by adopting a "systems approach" that reports the chemicals added separately from the additive names and product names that contain them instead of permitting non-disclosure.
- Reporting needs to be via Chemical Abstract Service (CAS) numbers, which are the unique and universal identifier of individual chemicals, as many chemicals might go under a variety of different names.
- Water chemical content disclosure is recommended to analyse constituents in water (water is often recycled or taken from unknown sources).

4.2 Australian disclosure

APPEA, the peak body representing the oil and gas industry in Australia, list only 55 chemicals on their website handout (2015) [18] and say [19],

> *Industry and government have a detailed knowledge of the hydraulic fracturing process and of the chemicals being used….Companies must identify the chemicals*

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[17] U.S. Department of Energy (March 2014) Secretary of Energy Advisory Board Task Force Report on FracFocus 2.0 March 28, 2014 U.S. Department of Energy

[18] Australian Petroleum Production & Exploration Association (2013) 'Chemicals & Compounds Used in CSG Fraccing', Natural Coal Seam Gas. Retrieved Jan 2015, http://www.appea.com.au/wp-content/uploads/2014/08/CSG-fraccing-chemicals.pdf

[19] APPEA | Mythbusting Accessed January 2015

being used in any fraccing operation and detail any likely interactions with the water and rock formations in the area being fracced.

- This statement was not supported by the evidence heard by the New South Wales Legislative Council Committee in 2012, which determined "The Committee did not receive evidence that addressed the exact composition of fraccing fluids and the Committee received broad information only on the quantities and names of chemicals used."[20]

  There was clearly a failure to disclose chemicals being used by the industry increasing community distrust and suspicion of the gas industry.

  To address community concerns about chemicals used in the coal seam gas (CSG) industry the *Australian Government's Office of Water Science*, has funded the **National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia** which began in July 2012 and is due to be released in April 2015.

  This is a collaboration between the *National Industrial Chemicals Notification and Assessment Scheme* (NICNAS—lead agency), *the Commonwealth Scientific and Industrial Research Organisation* (CSIRO), *the Department of the Environment* and *Geoscience Australia*.[21] The National Assessment will examine human health and environmental risks from chemicals used in drilling and hydraulic fracturing for CSG extraction in Australia.

  We understand that this report identifies over 142 chemicals used in drilling and hydraulic fracturing for CSG in Australia. We are unclear if all the chemicals used for shale gas extraction will be covered by this study.

- The APPEA statement is also not supported by Beach Energy's *Environmental Impact Report Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia*[22] from 2012, which lists 51 chemicals, of which 9 are undisclosed and named 'proprietary'.

  'Proprietary chemicals' means chemicals that are not disclosed on the grounds that the chemicals are intellectual property. These chemical(s) are often made by large

[20] New South Wales. Parliament. Legislative Council. General Purpose Standing Committee No. 5 Inquiry into coal seam gas / General Purpose Standing Committee No. 5. [Sydney, N.S.W.] : The Committee, 2012. – xxi, 330 p.; 30 cm. (Report No. 35) p 69.

[21] http://www.nicnas.gov.au/communications/issues/fracking-hydraulic-fracturing-coal-seam-gas-extraction

[22] Beach Energy (2012). Environmental Impact Report Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia.

multinational companies such as Halliburton or Baker Hughes. Tim Flowers from Beach Energy explained "With respect to the proprietary components within Table A2[23], the stimulation service provider invests research to develop intellectual property to provide a stimulation fluid that they feel is superior to their competitors. The service provider keeps this information confidential."[24]

In 2014, one company Baker Hughes [25] announced it will disclose all chemicals used in fracking. As recommended by the **U.S. Department of Energy Report[26]** there are ways of getting around 'trade secrets' and if one company can name the chemical components then there is no reason why the others can't as well.

The food industry similarly resisted disclosure of ingredients and quantities in food labelling due to concern about the loss of secret recipes, but improvements in food labelling laws are now accepted for the health and safety of the community.

Western Australia is the only state that requires full disclosure of each product, additive or substance including water used.[27]

We strongly advocate that full disclosure of chemicals will give greater transparency, accountability, and provide better ability for monitoring, and safety.

4.3 European Parliament recommendations

Based on concerns about the use of known toxic chemicals for unconventional gas extraction the European Parliament in 2011 recommended, [28]

> *It should be assessed whether the use of toxic chemicals for injection should be banned in general. At least, all chemicals to be used should be disclosed publicly, the number of allowed chemicals should be restricted and its use should be monitored.*

[23] Beach Energy (2012). Environmental Impact Report Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia.

[24] Email communication from Tim Flowers Beach Energy June 2014

[25] Mercury News report http://www.mercurynews.com/nation-world/ci_25630943/major-oil-amp-gas-firm-list-drilling-chemicals

[26] U.S. Department of Energy (March 2014) Secretary of Energy Advisory Board Task Force Report on FracFocus 2.0

[27] Government of Western Australia Department of Mines and Petroleum. Information Sheet Chemicals and Other Substance Disclosure Details. 2012. www.dmp.wa.gov.au

[28] Lechtenböhmer, S et al (2011). Impacts of Shale Gas and Shale Oil Extraction on the Environment and Human Health. European Parliament, Policy Department Economic and Scientific Policy, Environment, Public Health and Food Safety.

Statistics about the injected quantities and number of projects should be collected at European level.

4.4 Recommendations re chemicals

Recommendation 1

All chemical substances and additives used in drilling and hydraulic fracturing should be disclosed publicly. There should be no exemptions under intellectual property laws.

Recommendation 2

All chemical substances and additives used in drilling and hydraulic fracturing should be identified by CAS number.

Recommendation 3

Water should be listed as a chemical whether it is used as a base fluid or as an additive within a product.

Recommendation 4

The use of all chemicals for drilling and hydraulic fracturing should be prohibited until their use is subject to a full assessment of the risks they pose to human health and our environment.

Recommendation 5

All chemical substances and additives proposed to be used for drilling and hydraulic fracturing should be fully assessed by an 'appropriately qualified' body for its human and eco-toxicity and its persistence in the environment and other toxicology markers.

Recommendation 6

All chemical substances and additives proposed to be used for drilling and hydraulic fracturing should only be permitted when authorised by an ' appropriately qualified' body that has certified that the chemical is safe to human health and the environment *in* the specific environment and quantities which it is intended.

Recommendation 7

The 'appropriately qualified' authorising body must be independent from industry and its decisions must be amenable to judicial review on the merits.

Recommendation 8

The use of toxic and potentially toxic chemicals should be banned in general. This was recommended by European Parliament report.[29]

Recommendation 9

Statistics about the quantity of chemicals used and the number of projects should be collected at Regional and National levels.

Recommendation 10

Disclosure should include the maximum ingredient concentration in product and maximum ingredient concentration in total fluid used. Similar to what occurs in WA.

5 Types of chemicals used in and produced by gas drilling and hydraulic fracturing

Exposure to chemicals may be from chemicals that are used in the gas drilling and hydraulic fracturing process or chemicals that are produced by the gas drilling and hydraulic fracturing process. These may include volatile organic compounds, polyaromatic hydrocarbons, methane gas, heavy metals, naturally occurring radioactive material which are buried deep underground in the shale formation. The process of gas drilling and hydraulic fracturing (fracking) brings these substances to the surface.

There are increased pathways for contamination that were not there before due to the process of gas drilling and hydraulic fracturing with the potential to contaminate our surface aquifers, land, soil and air and impact negatively on our human and environmental health.

Potential pathways of exposure/contamination from the gas drilling and hydraulic fracturing process;

- well integrity failure,
- casing failure,
- cement failure,
- natural fault and fracture lines,
- fracture stimulation intersecting fault lines, or intersecting old wells,
- surface flowback of gas and fluids,
- spills and leaks
- holding ponds leaks and floods,
- disposal of waste water,

[29] Lechtenböhmer, S et al (2011). Impacts of Shale Gas and Shale Oil Extraction on the Environment and Human Health. European Parliament, Policy Department Economic and Scientific Policy, Environment, Public Health and Food Safety.

- transport accidents,
- venting or flaring of gas at surface,
- pipeline leaks,
- equipment corrosion and leaks,
- well blowouts.

The following subparagraphs describe these groups that are highly likely to be present and thus can impact on our human health and our environment.

5.1 Benzene, Toluene, Ethylbenzene and Xylene(s)

BTEX is a collective acronym for the volatile organic compounds Benzene, Toluene, Ethylbenzene and Xylene(s). These chemicals occur naturally in petroleum and are also human-made in large quantities for use during the processing of refined petroleum products and coal, and for use in consumer products (such as paints, solvents, cosmetics and pharmaceuticals). Humans are exposed to BTEX through use of these products and from breathing contaminated air from car exhaust, at petrol stations and cigarette smoke.
BTEX containing petroleum products – such as diesel – have been widely used in the U.S.A. as additives to hydraulic fracturing fluids, to thicken the fluid and improve the efficiency of the fracking process.[30]
BTEX can volatilize into air from soil or the water's surface, and once volatilized will disperse and readily biodegrade. BTEX can also pass through soil into the groundwater. Since BTEX are only slightly soluble in water, BTEX tend to collect at the top of the water table where they degrade more slowly than in the soil.[31]

Health effects

Benzene - the most toxic component of BTEX is a well-established cause of cancer in humans.[32] The World Health Organisation states that, Human *exposure to benzene has been associated with a range of acute and long-term adverse health effects and diseases, including cancer and aplastic anaemia* and that *Public health actions are needed to reduce the exposure of both workers and the general population to benzene*. Benzene is carcinogenic to humans, and no safe level of exposure can be recommended.

Toluene is readily absorbed from the gastrointestinal tract after ingestion, and is distributed preferentially in adipose tissue, then the kidneys, liver and brain. The main effect

[30] Parliament of Victoria. 2014. Research Note on the Resources Legislation Amendment.(BTEX Prohibition and Other Matters) Bill 2014.

[31] Agency for Toxic Substances and Disease Registry. 2007a. Toxicological profile for benzene. Atlanta, GA: U.S. Department of Health and Human Services, U.S. Public Health Service, Agency for Toxic Substances and Disease Registry.

[32] World Health Organisation (2010) 'Exposure to Benzene: A Major Public Health Concern', International Programme on Chemical Safety: Benzene, WHO website, p. 2.

of toluene is on the brain and nervous system, with fatigue and drowsiness being the most obvious symptoms.[33]

Ethylbenzene is also absorbed from the human gastrointestinal tract. Liver and kidney effects and irreversible damage to the inner ear and hearing have been found in animal studies. Irritation of the eyes and respiratory tract has been reported by humans exposed to high levels in the air. [34]

Xylene(s) are readily absorbed after inhalation. Both short- and long-term exposure to high concentrations of xylene can also cause a number of effects on the nervous system, such as headaches, lack of muscle coordination, dizziness, confusion, and changes in one's sense of balance as well as irritate the eyes and respiratory tract.[35]

The UK Chief Scientist in his Annual Report 2014 [36] named Benzene as a major problem for our society where "delayed recognition of adverse effects incurred not only serious environmental or health impacts, but massive expense and reductions in competitiveness for firms and economies persisting in the wrong path..."

Victorian policy on BTEX

The addition of BTEX to fracture fluids has been banned in Victoria since July 2014.

Qld and NSW policy on BTEX

Legislative amendments in Queensland and policy amendments in New South Wales have prohibited the addition of BTEX compounds to fracking fluids in those states. In 2010, the Queensland Government introduced the Natural Resources and Other Legislation Amendment Act (No. 2) 2010 which amended the Environmental Protection Act 1994 to

[33] Leusch F, Bartkow M. (2010) 'A short primer on benzene, toluene, ethylbenzene and xylenes (BTEX) in the environment and in hydraulic fracturing fluids', Griffith University Smart Water Research Centre, Queensland Government Department of Environment website

[34] Leusch F, Bartkow M. (2010) 'A short primer on benzene, toluene, ethylbenzene and xylenes (BTEX) in the environment and in hydraulic fracturing fluids', Griffith University Smart Water Research Centre, Queensland Government Department of Environment website

[35] Leusch F, Bartkow M. (2010) 'A short primer on benzene, toluene, ethylbenzene and xylenes (BTEX) in the environment and in hydraulic fracturing fluids', Griffith University Smart Water Research Centre, Queensland Government Department of Environment website.

[36] Annual Report of the Government Chief Scientific Adviser 2014. Innovation: Managing Risk, Not Avoiding It. Evidence and Case Studies.

restrict the use of stimulation fluids that contain BTEX. [37] In 2012, New South Wales introduced a formal policy banning the use of BTEX compounds in coal seam gas activities. [38]

SA poor policy on BTEX

Despite being banned in Victoria, Queensland, NSW, and WA, BTEX chemicals are still allowed to be used in SA.

Beach Energy Environmental Impact Report for Cooper Basin [39] states,

> *BTEX in Fracturing Additives; Fracturing fluid additives containing the volatile aromatic compounds benzene, toluene, ethylbenzene and xylene (collectively referred to as BTEX) have been identified as a potential concern in some areas where fracture stimulation operations are carried out much closer to water supply aquifers. Although the level of risk posed by additives containing BTEX is relatively low in the Cooper Basin (e.g. the target petroleum reservoirs can naturally contain BTEX and are not near water supply aquifers), it is not proposed to use additives where BTEX is present in significant quantities. Some additives in the acid blend (e.g. hydrochloric acid, corrosion inhibitor and acid penetrating agent) can contain trace levels of BTEX; however the dilution of the acid blend by subsequent stages of the fracture stimulation would result in very low levels, which would be below drinking water guidelines. Suppliers and fracturing contractors have been working to ensure that levels of BTEX in fracturing fluids are reduced as far as practicable and are not at significant levels.*

It would appear from this statement that it is possible that additives will contain BTEX. It is essential that contamination of surface aquifers, soil and air is prevented to avoid short-and long-term harm to human, animal and environmental health.

5.2 Poly Aromatic Hydrocarbons (PAH)

PAHs and their derivatives are among the most potent carcinogens and mutagenic substances. Neurodevelopmental disorders and lowered IQ in babies has been associated with the mother's exposure to PAHs during pregnancy.

PAH occur naturally as constituents of oil deposits. Gas drilling and hydraulic fracturing results in these chemicals reaching the surface in flow back water/gas and increases the pathways of contamination via fluid migration and faulty well casing.

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[37] Queensland; Section 16 of the Natural Resources and Other Legislation Amendment Act (No. 2) 2010 (Qld).

[38] NSW Government (2012) 'Ban on the use of BTEX compounds in CSG activities', NSW Trade & Investment website. Section 6 of the Code of Practice for Coal Seam Gas fracture simulation activities.

[39] Beach Energy (2012). Environmental Impact Report Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia.

It is likely that these chemicals would not be released without the gas drilling and hydraulic fracturing process. It is essential that contamination of surface aquifers, soil and air is prevented.

5.3 Recommendation re BTEX and PAH

BTEX and PAH are naturally found in hydrocarbon deposits and will be produced by the gas drilling and hydraulic fracturing process. BTEX and PAH are highly toxic and known carcinogens. Contamination of the air, soil and surface aquifers needs to be monitored and eliminated.

All states in Australia should follow the lead of NSW, QLD, WA and Victoria and ban the use of BTEX additives.

Recommendation 11

All states in Australia should ban use of BTEX additives to fracking fluids (in line with quality health and environmental guidelines interstate and overseas.)

Recommendation 12

Comprehensive baseline data on groundwater, air and soil must be collected before any gas drilling or hydraulic fracturing occurs anywhere in Australia. This should be continued regularly (as recommended by an 'independent scientific committee') and indefinitely.

Monitoring must include testing for BTEX, Polyaromatic Hydrocarbons, metals and radionuclides, NORMS and radon gas and other compounds produced by the gas drilling and hydraulic fracturing process.

Recommendation 13

All monitoring and testing should be done by an independent, accredited laboratory for the entire country.

Recommendation 14

All monitoring and testing should be done on a regular basis (as recommended by an 'independent scientific committee') during life of project and continued indefinitely for the entire country.

Recommendation 15

To enable transparency and adequate disclosure the results of testing/monitoring needs to be publicly available, as they are done, on the regulators website and in the local newspapers.

Recommendation 16

The companies need to have long term liability for any contamination that may occur and for any negative consequences on human or environmental health. This needs to apply to exploration and production wells i.e. such as those drilled at Penola. For example if in 30 years time there is a high incidence of cancer, then the company that caused this contamination should be liable.

6 Carcinogen use

A review in the Environmental Health journal published in 2014, by **Webb *et al***. reported, [40]

> *The Unconventional Oil and Gas industry reports using approximately 13 known or suspected carcinogens (including benzene and acrylamide), known developmental neurotoxicants, and many volatile organic compounds (VOCs) including the BTEX (benzene, toluene, ethylbenzene, and xylene) chemicals, which have numerous associated adverse health outcomes in humans.*[41]
>
> *Gas operations release large amounts of reproductive, immunological, and neurological toxicants, carcinogens as well as endocrine disrupting chemicals (EDCs) into the environment that may negatively affect human health. The chemicals used in or produced by Unconventional Oil Gas have been linked to negative health effects, including adverse reproductive and developmental outcomes in men, women, infants and children.*

7 Endocrine Disrupting Chemicals (EDC)

The American Endocrine Society defines Endocrine Disrupting Chemicals (EDC) as *Any chemical or mixture of chemicals that interferes with any aspect of hormone action.* More than 130 fracturing chemicals have been identified as known or potential EDCs, and many others have yet to be assessed due to lack of Chemical Abstract Service (CAS) numbers and/or proprietary information secrets.[42] EDCs present unique hazards, particularly during fetal and early childhood growth and development. [43] Adverse reproductive health

[40] Webb E, Bushkin-Bedient S, Cheng A, Kassotis C, Balise V and Nagel S. 2014. Developmental and reproductive effects of chemicals associated with unconventional oil and natural gas operations. Rev Environ Health 2014; 29(4): 307–318

[41] US House of Rep. C'tee on Energy & Commerce, April 2011 Chemicals Used In Hydraulic Fracturing. http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf

[42] Webb E, Bushkin-Bedient S, Cheng A, Kassotis C, Balise V and Nagel S. 2014. Developmental and reproductive effects of chemicals associated with unconventional oil and natural gas operations. Rev Environ Health 2014; 29(4): 307–318

[43] Diamanti-Kandarakis E, Bourguignon J-P, Giudice LC, Hauser R, Prins GS, Soto AM, et al. 2009. Endocrine-disrupting chemicals: an Endocrine Society scientific statement. Endocr Rev 30:293–342.

outcomes associated with EDC exposures are well documented, with reported effects on reproductive organs, body weight, puberty, fertility, and reproductive cancer incidence. Hormones work at very low concentrations, and so while typically less potent, EDCs are often present at much higher concentrations than endogenous hormones. EDCs have challenged traditional concepts in toxicology because effects at higher doses do not always predict effects at low doses.[44] In other words, the dose does not always make the poison. [45]

8 Recommendations regarding carcinogens and Endocrine Disrupting Chemicals

It is recommended that known and potential carcinogens and endocrine disrupting chemicals are not used for gas drilling and hydraulic fracturing. A chemical substance or additive should not be used unless its potential for endocrine disruption and as a carcinogen is known.

Recommendation 17

Known and potential carcinogens, as well as known and potential endocrine disrupting chemicals should not be used. All chemical substances or additives should be fully assessed by an 'appropriately qualified' body for their potential as an endocrine disrupter and carcinogen.

9 Flow back to the surface

Flowback refers to the 15 - 80% of the hydraulic fluid mixture that returns to the surface. It contains some of the chemicals injected plus methane and contaminants from the shale including other hydrocarbons, BTEX, (benzene, toluene, ethylbenzene, and xylene), polycyclic aromatic hydrocarbons (PAHs), naturally occurring radioactive materials (NORMs), heavy metals, other volatile organic compounds and new and unknown chemicals.[46]

> *After the drilling and fracturing phase, a portion of the fracturing fluids immediately return to the surface as flowback water. Large volumes of waste water, which originate from within the shale layer, later come to the surface throughout the life of*

[44] Vandenberg LN, Colborn T, Hayes TB, Heindel JJ, Jacobs DR Jr, Lee D-H, et al. 2012. Hormones and endocrine-disrupting chemicals: low-dose effects and nonmonotonic dose responses. Endocr Rev 33:378–455.

[45] Shonkoff, S, Hays, J, Finkel, M. 2014. Environmental Public Health Dimensions of Shale and Tight Gas Development http://dx.doi.org/10.1289/ehp.1307866

[46] Lloyd-Smith 2013. Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources National Toxics Network

the well. Residual fracturing chemicals can continue to emerge with waste water in addition to other compounds that are naturally occurring in the bedrock.[47]

The Cooper Basin EIR [48] estimates 20% of the chemicals return and that,

produced water, which contains high concentrations of salts and radioactivity, is brought to the surface along with the extracted gas and oil.

In their document for **ACOLA, Frogtech**[49] quotes the **US EPA 2011**[50]

In addition to the fracking fluid the recovered water is also mixed with formation water trapped in shale pores. This water is usually highly saline and may contain a range of harmful elements such as naturally occurring radioactive material (NORM), barium, trace elements and volatile organic compounds.

Wastewater from drilling and exploration practices, as well as produced water removed from oil or gas streams, is often saline, [51] radioactive, [52] and acidic due to dissolved H_2S and CO_2. The exact composition of 'produced water' depends on the geological formation from which it came. Traces of hydrocarbons such as PAH and drilling chemicals may also be present, as well as a variety of heavy metals.[53]

Recommendations re flow back waste water

Flow back waste water has come from underground and becomes contaminated not only with the chemicals used in the gas drilling and hydraulic fracturing process, but with salts,

[47] Webb E, Bushkin-Bedient S, Cheng A, Kassotis C, Balise V and Nagel S. 2014. Developmental and reproductive effects of chemicals associated with unconventional oil and natural gas operations. Rev Environ Health 2014; 29(4): 307–318

[48] Beach Energy 2012. Environmental Impact Report Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia.

[49] Frogtech 2013, Potential Geological Risks Associated with Shale Gas Production in Australia for Australian Council of Learned Academies (ACOLA) Project Code: AAS801 http://www.acola.org.au/

[50] Draft Report on Investigation of Ground Water Contamination near Pavillion, Wyoming. Dominic C. DiGiulio Richard T. Wilkin Carlyle Miller. U.S. Environmental Protection Agency Office of Research and Development National Risk Management Research Laboratory. December 2011

[51] MOE (Ministry of Environment). 2007a. Environmental Protection Division. Oil and gas waste regulation – users guide. (http://www. env.gov.bc.ca/epd/industrial/regs/oil_gas/pdf/ogwr_guide.pdf)

[52] Veil, J.A, et al 2004 A white paper describing produced water from production of crude oil, natural gas, and coal bed methane. Prepared for: U.S. Department of Energy. National Energy Technology Laboratory. Contract W-31-109-Eng-38. Prepared by: Argonne National Laboratory, Chicago, Ill.

[53] Tibbetts, P.J.C., Buchanan, I.T., Gawel, L.J., and Large, R. 1992. A comprehensive determination of produced water composition. In Produced water: technological/environmental issues and solutions. Edited by J.P. Ray and F.R Engelhardt. Plenum Publishing Corp.New York. pp. 97–113

heavy metals, PAH, NORM and unknowns, produced by the process itself and from underground. The storage, handling and disposal of this waste needs strong regulations to prevent leaks and spills. What happens to it, is of great concern. We do not think this waste water should be returned to our environment, put on any pasture, injected back into any underground aquifer or discharged into streams or the ocean. Even with reverse osmosis not all chemicals such as NORMs are removed.

Evaporation ponds are banned in New South Wales.[54]

Recommendation 18

Ban use of evaporation ponds.

Recommendation 19

Ban use of injection wells for the disposal of waste water.

Recommendation 20

Waste water should not be spread on any pasture or discharged into streams or the ocean.

9.1 Metals which flow back

Heavy metals are components of Earth's crust and may be naturally present in some aquifers. They may be bought to the surface by gas drilling and hydraulic fracturing process. Flow back and waste water may become contaminated by these naturally- occurring metals like arsenic, cadmium, lead, manganese, and mercury. The exact metals will depend what is present naturally.[55]

The European Parliament study [56] quotes the US EPA 2011[57]

> *Hydraulic fracturing may affect the mobility of naturally occurring toxic substances present in the subsurface such as mercury, lead and arsenic. These substances can find a pathway to an underground source of drinking water if fractures extend beyond the target formation, or if the casing or cement around the drilling fails under the pressures exerted during hydraulic fracturing.*

[54] Strategic Regional Land Use Policy, State of NSW, Sept 2012.

[55] Goldman L, Letter to New York Department of Health Review. 2014. Dean of School of Public Health and Health Services. The George Washington University, Washington.

[56] Lechtenböhmer, S et al (2011). Impacts of Shale Gas and Shale Oil Extraction on the Environment and Human Health. European Parliament, Policy Department Economic and Scientific Policy, Environment, Public Health and Food Safety.

[57] Draft Report on Investigation of Ground Water Contamination near Pavillion, Wyoming. Dominic C. DiGiulio Richard T. Wilkin Carlyle Miller. U.S. Environmental Protection Agency Office of Research and Development National Risk Management Research Laboratory. December 2011

Metals persist in the environment and bioaccumulate in food chains being virtually indestructible. All metals can be harmful in high and (or) prolonged doses.

> *Each metal has its own exposure limits and health impacts. Airborne metals such as arsenic and nickel cause respiratory problems, cardiovascular symptoms and kidney damage. The metals lead, mercury and arsenic exhibit nervous system toxicity.*[58] *Arsenic, lead, hexavalent chromium, and nickel have all been linked to lung and other cancers. When ingested, metals have similar effects as when inhaled, however rather than entering the lung and causing lung cancer, ingested metals may cause cancers of the bladder, kidneys, liver or pancreas.*[59]

It is likely that these metals would not be released without the gas drilling and hydraulic fracturing process. It is essential that contamination of surface aquifers, soil and air is prevented to avoid short-and long-term harm to human, animal and environmental health.

Recommendations regarding metals

The following recommendations are the same as for BTEX and PAH.

Recommendation 12

Comprehensive baseline data on groundwater, air and soil must be collected before any gas drilling or hydraulic fracturing occurs anywhere in Australia. This should be continued regularly (as recommended by an 'independent scientific committee') and indefinitely.

Monitoring must include testing for BTEX, Polyaromatic Hydrocarbons, metals and radionuclides, NORMS and radon gas and other compounds produced by the gas drilling and hydraulic fracturing process.

Recommendation 13

All monitoring and testing should be done by an independent, accredited laboratory for the entire country.

Recommendation 14

All monitoring and testing should be done on a regular basis (as recommended by an 'independent scientific committee') during life of project and continued indefinitely for the entire country.

[58] Kampa M, Castanas E. 2008 Human health effects of air pollution. Environmental Pollution 151 (2008) 362e367

[59] Belpomme D et al. 2007. A Review; The multitude and diversity of environmental carcinogens. Environmental Research 105 (2007) 414–429

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Recommendation 15

To enable transparency and adequate disclosure the results of testing/monitoring needs to be publicly available, as they are done, on the regulators website and in the local newspapers.

Recommendation 16

The companies need to have long term liability for any contamination that may occur and for any negative consequences on human or environmental health. This needs to apply to exploration and production wells i.e. such as those drilled at Penola. For example if in 30 years time there is a high incidence of cancer, then the company that caused this contamination should be liable.

Plus in relation to metals

Recommendation 21

Levels of metals in surface aquifers, land and air, must at all times be kept below recognised Australian and international guidelines.

9.2 Naturally occurring radioactive materials (NORMs) which flow back

9.2.1 Introduction

Fluids trapped in the shale are remnants of ancient seawater, these salts reach extreme concentrations over millions of years, and their chemical interactions with the surrounding rock can mobilize radionuclides which are known as Naturally Occurring Radioactive material (NORMs). Several studies indicate that, generally speaking, the saltier the water, the more radioactive it is. [60] [61]

National Toxic Network information on NORMs[62].

> *The NORMs Uranium, thorium, radium-228 and radium-226 are found in shale. These radioactive materials can be released to the environment through disposal of drill cuttings/muds, flowback water and through air emissions. Radium emits alpha particles, which are most dangerous when radium is inhaled or ingested. Radium is a*

[60] Rowan EL, et al. Radium Content of Oil- and Gas-Field Produced Waters in the Northern Appalachian Basin (USA)—Summary and Discussion of Data. Scientific Investigations Report 2011–5135. Washington, DC:U.S. Geological Survey, U.S. Department of the Interior (2011). Available: http://pubs.usgs.gov/sir/2011/5135/pdf/sir2011-5135.pdf

[61] GAO. Oil and Gas: Information on Shale Resources, Development, and Environmental and Public Health Risks. GAO-12-732. Washington, DC:U.S. Government Accountability Office (5 September 2012). Available: http://www.gao.gov/products/GAO-12-732

[62] National Toxic Network. 2014. Submission. Review of hydraulic fracturing in Tasmania. Available from Tasmanian review website.

known carcinogen and exposure can result in increased incidence of bone, liver and breast cancer. When inhaled, radon can cause lung cancer, and there is some evidence it may cause other cancers such as leukaemia. Consuming radium in drinking water can cause lymphoma, bone cancer, and leukaemias. Radium-226 and radium-228 have half-lives of 1,600 years and 5.75 years, respectively. Radium is known to bioaccumulate in invertebrates, mollusks, and freshwater fish, where it can substitute for calcium in bones.

The earth has a natural 'background' radiation, but gas drilling and fracking can mobilise NORMs and concentrate them on the surface. This concentration of radiation poses a higher risk to workers and the community than the earth's background radiation.

Beach Energy's Cooper Basin EIR [63] similarly states,

The potential for radioactivity resulting from Naturally Occurring Radioactive Materials (NORM) that are brought to the surface is perceived as a potential issue for fracture stimulation activities....NORM are usually only a potential issue when they are concentrated (e.g. by the formation of mineral scales or sludges over time in tanks, piping and facilities).

The work involved in drilling and maintaining a well produces so called Technologically Enhanced NORMs [64] and may concentrate it as;

- Scale. Excess salt – including radioactive salts – will precipitate out on nearby solid surfaces, including the well head, casing, plus water lines;
- Recycling water. Radioactive salts are not easily filtered out of water. Each time the water is reused, the concentration of radioactivity in the water increases;
- Separation pits are used to divide the solids (including drill cuttings) from the liquids (formation water and drill fluid). As the solids settle out, they may contain increased concentrations of radioactive material. The liquids may also have increased radioactive concentrations;
- Sludge is composed of dissolved (potentially radioactive) salts that precipitate from waste water as its temperature and pressure change;

[63] Beach Energy (2012). Environmental Impact Report Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia.

[64] Nicoll, G 2012. Radiation Sources in Natural Gas Well Activities More attention and monitoring of occupational radiation exposure in the natural gas industry are warranted. http://ohsonline.com/Articles/2012/10/01/Radiation-Sources-in-Natural-Gas-Well-Activities.aspx?admgarea=ht.PPE&Page=1

- Equipment can become contaminated with radiation over time. Gas processing equipment with the highest radiation levels includes reflux pumps, propane pumps and tanks;[65]

Regulatory guidelines may underestimate the significance of NORMs. Rich and Crosby (2013) [66]concluded that,

> *Evaluating the single radionuclide radium as regulatory exposure guidelines indicate, rather than considering all radionuclides, may indeed underestimate the potential for radiation exposure to workers, the general public, and the environment.*

9.2.2 Radioisotopes

In addition to naturally occurring radiation sources, radioisotopes are sometimes used in the gas industry in microseismic testing and to trace workovers during maintenance. It is important that if these sources of radiation are combined with solid wastes that they are monitored and appropriately disposed of.

9.2.3 Radon gas

Radon is a short lived noble gas and decay product of Uranium. A Southern Cross University[67] team found "a ~3 fold increase in maximum Radon-222 concentration was observed inside the Surat gas field compared to outside of it." The researchers suggest the presence of radon and CO2 indicates the possible release of other gases, such as VOCs. Despite the increased concentration of radon detected by the SCU study inside the gas fields, there has been little radionuclide analyses or testing for radon in the communities surrounding gas fields. Radon gas may also be extracted along with the natural gas.

9.2.4 Recommendations regarding naturally occurring radioactive materials

The following recommendations are the same as for BTEX, PAH and metals.

Recommendation 12

Comprehensive baseline data on groundwater, air and soil must be collected before any gas drilling or hydraulic fracturing occurs anywhere in Australia. This should be continued regularly (as recommended by an 'independent scientific committee') and indefinitely.

[65] Environmental Protection Agency (EPA). (2011). Oil and Gas Production Wastes. July 8. Available at http://www.epa.gov/rpdweb00/tenorm/oilandgas.html#residentsoffice.

[66] Rich AL, Crosby EC. Analysis of reserve pit sludge from unconventional natural gas hydraulic fracturing and drilling operations for the presence of technologically enhanced naturally occurring radioactive material (TENORM). New Solut 23(1):117–135 (2013); http://dx.doi.org/10.2190/NS.23.1.h

[67] Tait D 2013. Enrichment of Radon and Carbon Dioxide in the Open Atmosphere of an Australian Coal Seam Gas Field. Environ. Sci. Technol. 2013, 47, 3099−3104

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Monitoring must include testing for BTEX, Polyaromatic Hydrocarbons, metals and radionuclides, NORMS and radon gas and other compounds produced by the gas drilling and hydraulic fracturing process.

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All monitoring and testing should be done by an independent, accredited laboratory for the entire country.

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All monitoring and testing should be done on a regular basis (as recommended by an 'independent scientific committee') during life of project and continued indefinitely for the entire country.

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To enable transparency and adequate disclosure the results of testing/monitoring needs to be publicly available, as they are done, on the regulators website and in the local newspapers.

Recommendation 16

The companies need to have long term liability for any contamination that may occur and for any negative consequences on human or environmental health. This needs to apply to exploration and production wells i.e. such as those drilled at Penola. For example if in 30 years time there is a high incidence of cancer, then the company that caused this contamination should be liable.

Plus in relation to NORMS

Recommendation 22

A review of regulatory guidelines, to ensure they evaluate *all* radionuclides in waste water and solids rather than any 'single one". The total sum of radiation is needed to protect exposure of workers, community and environment from radiation.

Recommendation 23

Baseline testing and ongoing monitoring of radionuclide analyses must include radon gas in communities surrounding gas fields anywhere in Australia.

Recommendation 24

Total levels of radiation at gas drilling sites, in surface aquifers, land and air, anywhere in Australia, must at all times be kept below recognised Australian and international guidelines.

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10 Chemicals remaining underground

Cooper Basin EIR [68] states,

> *Chemicals returning from a well after a fracturing treatment are usually a fraction (usually 20% or less for chemicals and about 40% for polymers).*

This means that 80% of chemicals and 60% of polymers remain underground.

We are concerned about what happens to these chemicals.

It is known that they may 1) migrate to the surface or aquifers, 2) be adsorbed onto rock surface, and 3) degrade over time.

What is the future potential impacts of this many chemicals remaining underground? It is not clear that this has been answered.

It is absolutely essential that recommendation 9 and 10 are followed.

Recommendation 9

Statistics about the quantity of chemicals used and the number of projects should be collected at Regional and National levels.

Recommendation 10

Disclosure should include the maximum ingredient concentration in product and maximum ingredient concentration in total fluid used. Similar to what occurs in WA.

Plus

Recommendation 25

Statistics about the estimated volume of fluids and chemicals that remain underground at each well site, anywhere in Australia, should be collected at regional and project levels. This is important to identify if there are likely to be problems with future contamination and where.

11 Unknowns

11.1 New Compounds forming

Chemicals can form new compounds when exposed to sunlight, water, air, radioactive elements, or if exposed to pressure or heat, or other natural chemical catalysts. We don't

[68] Beach Energy 2012. Environmental Impact Report Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia.

know the safety of these new compounds, or if they persist long term, or cause health and environmental harm. [69] [70] [71]

- Given the high pressure and temperature in the underlying strata, both flowback and produced waters have the potential to contain transformation products that originate from the drilling muds and fracturing chemicals.[72]
- There are unknown degradation products.

11.2 Low levels do not make it safe

As Dr Colborn [73] has said,

> *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.*

11.3 Toxicology assessment difficulties

As Dr David Brown [74] has pointed out

Toxicology monitoring is not used to dealing with variable exposures, which is what occurs in a gas field. Exposure patterns are variable, unpredictable, and intermittent and weather dependent. Understanding gas field toxicology is complicated because:

a) We have incomplete identification of the chemicals present;
b) Chemicals can interact with other chemicals in complex unknown ways;
c) The presence of one agent can greatly increase the toxicity of another agent;
d) Agents have multiple physiological actions on various target organs;
e) Health effects of exposure to many chemicals is unknown;

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[69] Kortenkamp A, Faust M, Scholze M, Backhaus T. 2007. Low-level exposure to multiple chemicals: reason for human health concerns?. Environ Health Perspect 115 Suppl 1:106114.

[70] Teuschler LK, Hertzberg RC. 1995. Current and future risk assessment guidelines, policy, and methods development for chemical mixtures. Toxicology 105(2-3):137-144.

[71] Wilkinson CF, Christoph GR, Julien E, Kelley JM, Kronenberg J, McCarthy J, et al. Assessing the risks of exposures to multiple chemicals with a common mechanism of toxicity: how to cumulate?. Regul Toxicol Pharmacol 31(1):30-43.

[72] Adgate J, Goldstein B, and McKenzie L. 2014 Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development in Environmental Science and Technology, dx.doi.org/10.1021/es404621d | Environ. Sci. Technol.

[73] Colborn T, Kwiatkowski C, Schultz K, and Bachran M. 2011. Natural Gas from a Human Health Perspective, Human and Ecological Risk Assessment: An International Journal, 17(5), 1039-1056.

[74] Brown D, Weinberger B, Lewis C and Bonaparte H. 2014. Understanding exposure from natural gas drilling puts current air standards to the test. Rev Environ Health 2014; DOI 10.1515/reveh-2014-0002

f) How certain chemicals alter the biological processing of other chemicals is unknown;
g) Substances that inhibit metabolism or excretion magnify the effects of other chemicals;
h) Some agents can change the physiologic distribution of other chemicals;
i) Some agents can cause chemicals that would not normally do so to enter the brain;
j) Medications can affect the impact of toxic substances.

11.4 Detection difficult

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.[75]

12 Long term monitoring

Given that some of the potential contaminants persist in our environment for many years (greater than 50 years [76]) and that some radioactive elements have a half life of 1600 years, it is essential that water and soil monitoring continues indefinitely.

13 Conclusion

The onus of proof that a chemical substance or additive is safe must rest with the proponent to prove. It must not be up to the State or the community to prove that a chemical substance or additive is not safe. We urge that the precautionary principle (as discussed further in Section on Health) is enshrined in the petroleum legislation. We have made a series of recommendations which we suggest will provide better transparency, increase safety and give greater protection for our health and environmental health.

14 Summary of recommendations

Recommendation 1

<u>All chemical substances and additives used in drilling and hydraulic fracturing should be disclosed publicly. There should be no exemptions under intellectual property laws.</u>

Recommendation 2

[75] Ablett, E. (2013). Undetected Chemical Carcinogens released by CSG mining: A new major health risk for NSW, Submission to the NSW Chief Scientist & Engineer. http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review/?a=2987639

[76] Barber, L.B., Thurman, E.M., Schroeder, M.P., 1988. Long-term fate of organic micropollutants in sewage contaminated ground water. Environ. Sci. Technol. 22, 205–211.

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All chemical substances and additives used in drilling and hydraulic fracturing should be identified by CAS number.

Recommendation 3

Water should be listed as a chemical whether it is used as a base fluid or as an additive within a product.

Recommendation 4

The use of all chemicals for drilling and hydraulic fracturing should be prohibited until their use is subject to a full assessment of the risks they pose to human health and our environment.

Recommendation 5

All chemical substances and additives proposed to be used for drilling and hydraulic fracturing should be fully assessed by an ' appropriately qualified' body for its human and eco-toxicity and its persistence in the environment and other toxicology markers.

Recommendation 6

All chemical substances and additives proposed to be used for drilling and hydraulic fracturing should only be permitted when authorised by an ' appropriately qualified' body that has certified that the chemical is safe to human health and the environment *in* the specific environment and quantities which it is intended.

Recommendation 7

The 'appropriately qualified' authorising body must be independent from industry and its decisions must be amenable to judicial review on the merits.

Recommendation 8

The use of toxic and potentially toxic chemicals should be banned in general.

Recommendation 9

Statistics about the quantity of chemicals used and the number of projects should be collected at Regional and National levels.

Recommendation 10

Disclosure should include the maximum ingredient concentration in product and maximum ingredient concentration in total fluid used. Similar to what occurs in WA.

Recommendation 11

All states in Australia should ban use of BTEX additives to fracking fluids (in line with quality health and environmental guidelines interstate and overseas.)

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Recommendation 12

Comprehensive baseline data on groundwater, air and soil must be collected before any gas drilling or hydraulic fracturing occurs anywhere in Australia. This should be continued regularly (as recommended by an 'independent scientific committee') and indefinitely. Monitoring must include testing for BTEX, Polyaromatic Hydrocarbons, metals and radionuclides, NORMS and radon gas and other compounds produced by the gas drilling and hydraulic fracturing process.

Recommendation 13

All monitoring and testing should be done by an independent, accredited laboratory for the entire country.

Recommendation 14

All monitoring and testing should be done on a regular basis (as recommended by an 'independent scientific committee') during life of project and continued indefinitely for the entire country.

Recommendation 15

To enable transparency and adequate disclosure the results of testing/monitoring needs to be publicly available, as they are done, on the regulators website and in the local newspapers.

Recommendation 16

The companies need to have long term liability for any contamination that may occur and for any negative consequences on human or environmental health. This needs to apply to exploration and production wells i.e. such as those drilled at Penola. For example if in 30 years time there is a high incidence of cancer, then the company that caused this contamination should be liable.

Recommendation 17

Known and potential carcinogens, as well as known and potential endocrine disrupting chemicals should not be used. All chemical substances or additives should be fully assessed by an ‘ appropriately qualified’ body for their potential as an endocrine disrupter and carcinogen.

Recommendation 18

Ban use of evaporation ponds.

Recommendation 19

Ban use of injection wells for the disposal of waste water.

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Recommendation 20

Waste water should not be spread on any pasture or discharged into streams or the ocean.

Recommendation 21

Levels of metals in surface aquifers, land and air, must at all times be kept below recognised Australian and international guidelines.

Recommendation 22

A review of regulatory guidelines, to ensure they evaluate *all* radionuclides in waste water and solids rather than any 'single one". The total sum of radiation is needed to protect exposure of workers, community and environment from radiation.

Recommendation 23

Baseline testing and ongoing monitoring of radionuclide analyses must include radon gas in communities surrounding gas fields anywhere in Australia.

Recommendation 24

Total levels of radiation at gas drilling sites, in surface aquifers, land and air, anywhere in Australia, must at all times be kept below recognised Australian and international guidelines.

Recommendation 25

Statistics about the estimated volume of fluids and chemicals that remain underground at each well site, anywhere in Australia, should be collected at regional and project levels. This is important to identify if there are likely to be problems with future contamination and where.

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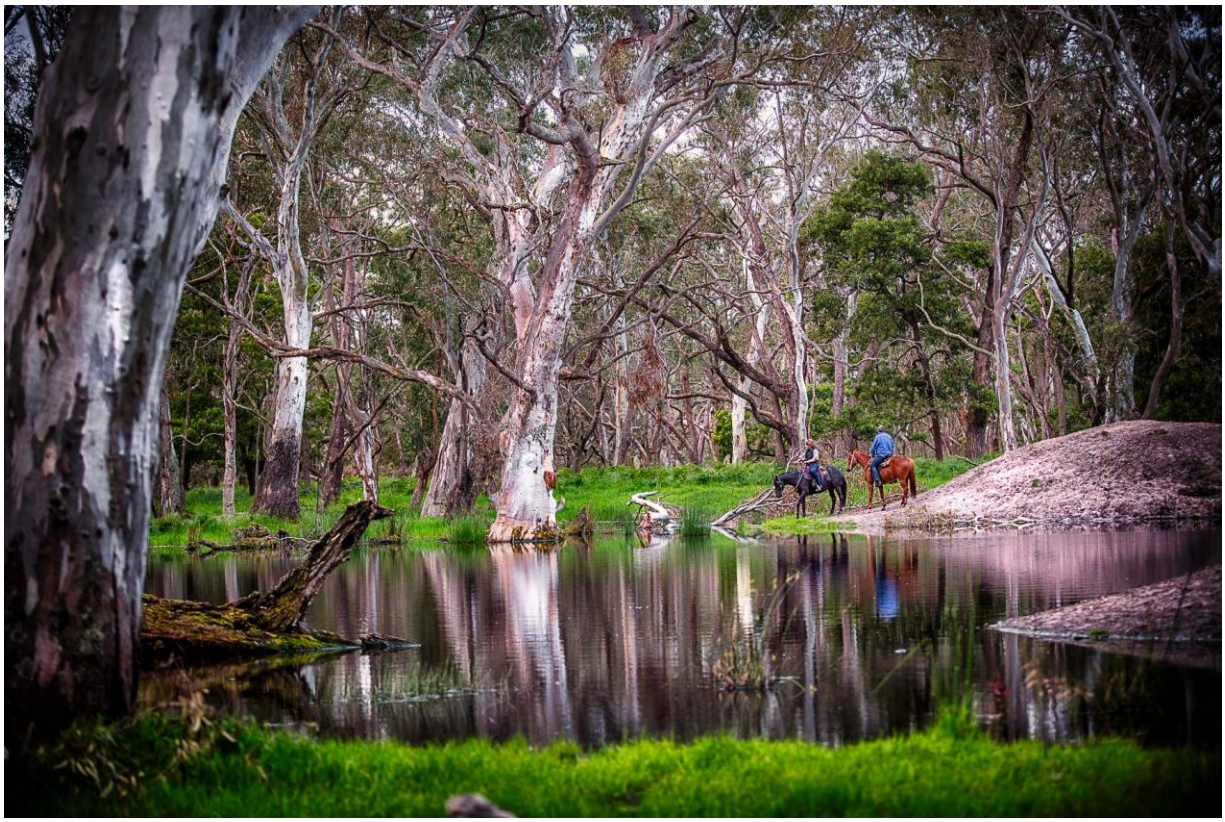
Senate
Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

SECTION 5: IMPACTS ON LANDSCAPE



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Main authors

Leanne Emery, has lived all her life in the South East of South Australia. Her grandparents and parents farmed in the Tatiara, where her brothers continue to farm. As his father and uncles were before him Leanne's husband and now also their eldest daughter are graziers in the Limestone Coast. Leanne has spent many years involved in various community organisations. In 2013 she became the secretary for twelve months of the Limestone Coast Protection Alliance Inc (then named the Limestone Coast Strike Out Alliance Inc). Leanne's concerned about the potential adverse consequences of the encroachment of invasive mining and unconventional gas onto productive agricultural land. She feels the South East of SA is a highly productive food bowl, the agricultural land and ground water are both a vital and important asset and both should be protected from any activity that compromises their productive capacity or quality. Leanne is not personally opposed to all gas drilling, in all areas but believes there is little evidence to suggest fracking is safe for the environment or the health of those living in the vicinity of such activities and feels unconventional gas in the South East of South Australia, a "food bowl" would be irresponsible and inappropriate."

Dr Catherine Pye, MBBS, FRACGP, FACRRM, Dip RACOG. General Medical Practitioner who has lived and worked in Mount Gambier for 24 years in the city and surrounding small towns in both SE of SA and SW Victoria. Professionally a Fellow of the Royal Australian College of General Practitioners, and the Royal Australian College of Rural and Remote Medicine. A member and previous secretary of Rural Doctors Association of SA, member of Doctors for the Environment Australia for 2 years and a member of the Medical Association for Prevention of War for 25 years. A founding member of Community Action for Sustainability Inc, a not- for- profit, non-party aligned NGO promoting sustainability in the Limestone Coast, long term member of the Mount Gambier Bushwalkers and member of Better HARTS Inc. and co-author of $2.5 million 400 page bike plan written by volunteers which has largely been adopted by the City of Mount Gambier. Nominated by City of Mount Gambier for a Community Commendation Award in 2012 from KESAB for “her genuine interest in the health of the community and environment in Mount Gambier and for enabling the community to understand and learn more about sustainability".

Heather Heggie, born and grew up in South East on a farm adjacent to pristine scrubland and waterbird swamps. Has worked with Natural Resource Management for 10 years as a weedbuster and reports sightings of red tailed black cockatoos. Love of South East stronger after 20 years working in noisy smoggy Melbourne. As a member of Rotary is aware that in places like South America people are being taught to build filters for water, which has been polluted by miners, in order to prevent further cancers. Heather has a deep affinity with whole of South East and it’s beautiful pristine qualities which the farmers value highly.

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1 Introduction

This section on landscape is written mainly regarding shale gas and the consequences it may have on the South East of South Australia as that is where the Limestone Coast Protection Alliance is based. However the research has come from broader afield and indicates the issues concerning residents of the South East of South Australia mirror the concerns from other areas of Australia and many parts of the world. The advancement of the fracking practice clearly needs to be treated with great caution as there is little evidence to suggest it is safe to the environment particularly if that environment is quite populated and is a "food bowl".

It is often those directly involved within the agricultural industry and rural communities that first realise gas and coal mining activities cannot co –exist in the same areas as agriculture. It is therefore the landholders who face losing their valuable land to gas and coal mining companies who best know if co-existence of the two industries can be feasible. It is crucial in order to maintain our food producing areas in Australia that we allow landholders the right to refuse the intrusion of gas and coal mining on their properties. The Crown may have rights to the resources under the ground of farming land as the law currently stands but the owner of the farming land should have far greater rights than they currently do to assist them in protecting that land to remain as a productive agricultural business, providing a livelihood and a home.

After decades of hard work, the South East community has achieved steady growth and productivity as a result of careful and thrifty planning. In line with world market demand for clean green food the graziers, dairy farmers, agriculturalists, orchardists, vignerons and seed and grain growers are constantly striving for a lighter environmental footprint. The region is now renowned for high quality clean food and wine production. Organic operators are prospering.

Careful breeding and investment have seen many valuable cattle and sheep studs evolve. Cell grazing which involves smaller paddocks and rotating stock through these paddocks is being used more and more to maximise productivity and improve healthy pasture and soil.

Landholders often own more than one property, and there is a lot of movement of stock and farm workers. Foresters, vineyard workers, cropping contractors, shearing teams, super spreaders, NRM, Council, Telstra, SA Power Network, school buses, tourists, stock agents, visitors and many others contribute to a lot of constant movement about the country all year round.

In relation to unconventional gas networks the level of vehicular access to each well pad over the mine life will be considerable; adding another layer of roads, traffic and well pads will use unacceptable amounts of rural land. This will seriously disrupt rural activity in this region. We understand a gas field would also require farmers in some instances to adhere to an imposed disruptive timetable. The weather itself is a hard enough taskmaster here.

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The very possible potential adverse effects of invasive mining and unconventional gas on the landscape of the South East of SA is a matter of great concern to many of us living and making a living in the region, and for all South Australians, because we need a 'clean and green' food bowl.

We believe it is irresponsible that government is allowing such practices to occur in such productive agricultural areas that assist in feeding the metropolitan population and contribute significantly to the State's and Australia's economy.

Over allocation, de-watering or contamination of the ground water would destroy the region as a food bowl and tourist destination. There is no alternative to water. It is the most precious resource and in the South East of SA there is no alternative to ground water, we do not have a river nearby. Surely the ground water would be better utilised for food production, because in the driest state in the driest continent, the South East of SA is one of the few fertile regions.

15 Clean and Green landscape is Government policy

Recommendation 1

South Australia is in a unique position to strongly promote and assist the existing businesses, tourism and agriculture to truly gain the "clean green" premium food and wine reputation without the impediment of the indecorous reputation of the mining industry being implanted amongst its "food bowl."

The gas mining proposals of the Department of State Development SA (DSD) are incompatible with the goals of other state government departments, independent government entities and regional and local government.

Whilst DSD advocates for an industrialised landscape that caters for the mining industry, all other sectors advocate the advantages of maintaining and building a clean green food bowl.

For example, Government of SA – Department for Manufacturing, Innovation, Trade, Resources & Energy (now DSD) titled "Excellence in Oil & Gas 2014"[77] states that,

South Australia has huge 'blue sky' potential for unconventional gas, the Roadmap is providing a very effective framework, but still early days – 29 wells, more to come!
- *Great opportunities to learn from US and to build local supply chain.*
- *Opportunities exist now for explorers, infrastructure developers, service & supply sectors.*
- *SA 1st in Oceania region in 2013 Fraser Institute Global Petroleum Survey, industry said:*

[77] Government of SA – Department for Manufacturing, Innovation, Trade, Resources & Energy, DMITRE titled "Excellence in Oil & Gas 2014

- "Pro-active government (and opposition), stable and attractive fiscal regime, informed and professional regulator, very superior access to essential data."
- "South Australia is becoming well-known for rapid approvals and cutting through green and red tape.

Rapid approvals and cutting green and red tape while making it easier for gas & mining will mean communities have less time to appeal and full and detailed scrutiny of projects just does not occur.

In contrast other sectors of government say,

- **Regional Development Australia**[78] :

  The Limestone Coast is a dynamic and sustainable "food bowl" region of Australia. Prime grass fed livestock and agricultural food production, wine, fishing and plantation forestry drive a diverse globally competitive economy where community well-being and lifestyle are highly valued.

- **SA Government Priorities** [79]

  The South Australian food and wine industry is worth over $14 billion and accounts for 36% of South Australia's total merchandise exports. The world demand for food will rise by 70% by 2050.
  To realise the opportunities this presents, South Australian food production needs to remain competitive. This will require a focus on markets, innovation and sustainable use of natural resources.
  South Australia has a challenge to grow the recognition of our premium food and wine, including the high standards of our producers, and the regions in which it is produced.

- **PIRSA**

  What's our vision for the future?
  South Australia is renowned as a producer of premium food and wine from its clean water, clean air and clean soil. More high quality food and wine produced across the state is consumed locally and exported around the world.
  South Australia is recognised globally for its premium food, beverages and culinary-tourism. The food industry holds a competitive edge in both domestic and export markets through innovation and a strong reputation for being clean and safe.[80]

[78] Regional Development Australia http://www.rdalimestonecoast.org.au/

[79] SA Government Priorities http://www.priorities.sa.gov.au/content/premium-food-and-wine-our-clean-environment

[80] PIRSA State Government www.pir.sa.gov.au/pirsa/about_pirsa/premium_food_and_wine_from_our_clean_environment

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The gas proposals for the Limestone Coast are inconsistent with other government policies and should not be permitted in this region. It is a premium food –growing region with prime agricultural land. The good climate, rainfall, fertile soils and greater water security strengthen our reputation as a 'food bowl' for South Australia. [81] There is only 4.3% of prime agricultural land in South Australia and over 40% of this is concentrated in the Limestone Coast. The Limestone Coast region which is only 2.2% of the State's land surface, is very valuable to the State contributing $3.44 billion to the state's economy in 2011/2012. Our economy is already more diversified than other regions of the State. [82]

16 Coexistence may not work

A study from *Rural Industries Research & Development Corporation* [83] provides an analysis of the impacts of new industries on agricultural landholders and their communities; documents best practice for co-existence; and provides a checklist for farmers needing to accommodate a new industry on their land.

Lesson from the Case Study Analysis

Summaries of the impact on agricultural landholders and their communities of adding a new land use, based on feedback received through the two case study areas. Impacts are ranked on severity using the following key:

Minor: Irritant or minor nuisance
Moderate: Some sustained effect on day to day life
Major: Permanent change to a core landholder or community value.

The analysis includes production, social, regional and other impacts. Positive as well as negative outcomes are included in this table:

Table 4.1 Impact on Agricultural Landholders of Adding a New land use [84]

Area of Impact	***Coal Seam Gas, Surat Basin Qld***	***Open Cut Coal, Hunter Valley NSW***
Farm amenity impact	*Construction visual irritant – moderate* *Construction noise – moderate*	*Visual impact of overburden - major* *Operating noise affects sleep – major*

[81] South Australian Centre for Economic Studies 2012, 'Regional Development Australia Limestone Coast', Regional Profiles, South Australia

[82] South Australian Centre for Economic Studies 2012, 'Regional Development Australia Limestone Coast', Regional Profiles, South Australia

[83] Clarke M. 2013. Principles for Negotiating Appropriate Co-existence Arrangements for Agricultural Landholders. Rural Industry Research and Development Corporation. RIRDC Publication No. 12/114

[84] Clarke M. 2013. Principles for Negotiating Appropriate Co-existence Arrangements for Agricultural Landholders. Rural Industry Research and Development Corporation. RIRDC Publication No. 12/114

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	Construction dust – major	*Explosives damage infrastructure –moderate*
	Personal enjoyment of your farm – major	*Dust inside family home –major*
		Personal enjoyment of your farm - major
Farm family, employees and OHS	*Personal security compromised – major*	*Increased road traffic - moderate*
	More on farm vehicles – major	*Vehicle accidents near farm – moderate*
	Farm succession – minor	*Dust, air quality and health - moderate*
	Family income boost – major	*Farms purchased, families move off - minor*
Farm management Activities	*Gates and fences - major*	*Farm fences cut and gates left open – major*
	Cattle management difficulties – moderate	*Moving cattle cross busy roads –minor*
	New livestock infrastructure – major	*Health impacts on thoroughbreds – major*
	Irrigation /cultivation layout – major	*Mining dust on grapevines - minor*
	Cultivation activities – moderate	
	Above ground electricity supply –major	
Farm income and costs	*Land loss broadacre – minor*	*Increased labour costs – major*
	Land loss intensive – moderate	*Off farm income earned in mines – major*
	Livestock productivity – unknown	*Farmers' markets supported by mines-minor*
	Market access risk – unknown	*Water filtration expenses – minor*
	Increased labour costs – major	*Rusted infrastructure - minor*
	Farmers time – major	*Cost of equipment and consumables - major*
	Loss future farm enterprise options-moderate	*Higher effective LGA land rates – moderate*
	Farm income boost – major	*Accelerated rust on farm assets- moderate*
Land impacts	*Loss of land during construction – major*	*Loss of land value outside buy zone – major*
	Retirees with fewer buyers during construction – major	*Retirees with fewer buyers in the zone of management- major*
	Recovery of land values after construction -major positive	*No recovery in land values in the zone of management – major*
Water impacts	*Potential for aquifer damage – major*	*Loss of river flow and salinity – major*
	Water generated from CSG – moderate	*Aquifer damage – major*
		Mines purchasing water rights - major
Biosecurity, weeds, pests and diseases	*Breaches in protocols – major*	*Overburden and buffers can act as a harbour for weeds and pests - major*
Other environmental Issues	*Stockpile erosion – moderate*	*Loss of fertile and productive alluvial river flats – major*
	Capacity of landholders to interpret environmental data – major	*Further pressure on water resources - major*
	Follow up DERM monitoring - major	
Permanence of change & ability and timetable to make good	*Co-existence required for 25 years – major*	*Zone of acquisition; land lost to agriculture for 30 years – major*
		Zone of management; co-existence required

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Summary of impacts – for agricultural land

The two case studies above share a number of common features that may have national implications for agricultural landholders accommodating new industries. Common features include:

- *Water – expect competition for water from the new land use, watch for aquifer damage*
- *Farm management – the new land use will create some negative interactions.*
- *Farm income – strong potential for the new land use to result in a net income gain.*
- *Land values - will be negatively affected at least in the short term.*
- *Vehicular traffic – a significant increase both on and off farm.*
- *Personal enjoyment of the farm – expect a visual impact, noise and dust.*
- *Biosecurity – increased risk that must be managed.*
- *Permanence of change – co-existence is a long term need.*

The RIRDC study also provides specific examples of situations where co-existence has been unsuccessful.

Unsuccessful Co-existence Examples

Two examples [85] of places where mining and agricultural enterprises have failed to satisfactorily coexist are coal and agriculture in the Margaret River Region of Western Australia and Oil sands and agriculture in Alberta Canada.

Agriculture and Coal, Margaret River WA

Large and well-funded new industries do not always overrule existing agricultural landholders.
Concerned communities are able to shape and even overturn forced co-existence.
In 2012 coal mining was effectively banned from the Margaret River region of Western Australia (WA) following successful action from a coalition of agricultural landholders, business owners and residents. The coalition acted on concern relating to a proposal from LD Operations to establish an underground coal mine 15km from the town of Margaret River. Agricultural landholders were concerned that the Vasse Coal proposal would impact the Leederville Aquifer that supplies fresh water to farmers, winemakers and residents in the Augusta-Margaret River shire. The coalition of local interests lobbied state members of parliament and worked through the media to argue that the undoubted financial benefits of coal did not negate the risk of an unacceptable environmental cost.
The coalition was so successful in making their case to the WA Parliament that an effective ban on coal mining within 230km^2 of the town of Margaret River was imposed. The ban affected 25 exploration licenses and 9 granted mineral titles. The ban came into effect in July 2012.

[85] Clarke M. 2013. Principles for Negotiating Appropriate Co-existence Arrangements for Agricultural Landholders. Rural Industry Research and Development Corporation. RIRDC Publication No. 12/114

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Agriculture and Oil Sands, Alberta Canada

Athabasca oil sand deposits around Fort McMurray in northern Alberta Canada have the potential to yield more oil than any other single source except Saudi Arabia. Virtually unexploited until this century, the resource may uncouple North America from Middle East oil dependence. Rising oil prices and new technology have resulted in a rush to exploit the potential of oil sands.

The rush to exploit Alberta oil sands has resulted in a range of both environmental and social issues. From an environmental perspective the industry requires the clearing of forest, the use of large amounts of fresh water to steam the oil from the sand and the creation of GHG rich smoke emissions. Refinery cities have emerged in rural areas. Emissions and wastewater in tailing ponds has been linked to a range of aquatic life and human health issues.

Landholders including farmers and Indigenous people from the Dene, Cree and Metis First Nations have received what they perceive to be unfair reparations and the centre of Fort McMurray has undergone a 'boom town' transformation.

The frontier town of Fort McMurray has grown from 10,000 to 80,000 while its infrastructure has stood still. Municipal services are overloaded; highways out of town are overcrowded and dangerous; housing is unaffordable and the crime rate has risen. FIFO and DIDO are issues and the town's demographics are now heavily skewed to young single men. Ordinary Albertans feel they are not sharing in the boom.

Lessons

These examples clearly show some of the impacts of mining on communities. In these examples communities are prepared to forego short term financial gain if it comes at the perceived risk of an unacceptable environmental cost. Elected representatives responded to community concerns. An equitable co-existence outcome cannot always be achieved.

Issues arise when rapid development occurs, when landscapes are transformed; environmental concerns arise; and landholders and communities perceive that they are being left out of the land use settlement.

Recommendation 2

The South East of SA is a very valuable region to the State in terms of its agriculture, livestock, fibre, cropping, dairy, hay, forestry and tourism contributions.
It is the belief of many of us living here that;

- Agriculture and gas mining are not readily compatible in such a confined area.
- Coexistence cannot occur without negatively impacting on existing land uses.
- The loss of the long term, traditional agricultural, and tourism role of parts of this region to the whole State for the short term monetary gain for a few from gas mining is unacceptable.

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17 Impacts on infrastructure and public services

The anticipated costs of fracking on public infrastructure and services can be estimated by considering the experiences of other communities where fracking has already occurred. For example, the *Environment America Research and Policy Centre* released the following report[86]:

- *Fracking strains infrastructure and public services and imposes cleanup costs that can fall on taxpayers.*
- *The truck traffic needed to deliver water to a single fracking well causes as much damage to local roads as nearly 3.5 million car trips. The state of Texas has approved $40 million in funding for road repairs in the Barnett Shale region, while Pennsylvania estimated in 2010 that $265 million would be needed to repair damaged roads in the Marcellus Shale region.*
- *The need for vast amounts of water for fracking is driving demand for new water infrastructure in arid regions of the country. Texas' official State Water Plan calls for the expenditure of $400 million on projects to support the mining sector over the next 50 years, with fracking projected to account for 42 percent of mining water use by 2020.*
- *The oil and gas industry has left thousands of orphaned wells from previous fossil fuel booms. Taxpayers may wind up on the hook for the considerable expense of plugging and reclaiming orphaned wells – Cabot Oil & Gas claims to have spent $730,000 per well to cap three shale gas wells in Pennsylvania.*
- *Fracking brings with it increased demands for public services. A 2011 survey of eight Pennsylvania counties found that emergency calls had increased in seven of them, with the number of calls increasing in one county by 49 percent over three years.*

Recommendation 3

Gas mining projects will put increasing strain on our public infrastructure including increased wear and tear on roads and increased use of public facilities in nearby towns.

18 Water

Water is discussed in depth in **Section 1. Risks to Groundwater**.

Both water quantity and water quality are important issues for our landscape. The land surface of the South East of SA is a huge catchment bowl for its groundwater aquifers, on which all the communities, agriculture, horticulture, viticulture and other industry depends. The Lower Limestone Coast Water Allocation Plan has recently been released, and this has required a reduction in water allocations for some parts of the region and industries. Adding

[86] The Costs of Fracking : Released by : Environment America Research and Policy Centre Release Date: September 20, 2012.

another industry such as fracking, which uses 5-40ML[87] of water for each gas well will only increase pressure on our region's water resources.

Dr Mark Broomfield in his AEA [88] report writes;

The hydraulic fracturing process is water-intensive and therefore the risk of significant effects due to water abstraction could be high where there are multiple installations.
A proportion of the water used is not recovered.
If water usage is excessive, this can result in a decrease in the availability of public water supply; adverse effects on aquatic habitats and ecosystems from water degradation, reduced water quantity and quality; changes to water temperature; and erosion.
Areas already experiencing water scarcity may be affected especially if the longer term climate change impacts of water supply and demand are taken into account.
Reduced water levels may also lead to chemical changes in the water aquifer resulting in bacterial growth causing taste and odour problems with drinking water.
The underlying geology may also become destabilised due to upwelling of lower quality water or other substances.
Water withdrawal licences for hydraulic fracturing have recently been suspended in some areas of the United States.

Eco Logical report [89] on groundwater impacts;

The major issue associated with shale gas development and groundwater aquifers is contamination and/or drawdown of groundwater aquifers that overlay the shale strata, and the impact to ecosystem services provided by these aquifers, including provision of drinking water, fresh water for agriculture, recharge of freshwater into river systems, and maintenance of health and function of GDEs and subterranean groundwater communities. This is an area of great uncertainty, as impacts to groundwater may be initially undetectable, and may not be evident for many decades.

Recommendations re Water

Recommendation 4

Public water should not be supplied to oil and gas companies.

[87] CSIRO

[88] Broomfield, M AEA (2012). Report for European Commission DG Environment. Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe. Cited with his written permission.

[89] Eco Logical Australia 2012 Shale Gas Development in Australia : Potential Impacts and Risks to Ecological Systems as a report prepared for ACOLA (Australian Council of Learned Academies) 11th January2013 www.acola.org.au

Competition for water between farmers/landowners and gas/mining companies will have a detrimental impact on the sustainability of our region.

Recommendation 5

A review of the sustainability of the water resources is required taking into account the impact of gas drilling and fracking prior to any gas drilling and fracking being allowed.

Recommendation 6

Gas drilling and fracking should not be allowed in the South East of SA as this region is a water catchment area.

19 Construction of gas infrastructure and land area

Land required is significant. Unconventional gas projects requires significantly more land than conventional gas projects.

Dr Mark Broomfield in his Ricardo AEA document talks of "Land-take,"[90]

The American experience shows there is a significant risk of impacts due to the amount of land used in shale gas extraction. Surface installations require an area of approximately 3.6 hectares per pad for high volume hydraulic fracturing during the fracturing and completion phases, compared to 1.9 hectares per pad for conventional drilling.

Additional land is also required during re-fracturing operations (each well can typically be re-fractured up to four times during a 40 years well lifetime).

Consequently, approximately 1.4% of the land above a productive shale gas well may need to be used to exploit the reservoir fully. This compares to 4% of land in Europe currently occupied by uses such as housing, industry and transportation.

This is considered to be of potentially major significance for shale gas development over a wide area and/or in the case of densely populated European regions.

Engineering Energy in their report for **ACOLA** [91] write,
The surface infrastructure and the surface footprint of the shale gas operation depend significantly upon whether vertical or horizontal wells are drilled. As an example, the surface infrastructure associated with the development of a 1000 ha shale play would range from:

[90] Broomfield, M AEA (2012). Report for European Commission DG Environment. Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe. Cited with his written permission.

[91] Engineering Energy: Unconventional Gas Production – A Study of Shale Gas in Australia. 2013. ACOLA

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- *Vertical - **64 vertical wells** on individual pads of 0.8 hectare each, **using 50 hectares of land in total**, about 40 kilometres of roads, 40 kilometres of pipelines, plus 4 to 8 facility pads*

to:

- *Horizontal - **16 horizontal wells** from 1 pad of **2.5 hectares**, with 3 kilometres of roads, 3 kilometres of pipeline and one facility on the same pad as the wells.*

The well construction site consists of workers accommodation, offices, lights, well pads, storage facilities for water, chemicals and proppants required for drilling, as well as storage for waste water; gas treatment and compression facilities including filtration, compression, cooling and dehydration process items; and power supply networks (above and below ground).

Broader field infrastructure will include access roads and tracks, storage warehouses, workers accommodation camps, offices and telecommunications. (DMITRE, SA, 2012; Submission to this Review by Beach Energy, 2012b).

For example, in the South East of SA it is reported that **Beach Energy** have indicated that they may use vertical deviated drilling which according to King [92] requires four (4) times as many wells and over twelve (12) times as many roads as horizontal drilling. Land required is significant.

20 Construction of roadways between wells (competition and disruption)

The criss-crossing of the landscape by wells and connecting pipelines and roads is likely to cause major disruption to existing businesses.

Engineering Energy write, [93]

> *Experience with production of unconventional gas in Queensland and NSW has shown that access roads and well networks can compromise the landscape for productive agricultural and pastoralist activities, and for indigenous land use, as well as for its habitat values and scenic and aural qualities. The US experience with shale gas production indicates that without measures being taken prior to the development of the industry in Australia, similar land use tensions are possible.*

[92] King, G. E. (2010d). Thirty Years of Gas Shale Fracturing: What Have We Learned? Florence, Italy: presentation to Society of Petroleum Engineers Annual Technical Conference and Exhibition

[93] Engineering Energy: Unconventional Gas Production – A Study of Shale Gas in Australia. 2013. ACOLA

New access roads and infrastructure are liable to be subject to erosion, adding dust and sediment movement to existing levels in that area.

Recommendation 7

A gas field requires a significant amount of land, but the impact is even greater than that area alone, because the gas field splits up the property with gas wells, connecting pipelines and roads. The disruption caused to existing landowners by the gas infrastructure is unworkable. Gas drilling and fracking should not occur in the South East of SA as this is prime agricultural land with multiple existing agricultural, viticultural and other land users who are likely to be negatively impacted upon.

21 Increased truck traffic

Dr Mark Broomfield; [94] *Total truck movements during the construction and development phases of a well are estimated at between 7,000 and 11,000 for a single ten-well pad.*

These movements are temporary in duration but would adversely affect both local and national roads and may have a significant effect in densely populated areas.

During the most intensive phases of development, it is estimated that there could be around ***250 truck trips per day onto an individual site –*** *noticeable by local residents but sustained at these levels for a few days.*

The effects may include increased traffic on public roadways (affecting traffic flows and causing congestion), road safety issues, damage to roads, bridges and other infrastructure, and increased risk of spillages and accidents involving hazardous materials.
The risk is considered to be moderate for an individual installation, and high for multiple installations.

Similarly, a report by the **University of Manchester's Tyndall Centre** in the U.K. [95] refers to a U.S.A. study that estimates a total of 4,300 to 6,600 truck visits to a 6-well pad, associated with site clearing and construction, drilling, hydraulic fracturing, flowback water removal and completion. Light vehicle visits associated with project management, safety inspections,

[94] Broomfield, M AEA (2012). Report for European Commission DG Environment. Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe.

[95] Broderick et al. 2011 Shale gas: an updated assessment of environmental and climate change impacts. A report by researchers at the Tyndall Centre University of Manchester.

internal and external audits, equipment maintenance, environmental surveys, site monitoring, and cleaning would also be substantial. [96]

Recommendation 8

A gas field will require large numbers of heavy truck traffic. This will increase the risk of road traffic accidents and reduce the attractiveness of the region for both residents and as a tourist destination.

22 Visual amenity loss

The South East of SA is a populated, green, rural landscape. Over 80% of the land is agricultural with nearly 60% of this used for livestock. The scale of change caused by the industrialisation of a rural landscape is markedly more noticeable than industrialisation of an already degraded landscape. The effects on the landscape of the agricultural area and tourist destinations could be devastating for those existing industries, and as such a loss to the state of South Australia.

Recommendation 9

Gas infrastructure, flare chimneys, holding ponds, connecting roads and pipelines will have a negative impact on the visual amenity of the region for both residents and tourists.

23 Twenty four (24) hour operation light and noise

The quality of the air and excessive light and noise from unconventional gas exploration and production will impact on tourism and the liveability of the region for humans, livestock and wildlife. These impacts will be made worse by flaring (burning of gas) and heavy vehicle traffic. Excessive noise and lights are common place within the mining industry's 24/7 work program. We have already seen this with the gas well at Penola only 2km from the centre of town.

24 Air pollution

Air impacts are discussed in depth in Section 6 on Health.

The air pollution problem for Australia with the potential growth in the oil and gas industry will be significant, as evidenced by what has occurred in the USA and in the Eastern states. For example, the *American Lung Association* report "State of the Air 2013" found that more than 131 million people (42 percent of the U.S. population) live in counties that have unhealthy levels of either ozone or particle pollution. This alone is staggering. Researchers

[96] Eco Logical Australia 2012 Shale Gas Development in Australia : Potential Impacts and Risks to Ecological Systems as a report prepared for ACOLA (Australian Council of Learned Academies) www.acola.org.au

[97] with the *Environmental Defence Fund* determined that air quality in rural areas with fracking was worse than air quality in urban areas. [98]

The Australian air monitoring guidelines are already overdue for review and there are numerous examples of where they are failing to protect health and environment. [99] The Environmental Protection Authority, is responsible for monitoring air quality within SA. Gasfields will escalate the need for comprehensive, baseline, and ongoing air monitoring.

There are no air monitoring facilities in the SE of SA.

Flaring

Is the burning of methane rather than direct release (venting) to the atmosphere. Flaring creates combustion pollutants such as carbon monoxide, nitrogen oxides, particulates and carbon dioxide plus heavy metals, radioactive elements and volatile organic compounds may be released. Under a petroleum exploration license in South Australia, gas flaring is permitted for a 10 day period.

In the USA, from January 2015, both venting and flaring will be generally banned. All the gas will need to be captured in separate flow lines. These new rules have come into place due to the massive air pollution problem created by flaring and venting. For example an investigation by the *San Antonio Express-News* found that natural gas flaring in the Eagle Ford Shale in Texas in 2012 contributed more than 15,000 tons of volatile organic compounds and other contaminants of air pollution.

Recommendation 10

We are opposed to flaring and venting.

25 Odour

Odour is not only a nuisance, but at certain levels and durations, offensive odours can induce health impacts such as headaches, nausea, sleeplessness, and throat irritation. [100]

[97] http://www.lung.org/about-us/our-impact/top-stories/state-of-the-air-much-progress-cut-challenges.html

[98] Grossman, D. (2013, April 29). Clean air report card: CO, WY Counties get F's due to oil and gas pollution. *Environmental Defense Fund*. Retrieved 2015 from http://blogs.edf.org/energyexchange/2013/04/29/clean-air-report-card-co-wy-counties-get-fs-due-to-oil-and-gas-pollution/#sthash.FXRV6Nxi.dpuf

[99] Doctors for Environment Australia website. www.dea.org.au

[100] Furberg M. 2005. FINAL REPORT; HEALTH AND AIR QUALITY 2005 –PHASE 2: VALUATION OF HEALTHIMPACTS FROM AIR QUALITY IN THE LOWER FRASER VALLEY AIRSHED RWDI AIR Inc.

26 Impact on native vegetation fauna and flora

26.1 Introduction

In the South East we have lost over 87% of the native vegetation and further fragmentation and degradation of what we have left will have a negative impact on the fauna and flora. It is critically important to develop native vegetation, biodiversity corridors to link remnant habitat and fauna population groups in order to maintain genetic viability.

The South East is home to internationally recognised wetland systems that include the 3200 hectares RAMSAR listed Bool and Hacks lagoons and the Coorong.

There are several unique and protected flora and fauna species which may be threatened by industrialisation, fragmentation and degradation of the landscape, and by deterioration in quality and quantity of water through gas mining proposals, waste water spills and leaks.

Native fauna are also at risk from truck traffic, noise and light. Night flying animals such as bats and owls may be deterred by bright lights/24 hour a day from gas drilling sites. The common bentwing bat is already dramatically in decline and is dependent on a healthy environment for food and water. 24 hour lights near bat roosting sites attract owls which then prey on the bats that come out to feed at night.

We have a vast array of birdlife in the South East dependent on clean food and water and an intact habitat. The red tailed black cockatoo requires specific trees for food and nesting and revegetation programs are currently underway.

Several species of fish, frog and reptiles are unique here as well, and frogs especially are very susceptible to changes in water quality and quantity.

Bees while not native are vital to the survival of some of the agricultural industries. The South East is a world renowned seed growing region. Bees pollinate one third of the food we eat and contribute $1.2billion to the Australian economy. A hive of bees requires 4 L of water per day, so drinking from holding ponds or other polluted water sources increases the risk of chemical death.

We are concerned that the shale gas industry in the United States and the coal seam gas industry in Australia have already seen a significant impact on biodiversity, native vegetation, flora and fauna species, soils and local water supplies for ecosystems.[101]

[101] Engineering Energy: Unconventional Gas Production – A Study of Shale Gas in Australia. 2013. ACOLA The Australian Council of Learned Academies (ACOLA)

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26.2 Biodiversity losses

Dr Mark Broomfield in the AEA document [102] outlines some chief concerns about biodiversity impacts; *Unconventional gas extraction can affect biodiversity in a number of ways.*

- *It may result in the degradation or complete removal of a natural habitat through excessive water abstraction, or the splitting up of a habitat as a result of road construction or fencing being erected, or for the construction of the well-pad itself.*
- *New, invasive species such as plants, animals or micro-organisms may be introduced during the development and operation of the well, affecting both land and water ecosystems.*
- *Well drilling could potentially affect biodiversity through noise, vehicle movements and site operations.*
- *The treatment and disposal of well drilling fluids also need to be adequately handled to avoid damaging natural habitats.*
- *During hydraulic fracturing, the impacts on ecosystems and wildlife will depend on the location of the well-pad and its proximity to endangered or threatened species.*
- *Sediment runoff into streams, reductions in stream flow, contamination through accidental spills and inadequate treatment of recovered waste-waters are all seen as realistic threats.*
- *and water depletion.*
- *Effects on natural ecosystems during the gas production phase may arise due to human activity, traffic, land-take, habitat degradation and fragmentation, and the introduction of invasive species.*
- *Pipeline construction could affect sensitive ecosystems and re-fracturing would also cause continuing impacts on biodiversity.*
- *The possibility of land not being suitable for return to its former use after well abandonment is another factor potentially affecting local ecosystems.*

Biodiversity risks during the production phase were considered to be potentially high for multiple installations.

Eco Logical Australia [103] states; *There is a large volume of literature that contends that removal of native vegetation as a result of land use activities associated with agriculture, mining, urban development or recreation results in negative and often irreversible*

[102] Broomfield, M AEA (2012). Report for European Commission DG Environment. Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe. Cited with his written permission.

[103] Eco Logical Australia 2012 Shale Gas Development in Australia : Potential Impacts and Risks to Ecological Systems as a report prepared for ACOLA (Australian Council of Learned Academies) 11th January2013 www.acola.org.au

environmental impacts. On a large scale, the permanent loss of vegetation has been shown to result in land degradation (e.g. Standish et al. 2006), decline in biodiversity (Johnson et al. 2007; Saunders et al. 1991) and release of significant volumes of greenhouse CO_2 (International Panel on Climate Change - IPCC 2001). Local removal of native vegetation may result in the potential loss of flora or fauna species.

Recommendation 11

Already 87% of the native vegetation has been lost in the South East and the remaining area should not be further fragmented and degraded by becoming a gas field.

Recommendation 12

The South Australian State Strategic plan calls for no loss of native species, therefore no native species of flora or fauna should be put at risk with gas drilling and fracking.

26.3 Princeton Study 2014

Eight conservation biologists from various organizations and institutions, including Princeton University, USA, [104] *found that shale-gas extraction in the United States has vastly outpaced scientists' understanding of the industry's environmental impact. Each gas well can act as a source of air, water, noise and light pollution (above) that — individually and collectively — can interfere with wild animal health, habitats and reproduction. Of particular concern is the fluid and wastewater associated with hydraulic fracturing, or "fracking," a technique that releases natural gas from shale by breaking the rock up with a high-pressure blend of water, sand and chemicals.*

26.4 Clearance of native vegetation laws

In South Australia, gas mining companies are exempt from native vegetation legislation, which means they are allowed to clear large areas of native bush for building well pads, holding ponds, gas infrastructure, roads and pipelines. Other land users have strict controls around native vegetation clearing.

Recommendation 13

Native vegetation laws should apply to gas drilling and fracking operations.

26.5 Fauna mortality

In addition to habitat loss and fragmentation direct mortality of native fauna may also arise from drowning in waste water ponds, poisoning from chemical spills and from road traffic accidents.

[104] Souther S, Tingley M, , Popescu V, Hayman D, Ryan M et al. 2014. Biotic impacts of energy development from shale: research priorities and knowledge gaps. Frontiers in Ecology and the Environment 12: 330–338.

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- **Drowning of native animals in waste water ponds**

Ponds that hold either waste water or freshwater may attract wildlife (e.g. Hein 2012; Ramirez 2009). Especially when there is little water around such as a drought year or in summer. Measures to reduce fauna deaths are important such as fencing around ponds, exclusion netting above the surface of dams, and absence of lighting around ponds that might attract insectivorous fauna species. [105]

The steep sides of holding ponds and evaporation ponds are a death trap for reptiles as well as animals which mistake them for dams as happened in WA in the Kimberley at Buru Energy's operation. [106] In Australia, animal deaths have also occurred due to containment ponds in the Pillaga Forest, NSW.

- **Poisoning**

Waste water ponds are particularly harmful because of the chemicals, heavy metals and salts that they contain which may be passed up the food chain from rabbits, sheep, cattle, kangaroo or deer to humans or birds of prey such as wedge-tailed eagles.

Insects and fish are the food for the beautiful regional wetland and water birds, including the brolga which has a small but vulnerable population in South East of SA. Poisoning of the water may have an impact on these populations of birds and their food source.

- **Road kill**

Eco Logical report [107] state; *There is substantial literature available based on wildlife mortality associated with vehicular traffic ('road kill') in Australia and overseas. The major findings of the literature are that;*

Road kill

- *affects a wide diversity of fauna species*
- *can reduce the persistence of local fauna populations and result in local extinctions, including populations of threatened fauna species*
- *is more acute in areas of high animal density and on roads that are close to wetlands and ponds*

[105] Eco Logical Australia 2012 Shale Gas Development in Australia : Potential Impacts and Risks to Ecological Systems as a report prepared for ACOLA (Australian Council of Learned Academies) 11th January2013 www.acola.org.au

[106] http://www.watoday.com.au/wa-news/wa-gas-explorer-creates-death-trap-for-native-animals-20141214-126u3r.html

[107] Eco Logical Australia 2012 Shale Gas Development in Australia : Potential Impacts and Risks to Ecological Systems as a report prepared for ACOLA (Australian Council of Learned Academies) 11th January2013 www.acola.org.au

- *increases in number when vehicles travel faster and if there is more traffic and is influenced by traffic pulses*
- *most commonly occurs at night or in early morning and late afternoon*
- *can cause substantial damage to vehicles and may result in injury or death of occupants*

It is worth noting that road kill attracts birds of prey such as wedge-tailed eagles who are then at risk of becoming road kill themselves.

- **Fish deaths**

Several incidents have been recorded in the United States that have led to fish kills and wetland contamination, mainly associated with spills, equipment failure and waste management.

> *Surface ecosystems are at risk from well failure in the form of blowout, which is a sudden and unplanned escape of fluids to the surface. Blowouts are uncommon but may be prolonged leading to longer term damage to ecosystems*.[108]
>
> *Contamination of freshwater aquifers can occur due to accidental leakage of brines or chemically-modified fluids during shale gas drilling or production; through well failure; via leakage along faults; or by diffusion through over-pressured seals. Contamination of terrestrial and riverine ecosystems may occur from spills associated with chemicals used during the early stages of production; from impoundment ponds and holding tanks; and because of the volume of traffic needed to service operations. The petroleum industry has experience in managing these issues and remediating them, but in a relatively new shale gas industry, unanticipated problems may arise and it is important to have best practice in place, to minimise the possibility of this risk.* [109]

Dredging at Gladstone harbour (to build gas infrastructure) has also recorded fish deaths.

Recommendation 14

Gas drilling and fracking should not occur within the South East as this has important and Internationally recognised RAMSAR listed wetland areas such as Bool Lagoon, Hacks Lagoon and the Coorong. Birdwatching is a recognised tourist attraction.

[108] Eco Logical Australia 2012 Shale Gas Development in Australia : Potential Impacts and Risks to Ecological Systems as a report prepared for ACOLA (Australian Council of Learned Academies) 11th January2013 www.acola.org.au

[109] Engineering Energy: Unconventional Gas Production – A Study of Shale Gas in Australia. 2013. ACOLA

27 Threats to agriculture and soil quality

27.1 Crops and other vegetation

will take up contaminants into their tissues from air, soil, irrigation water and rain. Sulfur levels in vegetation following gas flare events have been found directly correlated with atmospheric sulfur concentrations. [110] Polyaromatic hydrocarbons (PAH) can be absorbed directly into crop foliage and such compounds in soil can evaporate into the air before being absorbed by, or deposited on, crop foliage.[111] Nitrous oxides and sulfur dioxide is an issue for crops and plantations due to acid rain reducing crop and forest production. Radionuclides such as of lead can deposit on food crops.

27.2 Vegetation impacts from air pollution

The **U.S. Forest Service** researchers [112] reported *dramatic negative effects on vegetation caused by the drilling and fracking of a natural gas well in an experimental forest in north eastern West Virginia.* The researchers also found *dramatic impacts on vegetation where drilling and fracking wastewater had been sprayed on the land as a disposal technique following completion of the well. Just after the spraying of approximately 60,000 gallons of wastewater at the first disposal site, the Forest Service researchers found 115 damaged trees and other evidence of harm. The researchers concluded that the spraying of the drilling fluids resulted in an "extreme" dose of chlorides to the forest.*

27.3 Introduction of weed species

ABC News from May 24, 2013 – A property affected by African lovegrass infestation due to failure by gas company employees (**Queensland Gas Company**) [113]
*Cattle farmer Allan Leech is seeking the damages after his 618ha property at Dalby, which holds four QGC gas wells, was inundated with **African lovegrass weed** more than two years ago. After inviting a leading academic expert on lovegrass to inspect his property, Mr Leech claims the inundation can be pinpointed to a slasher driven by*

[110] Enns K. 2004. Impact of Sour Gas Production Flare Tests on Vegetation Final Report Prepared for: Oil and Gas Commission, Fort St. John, B.C.

[111] Collins, C.D., and Finnegan, E. 2010. Modeling the plant uptake of organic chemicals, including the soil-air-plant pathway. Environ.Sci. Technol. 44(3): 998–1003. doi:10.1021/es901941z. PMID:20055408.

[112] Adams, M., Edwards, P. J., Ford, W. M., Johnson, J. B., Schuler, T. M., Thomas-Van Gundy, M., & Wood, F. (2011, January). *Effects of development of a natural gas well and associated pipeline on the natural and scientific resources of the Fernow experimental forest* (Rep.).

[113] http://www.abc.net.au/news/2014-08-23/farmer-claims-csg-companies-spread-weeds-on-southern-qld-propert/5661016

a QGC contractor in 2010, which the landholder confronted at the time and discovered did not possess a wash down certificate.

Allan Leech had to destock his property at Dalby, after a sudden infestation of the noxious African lovegrass weed. Mr Leech, who has been working in the real estate industry for many years, claimed the weed infestation had more than halved his farm's value. "I've got to keep improving the property with fencing and things like that just to try and recover the value that I have lost," he said. "This company has ruined my property and ruined my family's lifestyle."

Weed introduction and/or spread will impact negatively on the region's agriculture industry and ability to grow high quality produce.

27.4 Spills

North Dakota

September 6, 2014 – *Al Jazeera America* examined the challenges that North Dakota farmers are facing in light of wastewater spills from oil and gas development. *Notably, in heavily drilled Bottineau County, some levels of chloride, from sites where an estimated 16,800 to 25,200 gallons of wastewater had seeped into the ground, were so high that they exceeded the levels measurable with the North Dakota Department of Health's test strips. State records, testimonies from oil workers and various residents, and the decades-long failure of contaminated fields to produce crops indicate that wastewater spills are a significant hazard in the current fracking boom.* [114]

Colorado

May 4, 2014 – In an analysis of state data from Colorado, the *Denver Post* reported *that fracking related to oil and gas drilling is putting soil quality and farmlands at risk due to significant amounts of toxic fluids penetrating the soil. According to the Denver Post 578 spills were reported in 2013, which means that, on average in the state, a gallon of toxic liquid penetrates soil every eight minutes. Eugene Kelly, professor of Soil and Crop Sciences at Colorado State University, said that the overall impact of the oil and gas boom "**is like a death sentence for soil**".* [115]

Queensland QGC Kenya Project.

[114] Gottesdiener, L. (2014, September 6). In shadow of oil boom, North Dakota farmers fight contamination. *Al Jazeera America*. Retrieved from http://america.aljazeera.com/articles/2014/9/6/north-dakota-wastewaterlegacy.html

[115] Finley, B. (2014, May 4). Colorado faces oil boom "death sentence" for soil, eyes microbe fix. *The Denver Post*. Retrieved June 11, 2014, from http://www.denverpost.com/environment/ci_25692049/colorado-faces-oil-boom-death-sentence-soil-eyes

In March 29, 2013 [116] *Approximately 50,000L of production water was released to land during the testing of a pipeline pump at Kenya Block in the Gas Fields. Works on an open pipeline were being conducted in a temporary bell hole which resulted in the bell hole filling with water. The results of water and soil samples taken at the time of the incident showed that the water and soil were slightly saline. The saturated soils in the bell hole were removed and disposed of.*

New Zealand

September 20, 2012 - Taranaki gas field contaminates soil – *Hundreds, potentially thousands of cubic metres of soil have been contaminated by toxic chemicals at a gas field in Taranaki. Six well sites at the Kapuni gas field south of New Plymouth used unlined pits in the earth to store and burn off chemicals from operations, including hydraulic fracturing. Six well sites are contaminated. Soil from one had to be transported recently to a waste treatment plant in Wellington to be stabilised.*[117]

Recommendation 15

The South East of SA has fertile soil and prime agricultural land which should not be put at risk by leaks and spills from gas mining operations. Contamination of soil will threaten the region's economy and therefore impact negatively on all South Australians.

27.5 Floods

September 2013 – *An extraordinary flood that struck the Front Range of Colorado killed ten people, forced the evacuation of 18,000 more, destroyed more than 1850 homes, and damaged roads, bridges, and farmland throughout the state. More than 2650 oil and gas wells and associated facilities were also affected, with 1614 wells lying directly within the flood impact zone. Many of these storm-damaged facilities and storage tanks leaked uncontrollably. In a later accounting, Matt Lepore, director of the Colorado Oil and Gas Conservation Commission, estimated the flooding had resulted in the release to the environment of 48,250 gallons of oil or condensate and 43,479 gallons of fracking wastewater from 50 different spill sites across the state. In Colorado, more than 20,850 oil and gas wells lie within 500 feet of a river, stream, or other drainage.* [118]

[116] http://www.qgc.com.au/media/317603/annual_return_-_epbc_2008-4393_lng_gasfields.pdf

[117] http://www.3news.co.nz/Taranaki-gas-field-contaminates-soil/tabid/1160/articleID/269871/Default.aspx

[118] Lepore, M. (2014, March). "Lessons Learned" in the front range flood of September 2013: a staff report to the commissioners of the Colorado Oil and Gas Conservation Commission. Retrieved July 7, 2012, from the Colorado Oil and Gas Conservation Commission website: http://cogcc.state.co.us/Announcements/Hot_Topics/Flood2013/FinalStaffReportLessonsLearned20140314.pdf

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Cooper Basin gas wells in flood.

These photos were taken of a Cooper Basin gas well and its holding ponds in 2010 in flood.

Cooper Basin gas well in flood.

Cooper Basin gas well one week later after the flood receded.

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Recommendation 16

The South East of SA has areas of permanent wetlands and extensive areas of seasonal wetlands from flooding. Gas drilling and fracking should not occur in the South East, because of the risks of contamination of the groundwater and fertile soils from waste water flooding.

27.6 Waste water disposal on land

Sydney Morning Herald reported on 23 November 2013 [119]

The NSW government has steamrolled the Environment Protection Agency (EPA) into pushing ahead with a coal seam gas project despite advice that it is high risk. In a submission which has been confidential until now, the EPA has warned the Department of Trade and Investment against approving the disposal of waste water at AGL's Gloucester project as it would lead to dangerously high salt levels and the potential destruction of farmland. In spite of this, the trials at Gloucester have already begun, with AGL's chosen method for disposal of waste water being to "irrigate" it over the floodplains of the Avon River. Should the project continue as planned, some 2500 tonnes of salt a year will be sprayed over the surrounding farmland, an outcome which an independent geo-technical engineer said "To me it is an untenable situation ripe for corruption." Professor Philip Pells said it could be disastrous for the environment. Pells is not anti-CSG. He approves of the AGL operations at Camden but says the geology at Gloucester is far more sensitive as the basin structure beneath the project means the underground aquifers are "intimately connected" with the surface water. Further, AGL has no proper procedures for disposal of its high-saline waste water.

Recommendation 17

Gas drilling and fracking should not occur in the South East, because there are serious concerns about managing the large volumes of waste water. Waste water has the potential to contaminate both groundwater, soil and air.

28 Geological impacts

Frogtech (2013) [120] state that,

There are a number of geological risk factors which may affect future shale gas development in Australia. While there is some inter-relationship between issues, the major issues are induced seismicity, water management (source of fracking water,

[119] Sydney Morning Herald. http://www.smh.com.au/business/environment-protection-agency-sidelined-after-warning-of-high-risks-at-agl-coal-seam-gas-project-20131124-2y41e.html

[120] Frogtech. 2013. Potential Geological Risks Associated with Shale Gas Production in Australia for Australian Council of Learned Academies (ACOLA) Project Code: AAS801 http://www.acola.org.au/

protection of potable aquifers, and disposal and reuse of recovered water) and well integrity.

Mines and Energy SA have published a book written by Tom Dyster called ***The Strong Shock of Earthquake : The Story of the four greatest earthquakes in the history of SA*.**[121] The 1897 Kingston and Beachport earthquake is one of those written about. According to the Government SA Department of State Development it was the largest to have occurred in South Australia since 1837.

> *It caused massive damage in the South East at Kingston, Robe and Beachport and caused minor damage even in Adelaide. It was felt as far away as Port Augusta and Melbourne.*

28.1 Seismic activity caused by fracking

Although there is ample evidence in Australia of induced seismic activity associated with large dams, mining operations and geothermal operations, there is currently no seismic risk data for gas-related activity in Australia, such as hydraulic fracturing operations.[122]

Example 1: UK

In 2011 the United Kingdom (UK) Parliament commissioned a study into earthquakes following observed events in northwest shale exploration in England where fluid was injected directly into a known fault and held under pressure. The report concluded that the events were related to fracture stimulation (The Royal Society & The Royal Academy of Engineering, 2013).[123]

Example 2: Ohio

As media outlet RT reported in March and April 2014, [124]

> *A series of earthquakes over the weekend continued to break alarming records of seismic activity in Oklahoma, which some scientists say is linked to increased fracking operations in the state. State officials from Ohio, Oklahoma, Kansas and Texas have initiated coordinated efforts to discuss strengthening regulations and standards regarding fracking operations, including possibly requiring oil companies to record the pressure in waste disposal wells every day instead of every month.*

[121] Dyster, T; The Strong Shock of Earthquake; The story of the four greatest earthquakes in the history of SA

[122] Engineering Energy: Unconventional Gas Production – A Study of Shale Gas in Australia. 2013. ACOLA

[123] Chief Scientist and Engineer. 2014. Independent Review of Coal Seam Gas Activities in NSW Information paper: Fracture stimulation activities.

[124] http://rt.com/usa/oklahoma-earthquake-record-fracking-961/

Example 3: Canada

> September 6, 2012 – The *British Columbia Oil and Gas Commission* determined that fracking itself causes earthquakes, *pointing to the results of a probe into 38 seismic events near fracking operations in the Horn River Basin.* The report noted *that no quakes had been recorded in the area prior to April, 2009, before fracking activities began.* The report recommended that the link between fracking and seismic activity be further examined.[125]

Example 4: South Australia

In the Naracoorte *Herald* dated May 15th 2014, the suggestion was made that mining practices such as hydraulic fracturing (fracking) could cause seismic activity. In 1897 an earthquake north of Beachport was recorded at magnitude 6.7. The concern being earthquakes could cause chemicals used in the drilling or even the gas itself to be diverted beneath the earth into aquifers along cracks formed by the movement of the earth. In the article the Department for Manufacturing, Innovation, Trade, Resources and Energy (now called The Department of State Development SA (DSD)) resource division's engineering operations director Michael Malavazos admitted earthquakes could be caused by mining and they did pose a risk. "*Induced seismic activity is a known phenomenon*" he said. He also suggested *"It is a risk but it can be a manageable risk."*

How could this risk be 'managed'?

Earthquakes cost the State enormously emotionally and economically, in human life and damage to the built and natural environment. South Australians do not need to increase the State's risk of earthquake.

28.2 Seismicity caused by reinjection of waste water

As heard in the NSW inquiry into coal seam gas, [126]

> *It is also suggested that hydraulic fracturing may lead to an increase in seismic activity although, as stated earlier, the reinjection of produced water into aquifers may be more likely to induce seismic events than fracking.*

U.S.A. earthquakes from reinjection underground

> July 1, 2014 – *Seismologists linked the emergence of a giant sinkhole that formed in August 2012 near Bayou Corne in southeast Louisiana to tremors (earthquakes)*

[125] The Canadian Press. (2012, September 06). Fracking causes minor earthquakes, B.C. regulator says. *CBC News*. Retrieved June 9, 2014, from http://www.cbc.ca/news/canada/british-columbia/fracking-causes-minor-earthquakes-b-c-regulator-says-1.1209063

[126] COAG Standing Council on Energy and Resources (2013) op. cit., p. 54; NSW Chief Scientist & Engineer (2013) op. cit., p. 86.

caused by high-pressure pulses of either natural gas or water charged with natural gas. The surges of natural gas that caused the explosive tremors (earthquakes) may have weakened the salt cavern and caused its collapse. Alternatively, part of the salt cavern may have collapsed, causing a nearby gas pocket to give off surges of gas, later followed by the complete collapse of the salt cavern. These findings help illuminate the role of pressurized fluids in triggering seismic events.[127]

May 2, 2014 – At the annual meeting of the **Seismological Society of America**, leading geologists warned that, *the risks and impacts of earthquakes from fracking and injection wells are even more significant than previously thought, pointing out that such earthquakes could occur tens of miles away from wells themselves, including quakes greater than 5.0 magnitude on the Richter scale.* Justin Rubinstein, a research geophysicist at the U.S. Geological Survey said, "*This demonstrates there is a significant hazard. We need to address ongoing seismicity."* Seismologist Gail Atkinson reported, *"We don't know how to evaluate the likelihood that a [fracking or wastewater] operation will be a seismic source in advance*."[128]

Earthquakes with magnitude (M) ≥ 3 in the U.S. midcontinent, 1967–2012. [129] *After decades of a steady earthquake rate (average of 21 events/year), activity increased starting in 2001 and peaked at 188 earthquakes in 2011. Human-induced earthquakes are suspected to be partially responsible for the increase and have become an important topic of political and scientific discussion, owing to the concern that these events may be responsible for widespread damage and an overall increase in seismicity. It has long been known that impoundment of reservoirs, surface and underground mining, withdrawal of fluids and gas from the subsurface, and injection of fluids into underground formations are capable of inducing earthquakes.*

28.3 Subsidence

Subsidence could also be a concern for the landscape and environment in the Limestone Coast, because it is irreversible once it has occurred. Subsidence is the sinking downward of the earth's surface**.** The extraction of groundwater, oil and gas can increase the risk of subsidence.

[127] Nayak, A. and Dreger, D. 2014. Moment tensor inversion of seismic events associated with the sinkhole at Napoleonville Salt Dome, Louisiana. Bulletin of Seismological Society of America. Retrieved from http://www.seismosoc.org/society/press_releases/BSSA_104-4_Nayak_and_Dreger_Press_Release.pdf

[128] Kiger, P. J. (2014, May 2). Scientists warn of quake risk from fracking operations. *National Geographic*. Retrieved June 9, 2014, from http://news.nationalgeographic.com/news/energy/2014/05/140502-scientists-warn-of-quake-risk-from-fracking-operations/

[129] Ellsworth W. 2013. Injection-Induced Earthquakes. Science 2013: Vol. 341 no. 6142

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An example of subsidence caused by gas extraction and its adverse impacts on the environment is provided in the *2008 Gippsland Coastal Board Report*. It notes that:[130]

> *Gippsland land subsidence has occurred over 40 years because of the extraction of underground water, oil or natural gas resulting in a relatively rapid collapse (compaction) of underlying strata and hence a lowering of the land surface. The principal causes of the lowering of pressures in the Latrobe Aquifer, and hence any resulting subsidence are;*
>
> - *extraction of oil and gas*
> - *dewatering of the Latrobe Valley open pit brown coal mines, and*
> - *extraction of groundwater for irrigation.*
>
> *This has lowered groundwater levels in the Latrobe Aquifer at a rate of approximately 1 m per year resulting in a relatively rapid collapse (compaction) of underlying strata and hence a lowering of the land surface - such as is the case surrounding the Latrobe Valley open pit coal mines where groundwater from the Latrobe Aquifer is extracted for dewatering purposes.*

28.4 Sinkholes

Sink holes are noted as part of the possible dangers of living in the South East of SA. Sinkholes appear to be increasing with human activity. It seems an unacceptable risk to encourage far greater heavy vehicle traffic as would be required for the unconventional gas industry into a region such as the South East when heavy machinery travelling over sink hole areas can cause such damage.

Sunday Night Australian TV program reported, [131]

> *'Sinkholes are sudden, catastrophic, and almost entirely unpredictable and Mount Gambier sits on a rabbit warren of potential sinkholes'.*
> *Across the globe they have caused houses, apartment blocks, roads and even a sleeping man, to disappear into the ground without warning – and every year there are more destructive sinkholes than ever before. Florida also has one of the highest sinkhole rates in the world – the epicentre is a place they call "Sinkhole Alley" where more than 19,000 sinkhole cases have been documented. It was here in 2013 that cameras captured an entire apartment building collapsing as a sinkhole opened up beneath it.*
>
> *<u>What about Australia?</u>*

[130] Climate Change, Sea Level Rise and Coastal Subsidence along the Gippsland Coast: Implications for geomorphological features, natural values and physical assets Phase 2 - Gippsland Climate Change Study. Gippsland Coastal Board. Final Report 2008.

[131] Sunday Night TV; http://au.news.yahoo.com/sunday-night/features/a/25707505/sinkholes-in-australia-where-and-when-can-they-strike/

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Mount Gambier is one of a very small handful of places in the world with the soft limestone bedrock that creates deep, circular, spectacular sinkholes like the ones found in Mexico and Florida. Beneath Mount Gambier there is a myriad of caves. According to Aussie geologist and sinkhole buff, Ian Lewis, the only things keeping them from collapsing are the dry conditions and relatively stable water table. "Mount Gambier only has a population of 20,000, but if you built a city there with a few million people, it would be the next Florida," Lewis said.
Australia's largest sinkhole has a lake at its floor and it is a popular tourist attraction, but the diving expedition to the bottom of two at Ewen's Ponds and Piccaninnie Ponds, which no one has ever been to the bottom of, revealed the caves that could be the next sinkholes waiting to happen.

The anatomy of a sinkhole

Geophysicist, Tim Bechtel explained to **Sunday Night** [132] that if your home happens to be built over limestone, beneath it the ground will be "like Swiss cheese" and riddled with caves.

Groundwater dissolves the limestone until, in the right conditions, all it takes is heavy rain or a faulty sewer to trigger a dramatic and dangerous sinkhole. A sinkhole is basically a hole underneath the ground that is slowly eating its way up. The roof gets higher and higher until the weight of someone walking over the top or a truck driving over collapses the roof. That vertical tunnel has probably been eating its way up for days, if not months or years.

He also believes human activity is causing more sinkholes than ever before. In the right conditions something as simple as urban drainage, that concentrates water runoff in one place rather than dispersing it, can cause a sinkhole. Sinkholes happen naturally but very, very rarely. Without humans around, one sinkhole may occur in a lifetime, Bechtel said.

A report from the local SE of SA ABC stated [133]

On a Saturday in August, 1971, during a football game at the local football oval, while players from Robe and Glencoe dueled down the eastern end of the ground, a large hole had suddenly and spectacularly appeared. All thoughts of football were abandoned as a large gaggle of spectators surrounded the new intruder - a sinkhole measuring 8 foot wide and 12 foot deep. The town is quite well known for its sudden ground subsidence occurrences. Small sinkholes to a depth of about 5 metres, have been appearing on property over the last few decades, as is the norm around the

[132] Sunday Night TV; http://au.news.yahoo.com/sunday-night/features/a/25707505/sinkholes-in-australia-where-and-when-can-they-strike/

[133] http://www.abc.net.au/local/photos/2014/01/30/3934897.htm

small town and in many areas of the South East. "10 or 15 years ago, my neighbour had a cow fall down one and we had to go get a backhoe to get her out," a local said.

A report in The Border Watch as recently as May 23rd 2014
told of a Hatherleigh farmer narrowly missing being buried alive as the ground collapsed under his tractor to form a 1.5 metre sink hole on his property. The report stated a member from the South Australia Cave Exploration Group said it was a normal occurrence in geological limestone-based form of the South East.

Limestone in the region has been formed under stress and there's a lot of cracks and faults in the stone. Often if you get a little water or acid from the soil into the crack, it slowly erodes the rock. Over time, the stuff in between of the rocks open them up and sometimes it can be sitting there for years. All it takes is a little pressure to collapse.

The South East is a Karst area (limestone geology) with underground cave systems and sinkholes. It contains the World Heritage UNESCO listed Naracoorte Caves, and is internationally renowned for its cave diving. There are numerous other caves found in the South East and it is said to have one of the longest cave systems in Australia.

Recommendation 18

<u>The World Heritage UNESCO listed Naracoorte Caves are a significant tourist attraction drawing visitors from South Australia, interstate and overseas. There is a gas exploration license within 500m of the Naracoorte caves. There are other significant cave systems throughout the South East. Gas drilling and fracking poses a significant threat to these cave systems and should not proceed in this region.</u>

29 Well Abandonment

Dr Mark Broomfield in his AEA report [134],

The evidence suggests that it may not be possible fully to restore sites in sensitive areas following well completion or abandonment, particularly in areas of high agricultural, natural or cultural value. Over a wider area, with multiple installations, this could result in a significant loss or fragmentation of amenities or recreational facilities, valuable farmland or natural habitats.

Engineering Energy in their report for ACOLA, [135]

There are effective regulations in place covering abandonment for conventional gas wells, but shale gas regulations will need to take account of the fact that there could

[134] Broomfield, M. AEA (2012). Report for European Commission DG Environment. Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe. Cited with his written permission.

[135] Engineering Energy: Unconventional Gas Production – A Study of Shale Gas in Australia. 2013. ACOLA

be hundreds of abandoned wells, many of them penetrating major aquifers; long term monitoring will be needed and *well abandonment is not just a regulatory issue, but is also an issue that requires more research and development in areas such as the very long-term behaviour of cements and extended monitoring under hostile subsurface conditions. Abandonment of wells involves cementing and capping to ensure they are not a threat to water systems or lead to gas emissions*.

Engineering Energy [136] comment,

While no subsequent monitoring is currently required, it is recommended in the UK report that on-going monitoring arrangements should be developed for both surface gas monitoring and aquifer sampling, every few years. Operators are responsible for wells once abandoned, with liability to remediate ineffective abandonment operations.

The establishment of a common liability fund is discussed to cover the situation where the operator can no longer be identified.

The very long-term integrity of a cemented and plugged abandoned well (beyond 50 years) is a topic where more information will be essential. Cement and steel do not have the very long term integrity of geological materials.

If shale gas fields develop to the size and extent in Australia as in the United States, there will be a legacy of abandoned gas wells, which will need to retain integrity if we seek to avoid connections across stratigraphy over many thousands of metres, including confined aquifers and strata of water bearing material with very different chemistry.

The integrity of strata containing waters from re-injection of flowback and other wastewaters will also be compromised if well integrity is not maintained. Technology has been developed for assessing well integrity [137] *and monitoring regulated gas storage reservoirs, and for identifying old, abandoned well locations. These technologies include remote sensing (magnetic, infra-red), satellite surveys and ground-penetrating radar.*

Engineering Energy continue,

Given all of this, the long-term management of abandoned gas wells so as to protect cross contamination of waters and soils along with gas emissions to the atmosphere

[136] Engineering Energy: Unconventional Gas Production – A Study of Shale Gas in Australia. 2013. ACOLA

[137] Duguid, A. and Tombari, J. 2007. Technologies for Measuring Well Integrity in a CO2 Field. Sixth Annual Conference on Carbon Capture and Sequestration

is a matter that requires careful attention in terms of regulation and governance as well as perhaps an opportunity to develop technological solutions. There are effective regulations in place covering abandonment for conventional gas wells, but shale gas regulations will need to take account of the fact that there could be hundreds of abandoned wells, many of them penetrating major aquifers; long term monitoring will be needed.

Recommendation 19

Wells are constructed of steel and cement and as both of these corrode and fail with time, there is no guarantee how long a well will last. Studies have shown 6% of wells fail within the first year. The South East of SA is only 2.2% of the states land area and provided $3.44 billion to the States economy in 2011/2012. Gas wells that threaten this economy will place a long term cost burden on the rest of South Australia. We oppose gas drilling and fracking in the South East of SA.

30 Summary of Recommendations

Recommendation 1

South Australia is in a unique position to strongly promote and assist the existing businesses, tourism and agriculture to truly gain the "clean green" premium food and wine reputation without the impediment of the indecorous reputation of the mining industry being implanted amongst its "food bowl" .

Recommendation 2

The South East of SA is a very valuable region to the State in terms of its agriculture, livestock, fibre, cropping, dairy, hay, forestry and tourism contributions.
It is the belief of many of us living here that;

- Agriculture and gas mining are not readily compatible in such a confined area.
- Coexistence cannot occur without negatively impacting on existing land uses.
- The loss of the long term, traditional agricultural, and tourism role of parts of this region to the whole State for the short term monetary gain for a few from gas mining is unacceptable.

Recommendation 3

Gas mining projects will put increasing strain on our public infrastructure including increased wear and tear on roads and increased use of public facilities in nearby towns.

Recommendation 4

Public water should not be supplied to oil and gas companies.

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Recommendation 5

A review of the sustainability of the water resources is required taking into account the impact of gas drilling and fracking prior to any gas drilling and fracking being allowed.

Recommendation 6

Gas drilling and fracking should not be allowed in the South East of SA as this region is a water catchment area.

Recommendation 7

A gas field requires a significant amount of land, but the impact is even greater than that area alone, because the gas field splits up the property with gas wells, connecting pipelines and roads. The disruption caused to existing landowners by the gas infrastructure is unworkable. Gas drilling and fracking should not occur in the South East of SA as this is prime agricultural land with multiple existing agricultural, viticultural and other land users who are likely to be negatively impacted upon.

Recommendation 8

A gas field will require large numbers of heavy truck traffic. This will increase the risk of road traffic accidents and reduce the attractiveness of the region for both residents and as a tourist destination.

Recommendation 9

Gas infrastructure, flare chimneys, holding ponds, connecting roads and pipelines will have a negative impact on the visual amenity of the region for both residents and tourists.

Recommendation 10

We are opposed to flaring and venting.

Recommendation 11

Already 87% of the native vegetation has been lost in the South East and the remaining area should not be further fragmented and degraded by becoming a gas field.

Recommendation 12

The South Australian State Strategic plan calls for no loss of native species, therefore no native species of flora or fauna should be put at risk with gas drilling and fracking.

Recommendation 13

Native vegetation laws should apply to gas drilling and fracking operations.

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Recommendation 14

Gas drilling and fracking should not occur within the South East as this has important and Internationally recognised RAMSAR listed wetland areas such as Bool Lagoon, Hacks Lagoon and the Coorong. Birdwatching is a recognised tourist attraction.

Recommendation 15

The South East of SA has fertile soil and prime agricultural land which should not be put at risk by leaks and spills from gas mining operations. Contamination of soil will threaten the region's economy and therefore impact negatively on all South Australians.

Recommendation 16

The South East of SA has areas of permanent wetlands and extensive areas of seasonal wetlands from flooding. Gas drilling and fracking should not occur in the South East, because of the risks of contamination of the groundwater and fertile soils from waste water flooding.

Recommendation 17

Gas drilling and fracking should not occur in the South East, because there are serious concerns about managing the large volumes of waste water. Waste water has the potential to contaminate both groundwater, soil and air.

Recommendation 18

The World Heritage UNESCO listed Naracoorte Caves are a significant tourist attraction drawing visitors from South Australia, interstate and overseas. There is a gas exploration license within 500m of the Naracoorte caves. There are other significant cave systems throughout the South East some of which have not been discovered. Gas drilling and fracking poses a significant threat to these cave systems and should not proceed in this region.

Recommendation 19

Wells are constructed of steel and cement and as both of these corrode and fail with time, there is no guarantee how long a well will last. Studies have shown 6% of wells fail within the first year. The South East of SA is only 2.2% of the states land area and provided $3.44 billion to the States economy in 2011/2012. Gas wells that threaten this economy will place a long term cost burden on the rest of South Australia. We oppose gas drilling and fracking in the South East of SA.

31 Conclusion

It is sometimes considered that unconventional shale gas production involving fracking is only being suggested in arid, remote, sparsely populated areas. However, the South East of

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South Australia is also being investigated for shale gas production which will involve fracking.

The South East of South Australia is neither remote nor arid. It is a populated rural region consisting of many existing, highly productive industries including agriculture, grazing, cropping, vineyards, fishing and tourism. It boasts a "clean green" image and attracts many tourists to its scenic country side, native vegetation, wet lands, caves and beaches. The South East's agricultural land and ground water are both vital assets to the State, because they assist in maintaining the State and country's food and water security, and economic diversity. Both must be protected from any activity that compromises their productive capacity or quality.

Despite industry adopting "best practice," accidents continue to impact the landscape. Whether it be over-clearing, spreading weeds, spills or leaks[138] - accidents do occur - and all may lead to contamination of soil, air and water. The list of potential risks seem endless and these occur even when all the rules and regulations imposed to prevent them are supposedly securely in place. Evidence of adverse incidents and damage to the environment show that regulations are simply not capable of preventing all harm arising from the gas drilling and fracking processes.

Two significant trends emerge from the data to explain the failure of legislation and regulation to protect the environment:

- the number of wells and their attendant infrastructure keeps increasing so that it is difficult for a regulatory framework to keep pace
- some of fracking's many component parts are simply not controllable, this is especially the case with the subterranean geological landscape itself.[139]

As **Engineering Energy** say, [140]

> *A number of the activities associated with shale gas exploration development and production have the potential to have an adverse impact on the natural and the human environment and therefore it is essential that shale gas activities are carefully and comprehensively monitored and transparently regulated to best practice. These include monitoring of surface and subsurface water, air quality, greenhouse gas emissions, and seismicity. The current lack of baseline data in many areas and lack of information on natural variability in particular need to be addressed. Many existing*

[138] See part 1.12 of this submission.

[139] Concerned Health Professionals of New York. 2014, December 11. Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (2nd ed.). http://concernedhealthny.org/compendium/.

[140] Engineering Energy: Unconventional Gas Production – A Study of Shale Gas in Australia. 2013. ACOLA

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Australian regulations for onshore conventional and unconventional gas production will be applicable to shale gas. Nonetheless the overlapping and regional aspects of shale gas impacts will confront Australian regulators with new challenges.

The Limestone Coast poses particular problems because, as its name avows, it has a limestone substrate. The region has a special fragility arising from its limestone geology. The ground is a soft, porous sponge, soaking up liquid, readily soluble by acid and susceptible to collapse through sinkhole and cave formation.

All together, the findings from the scientific, medical, and journalistic investigations indicate that fracking poses significant threats to air, water, health, public safety, and long-term economic vitality. *Concerned both by the rapidly expanding evidence of harm and by the fundamental data gaps still remaining,* Concerned Health Professionals *consider a moratorium on unconventional oil and natural gas extraction (fracking) the only appropriate and ethical course of action while scientific and medical knowledge on the impacts of fracking continues to emerge.*[141]

We need to show greater respect for the landscape to protect agriculture, rural communities and existing rural businesses, land and ground water for Australia to be able to sustain or increase food production for the future. We need to value healthy soil and water to continue producing food. We cannot afford to allow invasive mining or unconventional gas practices to encroach upon productive versatile agricultural regions.

The best practice environmental and safety standard for hydraulic fracturing is to ban it. This fail-safe standard has been achieved in many jurisdictions including France, Bulgaria, Germany, Los Angeles, Washington DC, Dallas, Nova Scotia and Geelong in Australia.[142] Victoria has announced that it is continuing its moratorium on fracking until there is an inquiry which includes genuine and inclusive community consultation.

Considering the South East of South Australia's productivity and longevity as a food bowl, tourist destination and home to many thousands it would seem irresponsible to implement anything other than this best practice standard.

To the extent that scientific research may be incomplete, the Government should adopt the Precautionary Principle. [143] The gas mining industry must show that its practices are safe. It

[141] Concerned Health Professionals of New York. 2014, December 11. Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (2nd ed.). http://concernedhealthny.org/compendium/.

[142] Food and water watch, 2014. List of Bans Worldwide. http://keeptapwatersafe.org/global-bans-on-fracking/

[143] Wingspread Conference on the Precautionary Principle, January, 1998 see http://www.sehn.org/other.html

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is not up to the State to prove that they will be harmful. 'No data' does not = 'no problem'! This is simply not acceptable anywhere, but particularly not in an area such as the South East of South Australia. The region and much of Australia is better suited to more renewable energy investment such as solar and wind, rather than invasive mining and unconventional gas which is unlikely to help the sustainability of the area or be compatible with the existing industries.

Please also include amongst your reading and studying of this topic a book written by Sharyn Munro, "Richland, Wasteland," written about coal mining and coal seam gas in Australia it is a very important reference to what is occurring across our rural landscape and why invasive gas fields and mining should not be left unchecked.

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Senate

Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

SECTION 6: THE EFFECTIVENESS OF THE EXISTING LEGISLATION AND REGULATION

Limestone Coast Protection Alliance Inc.

Author

Merilyn Paxton, was employed for 15 years in Marketing, Advertising, Public Relations, Sales Promotion and TV commercial production in Melbourne followed by 12 years as the proprietor of a premium wine and spirits retail outlet in Albert Park in Melbourne. During the '70s she was an executive member of the very successful Emerald Hill Association, a resident group for South Melbourne, Albert Park, Middle Park and West St Kilda, which had enormous success in changing many inner suburban planning concepts for freeways, high rise, public housing, demolition of historic buildings and shoreline development. In negotiation with the then South Melbourne Council, State Government and Federal government, the Emerald Hill Association managed to save the historic town hall precinct of some acres which was retained and renovated for public housing.

In 1989 Merilyn came to Robe and in 1990 she purchased a major share in a shark fishing enterprise which ran two boats out of Robe. In 1995 Merilyn and her husband bought a small farm at Mount Benson and commenced renovation of the property and the derelict homestead. In 2002 they sold their interest in fishing and purchased another farm in Nareen, Victoria, but sold that property in 2006 when blue gums encroached and their property was overrun with kangaroos. They purchased another property at Mount Benson at that time and have lived on the original property since 2001. They ran an Angus Stud for 17 years and now run a commercial cattle property.

Merilyn has always been involved in community activities. She delivered meals-on-wheels in South Melbourne for 18 years and was a volunteer ambulance officer in Robe for 5 years. She was also a founding director of Robe Community Bank (Bendigo Bank) and served on the board for 10 years in varying roles as Secretary, Treasurer and three years as Chairman.

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Introduction:

Existing legislation and regulation in all states of Australia in respect to gas production, and particularly fracking, does not protect the interests of landholders, the environment or sustainable development, and urgent amendments are required to legislation and regulatory procedures that control the environmental impact assessment procedure, communication with affected parties, location and monitoring of well sites.

There is also an urgent requirement to reverse the process that allows for self-regulation of mining and petroleum companies by mining and petroleum companies, and to put regulation in to the hand of a totally independent board.

Legal and Regulatory Changes needed:

Currently, for most states, Minister's have too much discretion to grant licences and impose conditions without consultation with other parties. There is no transparency or legislative requirement for adequate monitoring, enforcement or reporting activity at well sites and is currently simply a licence condition. This needs to be addressed to provide ongoing protection to landholders and the environment, and to protect properties from damage caused by unconventional gas and coal mining activities.

The department which issues the licence should be entirely separate from the regulator, and we recommend that assessment and monitoring should be the responsibility of the Environment Protection Authority (EPA) in every state

Further, a strong advisory board of independent scientific specialists should be created to provide an independent regulator to review all stages of the development, to consider and grant licences, assess environmental impacts, and to carry out monitoring and enforcement.

This 'independent advisory board' should be created urgently and take as its first priority a halt to fracking and coal mining until such time the board has been able to thoroughly research the growing worldwide evidence about the dangerous consequences of fracking, and report to the Minister.

ALL proposals should be subjected to public scrutiny. At the moment there is a great deal of secrecy regarding many aspects of coal mining and the fracking process. The Act should be amended to specify disclosure of each stage of the process:

1. No licence should be granted until approval of landholders and neighbouring landholders has been obtained.
2. Quantity and source of water to be used should be disclosed.
3. Method of disposal of water to be used.
4. Complete list of all chemicals to be used in the fracking process.
5. Construction and specifications of well casings.

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6. Depth of fracking
7. Size and construction of well pads.
8. Pond specifications
9. Method of monitoring of active sites
10. Immediate reporting of any accidents, spills, seismic activity
11. Agreements as to rehabilitation of well pads, ponds and roadways
12. Agreements with local councils as to road construction and maintenance sharing

There should be Federal legislation to control all mining throughout Australia and State Ministers should be issued with a list of criteria for assessing any mining proposal.

The specific criteria should include:

1. Economically sustainable development
2. Impact on water sources
3. Impact on agriculture
4. Landholders loss of amenity, increased workload and decreased lifestyle
5. Impact on the environment
6. Impact on the landscape
7. Impact on human and livestock health
8. Impact on the local community
9. Development and maintenance of local roadways.

Landholders on whose property the development is proposed, and all surrounding neighbouring landholders, should be personally notified and given a reasonable time to object.

Notifications should be placed on government and energy companies' websites throughout the notification period. Landholders consent should be required to drill a well prior to granting any exploration or production licence.

Should any company purchase land for any purpose associated with unconventional or conventional mining including wells, holding ponds or dispersal of treated water, then all conditions stated in this document should also apply to this purchased land, including notifications of neighbouring landholders, transparency and disclosure.

Regulation must not be presumed to endorse fracking or coal mining, and "*minimise* the environmental damage involved in exploration and recovery or commercial utilisation of petroleum and other regulated resources". It must be presumed that we will *eliminate* environmental damage or not proceed.

Agricultural areas of significant importance must be excluded from any fracking proposals. "No go" areas should be defined and fracking prohibited in these areas. A Planning Directive should clearly define these areas and set out requirements for assessing applications outside or adjacent to these areas.

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All State legislation which controls any form of resource mining in Australia should include the following to better protect the interests of landholders.

1. In order to give landholders sufficient time to understand what is proposed for their land a Notice of Entry should be served on a landholder 42 days before entry is planned.
2. A licensee who is giving Notice of Entry to a landholder before entering his/her land must attach a copy of any relevant State or Federal legislation.
3. Advise the landholder that they have a right of objection.
4. The time for objections by any landholder should be 30 Days.
5. The licensee or his representative should advise the landholder of their rights to compensation.
6. The licensee or his representative should advise the landholder of his rights to *negotiate* compensation.
7. There must be a requirement that the mining company provide to the landholder a complete contract which clearly states the work to be carried out, the start and finish time of the work to be carried, and any agreed compensation.
8. The licensee or his representative should advise the landholder that they should seek legal advice immediately they receive the Notice of Entry and *before they sign any contract with the petroleum company*.
9. The petroleum company should compensate the owner for legal fees incurred until the contract has been agreed to and signed.

All landholders and adjacent properties should be notified personally of any exploration or production licences that cover their property or an adjacent property and Legislation is needed to preclude mining or fracking in sensitive areas.

More equitable community participation in land use decisions must be made available with more regard for landholders rights in regard to mining. The process needs to be fairer to communities by improving notification procedures, public participation, appeal rights and social and economic impacts. *Any* person should be able to make an objection to proposed mining and given a right of appeal.

While energy companies may currently negotiate with landholders for compensation for loss of income because of decreased productivity, amendments to the Act are required also to cover landholders for loss of amenity, increased workload, decreased lifestyle and loss of property value. Landholders should be indemnified against loss of income due to residues in livestock or crops.

Legislation which makes it an offence to obstruct mining or petroleum activities should be amended to not apply to landholders, occupiers or their agents.

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Farmland must be rehabilitated to its previous productive use at the end of the mining development and landholders should have the right to "sign off" on the rehabilitation process, with a guarantee of generational maintenance which is transferable to other landholders and their descendants, with this responsibility also transferable to other energy companies *ad infinitum* should the initial energy company sell their interests.

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Senate

Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

SECTION 7. THE POTENTIAL NET ECONOMIC OUTCOMES TO THE REGION AND THE REST OF THE STATE

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Authors

Merilyn Paxton, was employed for 15 years in Marketing, Advertising, Public Relations, Sales Promotion and TV commercial production in Melbourne followed by 12 years as the proprietor of a premium wine and spirits retail outlet in Albert Park in Melbourne. During the '70s she was an executive member of the very successful Emerald Hill Association, a resident group for South Melbourne, Albert Park, Middle Park and West St Kilda, which had enormous success in changing many inner suburban planning concepts for freeways, high rise, public housing, demolition of historic buildings and shoreline development. In negotiation with the then South Melbourne Council, State Government and Federal government, the Emerald Hill Association managed to save the historic town hall precinct of some acres which was retained and renovated for public housing.

In 1989 Merilyn came to Robe and in 1990 she purchased a major share in a shark fishing enterprise which ran two boats out of Robe. In 1995 Merilyn and her husband bought a small farm at Mount Benson and commenced renovation of the property and the derelict homestead. In 2002 they sold their interest in fishing and purchased another farm in Nareen, Victoria, but sold that property in 2006 when blue gums encroached and their property was overrun with kangaroos. They purchased another property at Mount Benson at that time and have lived on the original property since 2001. They ran an Angus Stud for 17 years and now run a commercial cattle property.

Merilyn has always been involved in community activities. She delivered meals-on-wheels in South Melbourne for 18 years and was a volunteer ambulance officer in Robe for 5 years. She was also a founding director of Robe Community Bank (Bendigo Bank) and served on the board for 10 years in varying roles as Secretary, Treasurer and three years as Chairman.

Debbie Nulty, is a qualified veterinary nurse and has worked at the Kingston Veterinary Clinic for the past 17 years. Both Debbie and her husband Bruce have been farming at Tatatap, Kingston for 41 years. They have a commercial cattle and sheep enterprise which they run in conjunction with a successful South African Meat merino (SAMM) sheep stud. Debbie is the stud principal of Punari Prime SAMM, for which they have been awarded prizes for both Champion and Supreme Champion Ram and Ewe (SAMM) for 5 out of the last 6 years at the Royal Adelaide Show. Debbie is a mother of two children and two grandchildren, for which she considers herself a guardian of their future.

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Introduction

The potential economic damage to Australia's agricultural regions from shale or tight gas extraction by fracking would be enormous with the constant threat of water, soil and air contamination having a very negative effect on all of Australia's regional industries. Industrialised landscapes, with gas wells operating 24 hours a day, flaring of wells, constant and dangerous road traffic would certainly impact heavily on regional communities which play an important part in Australia's economy.

The extraction of non-renewable natural resources such as coal and petroleum is characterized by a "boom-bust" cycle, in which a rapid increase in economic activity is followed by a rapid decrease. The rapid increase occurs when drilling crews and other gas-related businesses move into a region to extract the resource. During this period, the local population grows because of skilled gas workers being imported by gas companies and jobs in construction, retail and services increase initially but, because the gas extraction industry is capital rather than labour intensive, drilling activity itself will produce relatively few jobs for locals, initially or in the future. Costs to communities also rise significantly, for everything from road maintenance and public safety to schools. When drilling ceases because the commercially recoverable resource is depleted, there is an economic "bust" -- population and jobs depart the region, and fewer people are left to support the boomtown infrastructure.

A growing body of credible research evidence in recent decades shows that resource dependent communities can and often do end up worse off than they would have been without exploiting their extractive reserves. They have to learn to deal with long term truck traffic, gas storage facilities, compressor plants, pipelines, noise, dust, dearer commodities and shortage of accommodation. The cumulative effect of these seemingly contradictory impacts -- a series of localized short-term boom-bust cycles coupled with regional long-term industrialization of life and landscape -- needs to be taken into account when anticipating what shale gas extraction will do to communities, their revenues, and the regional labour market, as well as to the environment.

Gas wells are predicted to last 3 to 30 years, but in spite of predictions may have a shorter productive life. The well is then closed, and another well will be drilled somewhere in the region, but the damage has already been done to the landscape and will take years to rehabilitate.

Coal mines also have finite production, dependent on the size of the resource, but have a long lasting environmental footprint of damage to the environment, and the health and wellbeing of surrounding communities which cannot be sustained.

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Even productive gas and coal fields are finite and as they become depleted we need to look for alternative sources of energy. The time to start preparing for long term sustainable energy sources is now.

State governments and petroleum companies constantly tell us that Australia has "best practice" as far as regulation and enforcement is concerned, but we know that the relevant acts governing petroleum are in many cases in contradiction to environmental policies. So, water, soil, air, environments that should be protected will not be protected once gas production licences are issued.

Even if "best practice" was available, accidents will happen and one accident can have devastating effects on the environment, health, and income of an effected property. We need legislation, not to ***minimise*** the effect of coal mining and gas extraction, but to *eliminate* any effects on communities' landscapes, health and the environment.

Contaminated water has been spilt and vegetation has died as a result, as is demonstrated in this paper. We know that the analysis of the water returned from Jolly 1 exploration gas well contained high levels of salt and barium.[144] The HDPE plastic liners in the Panax Geothermal holding ponds had broken down within four years.[145]

However the cost to Australian farmers of coal and petroleum exploration and extraction needs to include the serious risk of contamination of land, water and air, resulting in future losses of income from agriculture, viticulture farming and tourism, future health costs for community and tourism, and the potential cost of climate change.

Water

Water for gas drilling and fracking requires at least 5,000,000 litres for each fracking episode and up to 34 million litres for the life of a 'fracked well'. The usage by the petroleum companies will threaten the allocations needed for existing industry and land users and pose a serious risk to water available in the driest inhabited island in the world.

However, the threat of *contaminated* water is the greatest fear of all landholders. Livestock breeders are concerned that their animals will graze pastures contaminated by spills or drink water contaminated by drilling. Evidence is available, and irrigators and croppers have expressed concerns, about contaminated water affecting their crops and making them unsaleable. Above ground contamination from waste water threatens to poison vegetation, crops and livestock, while the threat to aquifers remains a major threat.

[144] ALSNATA Accredited Laboratory, March 2014 Water Analysis Beach Energy

[145] Photo in Stock Journal January 2014

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A study by Tom Myers[146] (extracted from ProPublica) has raised fresh concerns about the safety of gas drilling in the Marcellus Shale, concluding that "fracking" chemicals injected into the ground could migrate toward drinking water supplies far more quickly than experts have previously predicted.

Scientists have theorized that impermeable layers of rock would keep the fluid, which contains benzene and other dangerous chemicals safely locked nearly a mile below water supplies. This view of the earth's underground geology is a cornerstone of the industry's argument that "fracking" poses minimal threats to the environment.

But the study, using computer modelling concluded that natural faults and fractures in the Marcellus Shale, exacerbated the effects of fracking itself, could allow chemicals to reach the surface in as little as "just a few years".

Simply put the rock layers are not impermeable, said the study's author Tom Myers, an independent hydrologist whose clients are the (USA) federal government and environmental groups. The Marcellus shale is being fracked into a very high permeability," he said. "Fluids could move from most any injection process.

The study also concluded that the force that fracking exerts does not immediately let up when the process ends. It can take nearly a year to ease.
As a result, chemicals left underground are still being pushed away from the drill site long after drilling is finished. It can take five or six years before the natural balance of pressure in the underground system is fully restored, the study found.

It is stated that 'When man-made fractures intersect with natural faults, or break out of the Marcellus layer into the stone layer above it, the study found "contaminants could reach the surface areas in tens of years or less.

More than 5,000 wells were drilled in the Marcellus Shale between 2009 and mid 2010, according to the study, published in the journal "Ground Water. Operators inject up to 4 million gallons of fluid, under more than 10,000 pounds of pressure, to frack and drill each well."

There are many references available throughout Australia and the world to impacts of contaminated water.

Impact on Landholders and Farmers

Impacts of a new land use on agricultural landholders will be dependent on a wide array of conditions including the type of new land use, type of agricultural landholding and even the individual personality, abilities and policies of the landholders and companies involved.

[146] [146] Myers, T. Technical Memorandum: Assessment of Groundwater Sampling Results Completed by the U.S. Geological Survey (2012). available at http://www.sierraclub.org/pressroom/downloads/myers-tech-memo-093012.pdf

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If the new land use is extractive (e.g. minerals, coal, petroleum or gas) there is likely to be some diminution of the 'personal enjoyment' of private property which is valued by most agricultural landholders. New land uses will create a range of on-farm environmental affects which are likely to be documented through a formal environmental impact assessment and monitored by the agricultural landholder post project approval.

It is likely that a new land use will interfere with the efficient operation of existing farm enterprises and as a consequence would increase production costs and/or lower farm revenue. Accommodation of the new land use may also require a significant time commitment by the landholder. Changes in farm profitability and associated uncertainty would translate into changes in agricultural land values and increased competition for resources, such as water, from the new land use. Increased traffic through or around a property will also increase biosecurity risk, which will need to be addressed.

Although it may appear to some landholders that the lease payments they receive for having a well on their site is an opportunity for additional farm income, these payments will not compensate for the long term effects of wells on their property or that of their neighbours. The greatest fear is the unseen threat of groundwater contamination, but the intrusion on their land probably appears as a more immediate financial threat.

Destruction of large amounts of land to accommodate interconnecting pipelines, well pads of approximately 3.6 hectares per well, large waste water ponds, roads for access and to connect wells, and continuous well function and traffic intrusion on their property will have a real effect on the value of their property as well as their working life and their lifestyle. Farmers who have allowed their children to have free run of the property will feel inclined to keep them close to home. With thousands of truck trips per well making inroads across their property the safety of family, workers, stock, crops and machinery is a constant danger.

It has been clearly evidenced in northern Australia that farms with wells on their own property or adjacent properties have dropped their value. Many farmers have had their properties on the market for some time with no interest and some farmers have walked off their properties. Farmers often have no superannuation as they regard their property as their superannuation. If you cannot sell your property you have no retirement funds, and you will have to depend on government pensions and maybe disability pensions for mental health. This creates liabilities for the whole of Australia.

As farmers we know that we would not purchase a property with gas wells on it. We know that we could not sell a property with gas wells.

Banks and Farm Insurers are looking much more closely at their policies in regard to the detrimental effects of fracking and a Northern Rivers (NSW) property owner has been warned by her insurance company that her policy would be cancelled if unconventional gas drilling commenced on her property. Chief Scientist Mary O'Kane in a review of the gas

industry stated that there was no standard approach to insurance across the industry and stricter requirements were needed. The NSW Value General suggests that a mature gas industry may reduce property values.

Livestock journals have reported that Stock agents in the north of Australia have started to avoid purchasing cattle for the overseas live trade industry that have grazed properties with unconventional gas waste water ponds on them in case they show toxic residues or contamination when they are killed . They are concerned it will destroy the overseas markets.

Evidence is available and irrigators and croppers have expressed concerns about contaminated water affecting their crops and making them unsaleable. Above ground contamination from waste water threatens to poison vegetation, crops and livestock, while the threat to aquifers remains a major threat.

The perception of gas mining affecting livestock and crops means that people entering a property to negotiate a purchase have been known to refuse to buy from the landholder for fear of contaminated goods. Many South East livestock stud breeders have on-property sales annually and the fear of a visible gas well, even on a neighbouring property, would be a deterrent to a buyer, particularly as farmers are now aware that any possibility of a residue could mean financial disaster.

This report from "Food & Environment Reporting Network (USA), November 29, 2012
"In the midst of the domestic energy boom, livestock on farms near oil-and-gas drilling operations nationwide have been quietly falling sick and dying. While scientists have yet to isolate cause and effect, many suspect chemicals used in drilling and hydrofracking (or "fracking") operations are poisoning animals through the air, water, or soil.

In 2012, Michelle Bamberger, an Ithaca, New York, veterinarian, and Robert Oswald, a professor of molecular medicine at Cornell's College of Veterinary Medicine, published a peer-reviewed report to suggest a link between fracking and illness in food animals.

The authors compiled 24 case studies of farmers in six shale-gas states whose livestock experienced neurological, reproductive, and acute gastrointestinal problems after being exposed—either accidentally or incidentally—to fracking chemicals in the water or air. The article, published in New Solutions: A Journal of Environmental and Occupational Health Policy*, describes how scores of animals died over the course of several years.*

The death toll is insignificant when measured against the nation's livestock population (some 97 million beef cattle go to market each year in the USA), but environmental advocates believe these animals constitute an early warning.

Exposed livestock "are making their way into the food system, and it's very worrisome to us," Bamberger says. "They live in areas that have tested positive for air, water, and soil

contamination. Some of these chemicals could appear in milk and meat products made from these animals."

In Louisiana, 17 cows died after an hour's exposure to spilled fracking fluid, which is injected miles underground to crack open and release pockets of natural gas. The most likely cause of death: respiratory failure.

In New Mexico, hair testing of sick cattle that grazed near well pads found petroleum residues in 54 of 56 animals.

In northern central Pennsylvania, 140 cattle were exposed to fracking wastewater when an impoundment was breached. Approximately 70 cows died, and the remainder produced only 11 calves, of which three survived.

In western Pennsylvania, an overflowing wastewater pit sent fracking chemicals into a pond and a pasture where pregnant cows grazed: half their calves were born dead. Dairy operators in shale-gas areas of Colorado, Pennsylvania, West Virginia, and Texas have also reported the death of goats.

Drilling and fracking a single well requires up to 7 million gallons of water, plus an additional 400,000 gallons of additives, including lubricants, biocides, scale- and rust-inhibitors, solvents, foaming and defoaming agents, emulsifiers and de-emulsifiers, stabilizers and breakers. At almost every stage of developing and operating an oil or gas well, chemicals and compounds can be introduced into the environment.

After drilling began just over the property line of Jacki Schilke's ranch in the northwestern corner of North Dakota, in the heart of the state's booming Bakken Shale, cattle began limping, with swollen legs and infections. Cows quit producing milk for their calves, and they lost from 60 to 80 pounds in a week and their tails mysteriously dropped off. Eventually, five animals died, according to Schilke.

Ambient air testing by a certified environmental consultant detected elevated levels of benzene, methane, chloroform, butane, propane, toluene, and xylene—and well testing revealed high levels of sulfates, chromium, chloride, and strontium. Schilke says she moved her herd upwind and upstream from the nearest drill pad.

Although her steers currently look healthy, she says, "I won't sell them because I don't know if they're okay.""

Landholders in the heart of the Queensland coal seam gas fields have expressed ongoing frustration over the compensation offers for stock losses and the methods employed by QGC to prevent animal deaths during pipeline construction. (Queensland country life, 7th May 2013)

Producers north of Miles, who have spent more than two years managing coal seam gas pipeline construction from several competing companies, have told *Queensland Country Life*

they have concerns over QGC's compensation calculations for stock lost in pipeline trenches winding through their properties.

The Parliament of Victoria Research Paper, "*Unconventional Gas: Coal Seam Gas, Shale Gas and Tight Gas, Dr Catriona Ross, Paige Darby No. 2, December 2013*" discusses the "Reith Report, the Gas Market Taskforce Final Report and Recommendations, 1st November, 2013.

One of its recommendations was to "raise the legislated upper limit for compensation for landholders' loss of amenity during gas production from $10,000 to $20,000 and introduce indexation of this limit at CPI." We presume this amount is an annual payment because of the reference to CPI.

The suggestion that the amount of $20,000 for the intrusion of each well on a landholder's property would be compensation for the loss of amenity, widespread industrial activity, the interference to working life, threat of contamination to underground and above ground water, livestock and crops, trucks, roadways and pipelines through a property, the intrusion of a 3.6 hectare pad, water holding pond, risk of chemical residues in the soil, crops and livestock, severance, injurious affection, and the loss of value of the property which may not be regained for a lifetime is clearly inadequate compensation and an insult any landholder.

The National Vendor Declaration (NVD) for Cattle, Sheep and Goats.

Introduction

Meat & Livestock Australia (MLA)[147] and the red meat industry introduced the Livestock Production Assurance (LPA) NVD for cattle in 1996, sheep, goats, bobby calves and EU cattle in 2000, to implement measures to ensure traceability, food quality and safety, integrity and sustainability of Australian red meat. These measures ensure demand for Australia's meat from a *Clean, Green Environment*, our guarantee of our ongoing assurance of quality. The NVD is a legal document and must accompany every livestock transfer.

Fracking poses a potential risk to our export markets and the livelihood of livestock producers. Landholders may find themselves severely disadvantaged in regard to livestock contamination and subsequent litigation for meat contamination, damage to the environment and potential health risks to livestock in regard to world renowned agricultural, domestic & export markets.

Meat & Livestock Australia Limited (MLA) [148]delivers research and marketing and development for Australia's cattle, sheep and goat producers.

[147] http://www.mla.com.au/Meat-safety-and-traceability

[148] http://www.mla.com.au/Meat-safety-and-traceability

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A NVD is vital to ensure Australia is recognised as a world leader producing safe and quality food as a preferred global supplier. Australia's domestic and export markets demand our products are free of unacceptable chemical residue.

Australia's red meat producers have the ability and commitment to meet stringent demands underpinning our excellent agricultural and food safety guarantee to ***"stand by what we sell".***

On farm risk management is taken seriously by livestock producers and is enforced by law, by means of the legal document the *National Vendors Declaration (NVD*). This document ensures food production is non hazardous and safe for human consumption, whilst protecting our valuable domestic and export market, reinforcing Australia's commitment to a *Clean Green Environment* for food production.

The NVD is a pledge by the Australian Government and Australian producers to supply quality products for the world's food bowl, produced on Australian farms, while protecting the other industries connected to livestock protection and associated jobs for Australians.

So what is this report all about?

Our grave concern is Australia's reputation of a "*Clean Green Environment"* being put at risk with potential ramifications of losing our export markets. The potential for production animals being exposed to chemicals then making their way into the food chain and chemicals appearing in milk and meat products made from these animals is a concern to our domestic and export market.

The proposed unconventional and conventional gas projects, amongst others, for the South East of SA, could lead to fracking in our region and put at risk the State's prime agricultural land, the State's water resources, and the States food production, domestic and export markets.

Who is concerned?

Health and production threats have Veterinarians [149] concerned about heavy metal contaminating landscapes, accumulating over time when gas extraction stops with exposure of animals and humans to a cocktail of chemical pollutants like lead, mercury, arsenic and cadmium.

Exposure of our production animals to chemical pollutants must be seriously questioned and both water quality and quantity, and soil are the other issues concerning our food.

[149] Goldthorpe Kylie BVSc. Feature Article. 2013. Can Rural Vet Practice Survive Mining? Oakey Coal Action Alliance.

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If the State's food security and world renowned export markets is put at risk, by a contamination outbreak in our livestock this will have a negative impact on the State's economy.

There are pathways of environmental leakage with gas drilling, fracking and waste water chemicals which may increase the risks of contaminant residues in livestock while consuming pasture or drinking contaminated flow back water which would be detrimental to our domestic and export markets.

Other impacts could be loss of revenue through loss of sale weight due to interruptions to grazing and from dust reducing palatability of pasture.[150]

Pathways that could allow aquifer contamination from fracking fluid presented in this 2012 study by Tom Myers [151] (extract from Propublica printed below).

http://www.propublica.org/article/new-study-predicts-frack-fluids-can-migrate-to-aquifers-within-years

Study predicts Frack fluids can migrate to Aquifers within years

A study has raised fresh concerns about the safety of gas drilling in the Marcellus Shale, concluding that "fracking" chemicals injected into the ground could migrate toward drinking water supplies far more quickly than experts have previously predicted.

Scientists have theorized that impermeable layers of rock would keep the fluid, which contains *benzene* and other dangerous chemicals safely locked nearly a mile below water supplies. This view of the earth's underground geology is a cornerstone of the industry's argument that "fracking" poses minimal threats to the environment.

But the study, using computer modelling concluded that natural faults and fractures in the *Marcellus Shale, exacerbated the effects of fracking itself, could allow chemicals to reach the surface in as little as "just a few years". Simply put the rock layers are not impermeable, said the study's author Tom Meyers, an independent hydrologist whose clients are the federal government and environmental groups.*

[150] Principles for Negotiating Appropriate Co-existence Arrangements for agricultural Landowners. April 2013

[151] Myers, T. Technical Memorandum: Assessment of Groundwater Sampling Results Completed by the U.S. Geological Survey (2012). available at http://www.sierraclub.org/pressroom/downloads/myers-tech-memo-093012.pdf

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It is stated that 'When manmade fractures intersect with natural faults, or break out of the Marcellus layer into the stone layer above it, the study found "contaminants could reach the surface areas in tens of years or less.

More than 5,000 wells drilled in the Marcellus Shale between 2009 and mid 2010 , according to the study, published in the journal "Ground Water.. Operators inject up to 4 million gallons of fluid , under more than 10,000 pounds of pressure, to frack and drill each well

The Government and Livestock producers promote and guarantee a *"Clean Green Environment"* but government regulations continually and resiliently support mining and gas exploration above agriculture, making it very difficult to know and understand what the future holds for Australia and its agricultural sector....

Why does this happen?

Australia's rural sector since the beginning of the mining boom has lost $61.5 billion in export income. This includes $18.9 billion in 2011 - 2012 alone. The mining boom has forced the Australian dollar to historic highs causing these losses. [152]

The rural sector is heavily reliant on export earnings. In 2012 it exported almost $40 billion worth of produce, but in Australian terms this has been reduced to $18.9 billion, representing a decrease of 47% in export terms because of the high exchange rate attributable to the mining boom, *being gloom for agriculture.*

The mining boom has not been managed as well as it could have been. It has been allowed to expand with little consideration to the collateral damage it has caused other industries. The rural sector has been allowed to be badly affected, without any compensation of consequence and this has not been in Australia's national interest. The rural sector has been adversely affected by the high exchange rate, as the beef and veal industry is dependent on exports.

Populations are increasing and the way to address this is to become self sufficient in food production. Global meat production stands to increase by 2050, and is projected to almost double with an estimated 9.1 billion people to feed. This will require sustainable food production on a large scale, globally, nationally, regionally and locally.[153]

[152] Grudnoff M. 2013. Still beating around the bush: The continuing impacts of the mining boom on rural exports. The Australia Institute, Policy Brief No. 47 ISSN 1836-9014 http://www.tai.org.au/node/725

[153] Food Alliance Brief on the National Food Plan 27 May 2013. http://www.foodalliance.org.au/wp-content/uploads/2013/11/Brief-on-National-Food-Plan-May-2013.pdf

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What is a "National Vendor Declaration"....(NVD)

A legally binding document required by ***law,*** with *legal implications to the livestock producer*, owner or person responsible for the husbandry of the animal to be sold. The top sheet: (White) goes with the livestock. Middle sheet (green) goes to the carrier, Bottom sheet (Pink) stays in the book and should be kept for auditing purposes.

This declaration must be answered honestly. Any *FALSE* or *MISLEADING* information or unverified statements may result in prosecution or civil action. If you rely on the document to verify further claims about purchased stock, then the stock should be identifiable This document must be kept by the producer for 2 years.

However, if the NVD is filled in correctly, and identifies livestock that have been exposed to spray drift or grazed on pastures placed under restrictions, the farmer is unlikely to find a ready market.

The cost of potential residue testing required or undertaken in response to evidence given, on the document (NVD) is a commercial matter between the buyer and vendor (except where industry funds such testing).

What questions are on the National Vendor Declaration (Cattle)

Question 5: In the last 6 months have any of these animals been on a property listed Extended Residue Program (ERP) database or placed under restrictions because of chemical residues?
Yes or No

Question 6: Are any of the cattle in this consignment still within a Withholding Period (WHP) or Export Slaughter Interval (ESL) as set by the APVMA or Safemeat, following treatment with any veterinary drug or chemical?
Yes or No

Question 7: In the past 60 days, have any of the cattle in this consignment consumed any material that was still in a withholding period when harvested, collected or first grazed. ?
Yes or No

Question 8: In the past 42 days, were any of these cattle;

A: grazed in a spray drift area or

B: Fed fodder cut from a spray drift risk area

Yes or No

(Some questions for sheep and goat NVD's are slightly different, as are questions on the NVD's for crops and grains)

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What other Statutory Documents Are required?

Other documents relating to this movement e.g.: livestock health statement for some states, permit, including additional sheets of description of cattle/livestock. The words "Attachment to LPA/NVD Waybill serial number..." must be on every other additional document with the serial number recorded. Additional document(s) must be attached to the original and both copies.

Who must provide a "National Vendor Declaration" and Why & When?

A producer of livestock, (cattle, sheep or goats) is required by ***law,*** to fill out information required on the NVD declaration, and declare they are the owner and responsible for the husbandry of the livestock. Ensuring all information in part A of the declaration is true and correct. The producer *cannot legally sell or transfer stock* without a current ***"National Vendor Declaration***

What other ways do livestock producers protect Australia's World Renowned Global Reputation of a CLEAN GREEN environment?

An export slaughter interval (ESI),is a period where time must elapse between a chemical application to livestock and their slaughter for ***export....***An ***export grazing interval(EGI)***is the minimum time between the application of a chemical to a crop or pasture that is continually grazed before slaughter, Exposure to agricultural products, such as spray drift from a nearby paddock can cause potential residue contamination to livestock.

Adherence to these conditions ensures our export markets are not put in jeopardy....ever.

These measures are essential to ensure market access and demand for Australia's red meat [154]

Supply chain position	Safety program initiative
On farm	**Livestock Production Assurance (LPA)LPA Quality Assurance (National Vendor Decoration)**
Feedlot	**National Feedlot Accreditation Scheme**
Transport	**Truck Care**
Saleyards	**National Saleyard Quality Assurance Program**

[154] http://www.mla.com.au/Meat-safety-and-traceability

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Processing	**Australian Government Legislation and Standards** **AQIS health certificate** **Australian Government Halal Slaughter Program** **Micro - organism monitoring** **MLA food safety program** **National Residue Survey**
Export	**Department of Agriculture Biosecurity**
Overall supply chain	**National Livestock Identification System (NLIS)** **AUS - MEAT**

How does contamination occur?

- Contact with areas that are contaminated by persistent chemicals.
- Inappropriate storage of chemicals, resulting in animals coming in contact with chemical.
- Exposure to rubbish dumps and waste storage areas that had chemical containers.
- Exposure to chemicals used in petroleum activities, such as spray drift from waste water dispersal on roads and pastures.
- Increased risk of contaminant residues in cattle or other, sharing pastures with mining activities or consuming contaminated waters.
- Waste water runoff, flooding or leaks and spills.
- Air contamination from flaring, holding ponds.

Reference; Clarke M. 2013. Principles for Negotiating Appropriate Co-existence Arrangements for Agricultural Landholders. Rural Industry Research and Development Coorporation. RIRDC Publication No. 12/114

Landholder Case Study: Beef producer integrated supply chain.

A problem related to a potential risk of chemical contamination of "beef cattle" from the property of petroleum activities – CSG in this instance. The land holders supply chain partners indicated that the producer would be liable for any contamination and effective indemnity could not be secured from either an insurance company or the petroleum company.

Legal Advice received by the landholder was that the Conduct and Compensation Agreement on offer only provided indemnity to a shelf company and that the agreement

waived future compensation rights. Any compensation for a contamination event would need to be pursued in the courts.[155]

Devastating effects on Australian Agriculture.... and jobs

If unacceptable residues are found in animal products, carcases may be condemned without payment to the producer.

Producers could also be held responsible for costs imposed on processors and other associated industry.

A producers' livelihood and the "reputation" of the industries threatened with global markets being restricted or closed indefinitely.

Most other traditional industrial and heavy industry are in zoned industrial areas, or inside buildings, but separated from food producing areas and communities.

This potentially will risk the state's water resources, soil, air and noise quality, the health and well being of our families and friends, our climate, and our food and water security and sustainability.

Australian farmers have a stringent set of rules to abide by to protect the local and export markets so it is reasonable that petroleum companies should declare the "drilling and fracking chemicals" they use and be held responsible for testing and monitoring their practices.

Vets are concerned about heavy metal contaminated landscapes, accumulating over time potentially leading to exposure to a cocktail of chemical pollutants like lead, mercury, arsenic and cadmium.

State government

In Australia state governments have the primary responsibility for the management of resource development, and it is essential that they manage petroleum and mining projects without human or environmental health consequences. The petroleum and mining industry needs to recognise and acknowledge the importance of agriculture and other industries in the region and rural communities.

Agriculture and food production alike depend on our natural resources, like lush pastures, plentiful supplies of fresh water, high rainfall, sunlight and good quality soil.

Scenario: A

[155] Clarke M. 2013. Principles for Negotiating Appropriate Co-existence Arrangements for Agricultural Landholders. Rural Industry Research and Development Coorporation. RIRDC Publication No. 12/114 page 16.

The landowner has been forced by Government Regulations to allow unconventional and/or conventional gas exploration or production on his land.

Question: WHO is liable for contaminants caused by petroleum activities, taking into consideration all was fine before petroleum activities commenced?

Scenario: B

A farmer did not want petroleum activities on his property. He is a livestock producer or feedlot operator working in close proximity to petroleum activities and untreated water containing contaminants (uranium, arsenic, lead,?) seeps into the aquifer and unbeknown to the producer, his stock is drinking contaminated water.

Question: What are the legal implications for the livestock producer, when standard residue tests detect contaminants in the beef from those cattle for which the producer has signed a National Vendor Declaration, a legal document?

Impact on Tourism

As farmers in the South East of South Australia we have a very close connection with landholders, both in our local regional towns and on farmland who are conducting very successful tourism ventures such as accommodation, bed and breakfast establishments, vineyard cellar door sales, restaurants, to name a few.

We are aware that tourism is a big part of Australia's National Domestic Product but currently do not have enough information available to quote figures for the whole of Australia.

However, we have done intensive research in to what we believe would be the effects of fracking in our South East, and so we will quote you these figures to demonstrate one are of tourism that would be affected by fracking or coal mining.

The tourism sector in the South East added $285 million over a 3 year period to the State's economy. There are now over 1000 tourist beds in the South East with an average 42% occupancy per annum.

Twenty-five years ago the main source of tourism was holidaymakers visiting coastal towns during the summer and Easter, and visits to cellar doors in the wine regions. Over the years many South East organisations such as the Limestone Coast Development Board, Councils, tourism and trader organisations in South East tourist towns, and wine groups have embarked on extremely professional marketing strategies which has seen a steady growth in tourism and retail sales in the area. Rather than just confining the tourist earnings to the summer to Easter period this has seen tourism as an all year round business for the South East.

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This is a benefit to the local population as well as tourists as there are good income streams from rental and B & B accommodation as well as an abundance of good retail stores in the region catering for most of the needs of the local population.

Great food and wine produced in the South East is not only of benefit for all South Australians, but also a great attraction to tourists, whether they are enjoying a short or prolonged holiday in the region, simply a day trip, or passing through.

Nearly every weekend in the summer months sees the South East becoming a wedding venue on the beaches, in the vineyards and even on many farms.

As a result of this growing attraction to the South East, new restaurants and cafes open continuously and more accommodation opportunities are being offered to national and international tourists, as well as South Australians and Adelaide visitors. Good employment opportunities, both in food preparation and service, continue to grow, attracting families and singles to the area and a surge in building has occurred to provide permanent accommodation for new families.

The beauty and peace of the South East countryside and coastal towns is well known by those wishing to escape the hustle and bustle of Adelaide. However the major growth in tourism is from the interstate and international markets.

If the landscape were to take on the appearance of a major industrial region with gas wells dotted across the landscape there is little likelihood that the people of Adelaide, interstate or overseas would enjoy visiting the region or that the South East would survive as a tourist region. The traffic, smell, fumes and dust associated with an industrial gas site would be a major deterrent to those people seeking peace in a tranquil setting.

Shale gas drilling in Wyoming, Texas, and Pennsylvania (USA) has had serious economic consequences for existing industries like agriculture, and particularly the tourism sector, because of the widespread industrial activity that accompanies drilling. Examples of such impacts include strains on the available supply and pricing of hotel/motel rooms, visual impacts (including gas wells, drilling pads, compressor stations, equipment depots, etc.), vastly increased truck and vehicle traffic, potential degradation of waterways, forests and open space, and strains on the labour supply that the tourism sector draws from.

All told, the South East's ability to attract tourists could be damaged in the long-term if the perception of the region as an industrial landscape outlasts the employment and monetary benefits of gas drilling.

Impact on Wine and Food Industry

We are very aware that Australia has a reputation for producing some of the greatest wines in the world, a reputation built up over more than a century of innovation, trial and error. Also, our contribution to the food supply for the world is eagerly sought by many nations,

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and we feel that our reputation could be severely damaged by the demonstration of Australia and predominantly a mining nation.

Here again, we are only able to quote the effects of petroleum exploration and extraction for the wine and food industry in the South East of South Australia but we believe that the damage caused in our region has already been demonstrated to be harmful in several regions of Australia.

Although the South East is only 2.2% of the total area of South Australia it has 15,782 hectares of its region planted to vines, which represents 21% of South Australia's total vineyard area. 304 growers own these vineyards, a total of 17.65% of South Australia's growers and in 2014 these growers crushed 81,738 tonnes of grapes for a value of $79,375,237, representing 18.75% of the states revenue from winegrowing.

Minister for SA Agriculture, Food and Fisheries Leon Bignell said in a press release as recently as Thursday, 18th December, 2014 that Premium Food and Wine revenue has reached record levels in South Australia.

"South Australia's gross food and wine revenue has reached a record $17.1 billion in 2013-14, as revealed in the State Government's annual Food and Wine ScoreCard report.

A record breaking rise in total overseas exports had also contributed to a positive year for South Australia's food and wine industry, with China and Hong Kong emerging for the first time as the State's largest food export market.

"Significant revenue increases by the horticulture, livestock and grain industries contributed to an $834 million increase in gross food and wine revenue," Mr Bignell said.

"The positive results reflected in the Food and Wine ScoreCard confirms South Australia's agriculture, food and wine industries' important role as a key economic driver for this State.

"It is for this reason the State Government is affirming its support to the food and wine sector through the premium food and wine produced in our clean environment and exported to the world economic priority."

It is one of 10 economic priorities that form the basis of the State Government's economic reform agenda, announced in August this year, aimed at accelerating industry growth and job creation.

"The growing international demand for high quality food and wine, combined with South Australia's strong reputation for food safety, biosecurity and product integrity, creates significant opportunities for South Australia.

"We are the only mainland State that enjoys a fruit fly free status, has a moratorium on GM crops and is one of the few places in the world free of the vine-destroying pest phylloxera.

This assists South Australian products to stand out in the competitive global market, which is increasingly seeking clean and safe food and wine.

"Through this economic priority our world leading food, wine and agricultural research will provide the platform to expand this advantage and to export our ideas, intellectual capital, products and services.

Mr Bignell said the latest ScoreCard revealed an 11 per cent rise in South Australia's total food and wine overseas exports, increasing $469 million to reach a record $4.8 billion, with finished food and wine exports increasing by $308 million."

5.2% [156] of the state's GSP is produced in the South East, and food is a great part of that including crayfish and salt water fish, farmed fish, nuts, cheese, milk, and other dairy products, fruit, vegetables, and top quality beef, lamb, pork, goat and poultry.

The risk of contamination of water, air and soil by gas drilling, fracking, leaks, spillages, continuous flaring and the visible impact of the South East being a gasfield is unlikely to enhance the image of the region as a 'clean green' producer of food and wines. Prospective purchasers of our products visiting the region would no doubt be appalled to see an industrialised landscape and are most likely to doubt the quality of our products.

The effect on food, grapes, fruit and vegetables from dust and air-borne pollution is another major factor that would lower the standard of our product.

All these local food producing industries have seen major and consistent growth for many years and have established their place firmly in the GSP of South Australia.

To introduce a source of income to the area that will deplete these industries will see food and wine production affected for the whole state.

Impact on Employment

While a few studies have projected impressive levels of job creation, the actual job picture will be very different. In spite of the claim by companies that they improve employment in the area, it will make no positive influence and ultimately it will destroy the balance of the existing workforce. It would affect the profitability of many of our current industries and therefore create declining employment in many industries.

The Australia Institute report Fracking the Future, commented on gas and oil employment, [157]

[156] PIRSA

[157] Grudnoff M. 2014. Fracking the future Busting industry myths about coal seam gas. The Australia Institute. Policy Paper No. 16. March 2014 ISSN 1836-8948 page ix

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The ABS publishes job numbers for Australia's main industries. The ABS does not publish separate numbers for CSG or even for the gas industry; it publishes figures for the combined oil and gas industry of which CSG is a part. In August 2013 the entire oil and gas industry employed 20,700 people – that is, 0.2 per cent of the workforce or one in 500 workers. To put this figure into context, hardware retail company Bunnings employs 33,000 people.

Agricultural employment has decreased by 28% in Queensland during the mining investment boom. Manufacturing has been steady, despite modelled predictions of large increases.[158]

It takes only about a year to prepare, drill and frack a shale gas well. A study by Pennsylvania's Marcellus Shale Education and Training Center (MSETC) found that about, 98% of jobs are concerned with developing the gas well, and are not needed after the well has been drilled, while 2% of the jobs are concerned with the long-term production of gas. Many of the better paying jobs at the well go to transient, out-of-state workers who have industry experience, not to residents of the areas targeted for development. Of those 98% employed to develop the gas wells, most are skilled workers who will be sourced from other well sites and probably be "fly in fly out" or "drive in drive out" workers[159]

After this work is performed, the number of workers needed to keep producing gas for the remainder of the life of the well -- the Production Phase -- is much smaller. One worker is needed to monitor and maintain 6 wells under production. Clearing and constructing a natural gas well site, drilling and casing the well, performing the fracking process, and constructing the associated pipeline infrastructure are all considered part of the Drilling Phase. These jobs include those who work on drilling rigs, excavation crews, tractor and truck drivers, heavy equipment operators, hydro-fracturing equipment operators, and semi-skilled general labourers.

The remainder may be local workers, but as petroleum companies pay very good wages this will impact on the local workforce by taking skilled workers out of local jobs and forcing up the price of wages in the local area. When production from the well ceases these jobs disappear.

A skills drain will affect all industries in the region – farming, tourism, viticulture, agriculture, aquaculture, forestry, fishing and local government.

In a recent study commissioned by the Climate Institute the Limestone Coast is recognised as a "clean energy hotspot" anticipating the creation of 497 permanent jobs (both existing

[158] The Australia Institute 'Are there 27,000 jobs in the Galilee Basin? January 2014.

[159] Cardi Reports Issue Number 14/September 2011

and new) in operation and maintenance of renewable energy infrastructure and 2,858 jobs in construction by 2020. [160]

Impact on Rental Property and Real Estate

Prices for local rental properties increase and possibly price locals out of the rental market as "fly in fly out" accommodation is procured from existing accommodation. Because the South East is such a major holiday destination there are a high number of holiday houses in many of the region's townships, but there is no way of knowing how many of these would become available for long-term rental or sale for petroleum industry employees.

If sufficient accommodation is not available for the large numbers of skilled workers required for the initial stages of construction then temporary accommodation may need to be built in the form of inexpensive housing. This may provide some work for local builders initially, but is more likely to result in cheap relocatable housing which then will become a "satellite city" after the gas wells are in production.

Development of gas fields and mines in regional areas can have a significant impact on the availability and affordability of accommodation. Two general examples taken from the "Local government, mining companies and resource development: Meeting the governance challenge", (Centre for Social Responsibility in Mining, 2012) report cites the Pilbara region in Western Australia and the Bowen Basin in Queensland as examples of areas which have become unaffordable due to high demand for houses. Pilbara residents in Karratha and Port Hedland pay amongst the highest real estate prices and rental in the country caused by strong demand for accommodation and a slow supply response. Median house prices are well in excess of those paid in metropolitan Perth and other regional areas. In the Bowen Basin median rent is the highest in the State of Queensland at around $2,000 per week.

The effect of this on the local community would be disastrous. Families employed in other industries would be forced out of the property purchase or rental market and would most likely leave the region to locations where housing costs are lower. While the price of residential property is escalating, the price of farm property will be dropping. As many farmers have little or no superannuation they regard their properties as their retirement fund. If they can't sell property or they must accept a reduced price for it they will have a bleak future. We may see an increase in the number of regional people relying on welfare.

Impact on Regional Retail

There may be a boost in activity for some local retail business such as hotels, motels, supermarkets, bakeries, restaurants, service stations, and earthmovers which may also increase local employment during the development of the gas fields, but for many commodities prices will increase and become too expensive for locals who are not

[160] SA Centre for Economic Studies, Regional Development Australia, Limestone Coast, Paper 28, December 10, 2014

employed by petroleum companies. Other retail business, which do not provide for the petroleum work force but who are providing services only for locals whose numbers are declining and tourists, who are no longer coming, would be seriously affected and may disappear altogether.

Impact on Local Roads

There will be major devastation of local roads at each stage of the well production as a huge number of trucks will be required during land clearing and constructing a gas well site, drilling and casing the well, constructing the associated pipeline infrastructure, and finally performing the fracking process. Fracking requires approximately 5,000,000 litres of water for every frack, and that water has to be trucked in to each site which would require about 91 B double tankers to transport that amount of water to each well each time it is fracked. Over the life of a fracked well, 30 million litres may be required. After fracking, the residue of water that is returned from the well will be directed to a holding pond. It then needs to be trucked to a treatment plant, and when "purified" either trucked to another well site, or trucked to its point of dispersal.

Road access and maintenance are critical to shale gas exploration and production. At the same time, drilling communities are seriously affected by the attendant road damage. Local roads have neither the width nor depth to handle sustained pummeling by heavy trucks. Potholes and ruts, 15cm to 25cm deep, and complete road failures are not uncommon. The impact of 1000 extra trucks per year on a country primary road uses up 0.13% of that road's lifespan, but the impact of those same trucks on local roads consumes 2% of the roads' life.

Region will be affected by this traffic in many ways, but the cost to the local government of maintaining roads will be enormous. Local councils will need to be aware of this and require from gas mining companies some form of *Road Use Agreement* which puts the costs of repair to the petroleum companies, otherwise local rates will need to increase dramatically to cover these costs, which in turn may force some people out of their communities, particularly retirees who could not afford high increases in rates. This will put a strain on Adelaide resources.

Petroleum companies need to consider the damage they cause to local roads because of the heavy traffic required during the construction period of gas wells, or during the monitoring of production once wells are installed. They may consider that this is the responsibility of Councils, who clearly cannot cover these costs without a severe financial strain on their finances but it should be costed on a user pays basis. Councils should consider also that if State or Federal governments support any form of petroleum extraction in their region then they must contribute to the costs, perhaps by a share of royalties. If governments can pay huge subsidies to petroleum companies they should be prepared to pay compensation to communities for damaged caused.

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Petroleum companies have provided funds for updating some sporting facilities in some towns in the regions in which they have commenced, or are planning to commence, mining. These practices should be made illegal. While sporting clubs may wish to take advantage of the company donation this creates further stress in the community through division.

Impact on Local Councils and Local Amenities

Electricity supplies in regional areas can be affected by the huge demand by mining.. Without considerable infrastructure upgrades it is unlikely to be able to support a massive increase in industry.

Water, as has been previously discussed, is a precious commodity in most parts of Australia and should not be stretched to accommodate on-going fracking or coal mining for years.

Residents or regional areas do not want saline toxic water brought to the surface for fracking activities from aquifers deep below the ground. The impacts on doing this are unknown as far as triggering earthquakes, spillage of toxic saline water when it is at the surface and well integrity, with the use of this water.

Regional Councils would not be in a position to finance the massive expenditure for road construction and maintenance which would be required to service an industrial gasfield or coal mine. It is hard to predict what strains will be placed on other amenities or resources in local communities without any real concept of what would occur as far as the work force is concerned. If it is basically a FIFO work force in the construction stage, then temporary housing, roads, water and electricity will be the main concerns. If the energy companies were to relocate skilled workers, including families, then a much more serious situation would arise. In addition to the pressure on roads, water and electricity, there would be additional pressure on rental and real estate, employment, schools, pre-schools, accommodation, sporting, recreational and health facilities. It is already very hard to attract professionals, including doctors and nurses to regional communities and with increased demand it would create health risks for the existing communities. Most regional councils in Australia would not be able to financially cope with the need to upgrade the facilities.

Impact Conclusions

"The prospects for positive economic impacts in the short run should not blind policy makers to the potential for long term harm to overall economic development. Both surface and subsurface impacts warrant serious attention from all stakeholders."

Energy companies and state governments tout that unconventional gas projects are an economic boost to a region, but it has been demonstrated that it is much more likely that the opposite will occur. Loss of local, national and international export markets would result in declining employment prospects, as well as impacting other economic areas such as the purchasing capacity of residents.

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Unconventional gas projects, hydraulic fracture stimulation, and coal mining cannot exist with agriculture, horticulture, aquaculture, viticulture, fishing, food production and tourism.

We are constantly assured of "best practice regulation" in Australia. We are sure that all the states would make these claims but, *in spite of "best practice",* accidents are happening all over Australia and all over the world. Mining acts and environmental acts in all states are seriously deficient to protect landholders and must be revised.

It would take only one accident to the aquifer, the soil or the air in the South East to permanently destroy the clean and green reputation of the South East and the State of South Australia. Our socio-demographic will have changed and many of the families who have been here for generations may have left.

Gas fields and coal mines are finite, and are expensive both economically and environmentally. After their lifetime they will need to be rehabilitated to begin to recreate what we currently have and this will be very expensive.

Renewable energy is available now and capable of meeting most of our energy needs. We therefore need to be looking to renewable energy sources to sustain the lifestyle of the country's population. The time to begin looking for these alternative energy sources is now.

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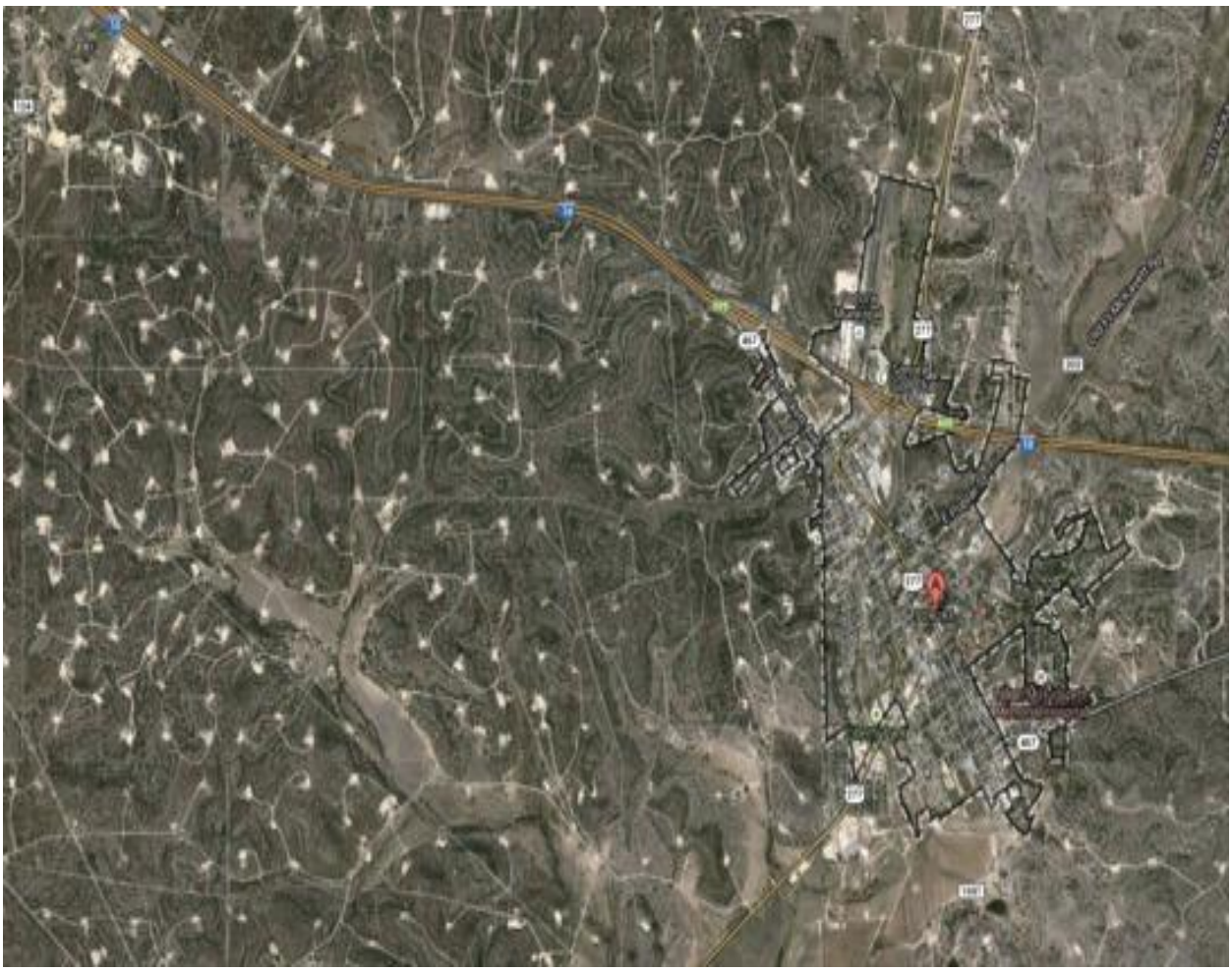
Senate
Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

SECTION 8. HEALTH



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Gratefully acknowledging help from

Dr David Senior, MBBS, FACOM, FACRRM. David had a lengthy medical career in the RAAF from 1975-1993 including service in Malaysia and USA. Since 1993, he has been self-employed as a rural General Medical Practitioner in the Limestone Coast of SA. He obtained a Master of Science (Occupational Medicine) in 1989 and was Director, Defence Force Environmental Medical Policy, Office of the Surgeon General from 1991-93. His civil experience includes both city and rural practice. He was Dux of Pulteney Grammar School 1965, Dux International Course, School of Aerospace Medicine AFB, TX, USA in 1983. He is a Fellow of the Australian College of Occupational Medicine, Australian Faculty of Occupational and Environmental Medicine, the Royal Australian College of Physicians and the Australian College of Rural and Remote Medicine. He has a continuing interest in research and has published several professional papers on a variety of topics with a particular focus on occupational and environmental medicine and health needs specific to the Limestone Coast.

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1 Introduction

Unconventional gas extraction (UCG) is an industrial process with a massive environmental footprint and significant potential to damage human health. To date, experience in South Australia has been entirely limited to remote areas with tiny populations in the Cooper Basin, that do not rely on groundwater for human consumption.

Unconventional gas extraction has wide ranging detrimental impacts on human, animal and environmental health because it uses, produces, and releases huge quantities of chemicals, some of which are known carcinogens into the environment. Chemical issues are covered in the Section of this submission on Chemicals.

Evidence points to the high risks to health and safety arising from the process. Known and potential adverse health outcomes are evident from current and past health studies. The need for caution is expressed worldwide by medical organisations. Pathways of contamination exist and along with known toxins make the risk of health impacts high and worrying. Animals are often seen as sentinels for human disease and some of these case studies are presented. Preliminary studies into birth and reproductive issues, and acute toxic health impacts raise concern. Some long term health impacts are certain, but others remain unclear and require further comprehensive and ongoing research. As yet there have been no health assessments in the Limestone Coast, no baseline health, water or air testing and we strongly recommend that it would be wise and sensible for this to occur.

Air pollution is a known health hazard and there are known air pollutants from the gas industry including volatile organic compounds, diesel fumes and silica dust. Water contamination pathways exist and examples of water contamination is briefly touched on (this has been covered in depth in the Sections on Risks to Groundwater).

The application of the precautionary principle and need for intergenerational equity is outlined. In addition, unconventional gas is a fossil fuel and its use will increase global warming.

In addition, to environmental and physical health risks, there are known psychological harms and social changes wrought by the gas industry.

Numerous recommendations are included in this submission. The overriding recommendation is that, on the basis of the evidence presented, hydraulic fracturing should not occur in the Australia.

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32 Health impacts of unconventional gas fracking

32.1 Known Health impacts

Summarized below are some of the environmental impacts and health outcomes potentially associated with High Volume Hydraulic Fracturing (HVHF) activities identified by the Department of Health New York State Review, [161]

- *Air impacts that could affect respiratory health due to increased levels of particulate matter, diesel exhaust, or volatile organic chemicals.*
- *Climate change impacts due to methane and other volatile organic chemical releases to the atmosphere.*
- *Drinking water impacts from underground migration of methane and/or fracking chemicals associated with faulty well construction.*
- *Surface spills potentially resulting in soil and water contamination.*
- *Surface-water contamination resulting from inadequate wastewater treatment.*
- *Earthquakes induced during fracturing.*
- *Community impacts associated with boom-town economic effects such as increased vehicle traffic, road damage, noise, odour complaints, increased demand for housing and medical care, and stress.*

32.2 High risk of adverse health outcomes

In the **Department of Health New York State Review,** of 2014 [162] Dr Howard Zucker, Acting Commissioner of Health reviewed the weight of evidence and found significant uncertainties and this brought him to the conclusion that UCG should not proceed in New York State.

> *As with most complex human activities in modern societies, absolute scientific certainty regarding the relative contributions of positive and negative impacts of HVHF (high volume, hydraulic fracturing) on public health is unlikely to ever be attained.*
>
> *In this instance, however, the overall weight of the evidence from the cumulative body of information contained in this Public Health Review demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with HVHF, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health.*

[161] Department of Health. New York State. December 2014. A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development. Dr Howard Zucker, Acting Commissioner for Health.

[162] Department of Health. New York State. December 2014. A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development. Dr Howard Zucker, Acting Commissioner for Health.

While a guarantee of absolute safety is not possible, an assessment of the risk to public health must be supported by adequate scientific information to determine with confidence that the overall risk is sufficiently low to justify proceeding with HVHF in New York. The current scientific information is insufficient.

Furthermore, it is clear from the existing literature and experience that HVHF activity has resulted in environmental impacts that are potentially adverse to public health. Until the science provides sufficient information to determine the level of risk to public health from HVHF and whether the risks can be adequately managed, HVHF should not proceed in New York State.

Adgate *et al. 2014* [163] commented,

> *Major uncertainties are the unknown frequency and duration of human exposure, future extent of development, potential emission control and mitigation strategies, and a paucity of baseline data to enable substantive before and after comparisons for affected populations and environmental media. Overall, the current literature suggests that research needs to address these uncertainties before we can reasonably quantify the likelihood of occurrence or magnitude of adverse health effects associated with unconventional natural gas production in workers and communities.*

Shonkoff, Hays and Finkel [164] 2014 concluded in their review that,

> *Despite a growing body of evidence, a number of data gaps persist. Most importantly, there is a need for more epidemiological studies to assess associations between risk factors, such as air and water pollution and health outcomes among populations living in close proximity to shale gas operations*.

The Medical Journal of Australia 2014

In April 2014, Dr Coram wrote, [165]

> *The uncertainties surrounding the health implications of unconventional gas, when considered together with doubts surrounding its greenhouse gas profile and cost, weigh heavily against proceeding with proposed future developments.*

[163] Adgate J, Goldstein B, and McKenzie L. 2014 Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development in Environmental Science and Technology, dx.doi.org/10.1021/es404621d | Environ. Sci. Technol

[164] Shonkoff S, Hays J, Finkel M. 2014. Environmental Public Health Dimensions of Shale and Tight Gas Development http://dx.doi.org/10.1289/ehp.1307866

[165] Coram A, Moss J, Blashki G. 2014. Harms unknown: health uncertainties cast doubt on the role of unconventional gas in Australia's energy future. Med J Aust 2014; 200 (4): 210-213. doi: 10.5694/mja13.11023

The health and environmental impacts of hydraulic fracturing have been the source of widespread public concern. A review of available literature shows a considerable degree of uncertainty, but an emerging consensus about the main risks.

While the health effects associated with fracturing chemicals have attracted considerable public attention, risks posed by wastewater, community disruption and the interaction between exposures are of also of concern.

The health burdens of unconventional gas are likely to fall disproportionately on rural communities, the young and the elderly.

In conclusion, Dr Coram writes, [166]

The current evidence does not provide a clear picture of the health implications accompanying the proposed expansion of Australia's unconventional gas industry. In some cases, this is because of gaps in our knowledge that could be rectified, while other risks are inherently uncertain because they involve complex systems and interacting health pathways. It is important to note that the absence of concrete evidence of harm does not equate to evidence of its absence. (my emphasis)

32.3 Concerns expressed by medical organisations

Medical associations worldwide are raising concerns about climate change and public health. The uncertainties associated with UCG and the potential for harm is clearly a concern for public health associations around the world.

Doctors for the Environment Australia have listed four main concerns

1. The stress and impairment of well-being due to permanent alienation of people's land.

2. The known and un-knowable health problems from liquid chemical injection into fossil deposits with contamination of water sources.

3. The health problems due to surface escape of chemicals causing air, soil and water pollution.

4. The global health problems due to gas. Gas is simply another fossil fuel that, when burnt, will increase greenhouse gases.

33 Precautionary principle

As defined by the Wingspread conference, [167]

[166] Coram A, Moss J, Blashki G. 2014. Harms unknown: health uncertainties cast doubt on the role of unconventional gas in Australia's energy future. Med J Aust 2014; 200 (4): 210-213. doi: 10.5694/mja13.11023

When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.
In this context the proponent of an activity, rather than the public, should bear the burden of proof.
The process of applying the Precautionary Principle must be open, informed and democratic and must include potentially affected parties.
It must also involve an examination of the full range of alternatives, including no action.

All governments in Australia, including the South Australian State Government, agreed to a National Strategy for Ecologically Sustainable Development (ESD) which stated that all decisions needed to be guided by the following considerations and principles; the **Precautionary principle**, the principle of **Intergenerational equity** and the **Conservation of biological diversity and ecological integrity.** [168] .

In 2013, the Australian Medical Association President Dr Steve Hambleton, made a similar statement with respect to CSG,

AMA recommends that the precautionary principle should apply. This is essential given the threat of serious and irreversible harms to human health.

There are many examples where use of the precautionary principle would have saved lives, such as with cigarette smoking, asbestos and benzene.

Recommendation 1

The precautionary principle should apply in the case of gas drilling and hydraulic fracturing. This shifts the burden of proving safety onto the proponent rather than the state.

34 Intergenerational equity

The Intergovernmental Agreement on the Environment [169] (1992) states that,

the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations .

Doctors for the Environment Australia (DEA) conclude,

We hold the position that the gas industry should be deemed unsafe because the risks are potentially serious, difficult to manage and likely to be long-lived." [170]

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[167] Wingspread Conference on the Precautionary Principle, January, 1998 see http://www.sehn.org/other.html (accessed 30/12/2014)

[168] Intergovernmental Agreement on the Environment, May 1992. http://www.environment.gov.au/

[169] Intergovernmental Agreement on the Environment, May 1992. http://www.environment.gov.au/

Infants and children are more likely to be exposed to these risks, because they are long lived and so more likely to develop cancers that have a long latency period. [171] Infants and children are physiologically immature and therefore more vulnerable to pollution.

Recommendation 2

A risk assessment is required that takes into account the impact of gas drilling and hydraulic fracturing on future generations and the likelihood of problems arising for these activities.

Recommendation 3

The principle of intergenerational equity considerations must guide any decisions regarding gas drilling and hydraulic fracturing.

35 Climate Change

Climate change is one of, if not the greatest challenge of the 21st Century and will impact on all aspects of our society especially health. The **Global Carbon Project 2014**,[172] warns that if we continue at current rates of greenhouse gas emissions it is likely we will have a 3.2 - 5.4 degree temperature rise by 2100 which is beyond comprehension, and our children will have to experience rapid changes to both human civilisation and their natural world.

Unconventional gas is predominantly methane, a fossil fuel which is 87 times more potent a greenhouse gas than carbon dioxide over a 20 year time frame and 36 times more potent over a 100 year time frame.[173] Gram for gram, methane gas releases less CO_2 compared to coal when used for electricity. However, when a full life-cycle analysis is done, gas does not compare as well to coal, because of fugitive (escaping gas) emissions that occur during exploration and production. The percentage of fugitive emissions from gas production is a subject of hot debate with figures ranging from 1% to 9%.[174] Australian scientist, Dr Paul Hardisty[175] in his analysis said,

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[170] DEA www.dea.org.au

[171] Paulson, J. (2013). Potential Health Impacts of Natural Gas Extraction, Physicians Scientists & Engineers for Healthy Energy, http://www.psehealthyenergy.org/COURSES

[172] Global Carbon Project (2014) Carbon budget and trends 2014. [www.globalcarbonproject.org/carbonbudget] released on 21 September 2014

[173] IPCC 2013 Intergovernmental Panel on Climate Change Fifth Synthesis report

[174] Day, S., Connell, L., Etheridge, D., Norgate, T., Sherwood, N. (2012) Fugitive greenhouse gas emissions from coal seam gas production in Australia. CSIRO, Australia.

[175] Hardisty P, Clark T, Hynes R. 2012. Life Cycle Greenhouse Gas Emissions from Electricity Generation: A Comparative Analysis of Australian Energy Sources. Energies 2012, 5, 872-897; doi:10.3390/en5040872

> *However, if methane leakage approaches the elevated levels recently reported in some US gas fields (circa 4% of gas production) and assuming a 20-year methane Global Warming Potential, the Greenhouse Gas intensity of CSG-LNG generation is on a par with sub-critical coal-fired generation.*

Further research needs to occur in Australia to determine the level of fugitive emissions in gas fields and to look at a full life-cycle analysis to determine if there is an advantage of gas[176] over coal at the current time. Gas will never be as greenhouse friendly as renewable energy, and there is some concern that investment in gas infrastructure diverts money and efforts away from clean energy such as energy efficiency and wind and solar power.[177]

It is not only fugitive emissions that are a concern, but the use of gas as a fossil fuel. As Carbon Tracker [178]said in their article on **Unburnable Carbon**,

> *In 2012, the International Energy Agency (IEA) acknowledged that, in the absence of carbon capture and storage (CCS) technology, more than two thirds of coal, oil and gas reserves cannot be burnt before 2050 if we are to have a 50% chance of limiting global warming to 2°C.*

This means the majority of fossil fuel reserves, including unconventional gas, that we have in the ground needs to remain unused if we are to limit global warming. The investment of public funds in what may well become "stranded" assets deserves far greater consideration and scrutiny.

Recommendation 4:

A full life cycle analysis of fugitive emissions from the gas industry in Australia is required.

36 Psychological harm

36.1 Introduction

These extracts relate to Australian coal seam gas development, but similar psychological impacts are likely to occur with shale gas development.

Doctors for the Environment Australia (DEA) noted in their submission to the NSW Parliamentary CSG Inquiry,[179]

[176] Tollefson, J. (2013). Methane leaks erode green credentials of natural gas. Nature, 493(7430), 12-12. doi: 10.1038/493012a

[177] McJeon H, Edmonds J. et al. 2014, Limited impact on decadal-scale climate change from increased use of natural gas. Nature 514, 482–485 (23 October 2014) doi:10.1038/nature13837

[178] Unburnable Carbon: Australia's carbon bubble. 2013. Carbon Tracker & The Climate Institute.

[179] Doctors for the Environment Australia Inc. (2011) NSW Parliamentary Inquiry into Coal Seam Gas, Submission Number 412, Received 16/09/2011.

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.

Dr Steve Robinson (psychiatrist)[180] explained in his submission what happened in Gloucester, NSW,

Exploration is when the psychological stresses are first noticed in the community... uncertainty starts to generate community anxiety…. The community starts to divide between the few who see it as an opportunity for an additional income and the larger number who hear the risks and see little in the way of benefits. ….Seismic surveys come and go with some damage to paddocks, heavy vehicle traffic ruining country roads, and noise. Drilling occurs with the same complications. The town takes on a different look…Lifetime plans are put on hold or cancelled. Property development in the area declines as a result of the general uncertainty. Rental property is more expensive… The gas company employs very few locals. Exploration wells are fracked to optimize the flow and the wells are flared for months. There is no explanation of the risks and precautions taken in these fracking and flaring operations. There is no publicity given to any air or water testing. There have been at least two separate unpredicted explosions locally due to gas migration known to the community from just a dozen exploration wells…This results in understandable anxiety about safety risks. In Gloucester this first phase has taken 5 years so far and production has yet to commence.

CSIRO Landmark Study [181] demonstrates division of communities with coal seam gas developments in the Western Downs in Qld,

To further summarise how communities were viewing their type of adaption to coal seam gas development, responses were combined into 'favourable' and 'unfavourable' perceptions. Approximately half (51.5%) of the participants felt that their community was adjusting favourably either adapting to the changes or changing into something different, but better. However, the other half of the participants (48.5%) viewed things unfavourably and felt that the community was either resisting CSG, not coping, or only just coping with the changes.

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

[180] NSW Parliament Inquiry into Coal Seam Gas. Dr Steve Robinson submission
http://www.parliament.nsw.gov.au/Prod/parlment/committee.nsf/0/F96D076732225603CA25791B00102098

[181] CSIRO survey of Community Wellbeing and responding to change: Western Downs region in Queensland. 2014. Andrea Walton, Rod McCrea and Rosemary Leonard

Dr Geralyn McCarron performed a health survey in Tara Queensland in 2012, and 18 months later followed up on the participants,

> *Of the 113 people surveyed, 41 (36%) have permanently left the area, 2 are determined to stay, 15 (13%) are trying desperately to get out. Some of the families have walked away with nothing, while 6 families were bought out by the gas company under confidentiality agreements.*[182]

A study of the impacts of mining and CSG operations on the mental health of landholders in Queensland concluded that,

> *these operations placed rural communities under sustained stress, with study participants perceiving that these operations "significantly impacted or exacerbated issues such as the health, social fabric and economy of the community", and the authors noting that local health services faced "unsustainable pressure".*[183]

Dr Wayne Somerville [184] psychologist has written,

> *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.*
>
> *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 and diminished quality of lifestyle.*

Australian psychiatrist **Glenn Albrecht** [185] has coined the term "Solastalgia" to mean a loss of solace which describes the distress that people who are connected to the land feel when their environment is damaged.

36.2 Potential psychological impacts beyond South East

In Australia, there is a risk that psychological harm caused by damage to the rural and remote landscape will impact upon city dwellers and Australia as a nation, not just the few

[182] Personal communication with Dr McCarron.

[183] Hossain D, Gorman D, Chapelle B, et al. Impact of the mining industry on the mental health of landholders and rural communities in southwest Queensland. Australas Psychiatry 2013; 21: 32-37.

[184] Dr Wayne Somerville 2013, Report on the Health Impacts of CSG and Shale Gas Mining. www.creeksbend.com/csg

[185] Albrecht, G.A. (2005). Solastalgia: A New Concept in Human Health and Identity, in PAN (Philosophy, Activism, Nature), Issue 3, 41-55.

residents who reside in rural and remote areas. Despite a city-dwelling lifestyle, Australians hold a great cultural love and affinity with their rural and remote landscape. This is evidenced by the huge increase in our 'grey nomads'. A vast proportion of Australians, from all cultural and socio-economic backgrounds, plan to tour the country for the purpose of viewing and experiencing the 'real Australia' when they retire. The love for Australia's rural and remote landscape is further evidenced by the popularity, both within Australia and overseas, of movies such as 'Australia', 'Crocodile Dundee', 'Picnic at Hanging Rock' and television series and identities such as the late Steve Irwin and his daughter Bindi. And this is further evidenced by the increased vote and interest in both The Green Party [186] and Katter's Australian party.[187]

At the moment, city dwellers in Australia are largely unaware, and relatively unconcerned by the changes created by mining in their regional, rural and remote landscapes. Australia is the most urbanized country in the world and South Australia has the most centralised urban population within this construct. As a result, Australian city dwellers, and particularly most Adelaideians tend primarily to only observe the changes in the rural and remote landscape as tourists or when they are informed about pending damage by campaigns such as those that gave rise to the Tasmanian Dams Legislation for the protection of Lake Pedder, and the Franklin River. When Australians travel, and become increasingly more informed, about the impacts of fracking on the landscape they are likely to become alarmed, distressed and saddened. If fracking is permitted, South Australia will no longer look like the country to which its residents imagined they belonged.

South Australians are aware that there are gas wells and mines in remote areas. They do not imagine that these gas wells and mines will overtake the landscape that they all call home.

36.3 Social Costs of Gas developments

A Social impact assessment performed in the Bowen Basin in Queensland [188] reported that,

> Mining industrialisation in some communities has led 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*.

The **House of Representatives Standing Committee on Regional Australia** report on 'Fly-in, fly-out and drive-in, drive-out workforce practices in regional Australia' [189]said,

[186] Victorian State election 2014

[187] Queensland State election 2015

[188] Petkova V, Lockie, S., Rolfe, J. and Ivanova, G. 2009. Mining developments and social impacts on communities: Bowen Basin case studies. Rural Society, Oct 2009, 19(3), 211-228.

While these arrangements have some benefits, they have come under scrutiny for their negative influence on community cohesion, increasing the cost of living, and their association with high levels of alcohol and drug use, mental health issues and violence (although these latter are also more generally associated with the demographic of young men who make up most of these workers).

The Chief Medical Officer of Health in New Brunswick Canada [190] commented on the Boomtown Effect,

One particular possible social and community health risk that the Province will need to guard against is the "Boomtown Effect" that can arise during economic development. This effect occurs when a rapid change in population, industrialization and economic prosperity also leads to a host of social ills that impact community health. These can include increased rates of crime, drug and alcohol abuse, sexually-transmitted infections (STIs), and domestic violence; inadequate supply and quality of housing; increased cost of living; increased community dissatisfaction; increased mental health and social services case loads; increased hospital admissions; insufficient infrastructure; and insufficient capacity in public services, including policing, local government, social services, and health care.

The Boomtown Effect is thought to be more intense for small communities with a traditional way of life that did not previously involve the industrial sector responsible for the boom, so there may be a risk to New Brunswick communities unless this effect is anticipated and mitigated through strategic investments.

Social Costs of Fracking; A Pennsylvania Case Study by **Food and Water Watch**[191] in 2013

Food & Water Watch found that fracking undermined the quality of life in Pennsylvania's rural communities.

Key findings;

• Fracking is associated with more heavy-truck crashes: Heavy-truck crashes rose 7.2 percent in heavily fracked rural Pennsylvania counties (with at least one well for

[189] House of Representatives Standing Committee on Regional Australia. Cancer of the bush or salvation for our cities? Fly-in, fly-out and drivein, drive-out workforce practices in regional Australia. Canberra: Commonwealth of Australia, 2013.
http://www.aph.gov.au/parliamentary_business/committees/house_of_representatives_committees?url=ra/fifodido/report.htm (accessed Nov 2013).

[190] The Chief Medical Officer of Health's Recommendations Concerning Shale Gas Development in New Brunswick. 2012. Office of the Chief Medical Officer of Health (OCMOH) New Brunswick Department of Health.

[191] Social Costs of Fracking; A Pennsylvania Case Study by Food and Water Watch, Sept 2013. www.foodandwaterwatch.org

every 15 square miles) but fell 12.4 in unfracked rural counties after fracking began in 2005.

• Fracking is associated with more social disorder arrests: Disorderly conduct arrests increased by 17.1 percent in heavily fracked rural counties, compared to 12.7 percent in unfracked rural counties.

• Fracking is associated with more cases of sexually transmitted infections: After fracking, the average increase in chlamydia and gonorrhea cases was 62 percent greater in heavily fracked rural counties than in unfracked rural counties.

The shale oil and gas boom generates tangible social costs that undermine the quality of life in rural communities. Communities and states must take these real costs into account when they consider approving controversial new oil and gas fracking.

In North Dakota, the influx of young male fracking workers, many of whom retain their primary homes elsewhere and live in man camps, has created an unsafe atmosphere for women and given the state the nation's third-highest single male-to-female ratio.

36.4 Mental illness and suicide risk

Unconventional Gas developments can cause conflict for land use, damage and loss of natural environment, and loss of beauty and biodiversity. The natural environment is important for our sense of well-being and loss or damage to it, may become overwhelming and lead to a feeling of powerlessness, anger, increase substance abuse, stress and mental illness. Suicide can result.

In the Limestone Coast, between June 2009 and August 2013, one person committed suicide every seven (7) weeks.[192] This is particularly the case with men, and a recent study[193] has shown that men in regional and remote areas were 1.3 to 2.6 times more likely to suicide than their urban counterparts. At least two-thirds of all farmer suicides occur in older age groups, and mainly in those over the age of 55. Suicide has increased for people in remote areas, and among particular marginalised groups, including indigenous people and disadvantaged males.

Factors relevant to unconventional gas developments and suicide are that economic change leading to financial insecurity and vulnerability may make suicide more likely especially for men and older people. Substance abuse, drought, floods and bushfires also increase the risk of suicide.

[192] Superintendent Trevor Twilley (2013) http://www.abc.net.au/local/stories/2013/08/08/3821329.htm

[193] National Rural Health Alliance Fact Sheet 14 Suicide in rural Australia MAY 2009

36.5 Summary

It is clear that there are social and mental health implications to communities imposed upon by unconventional gas developments. There may be financial benefits to the state although these are relatively small and will be short-lived, but it is the rural community near the UCG development who will face the most significant changes. The boom and bust cycle [194] associated with mining developments, and also expected with unconventional gas, leads to an increased male to female ratio, inadequate supply and quality of housing and increased cost of living. Other studies of impacts with gas developments have shown increased road accidents, sexually transmitted diseases, substance abuse, and violence in these communities. This will place pressure on already stretched health workers, rural hospitals and emergency support services. This may lead to divisions within communities, stress, mental illness, and potentially suicide. Rural communities in South Australia have poor mental health services and often have to travel to Adelaide for treatment which will put more pressure on beds in Adelaide.

Recommendation 5

Research is required into the unforeseen consequences from the industrialisation of a rural community, with reference to prevention and management of these risks and the unknown long term and intergenerational impacts.

37 Pathways of contamination

Contaminants reach human receptors through environmental pathways, namely air, soil, water, and food. Each contaminant or stressor has specific sources, transport, exposure mechanisms, and biochemistry; and each can impact health both directly and indirectly. [195]

Airborne contaminants such as particulates, sulfur and nitrogen oxides, hazardous volatile organic compounds, hydrogen sulfide, ozone, noise, and radiation.

Soil or water borne contaminants such as hydrocarbons, chemicals, heavy metals, and radiation.

Food contamination - by some of the above can also impact on human health.

Toxic chemicals are used or released by unconventional gas and fracking, and contamination may occur via a physical mechanism for exposure (through leaks, spills, loss of well integrity

[194] Petkova V, Lockie, S., Rolfe, J. and Ivanova, G. 2009. Mining developments and social impacts on communities: Bowen Basin case studies. Rural Society, Oct 2009, 19(3), 211-228.

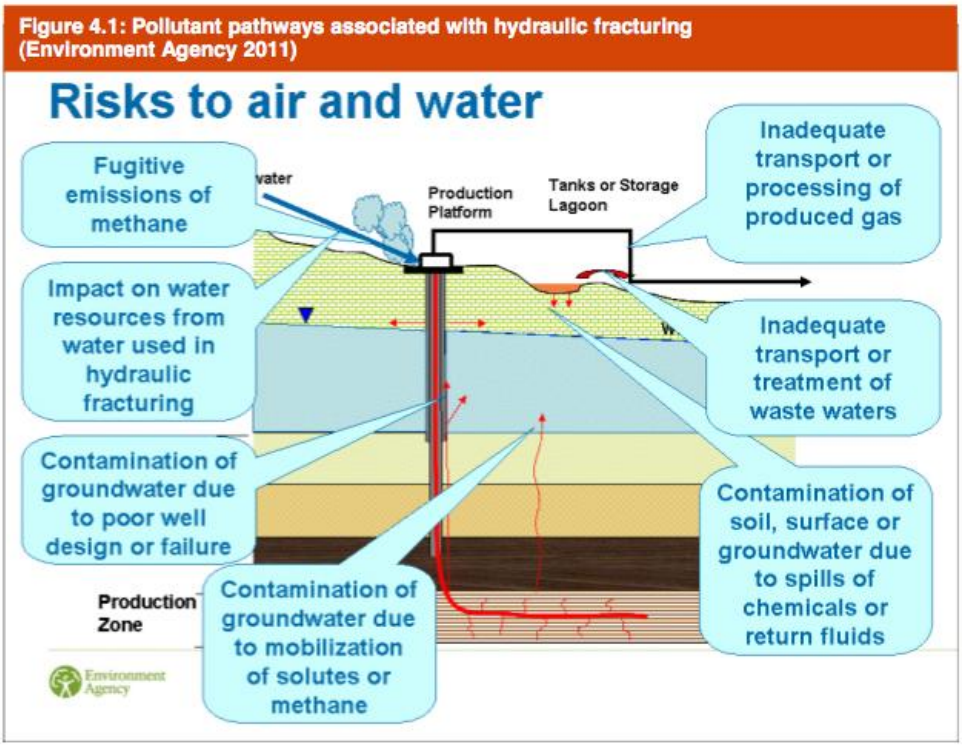
[195] Krzyzanowski, J 2012; Environmental pathways of potential impacts to human health from oil and gas development in northeast British Columbia, Canada. Environ. Rev. 20: 122–134 (2012)

etc), which gives a pathway for harm. And there are studies to support both toxicity and potential exposure routes.

Shonkoff, Hays and Finkel (2014) [196] in a review, looked at the body of evidence that focused on exposure pathways and similarly wrote,

> *There is evidence of potential environmental public health risks associated with shale gas development.*
>
> Air; *A number of studies suggest that shale gas development contributes to levels of ambient air concentrations known to be associated with increased risk of morbidity and mortality.*
>
> Water; *Similarly an increasing body of studies suggest water contamination risks exist through a variety of environmental pathways, most notably during wastewater transport and disposal and via poor zonal isolation of gases and fluids due to structural integrity impairment of cement in gas wells.*

Diagram of Risks to air and water from Environmental Agency 2011



[196] Shonkoff S, Hays J, Finkel M. 2014. Environmental Public Health Dimensions of Shale and Tight Gas Development http://dx.doi.org/10.1289/ehp.1307866

38 Health studies

There have been an increasing number of papers in scientific literature regarding unconventional gas and health. A recent review performed for the **New York Department of Health** [197] outlines some of these studies.

38.1 The European Commission

Published a report by Dr Mark Broomfield [198] on the results of a preliminary screening of potential public health and environmental risks related to High Volume Hydraulic Fracturing (HVHF) in Europe, along with risk management recommendations. The Commission determined that,

> *High Volume Hydraulic Fracturing in Europe will entail "high" cumulative risks of groundwater contamination, surface water contamination, depletion of water resources, releases to air, increased noise, and increased traffic.*

38.2 Marcellus Shale Public Health Report

The **Maryland Department of the Environment** and the **Maryland Department of Natural Resources** released an assessment of the potential public health impacts associated with drilling in the Marcellus Shale in Maryland. [199]

> *The report presents a hazard evaluation summary of eight potential adverse impacts, rating four (air quality, healthcare infrastructure, occupational health, and social determinants of health) as having a high likelihood of negative public health impact.*
>
> *Three potential impacts (cumulative exposures/risks, flowback and production water-related, and noise) were rated as moderately high, and one (earthquakes) was rated as low.*

38.3 Graham Sustainability Institute University of Michigan

Released a series of reports for comment in 2013, [200]

[197] Department of Health. New York State. December 2014. A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development. Dr Howard Zucker, Acting Commissioner for Health.

[198] Broomfield, M AEA (2012). Report for European Commission DG Environment. Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe.

[199] Maryland Department of the Environment and the Maryland Department of Health and Mental Hygiene (2014). Potential Public Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland.

which identified 18 issues with eight given the highest plausibility score; silica exposure, intentional-use chemicals, by-product chemicals, transportation, air quality, water quality, habitat and wildlife (impacts on recreational opportunities, cultural/spiritual practices), and public perceptions (causing e.g., increased anxiety, family quarrels, depression).

38.4 Inter-Environmental Health Sciences Core Center Working Group (USA)

Issued its recommendations on Unconventional Natural Gas Drilling Operations [201] and concluded,

> *that there are data gaps and uncertainties regarding impacts and the effectiveness of HVHF mitigation measures....*and *...a potential for water and air pollution exists which might endanger public health, and that the social fabric of communities could be impacted by the rapid emergence of drilling operations.*

38.5 Studies not yet available

The New York Department of Health [202] review outlined several ongoing studies which will try to fill in knowledge gaps including Marcellus Shale Initiative Study, the University of Colorado at Boulder, Sustainability Research Network, the EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources, the Pennsylvania Department of Environmental Protection (PA DEP) Comprehensive Oil and Gas Development Radiation Study and the University of Pennsylvania Study.

38.6 Limestone Coast Health Assessment Study

There has been no attempt by the State Government to develop or establish a baseline study of the health of the Limestone Coast of South Australia.

Listed here are some of the recommendations made by Bamberger and Oswald [203]from New York regarding health studies,

- *Testing before and during drilling operations is an important part of documenting health effects.*

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[200] Basu, N (2013). University of Michigan School of Public Health. Public Health and Hydraulic Fracturing in Michigan. Hydraulic Fracturing in the State of Michigan.

[201] Penning, T University of Pennsylvania (2014). Inter-Environmental Health Sciences Core Center Working Group on Unconventional Natural Gas Drilling Operations

[202] Department of Health. New York State. December 2014. A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development. Dr Howard Zucker, Acting Commissioner for Health.

[203] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

- *The sampling must be done by a disinterested third party with a clear chain of custody between sampling and testing. A certified independent laboratory must do the testing, and the results must be available to all interested parties.*
- *Sampling must then be repeated at intervals following the commencement of drilling as well as upon suspicion of adverse effects.*
- *All chemicals (with IUPAC names and CAS numbers) used in the hydraulic fracturing fluid at any concentration for each well must be disclosed to the property owners within a five-mile radius, testing laboratories, local governments, and state agencies.*
- *Material Safety Data Sheets (MSDSs) for each chemical and chemical mixture must accompany this disclosure. Following this procedure will allow prior testing to be targeted to specific chemicals to be used in the drilling process for a specific well, as well as providing valuable information to first responders and hospital personnel in the case of an accident.*
- *Upon suspicion of adverse health effects, testing must include air, soil, wastewater, all sources of drinking water, and blood, urine and tissue samples from affected animals and humans. If methane is present in drinking water, isotopic analysis to determine the origin (thermogenic vs. biogenic) must be done.*
- *All testing expenses must be a part of the cost of doing business for gas drilling companies.*

Recommendation 6

Limestone Coast Health Assessment Study

Before any gas extraction were to be allowed to occur, a comprehensive, ongoing and detailed study of the entire region should be undertaken, to include the health of humans, animals and plants, with samples kept for future comparative analysis. Water, soil and air samples should be collected from a large number of sites across the region in addition to tissue samples from humans, animals and plants, as a baseline against which future similar samples could be measured.

This study would need input from organisations such as Doctors for the Environment and public health professionals.

39 Birth and reproductive issues

Several studies have shown an association between UCG and birth defects or low birth weight and have indicated the need for more ongoing studies in this area.

Adgate *et al*. 2014 [204] wrote,

[204] Adgate J, Goldstein B, and McKenzie L. 2014 Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development in Environmental Science and Technology, dx.doi.org/10.1021/es404621d | Environ. Sci. Technol.

While these preliminary epidemiological studies are hindered by a lack of spatial and temporal specificity in exposure and individual level risk factors, they underscore the need for a better understanding of exposures and health effects in populations living in UNG development and production areas.

Birth defects

- A retrospective study of 124,862 births in rural Colorado indicated an association between maternal proximity to natural gas well sites and birth prevalence of congenital heart defects and neural tube defects, but no association with oral clefts, term low birth weight or preterm birth. [205]
- A working paper exploring 1,069,699 births in Pennsylvania reported increased prevalence of low birth weight and small for gestational age births, as well as reduced appearance, pulse, grimace, activity, respiration (APGAR) scores in infants born to mothers living within 2.5 km of a natural gas well compared to infants born to mothers living further than 2.5 km from a well. [206]

Developmental and Reproductive issues

Webb, Bushkin-Bedient *et al.* [207] studied more than 150 papers from 1970 to 2014 that analyzed the compounds and metals released in UCG, looking at how they affect humans as well as animals. As reported in US News, [208]

Children and developing fetuses are especially vulnerable to environmental factors. The risks from exposure to toxic chemicals, heavy metals and radioactive materials include a parent's worst nightmares: infertility, miscarriage or spontaneous abortion, impaired fetal growth, and Low Birth Weight. The report also sounded an alarm about possible birth defects and long-term chronic conditions the symptoms for which may not emerge for years.

Key findings,

[205] McKenzie, L. M.; Guo, R.; Witter, R. Z.; Satvitz, D. A.; Newman, L. S.; Adgate, J. L. Maternal residential proximity to natural gas development and adverse birth outcomes in rural Colorado. Environ. Health Perspect. 2014, DOI: 10.1289/ehp.1306722.

[206] Hill, E.L. (2013, December). Shale Gas Development and Infant Health: Evidence from Pennsylvania (under review). http://www.elainelhill.com/research

[207] Webb E, Bushkin-Bedient S, Cheng A, Kassotis C, Balise V and Nagel S. 2014. Developmental and reproductive effects of chemicals associated with unconventional oil and natural gas operations. Rev Environ Health 2014; 29(4): 307–318

[208] http://www.usnews.com/news/special-reports/energy-of-tomorrow/articles/2014/12/05/fracking-linked-to-infertility-miscarriages-birth-defects

- *Exposure to chemicals associated with Unconventional Oil Gas operations has been associated with reduced semen quality in men and laboratory animals.*
- *Unconventional Oil Gas chemicals have been associated with adverse effects on the menstrual cycle and overall fecundity in women.*
- *Direct epidemiological associations between UOG development and miscarriage is lacking, but exposure to heavy metals during pregnancy is associated with increased risks of miscarriage and/or stillbirths. Exposure to benzene and toluene, commonly used and produced by UOG operations, have been associated with increased risks for miscarriage .*
- *Paternal occupational exposure to toluene and formaldehyde has also been linked to miscarriage in their partners.*

Animal studies

Bamberger and Oswald [209] make the comment that,

> *Contamination of food can be passed to breast milk and infants.*

In their paper they presented this case study,

> *At one farm, 140 head were exposed when the liner of a wastewater impoundment was allegedly slit, as reported by the farmer, and the fluid drained into the pasture and the pond used as a source of water for the cows.*
>
> - *Of those 140 head exposed to the wastewater, approximately 70 died and there was a high incidence of stillborn and stunted calves.*
> - *The remainder of the herd (60 head) was held in another pasture and did not have access to the wastewater; they showed no health or growth problems.*
>
> *These cases approach the design of a controlled experiment, and strongly implicate wastewater exposure in the death, failure to breed, and reduced growth rate of cattle.*

Autism

Autism is increasing in Australia and studies have linked industrial chemicals with this increase. Some of these chemicals, such as arsenic and toluene, are used in or produced by unconventional gas operations.

> *Neurodevelopmental disabilities, including autism, attention-deficit hyperactivity disorder, dyslexia, and other cognitive impairments, affect millions of children worldwide, and some diagnoses seem to be increasing in frequency. Industrial chemicals that injure the developing brain are among the known causes for this rise in*

[209] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

prevalence. In 2006, we did a systematic review and identified five industrial chemicals as developmental neurotoxicants: lead, methylmercury, polychlorinated biphenyls, arsenic, and toluene. Since 2006, epidemiological studies have documented six additional developmental neurotoxicants—manganese, fluoride, chlorpyrifos, dichlorodiphenyltrichloroethane, tetrachloroethylene, and the polybrominated diphenyl ethers.[210]

40 Acute health effects

Pennsylvania Survey

Rabinowitz *et al*. 2014 [211] conducted a preliminary study and found,

> s*ome evidence that residential proximity of natural gas wells may be associated with the prevalence of certain health symptoms, largely acute or self-limiting dermal and upper-respiratory conditions. People who lived less than 1 kilometer away from a well were more than four times as likely to have symptoms than the control group, composed of those who live more than 2 kilometers away. The major symptoms seem to be upper-respiratory symptoms, including "coughing … itchy eyes, nosebleeds" as well as skin problems such as rashes, itching and burning. The study does not claim that the wells cause the health problems, which requires further investigation to determine.*

Tara Survey

In this Queensland health survey at Tara, Dr Geralyn McCarron [212] noted,

> *A range of symptoms were reported which can sometimes be related to neurotoxicity (damage to the nervous system), including severe fatigue, weakness, headaches, numbness and paraesthesia (abnormal sensations such as pins and needles, burning or tingling).*
>
> *Approximately a third of all the 48 children to age 18 (15/48) were reported to experience paraesthesia.*
>
> *Almost all the 31 children aged 6-18 were reported to suffer from headaches and for over half of these the headaches were severe.*

[210] Grandjean P. 2014. Neurobehavioural effects of developmental toxicity. The Lancet Neurology, Volume 13, Issue 3, Pages 330 - 338, March 2014

[211] Rabinowitz P, Slizovskiy I, Lamers V, Trufan S, Holford T, Dziura J et al. 2014. Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania. ENVIRONMENTAL HEALTH PERSPECTIVES. http://dx.doi.org/10.1289/ehp.1307732

[212] McCarron G. 2013. Symptomatology of a gas field, An independent health survey in the Tara rural residential estates and environs. http://www.ntn.org.au/wp/wp-content/uploads/2013/05/Symptomatology-of-a-gas-field-An-independent-healthsurvey-in-the-Tara-rural-residential-estates-and-environs-April-2013.pdf

Of people aged 6 years and over, severe fatigue and difficulty concentrating was reported for over half. Parents of a number of young children reported twitching or unusual movements, and clumsiness or unsteadiness.

Animal effects

Introduction

A paper by Michelle Bamberger and Robert Oswald [213] in 2012, investigated case studies in animals that are highly suggestive of toxicity in animals, but requires further studies with analysis of soil, air and water and animal tissues to determine risks to human health. They investigated,

the impact of gas drilling on animal health in six US states, (Colorado, Louisiana, New York, Ohio, Pennsylvania, Texas) and documented cases of reproductive (e.g., irregular cycles, failure to breed, stillbirths), neurological (e.g., seizures, incoordination, ataxia), gastrointestinal (e.g., vomiting, diarrhoea), and dermatological (e.g., hair and feather loss, rashes) problems among livestock exposed to gas mining contaminants. Where possible they obtained results of water, soil, and air testing as well as the results of laboratory tests on affected animals and their owners.

More than one-third of the cases involved conventional wells (shallow or deep vertical wells), with the remainder comprising horizontal wells subjected to high-volume hydraulic fracturing.

Animals as sentinels of health effects

Bamberger and Oswald [214] write,

Animals are likely to be sentinels of health effects – as they are more continually exposed to air, soil and water and have more frequent reproductive cycles and more offspring. Illness in cows, horses, poultry, and other wildlife can foreshadow impacts to human health.

First, clear health risks are present in gas drilling operations. These cannot be eliminated but can be decreased by commonsense reforms.

Second, our study illustrates not only several possible links between gas drilling and negative health effects, but also the difficulties associated with conducting careful studies of such a link.

[213] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

[214] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

Again, simple commonsense policy reforms could facilitate the collection of data that would lead to a careful assessment of the health consequences of gas drilling on both humans and animals.

Bamberger and Oswald [215] outline these two cases,

Case 1;

Two homes (A and B) are located within two miles of approximately 25 shale gas wells. The closest pad, drilling mud pit, and wastewater impoundment are within one mile of both homes. These two families 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. After one month of being away, the phenol levels as well as the symptoms of the children in Home B decreased, while the owner of Home B, who returns to the home for a few hours each day, has increased phenol levels and worsening of symptoms.

Case 2;

A creek into which wastewater was allegedly dumped was the source of water for 60 head, with the remaining 36 head in the herd kept in other pastures without access to the creek.

- *Of the 60 head that were exposed to the creek water, 21 died. Of the 39 cows that survived, 16 failed to breed and several cows produced stillborn calves with white and blue eyes.*
- *Of the 36 that were not exposed, no health problems were observed, and only one cow failed to breed.*
- *The farm is located in an area of intensive gas drilling, with two active shallow vertical gas wells on the farmer's property and approximately 190 active gas wells within five miles of the property; of these, approximately 11 are shale gas wells and approximately 26 are deep vertical gas wells.*

41 Air impacts

41.1 Introduction

The air pollution problem for Australia with the potential growth in the oil and gas industry will be significant, as evidenced by what has occurred in the U.S.A and in the Eastern states. These impacts will not only be felt on resident communities, but be a deterrent and a health concern to visitors and tourists alike. Native flora and fauna, and our food supply - livestock, crops, and wine - may also be negatively impacted on by air pollution.

[215] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

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The discussion below covers the industry sources of air pollution and evidence for this. The recognition that air pollution causes cancer, the special impacts on children, the main air pollutants and their health effects. Special cases discussed are flaring, diesel emissions and proppants. Lastly a discussion on the national standards and the difficulties surrounding gas field air pollution and some recommendations.

41.2 Sources of main pollutants from gas drilling and fracking

The United Kingdom's Public Health Association identified UCG activities as sources of air pollution by primary pollutants such as oxides of nitrogen (NOx) and particulate matter (PM) and the precursors of secondary pollutants such as ozone (O_3). [216] They highlighted a diverse range of sources and air pollutants associated with the unconventional gas industry including

- ***Carbon monoxide*** *- CO is emitted during flaring and from machinery used in CSG.*
- ***Sulfur dioxide*** *- CSG may contain traces of sulfur, which can be emitted during flaring or from equipment onsite.*
- ***Hydrogen sulfide*** *– H_2S occurs naturally in some gas formations and can be released when gas is vented or flared, or via fugitive emissions.*
- ***Nitrogen Oxides*** *- NOx are emitted from machinery and compressors as well as during flaring.*
- ***Particulate Matter*** *- Particulate matter can be emitted during construction, venting, flaring and transport operations.*
- ***Volatile organic compounds*** *- VOCs can be emitted during drilling, flaring, from machinery and from produced water.*
- ***Hydrocarbon Gases*** *- while the primary component of gas is methane, it typically contains other hydrocarbons such as ethane, propane, butane, and pentanes and in some cases, may also contain hazardous air pollutants such as BTEX, hexanes, hydrogen sulphide, and carbon dioxide.*

41.3 Air pollution in U.S.A. from oil and gas industry

The U.S.E.P.A. 2013; [217]

[216] Kibble A et al. 2013. Draft for Comment; Review of Potential Public Health Impacts of Exposures to Chemicals and Radioactive Pollutants as a result of Shale Gas Extraction. Department of Health. Public Health England.

[217] The United States Environmental Protection Agency, Office of the Inspector General. EPA needs to improve air emissions data for the oil and natural gas production sector. February 20, 2013.Report No. 13-P-016.

> *Recent and projected growth in the oil and gas production sector has underscored the need for the Environmental Protection Agency to gain a better understanding of emissions and potential risks from this industry sector.*
>
> *Harmful pollutants emitted from this industry include air toxics such as benzene, toluene, ethylbenzene, and xylene; criteria pollutants and ozone precursors such as Nitrous Oxides and Volatile Organic Compounds; and greenhouse gases such as methane. These pollutants can result in serious health impacts such as cancer, respiratory disease, aggravation of respiratory illnesses, and premature death.*

It is recognised by the EPA that the oil and gas industry is the largest industrial source of volatile organic compound emissions in the U.S.,

> *Once considered a summertime pollutant, ozone had now become a problem in winter in areas with significant natural gas production.*[218]

As a result of this, legislation in the U.S.A has been significantly overhauled both federally and in many states, with ongoing improvements and tightening up of legislation. Here are some examples.

Dish, Texas

Residents in Dish, Texas have been complaining of air pollution associated with human and animal illness as far back as 2009. As there is no other industrial activity in that region, natural gas extraction activities in and around the city are believed to be the only source of these impacts.

A study in 2009 [219], confirmed,

> *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 TCEQ regulations. Of particular concern are those compounds with potential for disaster as defined by TCEQ [Texas Commission on Environmental Quality].*

Stricter legislation has improved air quality in the USA

In 2014, **The Texas Commission on Environmental Quality** (TCEQ) noted improvement in legislation has led to improvements in air quality,[220]

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[218] Reducing Air Pollution from the Oil and Natural Gas Industry EPA's Final New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants, April 17, 2012 http://www.epa.gov/airquality/oilandgas/pdfs/20120417presentation.pdf

[219] http://www.townofdish.com/objects/Dish_Texas_Ambient_Air_Monitoring_Analysis.pdf or http://passthrough.fw-notify.net/download/907202/http://www.townofdish.com/objects/DISH_-_final_report_revised.pdf

Point source emissions limits in Texas have been tightened during the last decade to address the oil and gas industry and the impact this has on air pollution and ozone levels. This includes the addition of several new regulations: a new Barnett Shale Permit by Rule and Standard Permit; the new Maintenance, Startup and Shutdown PBR that applies statewide to the oil and gas sector; a North Texas Gas Compressor rule to control NOx emissions; and the EPA's New Source Performance Standard for which the TCEQ is the delegated authority.

It is clear that regulation can improve air quality.

41.4 Air pollution in Australia from gas fields

National Pollutant Inventory of Emissions

Air pollution from gas projects is seen as a major and growing contributor to emissions in Australia as pointed out by the National Toxic Network, [221]

The Australian government's National Pollutant Inventory (NPI) requires companies to self report their calculated emissions for a limited list of around 100 chemicals and heavy metals. The NPI indicates that toxic air emissions are increasing over time. Data submitted by QGC (British Gas) to the NPI46 for their emissions in 2010 and in 2013 demonstrate clearly the escalation of air pollution. Particulate matter increased by 126 times from less than 16 thousand kilograms in 2010 to almost 2 million kilograms three years later. Carbon monoxide emissions were 17 times higher at over a million kilograms and the emission of total volatile organic compounds or VOCs had escalated 100 times to 262,000 kilograms in 2013. In 2013 QGC emitted 62,000 kilograms of formaldehyde into the air whereas none had been reported in 2010.

This increase in particulate matter, carbon monoxide, volatile organic compounds and formaldehyde increases air pollution and can have negative health consequences.

While Coal seam gas and shale gas differ in the geological formations targeted and some of the technology, air pollutants are the same.

Tara coal seam gas fields

A health survey of residents near the Tara Coal Seam Gas field conducted by Brisbane GP, Dr Geralyn McCarron[222] and referred to by Dr Mariann Lloyd-Smith from the National Toxic Network [223] found that,

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[220] https://www.tceq.state.tx.us/news/releases/12-14airquality

[221] National Toxic Network. 2014. Submission to the Tasmanian Fracking Inquiry

[222] McCarron G. 2013. Symptomatology of a gas field, An independent health survey in the Tara rural residential estates and environs

> *In the Tara gasfields in Qld, there has been no comprehensive monitoring of air pollutants, but industry and government sampling of ambient air around homes has detected a wide range of VOCs. These included many toxic VOCs. Toluene, a neurotoxin was detected in the air around at least eight Tara homes and in the air over a private bore. In the latter,* [224] *it was well above the 'Chronic Reference Exposure Limits' used by many states in the USA (e.g. California, Massachusetts, Michigan) for assessing the impacts of long term exposure. Community sampling in the vicinity of gas activities over an eight hour period also detected ethanol and chlorofluorocarbons (CFCs).*[225] *In July 2014, State government sampling outside a family residence adjacent to the gasfields identified Acrolein at 9.6ppb, more than 100 times higher than acceptable chronic exposure standard.* [226] *Formaldehyde, as well as acetaldehyde was also detected.*

Many residents in Tara are experiencing symptoms of acute exposure to chemicals with eye and skin irritation, nose bleeds, headaches and nausea. Some are experiencing neurological symptoms such as paraesthesia and fitting.[227]

There are cumulative effects of air pollution arising from living in a gas field - the more gas wells the higher the risks of air pollution.

41.5 Air pollution is a health hazard

WHO Statement

In 2013 the World Health Organization declared that outdoor air pollution is carcinogenic.

> *Particulate matter, as well as being a carcinogen has widespread adverse health impacts including heart attacks, strokes, diabetes, asthma, hypertension and renal disease amongst others.* [228]

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[223] National Toxic Network. 2014. Submission. Review of hydraulic fracturing in Tasmania. Available from Tasmanian review website.

[224] Simtars Investigation of Kogan Water Bore (RN147705) -16 October 2012

[225] Australian Government National Measurement Institute, Report of Analysis of Air Canisters Low Level, Report No. RN900555 (2 Feb 2012), Report No. RN893233 and Report No. RN893232 (16 Dec 2011)

[226] McCarron G. 2014. Submission to the Senate Select Committee on Certain Aspects of Queensland Government Administration related to Commonwealth Government Affairs.

[227] McCarron G. 2013. Symptomatology of a gas field, An independent health survey in the Tara rural residential estates and environs. http://www.ntn.org.au/wp/wp-content/uploads/2013/05/Symptomatology-of-a-gas-field-An-independent-healthsurvey-in-the-Tara-rural-residential-estates-and-environs-April-2013.pdf

[228] International Agency for Research on Cancer, press release no 221 17 Oct 2013 http://www.iarc.fr/en/mediacentre/iarcnews/pdf/pr221_E.pdf

Air pollutants that cause cancer

The International Agency for Research on Cancer (IARC) includes these agents as Class 1 carcinogens asbestos, tobacco smoke, diesel exhaust and particulate matter.

Human health risk assessments from air pollutants.

A study by McKenzie *et al*. 2012 [229] found,

> *that residents living ≤½ mile from wells are at greater risk for health effects from Natural Gas Developments than are residents living >½ mile from wells. Subchronic exposures to air pollutants during well completion activities present the greatest potential for health effects mainly due to exposure to trimethylbenzenes, xylenes, and aliphatic hydrocarbons.*

The impacts identified were acute and subchronic respiratory, neurological and reproductive effects. Researchers in this study also found that,

> *based on toxicity values for six carcinogenic contaminants in one Garfield County, Colorado study, there was low but increased risk of developing cancer in residents living near Unconventional Natural Gas Development activity. Additionally, based on the presence of non cancer hazards, close proximity to Unconventional Natural Gas Development activity was associated with low but increased risk of developing acute non cancer health effects.*

The authors reported that insufficient data makes this finding inconclusive and that more research is needed.

41.6 Air pollution and children

Unconventional gas developments emitting high levels of particulates, diesel and other fumes are likely to have negative health effects on infants and children. [230] This is because children are particularly susceptible to air pollution for a range of reasons. Air pollution may damage the lungs, reduce adult lung function, aggravate asthma and lead to school and learning disturbances. **Doctors for the Environment** in their Submission to the Senate said, [231]

[229] McKenzie, L. M.; Witter, R. Z.; Newman, L. S.; Adgate, J. L. Human health risk assessment of air emissions from development of unconventional natural gas resources. Sci. Total Environ. 2012, 424, 79−87, DOI: 10.1016/j.scitotenv.2012.02.018.15.

[230] Effects of Air Pollution on Children's Health and Development – A Review of the Evidence, World Health Organization, 2005. Pediatrics, 2004, 113(Suppl.): 932–1172.)

[231] Shearman D. Submission to the Senate Committee on The impacts on health of air quality in Australia March 2013. Doctors for the Environment Australia Inc

Air pollution causes increased rates of infant mortality, particularly respiratory deaths in the post-neonatal period. Particulates are most strongly implicated but nitrogen dioxide, sulphur dioxide and ozone also appear to contribute. Evidence suggests a causal link between air pollution and lower birth weight, a higher incidence of preterm births and intrauterine growth retardation.

Pope et al. in the USA found that each 10µg/m3 elevation in fine particulate air pollution was associated with approximately a 4%, 6% and 8% increased risk of all-cause, cardiopulmonary and lung cancer mortality, respectively.[232]

41.7 The major air pollutants from gas fields

Compiled from information from the National Toxic Network[233].

Hydrogen sulfide (H_2S);

May be naturally occurring in gas reserves. It is an explosion risk and is one of the greatest acute toxicity hazards for natural gas workers. Significant irritant and other central nervous system health effects occur at or above 100 ppm, and these effects gradually increase in severity with duration of exposure, with immediate death occurring at ~1000 ppm. Little data exist on the frequency of occupational exposure to H_2S, but many companies require use of alarmed personal monitors to prevent fatalities.[234]

Particulates (particles);

UCG activities result in the formation and distribution of particulate pollution from a range of sources including diesel engines and the use of proppants in hydraulic fracturing. Up to 50,000 kg of proppants may be used per hydraulic fracture. These consist of either silica or manufactured ceramic polymer spheres based on alumino-silicates, which are injected as part of the fracturing fluid mixture and intended to remain in the formation to hold open the fractures once the pressure is released. Particulates may be 10 micrometres, (PM10) or 2.5 micrometres (PM 2.5) in diameter and both types of particulates cause cancer.

Silica;

Crystalline silica, in the form of sand ("frac sand"), plays a major role in the hydraulic fracturing process. Each stage of the fracking operation typically involves hundreds of thousands of pounds of "frac sand." Inhalation of fine dusts of respirable crystalline silica

[232] http://jama.jamanetwork.com/article.aspx?articleid=194704

[233] Lloyd-Smith M. 2013. Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources National Toxics Network

[234] Hendrickson, R. G.; Chang, A.; Hamilton, R. J. Co-worker fatalities from hydrogen sulfide. Am. J. Ind. Med. 2004, 45 (4), 346−350, DOI: 10.1002/ajim.10355. and Guidotti, T. L. Hydrogen sulfide advances in understanding human toxicity. Int. J. Toxicol. 2010, 29 (6), 569−581, DOI: 10.1177/1091581810384882.

can cause silicosis. Silicosis is an incurable but preventable lung disease. Crystalline silica has also been determined to be an occupational lung carcinogen and there is evidence that inhaling respirable silica dust causes chronic obstructive pulmonary disease (COPD), chronic renal (kidney) disease and various autoimmune diseases. Individuals with silicosis are known to be at higher risk of tuberculosis and several other respiratory infections. Silica may cause cancer.

U.S National Institute for Occupational Safety and Health (NIOSH)

> *collected 116 air samples at 11 different hydraulic fracturing sites in five different states to evaluate worker exposure to crystalline silica. At these sites, 79% exceeded the NIOSH Recommended Exposure Limit (NIOSH REL). The magnitude of the exposures is particularly important; 31% samples exceeded the NIOSH REL by a factor of 10 or more.* [235]

This study [236] identified,

> S*even primary sources of silica dust exposure during hydraulic fracturing operations:*
>
> - *dust ejected from thief hatches (access ports) on top of the sand movers during refilling operations while the machines are running (hot loading);*
> - *dust ejected and pulsed through open side fill ports on the sand movers during refilling operations;*
> - *dust generated by on-site vehicle traffic;*
> - *dust released from the transfer belt under the sand mover;*
> - *dust created as sand drops into, or is agitated in, the blender hopper and on transfer belts;*
> - *dust released from operations of transfer belts between the sand mover and the blender; and*
> - *dust released from the top of the end of the sand transfer belt (dragon's tail) on sand movers*

Based on these results, **NIOSH** concluded that,

[235] Essweina E, Breitensteinb M, Snawderb J, Kiefera M & Sieberc W. 2013. Occupational Exposures to Respirable Crystalline Silica During Hydraulic Fracturing. Journal of Occupational and Environmental Hygiene Volume 10, Issue 7, 2013.

[236] Essweina E, Breitensteinb M, Snawderb J, Kiefera M & Sieberc W. 2013. Occupational Exposures to Respirable Crystalline Silica During Hydraulic Fracturing. Journal of Occupational and Environmental Hygiene Volume 10, Issue 7, 2013.

an inhalation health hazard existed for workers exposed to crystalline silica at the evaluated hydraulic fracturing sites.

This report is suggestive,

that uncontrolled silica emissions could affect the air quality of residences or businesses near well pads and not just workers health. [237]

U.S. Occupational Safety and Health Administration (OSHA)

Announced in 2013 that,

it intended to propose a revised standard (called a permissible exposure limit) to protect workers from exposure to respirable crystalline silica. [238]

Proppants based on ceramic polymers ;

According to Halliburton's patent, 25 acrylic polymers, consisting of 85% of the human carcinogen acrylonitrile are used for proppant spheres. Acrylonitrile has been detected in US air sampling of gas sites at high levels. Acrylonitrile is also a respiratory irritant, causing degeneration and inflammation of nasal epithelium.

Asbestos found in drilling powder;

Asbestos has been found in imported drilling powder used at Origin Energy gas drilling rigs in Queensland in 2014. This concern was highlighted by **Doctors for the Environment Australia** on the ABC news.[239] Asbestos causes cancer.

Diesel use is high;

a. Cooper Basin EIR [240] states that 16,000 L of diesel will be used for each stimulation treatment and there may be 10-15 stimulations per well.

Each stimulation treatment requires approximately 16,000 L of diesel and storage of sufficient fuel for four to five treatments will be on site. This equates to 160,000L of diesel for a 10 stage fracking operation.

b. Diesel classified a carcinogen by the **World Health Organization (WHO**),

[237] Concerned Health Professionals of New York. 2014, December 11. Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (2nd ed.). http://concernedhealthny.org/compendium/.

[238] OSHA's Notice of Proposed Rulemaking for Occupational Exposure to Respirable Crystalline Silica was published in the Federal Register on September 12, 2013

[239] http://www.abc.net.au/news/2014-03-20/green-group-questions-csg-regulation/5333462

[240] Beach Energy 2012. Environmental Impact Report Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia

In 2012, WHO classified diesel engine exhaust as carcinogenic to humans (Group 1) due to an increased risk of lung cancer. Diesel motors emit particles PM 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. [241]

c. A recent West Virginia study [242] identified that increased truck traffic and trucks idling at well pads increased levels of dust (particles) and benzene nearby.

Secondary pollutants;

New pollutants will form under the influence of sunlight and other factors. These are unknown and have potential harmful effects on health and our environment.

Ozone;

Ozone causes lung inflammation (even in healthy lungs), decreases lung function and increases respiratory symptoms and leads to an increase in mortality from lung disease. There is no safe threshold level.

Multiple studies have shown levels of ozone are raised around UCG sites in the U.S.A.[243] Elevated levels (≥75 ppb) are common in large urban areas, but not in rural areas. Exposure to ground-level ozone can result in respiratory health effects. One population-based study [244] on ozone and health effects in a UNG development region found that,

Between 2008 and 2011, Sublette County, Wyoming observed a 3% increase in the number of clinic visits for adverse respiratory-related effects for every 10 ppb increase in the 8 hour ozone concentration the previous day.

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[241] Lloyd-Smith M. 2013. Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources National Toxics Network

[242] McCawley M. 2013. Air, Noise, and Light Monitoring Results For Assessing Environmental Impacts of Horizontal Gas Well Drilling Operations (ETD-10 Project). West Virginia Department of Environmental Protection

[243] Kemball-Cook, S., Bar-Ilan, A., Grant, J., Parker, L., Jung, J., Santamaria, W., ... Yarwood, G. (2010). Ozone Impacts of Natural Gas Development in the Haynesville Shale. Environmental Science & Technology, 44(24), 9357-9363. doi: 10.1021/es1021137

[244] Pride, K., Peel, J., Robinson, B., Busacker, A., Grandpre, J., Yip, F., Murphy, T. 2013. Associations of Short-Term Exposure to Ozone and Respiratory Outpatient Clinic Visits - Sublette County, Wyoming, 2008–2011. State of Wyoming Department of Health: Cheyenne, WY. https://cste.confex.com/cste/2013/webprogram/Paper1219.html

In a remote basin in Utah, high levels of winter ozone have been recorded and this is thought due to oil and gas drilling in this region.[245]

> *Winter ozone concentrations above the 8 hr National Ambient Air Quality Standards were observed in relatively remote areas in Utah's Uintah Basin and Wyoming's Upper Green River Basin in recent years. Peak ozone concentrations reached 149 ppb and 8 hr averages reached 134.6 ppb in the Uintah basin, and emissions inventories indicate that oil and gas operations were responsible for 98–99% of the VOCs and 57–61% of the nitrogen oxides ozone precursors*.[246]

Holding ponds release air contaminants;

Holding ponds contain a cocktail of chemicals some of which can be released into the air including methane, hydrogen sulphide, poly-aromatic hydrocarbons, volatile organic compounds, naturally occurring radioactive materials and heavy metals. The use of holding/evaporation ponds in now banned in NSW and it is recommended that SA do the same.

41.8 Flaring

This is the burning of methane rather than direct release (venting) to the atmosphere. Flaring has been considered preferable to venting mainly because it converts methane to CO_2 which is a less potent greenhouse gas. It is better to burn methane than release it, as methane as a greenhouse gas is over 86 times [247] more potent than carbon dioxide over a 20 year time frame. However, flaring creates combustion pollutants such as carbon monoxide, nitrogen oxides, particulates 2.5, and CO_2, and contributes to formation of often-uncharacterized secondary compounds. Incomplete combustion during flaring may result in release of volatile organic compounds, heavy metals and NORMs. Flaring is wasteful in that valuable methane and other hydrocarbon gases are also burnt rather than being collected and then sold.

Under a petroleum exploration license in South Australia, gas production and flaring is permitted for a 10 day period under Section 27 of the Petroleum and Geothermal Energy Act 2000, unless otherwise approved by the Minister.

[245] Utah Department of Environmental Quality. Final Report: 2012 Unitah Basin Winter Ozone & Air Study. Uintah Basin Winter Ozone Study. 2013; http://rd.usu.edu/files/uploads/ubos_2011-12_final_report.pdf

[246] Adgate J, Goldstein B, and McKenzie L. 2014 Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development in Environmental Science and Technology,

[247] IPCC 2014

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- **USA**

In the USA flaring is no longer considered best-practice. From January 2015 both venting and flaring will be generally banned. Drillers will be required to capture all the gas in separate flow lines.

The New Rule,

> *For the duration of flowback, route the recovered liquids into one or more storage vessels or re-inject the recovered liquids into the well or another well, and route the recovered gas into a gas flow line or collection system, re-inject the recovered gas into the well or another well, use the recovered gas as an on-site fuel source, or use the recovered gas for another useful purpose that a purchased fuel or raw material would serve, with no direct release to the atmosphere.*

South Australia should adopt a similar position.

- **U.S.E.P.A.**

David McCabe, an atmospheric scientist at the USA Clean Air Task Force said about the final rule.

> *It's very clear that flaring is not the best system of emissions reduction particularly for air quality, but also for climate. Flaring the initial emissions, which mainly come in a rush in the first days after fracking a new well, emits millions of tons of carbon dioxide. Much of the waste gas is methane, the main component of gas, which drillers should be required to capture.* [248]

- **Eagle Ford Shale**

August, 2014 – A four-part investigation by the *San Antonio Express-News* found that natural gas flaring in the Eagle Ford Shale in 2012 contributed more than 15,000 tons of volatile organic compounds and other contaminants to the air of southern Texas—which is roughly equivalent to the pollution that would be released annually by six oil refineries. No state or federal agency is tracking the emissions from individual flares.[249]

[248] Reuters news report http://www.reuters.com/article/2012/04/18/us-usa-fracking-emissions-idUSBRE83H0UH20120418

[249] Hiller, J. and Tedesco, J. (2014, August). Up in flames: Flare in Eagle Ford Shale wasting natural gas. *San Antonio Express News.* Retrieved from: http://www.expressnews.com/business/eagleford/item/Up-in-Flames-Day-1-Flares-in-Eagle-Ford-Shale-32626.php

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41.9 Improving National Guidelines

Detecting air pollution may be difficult at gas sites

Dr David Brown *et al*.[250] have pointed out,

> *problems associated with national standards of air quality and Unconventional Gas (UCG) drilling include 1) current National Ambient Air Quality Standards do not address the interactions of the chemical agents in the air and then in the body; 2) long-term averages fail to capture the frequency or magnitude of very high readings; and 3) with periodic data collection, important spikes or episodic exposures (common in UCG) can be missed.*
>
> *The central problem identified in this paper is that at sites where it appears that health effects are produced by UCG, toxic emissions are often not being measured or not detected at levels deemed dangerous. Our concern is that this may be an artefact of the sampling methodologies and analyses currently being used today.*
>
> *An inspection of the pathophysiological effects of acute toxic actions reveals that current environmental monitoring protocols are incompatible with the goal of protecting the health of those living and working near UCG activities.*
>
> *A) Current protocols used for assessing compliance with ambient air standards do not adequately determine the intensity, frequency or durations of the actual human exposures to the mixtures of toxic materials released regularly at UNGD sites.*
>
> *B) the typically used periodic 24-h average measures can underestimate actual exposures by an order of magnitude.*
>
> *C) reference standards are set in a form that inaccurately determines health risk because they do not fully consider the potential synergistic combinations of toxic air emissions.*
>
> *D) air dispersion modelling shows that local weather conditions are strong determinates of individual exposures.*

Measuring Peak Exposures is important at gas sites

Darrow[251] writes,

> *Peak exposures can sometimes better capture relevant biological processes. This is the case for health effects that are triggered by short-term, high doses.*

[250] Brown D, Weinberger B, Lewis C and Bonaparte H. 2014. Understanding exposure from natural gas drilling puts current air standards to the test. Rev Environ Health 2014; DOI 10.1515/reveh-2014-0002

[251] Darrow LA, Klein M, Sarnat JA, Mulholland JA, Strickland MJ, Sarnat SE, et al. The use of alternative pollutant metrics in time-series studies of ambient air pollution and respiratory emergency department visits. J Expo Sci Environ Epidemiol 2011;21:10 – 9.

*For example exposure for **1 to 2 h to diesel exhaust** exposure can cause ECG changes in people with pre-existing coronary artery disease and lead to ischemic and thrombotic effects in men with coronary heart disease.* [252]

Cumulative impacts

Individual drilling may not create air emissions that trigger regulations. But cumulative impacts of air emissions may create significant public health risks for local communities.

41.10 Australian National Air Standards

The National Environment Protection (Ambient Air Quality) Measure (NEPM 2003) [253] and its five schedules provide a framework and guidelines about standards and methods for monitoring ambient air quality. The regulatory assumption is that the variations in ambient air levels are negligible.

The National Environment Protection (Air Toxics) Measure [254] includes the following Air Toxics; benzene, formaldehyde, benzo(a)pyrene as a marker for polycyclic aromatic hydrocarbons, toluene and xylenes.

Air quality monitoring and how to protect human and environmental health from air pollution is the focus of ongoing research worldwide. Air is not something we have a choice about and clean air is essential for our health. The Australian air monitoring guidelines are overdue for review and recent submissions have been made by **Doctors for the Environment Australia** to the Senate Committee on impacts such as air 'toxics' and particulates on health. [255]

41.11 South Australian air measurements

The Environmental Protection Authority is responsible for monitoring air quality within South Australia and air monitoring stations are set up in Adelaide, Whyalla and Port Pirie to measure Carbon monoxide, Nitrogen dioxide, Ozone, Sulfur dioxide, Particulate matter as PM10, Lead, and Particulate matter as PM2.5.

[252] Mills NL, Tornqvist H, Gonzalez MC, Vinc E, Robinson SD, Soderberg S, et al. Ischemic and thrombotic effects of dilute diesel-exhaust inhalation in men with coronary heart disease. N Engl J Med 2007;357:1075 – 82.

[253] http://www.environment.gov.au/resource/national-environment-protection-measure-ambient-air-quality-%E2%80%93-commonwealth-monitoring-plan

[254] National Environmental Protection Measures Air Toxic

[255] Shearman D. Submission to the Senate Committee on The impacts on health of air quality in Australia March 2013. Doctors for the Environment Australia Inc

In SA, regulations have failed to protect children from lead poisoning in Port Pirie or improve air quality in Port Augusta, which has three times the average rate of lung cancer.[256]

41.12 There is no permanent air monitoring in South East of SA

The Smoke Watch program monitored particulate matter in Mount Gambier during winter between 2009-2011. This showed that Mount Gambier has one of, if not the worst, winter air qualities of any city in Australia due to temperature inversions, wood heaters and the existing industry. This program and the monitoring is now complete and there are no air monitoring facilities now in the South East of SA.

41.13 Recommendations around air pollution guidelines

Seek advice from sources such as Doctors for the Environment Australia and public health experts on the best way South Australia can protect the health of South Australians from air pollutants and action.

Institute and action best practice legislation, guidelines and protocols

As recommended in health literature, guidelines and protocols for air monitoring need to take into account the variable and unpredictable nature of gasfield emissions e.g. intermittent, short term, and multiple chemicals exposure. It is suggested that they include real-time measures of patterns of exposures including peak levels, durations, and components of mixtures.

41.14 Recommendations around monitoring

Comprehensive baseline, ongoing and long term air monitoring is needed.

This must include rural and regional areas.

Air monitoring downwind of all gas wells and infrastructure.

Air monitoring to include cumulative impacts of air emissions from the entire gas field.

Weather patterns that increase the risk of air pollution identified and mitigated.

Air monitoring information must be made readily accessible to the community.

41.15 Recommendations related to specific emissions

Diesel fumes and particulate exposure - research into ways to reduce emissions and action.

Air toxics and particulate exposure - research into ways to reduce emissions and action.

Ban holding ponds anywhere in the State. As in NSW.

[256] Cite available at request

Ban use of polymers containing acrylonitrile and other possible carcinogens.

Ban all flaring anywhere in the State. Require gas capture.

41.16 Conclusion

The popular and scientific literature is full of examples of deterioration of air quality from the increase in oil and gas exploration and production, and from the processes involved in its production. Recently, legislation in the U.S.A has been significantly overhauled both Federally and in many States to reduce the amount of fugitive emissions, particulates and air 'toxics' released by the oil and gas industry. This includes legislation around venting and flaring.

The Australian air monitoring guidelines are long overdue for review and there are numerous examples of where they have failed to protect health and environment.(Port Pirie, Port Augusta). The Environmental Protection Authority is responsible for monitoring air quality within SA, but there is no air monitoring available in the South East of SA.

Gasfields present specific challenges for good air quality and escalate the need for comprehensive, baseline, and ongoing air monitoring for rural and regional areas. The institution and action of best practice guidelines and protocols as well as strengthening legislation and seeking advice on this from organisations such as Doctors for the Environment Australia and public health specialists is needed.

Comprehensive, authentic and accessible air monitoring is essential to protect the health and environment for all South Australians. Until such time as these things are in place, we have little confidence in the ability of our current legislation to protect human and environmental health from air pollution from the gas industry.

42 Water contamination and health.

The risk of groundwater contamination has been covered in Section 1 and Section 2 of this submission. Specifically the gas industry presents pathways for water contamination and water contaminants identified that may cause harm to human and environmental health.

42.1 Pathways of contamination

There is an increasing body of studies that suggest that water contamination can occur through a variety of pathways.

- The surface from waste water spills, leaks and accidents.
- The method of disposal of waste water.
- The method of storage of waste water in holding ponds subject to leaks and flooding.
- Well integrity is critical to the prevention of contamination of groundwater contamination.

- Fracking itself may intersect natural fault lines and cause contamination.
- Fracking may mobilise naturally occurring contaminants.

42.2 Contaminants in water have harmful effects

There are identified contaminants in waste water, those that have been used in the gas drilling and fracking process and those that have been produced by the process itself or those that have come up from deep underground. The exact type depends on various things including the chemicals used, geology, and radioactivity of underlying rock. (More in Section 3 Chemicals.) Many of these contaminants are known to cause harm to health or to the environment.

> *The materials extracted from underground can be equally or more toxic than the hydraulic fracturing fluid, and include radioactive material (e.g., radium-226, radon-222, and uranium-238), arsenic, lead, strontium, barium, benzene, chromium and 4-nitroquinoline-1- oxide.*[257]

For example the exploration well at Penola's waste water is high in salinity (60% as salty as seawater), potassium, barium and low in calcium. It has levels of heavy metals over Australian Drinking Water guidelines and traces of poly-aromatic hydrocarbons.[258]

42.3 Surface contamination

The issues of waste water management and disposal has been classified as one of the direct unquestioned impacts of shale gas exploration on water quality. [259] Frogtech in their report for ACOLA, [260] Dr Alicia Coram in the Medical Journal of Australia[261] and Doctors for Environment Australia [262] state that the disposal of waste water has the potential for greatest environmental and health risks for the community.

[257] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

[258] ALS, NATA Accredited Laboratory 825. March 2014. Analysis of Jolly 1 waste water for Beach Energy

[259] Vengosh A, Jackson RB, Warner N, Darrah TH, Kondash A. A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States. Environ Sci Technol 2014;48(15):8334–48.

[260] Frogtech. 2013. Potential Geological Risks Associated with Shale Gas Production in Australia for Australian Council of Learned Academies (ACOLA) Project Code: AAS801 http://www.acola.org.au/

[261] Coram A, Moss J, Blashki G. 2014. Harms unknown: health uncertainties cast doubt on the role of unconventional gas in Australia's energy future. Med J Aust 2014; 200 (4): 210-213. doi: 10.5694/mja13.11023

[262] www.dea.org.au Unconventional Gas fact sheet.

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It is estimated by CSIRO that a fracked gas well may require 5-40ML of water. It is also estimated that 15-80% comes back as waste water.[263] Each production well will therefore have millions of litres of waste water.

The disposal of large quantities of contaminated water in an area with a shallow groundwater table, significant wetlands, flat topography and a landscape prone to flooding significantly increases the risks of ground water contamination.

There were 59 spills, discharges and similar incidents involving hydraulic fracturing in QLD and NSW between 2009-2013.

Incidents involving hydraulic fracturing in QLD and NSW (2009-2013) [264]

Type of incident	Number of incidents	Percentage of total
Spills Releases of CSG water during operations account for the largest incident type. These spills typically occurred during drilling activities or result from opened/faulty valves within pipework. NICNAS (2014a) reported one truck rollover involving drilling mud and one tank overflow incident involving hydraulic fracturing fluid. NICNAS (2014a) further reported four well injection incidents (valve and burst disc failure).	35	59.3
Discharge These incidents involve the controlled or uncontrolled release of coal seam gas water or permeate to the environment.	6	10.2
Overflow (flooding) This includes water from pond/dam that overtopped during Queensland flooding (December 2010 and January 2011), an incident in NSW involving untreated pond water and an abandoned CSG drill site where two water storage ponds were not properly managed and overflow was evident during inspection. NICNAS (2014) reported 3 flooding events involving storage ponds.	9	15.3
Exceedance release limits Discharge limits and storage of fluids are regulated by environmental authorities and non-compliance was assessed on at least five occasions.	5	8.5
Other contamination BTEX (Benzene, toluene, ethylbenzene, xylenes) contamination. BTEX was not used in the fracturing activities at these sites and may be related to the use of certain fuels during drilling.	2	3.4

[263] Lloyd-Smith M. 2013. Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources National Toxics Network

[264] CSIRO slideshow

Pond leakage *Leaks in storage pond liner occur over extended periods with produced water leaking into the soil (Pilliga Pond Incident, NSM). NICNAS (2014a) reported one leakage incident involving flowback water.*	2	3.4
Total	***59***	***100%***

42.4 Disposal of water

Methods of disposal include; holding ponds via evaporation (harmful to native animals, bees, birds, risk of drowning and chemical poisoning), recycling (concentrates, and does not remove all contaminants, produces solid waste), spreading on land, rivers, or injection underground. None of these methods are without risks of environmental contamination.

> *Substances must not be spread on roads to minimise dust as this sets up a potentially lethal threat, particularly to companion animals, wildlife, and children. Typically these solutions contain high salt concentrations and attract dogs and cats.*[265]

Most of these practices can either directly or indirectly aerosolize chemicals or contaminate surface and ground water. Plus some naturally occurring radioactive elements such as radium (a known carcinogen), will not be removed at wastewater treatment centres, but will persist in the environment either through incomplete removal from wastewater or as solid waste produced via co-precipitation.[266]

> *Recycling increasing fractions of the wastewater. This decreases the total volume of wastewater but increases its toxicity due to the successive increase in the concentrations of total dissolved solids.*[267]

In 2013, scientists reported tests on sediment from the bed of Blacklick Creek, in Pennsylvania, at the point where effluent flowed into the creek from an industrial treatment plant with a history of accepting oil and gas industry wastes. The sediment contained greatly enhanced levels of radioactive material, with radiation at 200 times the level found in background sediments. [268]

[265] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

[266] Webb E, Bushkin-Bedient S, Cheng A, Kassotis C, Balise V and Nagel S. 2014. Developmental and reproductive effects of chemicals associated with unconventional oil and natural gas operations. Rev Environ Health 2014; 29(4): 307–318

[267] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

[268] Warner, Nathaniel R. et al. "Impacts of shale gas wastewater disposal on water quality in western Pennsylvania." Environmental Science & Technology vol 47 issue 20 October 15, 2013 at 11849

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42.5 Holding ponds

Holding ponds should not be allowed in SA, as is the case in NSW.

The structural integrity of holding ponds must be monitored and ensured to protect the surrounding landscape and groundwater. That the extant regulations are not properly enforced is evidenced by the deplorable condition of this abandoned holding pond at Panax Geothermal well near Nangwarry where there is extensive breakdown/tearing of the liner and, presumably, contamination of underlying soil and possibly groundwater. The holding pond only lasted 4 years.

Pond liners have a finite lifespan and they are not impermeable but allow slow seepage. (CSIRO).

Precautions should be in place to monitor and prevent rainfall causing overflow and contaminating surrounding soil, vegetation and seeping into groundwater.

Holding ponds should be fenced away from animals. Regulations should be developed to determine how the mud from the holding ponds can eventually be dealt with in a way to prevent danger to the environment and to human, animal and plant health.

Cooper Basin gas well showing holding ponds banks breeched 2010.

Penola

Beach Energy applied to the EPA for an emergency authorisation in 2014, to move waste water from its holding ponds near Penola to prevent overflooding.[269]

42.6 Contamination in aquifers from gas migration

There have been cases of methane contamination of aquifers in the U.S.A from shale gas wells and in Australia from coal seam gas. The depth of the shale gas formation does not make it any less likely for a gas well to have its casing or cement fail.

Mechanisms of aquifer contamination suggested by Osborn and Jackson [270] in their paper include,

> *leaky gas-well casings. Such leaks could occur at hundreds of meters underground, with methane passing laterally and vertically through fracture systems or the process*

[269] Application to Wattle Range council for Development application. 2014. Beach Energy.

[270] Osborn, S.G, Vengosh A, Warner N.R, and Jackson R.B. 2011. Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. Proc. Natl. Acad. Sci. USA 108(20): 8172–76. doi:10.1073/pnas.1100682108

of hydraulic fracturing generating new fractures or enlarging existing ones above the target shale formation, increasing the connectivity of the fracture system.

Likewise,

Any assertion that hydraulic fracturing is unrelated to contamination remains equally unproven. [271]

42.7 Well integrity failure

There is a big uncertainty about long term well integrity. There are numerous studies on this including;

Teodoriu C et al. 2012. WELLBORE INTEGRITY AND CEMENT FAILURE AT HPHT CONDITIONS. International Journal of Engineering and Applied Sciences www.eaas-journal.org

Dusseault M. et al. 2014 Towards a Road Map for Mitigating the Rates and Occurrences of Long-Term Wellbore Leakage.

Ingraffea A. 2012. FLUID MIGRATION MECHANISMS DUE TO FAULTY WELL DESIGN AND/OR CONSTRUCTION: AN OVERVIEW AND RECENT EXPERIENCES IN THE PENNSYLVANIA MARCELLUS PLAY.

Watson T, Bacchu S. 2009 Evaluation of the potential for Gas and CO_2 leakage along Well Bores. SPE Drilling and Completion.

In 2014 in Canada, a report was released about the flow to surface bitumen leaks from the Clearwater reservoir into the Grand Rapid formation and an independent panel review[272] found that there were uncontrollable enabling conditions due to natural fault and fracture propensity.

The Council of Canadian Academies [273] has said,

Natural gas leakage from improperly formed, damaged, or deteriorated cement seals is a long-recognized yet unresolved problem that continues to challenge engineers. Leaky wells due to improperly placed cement seals, damage from repeated fracturing treatments, or cement deterioration over time, have the potential to create

[271]Osborn, S.G, Vengosh A, Warner N.R, and Jackson R.B. 2011. Reply to Davies: Hydraulic fracturing remains a possible mechanism for observed methane contamination of drinking water. Proc. Natl. Acad. Sci. USA October 25, 2011 | vol. 108 | no. 43

[272] Canadian Natural. 2014. Independent Panel Review of the Canadian Natural Primrose FTS Causation Report. Page 3.

[273] Council of Canadian Academies, 2014. Environmental Impacts of Shale Gas Extraction in Canada. Ottawa (ON): The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction, Council of Canadian Academies.

pathways for contamination of groundwater resources and to increase GHG emissions. The issue of well integrity applies to all well types, including water and conventional gas or oil wells. Several factors make the long-term impact related to leakage greater for shale gas development than for conventional oil and gas development. These are the larger number of wells needed for shale gas extraction; the diverse chemicals used in hydraulic fracturing operations; the potential development of shale gas resources in rural and suburban areas that rely on groundwater resources; and possibly the repetitive fracturing process itself.

In 2010, the Pennsylvania Department of Environmental Protection (PDEP) issued 90 violations for faulty casing and cementing on 64 Marcellus shale gas wells; 119 similar violations were issued in 2011. In September 2014, the PDEP released a detailed report [274] outlining 243 cases of contamination from oil and gas drilling operations in the last 7 years. The main contaminants were methane (115 water supplies), iron (79 water supplies) and manganese (76 water supplies).

In Pennsylvania the rate of well failure (based on violations) between 2010 and 2012 was between 6.2 -7.2% each year. [275]

Failure of casing and cement

In 2014, Darrah *et al* in their paper [276] identified mechanisms of gas contamination in drinking wells overlying Marcellus and Barnett Shales.

Gas geochemistry data implicate leaks through annulus cement (four cases), production casings (three cases), and underground well failure (one case) rather than gas migration induced by hydraulic fracturing deep underground.

Failure of casing

Steel corrodes with time; the average uniform corrosion rate is 1.0 micrometre a year plus there pitting corrosion can increase this rate.[277]

[274] Pennsylvania Department of Environmental Protection. 2014 http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/Determination_Letters/Regional_Determination_Letters.pdf

[275] Ingraffea A. 2012. FLUID MIGRATION MECHANISMS DUE TO FAULTY WELL DESIGN AND/OR CONSTRUCTION: AN OVERVIEW AND RECENT EXPERIENCES IN THE PENNSYLVANIA MARCELLUS PLAY.

[276] Darrah TH, Vengosh A, Jackson RB, Warner NR, Poreda RJ. Noble gases identify the mechanisms of fugitive gas contamination in drinking-water wells overlying the Marcellus and Barnett Shales. Proc Natl Acad Sci USA 2014; 111(39):14076–81.

[277] CSIRO

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Failure of cement [278]

As discussed in this paper of Downhole risks in Cooper Eromanga Basin,

> *However, with time it is likely that cements exposed to even moderate conditions will deteriorate. It is important to understand that the risk of cement failure increases over time: once initiated the risk is most likely to grow exponentially.... The well in the case history started to fail 15 years after the cement had been put in place. Deterioration most probably occurred long before this time.... Absolute favourable conditions would need to be present to ensure that cement integrity is maintained for an infinite time after well abandonment. This is never likely to occur since wellbore cement is exposed to dynamic conditions and streams of potentially corrosive compounds.*

US NATIONAL ENERGY TECHNOLOGY LABORATORY on Cementing Research Five Challenges: Foci in the E&P Focus, of Winter 2014 Oil & Natural Gas Program Newsletter,.

> *To ensure that the cementing R&D undertaken addresses practical problems in cement integrity, NETL polled the industry to determine those cementing issues that had the greatest impact on cement integrity. Basically, the polling asked two questions: What is the current state of wellbore cementing; and where can we best direct R&D efforts to improve current technologies and develop new approaches? Among them were representatives from major oil and gas service companies, the American Petroleum Institute, the International Association of Drilling Contractors, the Drilling Engineering Association, and the American Association of Drilling Engineers. Collectively they characterized five primary research challenges related to borehole design, placement, and long-term integrity and suggested R&D pathways that could lead to safer, more efficient operations.*
>
> *Challenge 1: Developing new monitoring for wellbore integrity*
>
> *Challenge 2: Understanding cement stability under field conditions*
>
> *Challenge 3: Ensuring quality control*
>
> *Challenge 4: Understanding the impact of temperature- and pressure induced*
>
> *Stress*
>
> *Challenge 5: Improving standard calculations*

42.8 Fracking mobilises naturally available chemicals

University of Texas Study 2014, [279]

[278] Mavroudis D, 2001, Downhole Environmental Risks Associated with Drilling and Well Completion Practices in the Cooper/Eromanga Basins.

A recent study of private drinking water wells in the Barnett Shale area of North Texas found arsenic, selenium and strontium at levels above EPA guidelines, in wells located within 1.8 miles of natural gas wells. The researchers surmise that fracking has increased pollution in drinking water supplies by freeing naturally available chemicals to move into groundwater at higher concentrations or through leaks from faulty well construction.

42.9 Contamination from fracking

Pavillion, Wyoming investigation of contamination by fracking

The U.S. EPA study [280] into Wyoming Pavillion reported that two deep monitoring wells near an aquifer in Pavillion, Wyoming, tested positive for glycols, alcohols, and high levels of methane, all of which were thought to originate from hydraulic fracturing activity conducted below the aquifer. This was the first report of drinking-water contamination resulting from the migration of chemicals from a fractured formation. In Pavillion, the gas wells are as shallow as 372 metres, while wells tapping groundwater are up to 244 metres deep; this makes movement of contaminants between the two zones much easier. The EPA investigation occurred in 2009 and the report was released in December 2011.

As expected this sparked a debate by both sides and ongoing discussion is occurring in the scientific literature. In September 2012, the US Geological Survey [281] (USGS) released data showing the presence of groundwater contamination in the region.

In 2013, the EPA decided to abandon finalizing the report and deferred it to the State of Wyoming for further investigation.

EPA study into fracking

The **EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources** is still ongoing and due to be released in 2016. This was started in 2011 to assess,

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[279] Fontenot B, Hunt L, Hildenbrand Z, Carlton Jr D, Oka H, et al. 2013. An Evaluation of Water Quality in Private Drinking Water Wells Near Natural Gas Extraction Sites in the Barnett Shale Formation. Environ. Sci. Technol., 2013, 47 (17), pp 10032–10040.DOI: 10.1021/es4011724

[280] DiGiulio, D.C., R.T.Wilkin, C. Miller, and G. Oberley. 2011. Draft: Investigation of ground water contamination near Pavillion, Wyoming. EPA 600/R-00/000. Ada, OK: U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory.

[281] US Geological Survey 2012. Groundwater-Quality and Quality-Control Data for Two Monitoring Wells near Pavillion, Wyoming available at http://pubs.usgs.gov/ds/718/DS718_508.pdf

the potential impacts of hydraulic fracturing on drinking water resources, if any, and to identify the driving factors that may affect the severity and frequency of such impacts.

43 Other impacts

43.1 Odour

Adgate *et al* [282]write,

> *There are many documented instances of odour complaints and increased air concentrations of volatile organic and other compounds at or near well pads during development. People living within 1/2 mile of a multiwell pad complained of odours during well completions in Garfield County, CO, and 81% of respondents to a self-reporting survey in active shale gas development areas in Pennsylvania reported odours. Hydrogen sulfide has a very low odour threshold and a 10 h half-life, so it may be responsible for some odour complaints.*

Some sulfur compounds such as hydrogen sulfide, dimethylsulfide, carbonyl sulfide, and carbon disulfide, may be emitted from flare stacks and other UCG sources.[283] These have a typical rotten egg smell. At certain exposure levels these compounds are potentially lethal.

Odour is not only a nuisance, but at certain levels and durations, offensive odours can induce health impacts such as headaches, nausea, sleeplessness, and throat irritation. [284]

43.2 Noise

Noise has an impact on human health. Loud continuous noise has health effects in working populations[285] and in children at school. It is particularly important for children as it may disrupt their learning at a critical stage of their life and so have lifelong implications.

The main occupational health and safety hazard for miners is industrial deafness. Levels near operations needs to be monitored to protect human and animal health.

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[282] Adgate J, Goldstein B, and McKenzie L. 2014 Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development in Environmental Science and Technology,

[283] Strosher, M.T. 1996. Investigations of flare gas emissions in Alberta. Final Report to: Environment Canada Conservation and Protection, the Alberta Energy and Utilities Board and the Canadian Association of Petroleum Producers. Alberta Research Council, Calgary, Alta.

[284] Furberg M. 2005. FINAL REPORT; HEALTH AND AIR QUALITY 2005 –PHASE 2: VALUATION OF HEALTHIMPACTS FROM AIR QUALITY IN THE LOWER FRASER VALLEY AIRSHED RWDI AIR Inc.

[285] Levy, B. S.; Wegman, D. H.; Baron, S. L.; Sokas, R. K. 2011. Occupational and Environmental Health: Recognizing and Preventing Disease and Injury, 6th ed.; Oxford University Press: New York, NY.

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Noise with UCG is greater than with conventional gas wells during the period of time when horizontal drilling is underway. Heavy truck traffic needed for carting water and chemicals is also a source of noise, dust and fumes. For example, engine-brake noise from large trucks passing a school or health facility will be intermittent but disruptive and potentially harmful. [286]

Engineering Energy in their report [287] noted,

> *Noise and light pollution, as well as traffic movement, will also contribute to loss of intactness in the landscape. In the USA, Broderick et al, [288](2011) have estimated that over the lifetime of a project, noisy surface activity associated with each well pad will occur on 800 - 2,500 days.*

Noise as an impact will affect both visitors to the region and residents, with a loss of visual amenity, sleep disturbance and enjoyment.

43.3 Noise from Flaring

> *December 1, 2014 – Range Resources Inc. warned supervisors in Pennsylvania's Donegal Township that a "big burn" natural gas flare will continue for as long as a week and will produce a continuous noise of as much as 95 decibels at the well pad.* [289]

> *May 30, 2014 – The Denver Post reported that in order to help meet Colorado's noise limits for fracking operations in suburban neighbourhoods, Encana Oil and Gas erected 4-inch-thick polyvinyl walls up to 32 feet high and 800 feet long. Residents said that the plastic walls do not completely solve the problem.*[290]

[286] Concerned Health Professionals of New York. 2014, December 11. Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (2nd ed.). http://concernedhealthny.org/compendium/.

[287] Engineering Energy: Unconventional Gas Production – A Study of Shale Gas in Australia. 2013. ACOLA The Australian Council of Learned Academies (ACOLA)

[288] Broderick et al. 2011 Shale gas: an updated assessment of environmental and climate change impacts. A report by researchers at the Tyndall Centre University of Manchester.

[289] Hopey, D. 2014. Gas flare to light up part of Washington County. *Pittsburgh Post Gazette.* Retrieved from http://powersource.post-gazette.com/powersource/companies-powersource/2014/12/01/Gas-flare-to-light-up-part-of-Washington-County/stories/201411250224

[290] Finley, B. (2014, May 29). Oil and gas industry building giant walls to try to ease impact. The Denver Post. from http://www.denverpost.com/ci_25859469/oil-and-gas-industry-building-giant-walls-try

43.4 Injuries and Accidents

In the USA oil and gas workers were found to have 7 times the injury rate of normal workers.[291] The main occupational health and safety issues for workers are road traffic accidents and industrial deafness. Specific concerns with UCF are potential exposure to hazardous materials including chemicals, particulates (from diesel), sand and radiation.

An ongoing health watch study by Monash University on oil and gas workers in Australia has found that certain types of cancers are more common. [292]

> *Two cancers, mesothelioma and melanoma, have been and are still occurring at statistically significantly higher rates than in the general population. Prostate cancer is also in statistically significant excess.*

44 Recommendations

Recommendation 1

The precautionary principle should apply in the case of gas drilling and hydraulic fracturing. This shifts the burden of proving safety onto the proponent rather than the state.

Recommendation 2

A risk assessment is required that takes into account the impact of gas drilling and hydraulic fracturing on future generations and the likelihood of problems arising for these activities.

Recommendation 3

The principle of intergenerational equity considerations must guide any decisions regarding gas drilling and hydraulic fracturing.

Recommendation 4:

A full life cycle analysis of fugitive emissions from the gas industry in Australia is required.

Recommendation 5

Research is required into the unforeseen consequences from the industrialisation of a rural community, with reference to prevention and management of these risks and the unknown long term and intergenerational impacts.

[291] Adgate J, Goldstein B, and McKenzie L. 2014 Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development in Environmental Science and Technology,

[292] Monash University; 2013. HEALTH WATCH The Australian Institute of Petroleum Health Surveillance Program Fourteenth Report November 2013, page 14.

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Recommendation 6

Limestone Coast Health Assessment Study

Before any gas extraction were to be allowed to occur, a comprehensive, ongoing and detailed study of the entire region should be undertaken, to include the health of humans, animals and plants, with samples kept for future comparative analysis. Water, soil and air samples should be collected from a large number of sites across the region in addition to tissue samples from humans, animals and plants, as a baseline against which future similar samples could be measured.

This study would need input from organisations such as Doctors for the Environment and public health professionals.

Recommendations from Bamberger relevant to human health.

From the report on animal case studies by Bamberger and Oswald [293] as it relates to the situation in the U.S.A,

- *In order to be complete, air, soil and all sources of potable water used for humans and animals in the vicinity of a well site (at least within 3,000 feet for soil and water tests, and five miles for air monitoring, based on dispersion modelling of emissions from compressor stations must be tested for all components that are involved in drilling and are likely to be found in wastewater, before any work on the site commences.*

- *This will be a benefit to people living in the midst of shale gas drilling and will, in fact, benefit the industry by providing consistent and useful data to guide operations. The current practice of under testing and denying any link between drilling and water, air, or soil contamination is beneficial to neither the public nor the industry.*

- *Nondisclosure agreements shield health problems associated with gas operations from public scrutiny.*

- *Failure of baseline and follow up testing of air and water impedes the analysis of health impacts.*

- *Food processing animals which are exposed to chemical contaminants are not tested for contamination putting at risk those who eat them.*

[293] Bamberger M, Oswald R. 2012. Impacts of Gas Drilling on Human and Animal Health. New Solutions, Vol. 22(1) 51-77. doi: http://dx.doi.org/10.2190/NS.22.1.e. http://baywood.com

Recommendations around air pollution guidelines

Seek advice from sources such as Doctors for the Environment Australia and public health experts on the best way Australia can protect the health of Australians from air pollutants and action.

Institute and action best practice legislation, guidelines and protocols

As recommended in health literature, guidelines and protocols for air monitoring need to take into account the variable and unpredictable nature of gasfield emissions e.g. intermittent, short term, and multiple chemicals exposure. It is suggested that they include real-time measures of patterns of exposures including peak levels, durations, and components of mixtures.

Recommendations around monitoring

Comprehensive baseline, ongoing and long term air monitoring is needed.

This must include rural and regional areas.

Air monitoring downwind of all gas wells and infrastructure.

Air monitoring to include cumulative impacts of air emissions from the entire gas field.

Weather patterns that increase the risk of air pollution identified and mitigated.

Air monitoring information must be made readily accessible to the community.

Recommendations related to specific emissions

Diesel fumes and particulate exposure - research into ways to reduce emissions and action.

Air toxics and particulate exposure - research into ways to reduce emissions and action.

Ban holding ponds anywhere in Australia.

Ban use of polymers containing acrylonitrile and other possible carcinogens.

Ban all flaring anywhere in Australia. Require Gas capture.

45 Conclusion

This submission refers to a number of studies raising concerns about human, animal and environmental health. The evidence for this is growing.[294] This is particularly alarming given that measureable health impacts will lag behind the factors responsible for causing them. For example lung cancer occurs some time after exposure to cigarettes or asbestos and, in some instances, it will also lag behind gas exploration, production and fracking. Pathways

[294] Concerned Health Professionals of New York. 2014, December 11. Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (2nd ed.). http://concernedhealthny.org/compendium/.

exist for contamination of water, air and food and many of the chemicals used by, produced by, or released by the process are known to be carcinogenic or capable of endocrine and reproductive harm. Birth data is emerging associating proximity of dwelling near gas wells with increases in congenital heart defects.

There have been and continue to be surface accidents, leaks, and spills and there is a big uncertainty about long term well integrity. This puts in question the capability of regulation to eliminate or even minimise harm and protect human and environmental health.

There is a need for caution expressed worldwide by medical organisations. There is a need to apply the precautionary principle and expect the proponents to provide proof that gas drilling and fracking can be done safely.

Hydraulic fracturing has been banned in many jurisdictions around the world, including France, Bulgaria, Germany, Washington DC, Quebec, and New York. Scotland has just introduced a moratorium while Victoria has recently increased the length of its moratorium due to concerns about the process. It would be a wise thing for Australia to do likewise.

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Senate
Inquiry into the Landholders' Rights to Refuse (Gas and Coal) Bill 2015

SECTION 9. RENEWABLE ENERGY

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Author

Merilyn Paxton, was employed for 15 years in Marketing, Advertising, Public Relations, Sales Promotion and TV commercial production in Melbourne followed by 12 years as the proprietor of a premium wine and spirits retail outlet in Albert Park in Melbourne. During the '70s she was an executive member of the very successful Emerald Hill Association, a resident group for South Melbourne, Albert Park, Middle Park and West St Kilda, which had enormous success in changing many inner suburban planning concepts for freeways, high rise, public housing, demolition of historic buildings and shoreline development. In negotiation with the then South Melbourne Council, State Government and Federal government, the Emerald Hill Association managed to save the historic town hall precinct of some acres which was retained and renovated for public housing.

In 1989 Merilyn came to Robe and in 1990 she purchased a major share in a shark fishing enterprise which ran two boats out of Robe. In 1995 Merilyn and her husband bought a small farm at Mount Benson and commenced renovation of the property and the derelict homestead. In 2002 they sold their interest in fishing and purchased another farm in Nareen, Victoria, but sold that property in 2006 when blue gums encroached and their property was overrun with kangaroos. They purchased another property at Mount Benson at that time and have lived on the original property since 2001. They ran an Angus Stud for 17 years and now run a commercial cattle property.

Merilyn has always been involved in community activities. She delivered meals-on-wheels in South Melbourne for 18 years and was a volunteer ambulance officer in Robe for 5 years. She was also a founding director of Robe Community Bank (Bendigo Bank) and served on the board for 10 years in varying roles as Secretary, Treasurer and three years as Chairman.

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The future of energy

Solar competes with coal, natural gas, hydro, and nuclear power. Solar, the newest to the mix, makes up less than 1 percent of the electricity market today but will be the world's biggest single source by 2050, according to the International Energy Agency. Demand is so strong that the biggest limit to installations this year may be the availability of panels.

Prices are falling so fast that solar will soon undercut even the cheapest fossil fuels, coal and natural gas. In the few places oil and solar compete directly, oil doesn't stand a chance. [295]

The prevalence of variable wind and solar underlines the importance of energy storage going forward. Battery storage is already proving to be economic, particularly in the role of avoiding costly upgrades and extensions to the network of poles and wires. This in turn would encourage more renewables. The SA grid operator itself suggests that the future may lie in a series of renewable based micro grids.

With the Federal government winding back its interest and commitment to renewable energy, Australian investment in clean energy plunged in 2014 to its lowest level since 2009, falling below that of small third world economies such as Honduras and Myanmar and against the global trend which grew strongly boosted by demand for large scale and roof top solar, and wind projects.

Bloomberg New Energy Finance said Australia had become "uninvestable" for large-scale projects while the scale and breadth of such projects increased dramatically around the world. The investment in rooftop solar by individual households and business prevented Australia's investment in renewable energy from reaching a virtual standstill, while large scale investment slumped 88% to its lowest level since 2002, believed to be directly related to the Federal government's attempt to cut or repeal the Renewable Energy Target. Australia's investment was only $240 million which let it slip from 11th to 39th spot in large-scale renewable investment. Myanmar is 24th, Costa Rica 27th and Honduras is 33rd. By contrast, Canada invested $US5.3 billion, Brazil $US4.7 billion, South Africa$US4.5 billion, all more than 20 times Australia's investment.

Australia's larger trading partners invested in renewable energy: China $US64 billion, United States $US12.9 billion, UK $US10.7 billion, Japan $US5.3 billion, India $US4.5 billion and Indonesia $US 1.8 billion.

According to BNEF, global investment in clean energy was $US310 billion last year, a rise of 16% from 2013 and five times the figure of a decade earlier. Solar accounted for $US150 billion, wind energy $US100 billion and energy smart technologies including storage $US37 billion.

[295] Seven Reasons Cheap Oil Can't Stop Renewables Now by Tom Randall – Bloomfield New Energy Finance

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The U.S. and China, the world's biggest emitters, reached a historic deal in November to rein in greenhouse gases. Pope Francis is preparing a papal encyclical on climate change, a letter to the world's bishops that will formalize the church's moral position on the issue for 1.2 billion Catholics. He may also convene a summit of the world's top religious leaders in advance of global climate talks in Paris in December.[296]

Oil-rich Dubai just tripled its solar target for the year 2030, to 15 percent of the country's total power capacity. Dubai's government-owned utility this week awarded a $330 million contract for a solar plant that will sell some of the cheapest electricity in the world.[297]

In China, the government is stepping up support for electric vehicles. Pollution has become a serious problem, and the Chinese are getting serious about fixing it. Plug-in sales are soaring.

Electric vehicles are moving like a Tesla: quietly, but with great acceleration. In 2017 Chevy and Tesla plan to release the first affordable mass-market plug-ins with a range of 200+ miles per charge. At that point, the price of fuel might be a real consideration for car buyers, and at that point it's more likely to tip the scales toward EVs, not away from them.[298]

The Australian Energy Market Operator has predicted that the demand for gas in Australia is decreasing and will continue to decline as renewable energy takes a greater share. In Tasmania, gas fired generation could virtually disappear altogether and in South Australia it will also fall dramatically because of the high use of wind and solar power.

If the government of South Australia does not seize the opportunity to be the leader in renewable energy in Australia it is most likely that the SA population will move this way independently and gas production will no longer be required in SA. We realise that this is unlikely to deter the SA government from producing gas and selling it overseas, but it seems like extreme development may destroy the South East, for a product the state, and possibly Australia, no longer wants, and which may no longer be available in 20 years.

More than a decade ago Turkey provided and financed every Turkish household with a roof top solar powered hot water system, valued at the time at about $A1000. Recipients had ten years to pay it back, which was then billed on their power bills until it was paid for.

Climate change and the impact of fugitive emissions on climate change also need to be part of the overall consideration in any form of energy production.

[296] Seven Reasons Cheap Oil Can't Stop Renewables Now by Tom Randall – Bloomfield New Energy Finance

[297] Seven Reasons Cheap Oil Can't Stop Renewables Now by Tom Randall – Bloomfield New Energy Finance

[298] Seven Reasons Cheap Oil Can't Stop Renewables Now by Tom Randall – Bloomfield New Energy Finance

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Conclusion

Shale gas mines have a life expectancy of around 20 years and billions of dollars of investment. But it is a finite source of energy and as the supply starts to dwindle new energy sources must be found.

Wind and solar power have no time restrictions. If the money to be spent on unconventional gas exploration and coal mining were to be redirected to Renewable Energy, in a very short time we would have an ongoing source of energy, still available in 20 or 30 years, and continuing on into the future, with continuous local employment available in the construction and maintenance into the future, and a healthy renewable energy which does no harm to landholders or the environment.

In a recent study commissioned by the Climate Institute the Limestone Coast is recognised as a "clean energy hotspot" anticipating the creation of 497 permanent jobs (both existing and new) in operation and maintenance of renewable energy infrastructure and 2,858 jobs in construction by 2020. (SA Centre for Economic Studies, Regional Development Australia, Limestone Coast, Paper 28, December 10, 2014)

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