

LOCK THE GATE ALLIANCE

AUSTRALIANS WORKING TOGETHER TO PROTECT OUR LAND, WATER, AND FUTURE

Submission to the NT Scientific Inquiry into Hydraulic Fracturing and Associated Activities

April 2017

Introduction

Lock the Gate Alliance is a national grassroots organisation made up of thousands of individuals and over 250 local groups who are concerned about unsafe or inappropriate mining. The mission of the Lock the Gate Alliance is to protect Australia's agricultural, environmental, and cultural resources from inappropriate mining and to educate and empower all Australians to demand sustainable solutions to food and energy production. Lock the Gate Alliance is committed to advocating for environmental and community health, and the productivity of local economies.

Lock the Gate Alliance wholeheartedly welcomes this Inquiry. The Alliance appreciates the opportunity to make a submission on the existing and potential impacts of the unconventional shale gas industry in the Northern Territory and the impacts on Territory communities, local environments, land and water resources on which they depend.

This submission is has two sections. The first considers the NT Fracking Inquiry's Background and Issues Paper, provides opening comments, detailed evidence and feedback in relation to risks identified and any recognized gaps. Throughout the first section, we aim to provide insights and examples of the gaps in data and knowledge, to provide clear feedback to questioning by the Panel of Naomi Hogan at the Inquiry Hearing on Friday 10 March 2017. The second section is a copy of the Lock the Gate Alliance's Powerpoint presentation provided to the Fracking Inquiry Panel, with a notes page with full references for all information provided.

Section 1: Response to the Background and Issues Paper

Opening Comments of Relevance to the Paper in General

Following two and a half decades of rapid development that has seen a massive expansion in the unconventional gas (UG) industry across twenty one states of the USA, there is a growing body of scientific literature detailing the many negative impacts of unconventional gas extraction, in particular shale gas extraction, including hydraulic fracturing (fracking) processes.

In the last few years, the state of knowledge about the risks and harms of unconventional gas mining has grown exponentially. When the New York State (NYS) Department of Health released its final Public Health Review¹ of fracking in December 2014, the number of studies in the peer-reviewed scientific literature exceeded 400, up from the 60 studies that existed two years previously in a similar review by the NYS Department of Conservation.

Summarized below is a list from the NYS Public Health Review outlining some of the environmental impacts and health outcomes that have been associated with UG operations:

- 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.
- A range of health complaints and impaired health outcomes among residents living near HVHF [fracking] activities.
- Community impacts associated with boom-town economic effects such as increased vehicle traffic, road damage, noise, odor complaints, increased demand for housing and medical care, and stress.

Additionally, the NYS Health Department review notes that an evaluation of the available research on fracking impacts reveals critical information gaps. They state: “These need to be filled to more fully understand the connections between risk factors, such as air and water

¹ New York State Department of Health (2014) A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development:
http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf

pollution, and public health outcomes among populations living in proximity to HVHF [fracking] shale gas operations.”²

The environmental impacts outlined in the NYS Health Department review and their potential adverse effects on public health led the Department to recommend to the state government that fracking should not proceed in the State of New York. (The NYS legislature subsequently announced plans to impose a ban on fracking in the state).

The New York based health organization, the *Concerned Health Professionals of New York*, have compiled the *Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking*³ (the *Compendium*) - “a fully-referenced compilation of the evidence for the risks and harms of fracking that brings together findings from the scientific and medical literature, government and industry reports, and journalistic investigation.” The Lock the Gate Alliance has worked through that report to pull out some of the summaries of peer-reviewed papers that demonstrate risks and impacts of the shale gas fracturing industry of relevance to this inquiry and the Northern Territory.

The growing evidence of actual harm, and the potential environmental and health risks from shale gas development, has now resulted in decisive action from governments across the globe to halt the expansion of this industry. Internationally, jurisdictions with some form of ban or moratorium in place include Scotland, Wales, Germany, Bulgaria, Romania, the Netherlands, Northern Ireland, Wales, the Czech Republic, Luxembourg and France as well as the US States of New York, Maryland, Florida and Vermont and the Canadian Provinces of New Brunswick, Newfoundland, Nova Scotia and Quebec.

In addition to the science, the Lock the Gate Alliance developed initial concerns with unconventional gas extraction from the lived experience of farmers and rural communities in Queensland. There are over 5000 coal seam gas (CSG) wells producing gas in that state⁴, with an additional 20,000 wells already approved. The rush to exploit CSG in Queensland and convert it to LNG, never previously attempted, has done lasting damage to the water resources and communities of the affected areas, and has had drastic negative economic consequences, rapidly driving up the price of gas for domestic consumers and industry, and throwing regional economies into turmoil. In Queensland, the approvals for large scale CSG projects were done in

² Ibid.

³ Concerned Health Professionals of New York & Physicians for Social Responsibility. (2016, November 17). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (4th ed.). http://concernedhealthny.org/wp-content/uploads/2016/12/COMPENDIUM-4.0_FINAL_11_16_16Corrected.pdf

⁴ QLD [CSG Production, 6 Monthly Statistics](https://data.qld.gov.au/dataset/petroleum-gas-production-and-reserve-statistics/resource/63a8a6cc-7fb6-4040-b4e7-9d453b14d3ed): <https://data.qld.gov.au/dataset/petroleum-gas-production-and-reserve-statistics/resource/63a8a6cc-7fb6-4040-b4e7-9d453b14d3ed>

haste and implemented before communities knew of the potential impacts and without any opportunity for them to object to the industry being imposed upon them.

The expanding scientific literature, coupled with the lived experience of unconventional gas extraction operations in Australia, and concurrent research of the impacts of shale and tight gas extraction from across North America, provides the basis of this submission to the NT Fracking Inquiry.

Specific responses to sections of the Background and Issues Paper:

Section 3.1 – The difference between conventional and unconventional gas

We recommend this further information is included in the comparison:

As unconventional gas is found in less permeable deposits or spread more diffusely throughout rock substrates than conventional (or so-called “natural”) gas, rather than in discrete pockets or reservoirs, it is more difficult to extract and therefore requires more specialized (i.e. ‘unconventional’) extraction techniques and processes. The methods required for the extraction of unconventional gas include hydraulic fracturing (fracking), horizontal drilling and multiple drilling. In addition to these extra processes, unconventional gasfields involve the industrialisation of entire landscapes with hundreds and often thousands of wells and ancillary infrastructure.

Unconventional Oil and Gas Magazine uses the following statement to highlight some of the differences and the need for more wells in unconventional gas extraction: *"High permeability rock equals higher flow rates and lower cost development by virtue of requiring a lesser number of wells (e.g. for sandstone and limestone reservoir gas) and by contrast lower permeability rock (e.g. shale, coal, and tight sandstone reservoir gas) equals lower flow rates and higher cost development as more wells are required to achieve the same flow rate."*⁵

More wells equals more risk. Shale gas fracking equals more water and more chemicals injected under higher pressures, producing more waste to get less gas. Whether shale wells are placed closely together or evenly spread across the landscape at about 1km intervals, the number of high number wells remains an inescapable reality of the industry.

This infrastructure includes vast networks of roads and pipelines, gas compressor stations and processing plants, and wastewater holding dams and treatment facilities. The number of wells required and area of land impacted is exponentially larger than for conventional gasfields. In summary, the technologies of scale and spatial intensity of unconventional gas development,

⁵ Unconventional Oil and Gas, (2016). <http://www.unconventionaloilandgas.com.au/east-coast-gas-prices-will-stimulate-the-search-for-new-resources/>

both at the surface and underground, makes it an entirely different proposition to conventional gas extraction. (For a useful explanation of scale and intensity of shale gas activities in comparison to conventional gas, see Professor Tony Ingraffea's December 2015 testimony to the South Australian Fracking Inquiry, **Attachment A**).

Section 3.5 Chemicals used in hydraulic fracturing

We recommend this section of the Paper would be strengthened with the inclusion of more recent peer reviewed science and analysis of the measured impacts of chemical use in hydraulic fracturing. For example, the 2014 paper *Environmental Public Health Dimensions of Shale and Tight Gas Development* discusses the body of scientific literature relevant to the environmental public health impacts of shale gas production.

Based on the literature available, here is an excerpt regarding chemicals used in hydraulic fracturing⁶:

Hydraulic Fracturing Fluids: Chemical Toxicology and Exposure Pathways

Shale gas development uses fracturing fluids that contain organic and inorganic chemicals known to be health damaging (Aminto and Olson 2012; U.S. House of Representatives, Committee on Energy and Commerce 2011). Fracturing fluids can move through the environment and come into contact with humans in a number of ways, including surface leaks, spills, releases from holding tanks, poor well construction, leaks and accidents during transportation of fluids, flowback and produced water to and from the well pad, and run-off during blowouts, storms, and flooding events (Rozell and Reaven 2012). Further, the mixing of these compounds under conditions of high pressure—and often high heat—may synergistically create additional potentially toxic compounds (Kortenkamp et al. 2007; Teuschler and Hertzberg 1995; Wilkinson et al. 2000). Compounds found in these mixtures may pose risks to the environment and to public health through numerous environmental pathways, including water, air, and soil (Leenheer et al. 1982).

Chemicals are used in drilling and fracturing processes as corrosion inhibitors, biocides, surfactants, friction reducers, gels, and scale inhibitors, among others (Aminto and Olson 2012; New York State Department of Environmental Conservation 2011; Southwest Energy 2012). These chemicals include methanol, ethylene glycol, naphthalene, xylene, toluene, ethylbenzene, formaldehyde, and sulfuric acid, some of which are known to be toxic, carcinogenic, or associated with reproductive harm (Colborn et al. 2011; New York State Department of Environmental Conservation 2011). Many of these compounds are considered

⁶Shonkoff, Hays and Finkel, 2014, Environmental Public Health Dimensions of Shale and Tight Gas Development, *Environ Health Perspect*; DOI:10.1289/ehp.1307866 <https://ehp.niehs.nih.gov/1307866/>

hazardous water pollutants and are regulated in other industries ([Clean Water Act of 1972](#); [Safe Drinking Water Act of 1974](#); [U.S. House of Representatives 2011](#)).

Many of the chemical compounds used in the fracturing process lack scientifically based maximum contaminant levels, making it more difficult to quantify their public health risks ([Colborn et al. 2011](#)). Moreover, uncertainty about the chemical makeup of fracturing fluids persists because of the limitations on required chemical disclosure, driven by the [Energy Policy Act of 2005](#). For instance, in many states, companies are not mandated to disclose information about the quantities, concentrations, or identities of chemicals used in the process on the principle that trade secrets might be revealed ([Centner 2013](#); [Centner and O’Connell 2014](#); [Maule et al. 2013](#)).

Section 7. The possible risks or issues associated with hydraulic fracturing

The Lock the Gate Alliance notes that submissions are invited to comment on what the acceptable levels of risk might be and how these levels might be achieved.

Firstly, unconventional gas development comes with a large number of known deleterious impacts. These include land use intensification, fragmentation, disruption to agricultural operations and alienation of agricultural land, large water demand, vegetation clearing and the production of polluting waste. These are not risks – they are known impacts. It is also known that the development of unconventional gas will produce substantial greenhouse gases that will contribute to global warming both during the extraction process and when finally used to create electricity or in other industrial processes.

On top of those known and accepted impacts, there are many very serious risks, which are frequently more difficult to quantify or assess. These include risks to groundwater and surface water resources, risks to public health and risks of induced seismicity, damage to existing industries, as well as far-reaching risks to social cohesion and wellbeing.

For example, across the vast majority of the Northern Territory, regional drinking water supplies, stock water, industry, tourism places, cultural sites and regional economies are entirely dependent on groundwater. Any level of risk to the Northern Territory’s groundwater poses a direct risk to regional communities and the Territory economy.

There are other proven and long term options for providing energy to the Northern Territory that do not carry risks to groundwater, or the other risks and known impacts that are associated with unconventional gas. There are also numerous other ways to stimulate growth in the Territory economy and population that do not put entire communities and their water supplies at risk of pollution from the shale gas fracking industry. Therefore, we invite the Panel to consider why Territorians should accept any level of risk to their water supply at all, if there is no need?

Overall, the scale of the risks is perhaps best quantified by reference to recent US research which involved a literature review of all 685 peer reviewed papers on unconventional gas in the US as of the end of 2015⁷. The review found that:

- 84% of public health studies contain findings that indicate public health hazards, elevated risks, or adverse health outcomes;
- 69% of water quality studies contain findings that indicate potential, positive association, or actual incidence of water contamination; and
- 87% of air quality studies contain findings that indicate elevated air pollutant emissions and/or atmospheric concentrations.

We believe that summary of the peer reviewed literature on risks combined with the known serious impacts caused by this industry, is sufficient to confirm that the risks are far, far too high.

This submission offers an overview of recent scientific evidence to demonstrate the risks and measured negative impacts of the unconventional gas industry, both in Australian and internationally. We encourage the Panel to consider for the Northern Territory: Who bears the brunt of these negative impacts risks and for how long into the future will these risks carry? What impacts have been measured across all projects to date and what risks are entrenched through geological reality or the shale gas extraction process itself, and therefore cannot be regulated away?

A further consideration in risk assessment is the environment in which the shale gas industry is proposed to operate. For example, have risk assessors measured what will be put at risk? Assessments to determine the baseline water quality and quantity available, the pre-existing health of communities to be impacted, the cultural significance of a landscape or the agricultural output and viability of an area – these are all required to help judge whether risks are acceptable. Risk mitigation would also be aided by knowledge of fault lines and other geological or landscape attributes that are known migration pathways for methane⁸.

It is apparent that the scale, nature and diversity of risks and impacts that unconventional gas poses means that it is entirely inappropriate to manage it through an adaptive management regime. Too many of the risks are irreversible and too much is at stake for communities and industries forced to deal with the industry, to leave it to a ‘suck it and see’ approach. In the NT, we have the benefit of being able to see the impacts that have occurred in the US and to take

⁷ Hays J, Shonkoff SBC (2016) Toward an Understanding of the Environmental and Public Health Impacts of Unconventional Natural Gas Development: A Categorical Assessment of the Peer-Reviewed Scientific Literature, 2009-2015. PLoS ONE 11(4): e0154164. doi:10.1371/journal.pone.0154164

⁸ http://energy.unimelb.edu.au/_data/assets/pdf_file/0019/2331604/Migratory_emissions_20160913.pdf

action to avoid them. We should not be subjecting our population here to an uncontrolled experiment in large-scale gasfield developments in a world class natural environment.

7.1. Water

Unconventional gas development has the potential to negatively impact on the Northern Territory's water resources, which in many instances are considered already fully allocated and/or gradually diminishing as a finite resource.

Water resources can be impacted by both contamination and depletion as a result of UG development, as outlined by the following evidence.

Water Quality

Groundwater

During fracking processes, contamination of underground water resources with flowback fluids can occur via a number of pathways. These include: migration of fluids via natural pathways in underground geologies; via pathways created by the fracking process; or as a result of well blow outs and well casing failure⁹. Flowback fluids contain hazardous fracking chemicals as well as naturally occurring toxic substances released from target geological zones such as methane, BTEX (benzene, toluene, ethylbenzene, xylene), polycyclic aromatic hydrocarbons (PAHs), naturally occurring radioactive materials (NORMs), heavy metals and other volatile organic compounds (VOCs)¹⁰.

Researchers have shown that liquid waste from shale gas fracking operations is chemically different than waste flowing out of conventional wells and hypothesize that the hydraulic fracturing process itself liberates elements from clay minerals in the shale formations, including boron and lithium, which then enter the liquid waste.¹¹

International science now clearly confirm the fact that drilling, fracking and other aspects of unconventional gas development inherently threaten groundwater and have contaminated drinking water sources in the United States.

⁹ National Toxics Network, 2013, Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources http://www.ntn.org.au/wp/wp-content/uploads/2013/04/UCgas_report-April-2013.pdf

¹⁰ Ibid.

¹¹ Warner, N. R., Darrah, T. H., Jackson, R. B., Millot, R., Kloppmann, W., & Vengosh, A. (2014). New tracers identify hydraulic fracturing fluids and accidental releases from oil and gas operations. *Environ. Sci. Technol.*, 48(21), 12552–12560. doi: 10.1021/es5032135

For example:

- Widespread drinking water contamination throughout the heavily drilled Barnett Shale region in northern Texas, where 550 water samples from public and private water wells, found elevated levels of 19 different hydrocarbon compounds associated with fracking (including the carcinogen benzene and the reproductive toxicant, toluene), detections of methanol and ethanol, and strikingly high levels of 10 different metals.¹²
- In the first fully documented case of a commonly used fracking chemical entering a drinking water source, researchers found the presence of a fracking-related solvent in private drinking water wells near drilling and fracking operations. Study authors propose that “the most likely explanation of the incident is that stray natural gas and drilling or [hydrofracking] compounds were driven ~1-3 km along shallow to intermediate depth fractures to the aquifer used as a potable water source.”¹³
- Elevated levels of methane in groundwater discharging into a stream near drilling and fracking operations in Pennsylvania along with high levels of methane in nearby private water wells as a result of gas migration near a gas well with a defective casing. The monitoring technique used in this study allowed researchers to demonstrate that the source of the methane was shale gas from the Middle Devonian period, which is the kind of gas found in the Marcellus Shale.¹⁴
- Comparison of pre-drill and post-drill data on water quality found changes in water chemistry that coincided with the advent of drilling and fracking activities. Elevated levels of chloride, iron, barium, strontium, and manganese were found with concentrations exceeding health-based maximum contaminant levels in some cases. Methane was also detected in most houses tested in this study.¹⁵

A 2016 study by Stanford University scientists determined that fracking and related oil and gas operations have contaminated drinking water in the town of Pavillion, Wyoming where residents have long complained about foul-tasting water. The researchers found substances in the water that match those used in local fracking operations or found in nearby pits used for

¹² Hildenbrand, Z. L., Carlton, D. D., Fontenot, B. E., Meik, J. M., Walton, J.L., Taylor, J. T., . . . Schug, K.A. (2015) A comprehensive analysis of groundwater quality in the Barnett Shale region. *Environmental Science & Technology*, 49(13), 8254-62. doi: 10.1021/acs.est.5b01526

¹³ Llewellyn G. T., Dorman, F., Westland, J. L., Yoxtheimer, D., Grieve, P. Sowers, T., Brantley, S. L. (2015). Evaluating a groundwater supply contamination incident attributed to Marcellus Shale gas development. *Proceedings of the National Academies of Science*, 112, 6325-30. doi: 10.1073/pnas.1420279112/-/DCSupplemental

¹⁴ U.S. Geological Survey. (2015, April 1). New stream monitoring method locates elevated groundwater methane in shale-gas development area. Retrieved from http://www.usgs.gov/newsroom/article.asp?ID=4176&from=rss&utm_source=dlvr.it&utm_medium=facebook http://www.readcube.com/articles/10.1002%2F2014WR016382?r3_referer=wol&tracking_action=previe [w_click&show_checkout=1&purchase_site_license=LICENSE_DENIED_NO_CUSTOMER#.VaPKNYsqd](http://www.readcube.com/articles/10.1002%2F2014WR016382?r3_referer=wol&tracking_action=preview_click&show_checkout=1&purchase_site_license=LICENSE_DENIED_NO_CUSTOMER#.VaPKNYsqd)

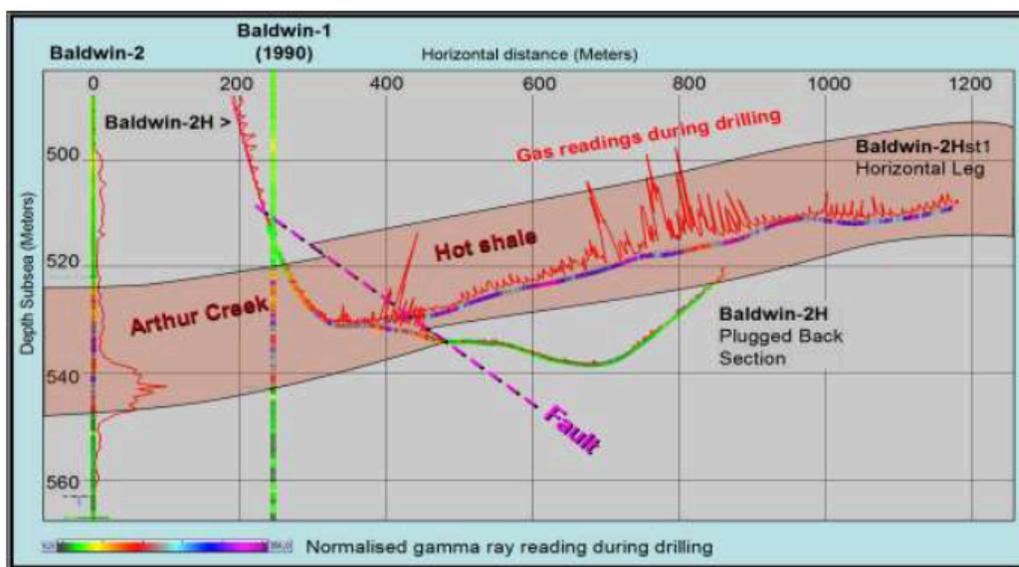
¹⁵ Alawattagama, S. K., Kondratyuk, T., Krynock, R., Bricker, M., Rutter, J. K., Bain, D. J., & Stolz, J. F. (2015). Well water contamination in a rural community in southwestern Pennsylvania near unconventional shale gas extraction. *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering*, 50, 516-528. doi: 10.1080/10934529.2015.992684

the disposal of drilling waste. Chemical contaminants included benzene, a known carcinogen, and toluene, a neurotoxicant. Possible mechanisms for contamination include defective cement well casings; spills and leaks from disposal pits; and underground migration of chemicals into aquifers from the fracked zone, which, in this area, is quite shallow.¹⁶

Risks of 'unexpected' fault lines

In 2011, trials of horizontal hydraulic fracturing by Petrofrontier in the Georgina Basin were ultimately unsuccessful for shale gas extraction. However, these old wells could be leading to ongoing methane and other contamination being brought to the surface. No one from the drilling company (which has since changed hands to Statoil) or the NT Government is monitoring these abandoned wells.

The below is an excerpt from the 2011 PetroFrontier press release (**Attachment B**).



Delays in drilling occurred when the bit tracked into the underlying Thorntonian Limestone Formation after encountering an unexpected fault. Every effort was made to redirect the bit upwards back into the Lower Arthur Creek "Hot Shale", but the bends in the hole became too severe for an effective future well completion.

Fault lines can act as a conduit for methane migration¹⁷. While in this case the fault eventually led to the unviable nature of this well, the potential increased risk of a long term pollution

¹⁶ DiGiulio, D. C. & Jackson, R. B. (2016). Impact to underground sources of drinking water and domestic wells from production well stimulation and completion practices in the Pavillion, Wyoming, Field. *Environmental Science & Technology*, 50(8). doi: 10.1021/acs.est.5b04970

¹⁷http://energy.unimelb.edu.au/__data/assets/pdf_file/0019/2331604/Migratory_emissions_20160913.pdf

pathway forming from intersecting this fault line is completely unknown. While the risk from just one well may not be considered great, the risk of a percentage of hundreds or thousands of shale gas wells across the Northern Territory intercepting deep fault lines is worthy of consideration.

One year later in 2012, Petrofrontier provided another media update that is of interest to the NT Fracking Inquiry. Here, they admit that *during the hydraulic stimulation program of the Baldwin-2Hst1 well (pictured above), a shallow casing failure occurred and as a result, PetroFrontier was unable to complete the program. The release continues: As expected, the multiple casing design protected the shallow aquifers. PetroFrontier plans to carry out remedial work to repair this well so that the planned hydraulic stimulation program can be completed.*¹⁸

For further detail on the groundwater contamination risks with a Northern Territory context, including details around the fact that some groundwater environments in the Northern Territory are naturally corrosive, please see the International Association of Hydrogeologists (NT) 2015 Submission to the Hawke Inquiry (**Attachment C**).

Methane Contamination

A review by Klohn Crippen Berger Free¹⁹ for the Queensland Department of Natural Resources and Mines considered methane migration from CSG extraction in Queensland. It concluded that gas from CSG development can even occur in water bores that do not experience a water level decline from CSG development. It also found that the presence of free gas in a water bore also directly and indirectly affects its capacity to supply water, unless remedial actions are taken. These impacts have also been reported by numerous landholders dealing with CSG in the Western Downs. They have suffered bore impairment caused not from drawdown, but from excess gas. This has led the Queensland Government to recently amend the Queensland *Water Act 2000* to formally recognise gassy bores as a form of impairment for which CSG companies are required to make good.

Surface Water

After fracking at each well, the large volumes (tens of thousands of litres per well) of hazardous flow back fluid (the 15 - 80% of the fracking fluid mixture that returns to the surface²⁰) must be stored and disposed of. Contamination of surface water may occur from release of insufficiently treated or untreated wastewater onto land surfaces or directly into waterways and as a result

¹⁸ Petrofrontier (2013) <http://www.pnewswire.com/news-releases/petrofrontier-corp-provides-operational-update-173879181.html>

¹⁹ Klohn Crippen Berge 2016. *Potential effects of free gas on bore water supply for CSG development*. Final report to the CSG Compliance Unit of the Department of Natural Resources and Mines.

²⁰ http://www.karooplaces.com/wp-content/uploads/2011/06/coop_shale_gas_report_final_200111.pdf

of leakage from storage facilities. Soil and surface water contamination may also occur from accidental spills or leakage of fracking fluids at the surface and via surface well blow outs.^{21 22}

Researchers found high levels of iodide, bromide, and ammonium in samples of wastewater from fracking operations in two US shale formations, with the same chemicals found to be present present when fracking wastewater was discharged into rivers and streams at three treatment sites in Pennsylvania and during an accidental spill in West Virginia.²³

Using geochemical and isotopic tracers to identify the unique chemical fingerprint of Bakken region brines, a 2016 Duke University study found that accidental spills of fracking wastewater have contaminated surface water and soils throughout North Dakota where more than 9,700 wells have been drilled in the past decade. Contaminants included salts as well as lead, selenium, and vanadium. In the polluted streams, levels of contaminants often exceeded federal drinking water guidelines. Soils at spill sites showed elevated levels of radium.²⁴

The study concluded that, “inorganic contamination associated with brine spills in North Dakota is remarkably persistent, with elevated levels of contaminants observed in spill sites up to 4 years following the spill events.” In a comment about this study, lead author and Duke University geochemist Avner Vengosh said, “Until now, research in many regions of the nation has shown that contamination from fracking has been fairly sporadic and inconsistent. In North Dakota, however, we find it is widespread and persistent, with clear evidence of direct water contamination from fracking.”²⁵

A 2015 study in Wyoming showed that the arrival of drilling and fracking activities coincided with an increase in salinity in a creek that drains public land in a semi-arid region of the state. The study found that the dissolved minerals associated with the rise in salinity matched those found in native soil salts, suggesting that disturbance of naturally salt rich soils by ongoing oil and gas activities, including pipeline, road, and well pad construction, was the culprit. “As [shale gas and oil] development continues to expand in semiarid lands worldwide, the potential for

²¹ NTN: Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources; http://www.karooplaces.com/wp-content/uploads/2011/06/coop_shale_gas_report_final_200111.pdf

²² Fracking: a serious concern for surface water as well as groundwater: <http://ec.europa.eu/environment/integration/research/newsalert/pdf/275na3.pdf>

²³ Harkness, J. S., Dwyer, G. S., Warner, N. R., Parker, K. M., Mitch, W. A., & Vengosh, A. (2015). Iodide, bromide, and ammonium in hydraulic fracturing and oil and gas wastewaters: environmental implications. *Environmental Science & Technology*, 49, 1955-63. doi: 10.1021/es504654n

²⁴ Lauer, N. E., Harkness, J. S., & Vengosh A. (2016). Brine spills associated with unconventional oil development in North Dakota. *Environmental Science & Technology*, 50(10). doi: 10.1021/acs.est.5b06349

²⁵ Nicholas School of the Environment, Duke University. (2016, April 27). Contamination in North Dakota linked to fracking spills [press release]. Retrieved from <https://nicholas.duke.edu/about/news/ContaminationinNDLinkedtoFrackingSpills>

soil disturbance to increase stream salinity should be considered, particularly where soils host substantial quantities of native salts.”²⁶

Water quantity

According to a 2015 water study from the United States, horizontal shale gas fracking uses the most water, requiring up to 36.6 million litres of water per well²⁷, or around 1200 truckloads of water for just one fracked well. In relation to water use, the European Commission report on fracking notes:

“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 destabilized due to upwelling of lower quality water or other substances.”²⁸

The potential for negative impacts on water supplies due to extraction of water for fracking operations is down played by industry, which often cites comparatively higher figures for irrigated agricultural production in their own defense. However, the Lock the Gate Alliance encourages the Panel to consider that depletion of ground and surface water resources from fracking operations can have significant impacts once the industry is in full production in a region.

The large number of wells needed to develop unconventional resources and the requirement for multiple fracturing of wells multiplies the overall take of water by the industry. The threat to water resources is greater in lower rainfall regions, and on a regional and local scale where water resources are already under pressure. In particular, future issues could arise in areas where water resources are relied upon by a range of existing industries and may already be subject to over allocation.

²⁶ Bern, C. R., Clark, M. L., Schmidt, T. S., Nolloway, J. M., & McDougal, R. R. (2015). Soil disturbance as a driver of increased stream salinity in a semiarid watershed undergoing energy development. *Journal of Hydrology*, 524, 123-136. doi: doi.org/10.1016/j.jhydrol.2015.02.020

²⁷ Gallegos et al, 2015, Hydraulic fracturing water use variability in the United States and potential environmental implications, *Water Resources Research Journal*.

²⁸ European Commission: DG Environment (August 2012) Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe

The extraction of water from underground aquifers for fracking has the potential to place significant stress on groundwater systems, particularly if they are already utilized by existing rural industries. This demand on groundwater for supplying fracking operations will be critical in semi-arid regions, where underground aquifers are often the sole or principal source of water, and more broadly, during extended drought periods and during periods of reduced rainfall.

A 2015 Californian study shows that while the volume of water used in fracking represents a small percentage of overall annual water consumption in California, fracking-related water use is disproportionately concentrated in areas of the state already suffering from water shortages, and further drawdowns of these aquifers may interfere with agricultural and municipal water needs²⁹.

Interestingly, a 2015 research paper from Southwest China states that, “data analysis indicates a significant correlation between water consumption and lateral length of wells.”³⁰ This correlation could be relevant in the NT context, resulting in higher water use if longer horizontal fracs are utilized, as has been mentioned in presentations as part of the NT Inquiry to date.

Whilst industry suggests overall water use could be minimised by reuse of fracking wastewater in new fracking operations, a 2013 US water report notes that whilst the oil and gas industry continues to talk about water recycling technologies, few operators in the US are using recycled fracking water in fracking operations. The study states: “with few exceptions, the rest of the water used for fracking is gone for good from the hydrological cycle” and “data on actual use of recycling are hard to come by, and it appears that these technologies are not yet widely used.”³¹

Aquatic ecosystems and biodiversity

There is increasing and ongoing evidence of point source impacts from the UG industry on ecosystems and biodiversity, while large scale regional assessments of impacts have been hampered by lack of baseline data.

²⁹ Long, J. C. S, Birkholzer, J. T., & Feinstein, L. C. (2015, July 9). Summary report. In: An Independent Scientific Assessment of Well Stimulation in California. California Council on Science and Technology, Sacramento, CA. <http://ccst.us/publications/2015/2015SB4summary.pdf>

³⁰ Yang, B. Huang, X. Yang Q. ... (2015) Water Requirements for Shale Gas Fracking in Fuling, Chongqing, Southwest China, Energy Procedia 76 (2015) 106 – 112

³¹ Western Organisation of Research Councils (2013) Gone for Good: Fracking and Water Loss in the West, http://www.worc.org/media/Gone_for_Good1.pdf

In 2013, a joint USGS and U.S. Fish and Wildlife Service study documented a causal link between a fracking wastewater spill and the widespread death of fish in the Acorn Fork, a creek in Kentucky.³²

A survey of streams in Arkansas, led by the University of Central Arkansas, found alterations in macroinvertebrate communities to be related to drilling and fracking operations in the Fayetteville Shale. Fracking activity near streams was associated with greater sediment and more chlorophyll. “This study suggests that land disturbance from gas development affected stream communities.”³³

In 2009, a leaking pipe carrying fracking waste in Washington County, Pennsylvania, polluted a tributary of Cross Creek Lake, killing fish, salamanders, crayfish, and aquatic insect life in approximately three-quarters of a mile of the stream.³⁴

A team of environmental scientists, biologists, and engineers, from institutions including the University of Michigan and McGill University, assessed the current state of understanding of the impact fracking and its associated activities have on the ecological health of surface waters. Though various approaches such as geographic information systems and site monitoring provide insights into potential risks to aquatic ecosystems, the authors concluded that inadequate data currently exist. They identified possible outcomes such as, “erosion and sedimentation, increased risk to aquatic ecosystems from chemical spills or runoff, habitat fragmentation, loss of stream riparian zones, altered biogeochemical cycling, and reduction of available surface and hyporheic water volumes because of withdrawal-induced lowering of local groundwater levels.”³⁵

In Australia, Environmental Engineer Stuart Khan of the University of NSW expressed in 2011 serious reservations about the disposal and use of produced water, claiming that: “Disposing of CSG waters directly to surface waters will significantly impact the quality of those surface waters. Attempts to beneficially reuse CSG water without treatment for application’s such as irrigation, poses risks to soil quality and shallow groundwater quality.” And further: “poorly managed discharge of reverse osmosis waters to the environment may also pose a risk to some surface water systems by disrupting (diluting) natural mineral and nutrient compositions, essential for

³² Papoulias, D., & MacKenzie, T. (2013, August 28). Hydraulic fracturing fluids likely harmed threatened Kentucky fish species. USGS Newsroom. <http://www.usgs.gov/newsroom/article.asp?ID=3677>

³³ Johnson, E., Austin, B. J., Inlander, E., Gallipeau, C., Evans-White, M. A., & Entekin, S. (2015). Stream macroinvertebrate communities across a gradient of natural gas development in the Fayetteville Shale. *Science of the Total Environment*, 530-531, 323-32. doi: 10.1016/j.scitotenv.2015.05.027

³⁴ Pittsburgh Post-Gazette. (2009, June 5). Waste from Marcellus shale drilling in Cross Creek Park kills fish. Pittsburgh Post-Gazette. <http://www.post-gazette.com/washington/2009/06/05/Waste-fromMarcellus-shale-drilling-in-Cross-Creek-Park-kills-fish/stories/200906050136>

³⁵ Burton Jr., G. A., Basu, N., Ellis, B. R., Kapo, K. E., Entekin, S. & Nadelhoffer, K. (2014). Hydraulic “fracking”: are surface water impacts an ecological concern? *Environmental Toxicology and Chemistry*, 33(8), 1679-1689.

many aquatic ecosystems. Uncontrolled discharges to ephemeral streams will disrupt natural flow regimes with potentially significant ecological implications.”³⁶

Additional water risk: Fluid treatments and waste disposal are ineffective and/or cause additional problems

The treatments to remove contaminants from produced water are limited by the chemicals they can remove, the energy needed and their economic costs. Reverse osmosis has significant limitations and cannot remove many of the organic chemicals used in UG activities. Low molecular weight, non polar, water-soluble solutes such as the methanol and ethylene glycol are poorly rejected by reverse osmosis filtration.³⁷ As the costs and difficulties of dealing with large quantities of wastewater grow, Australian UG companies are trialing reinjection into aquifer formations, despite the risks of seismic events, as experienced in the US.³⁸

Recent research from the US highlights the following issues with current waste disposal methods in the US unconventional gas industry:

- Alterations of local hydrology caused by the injection of large volumes of hydraulic fracturing fluids that may have mobilized contaminants left over from legacy oil, gas, and mining operations as well as opened pathways for the migration of fracking fluids themselves.³⁹

Identified risks in disposal practices include the use of wastewater for crop irrigation (whereby contaminants may seep from the surface of agricultural areas into groundwater), the use of unlined pits for waste storage and reinjection into potable aquifers.⁴⁰

³⁶ Khan, S. (2011) Submission to the NSW Parliamentary Inquiry into CSG, <https://www.parliament.nsw.gov.au/committees/DBAssets/InquirySubmission/Summary/39431/Submission%200330.pdf>

³⁷ Chemicals unable to be treated successfully include bromoform, chloroform, naphthalene, nonylphenol, ctylphenol, dichloroacetic acid, trichloroethylene. See www.industry.qld.gov.au/documents/LNG/csg-water-beneficial-use-approval.pdf; http://www.aquatechnology.net/reverse_osmosis.html; Stuart J. Khan Quantitative chemical exposure assessment for water recycling schemes, Waterlines Report Series No 27, March 2010 Commissioned by the National Water Commission

³⁸ Watson, B. A. (2016). Fracking and cracking: strict liability for earthquake damage due to wastewater injection and hydraulic fracturing. *Texas Journal of Oil, Gas and Energy Law*, 11(1). <http://ssrn.com/abstract=2735862>

³⁹ Alawattegama, S. K., Kondratyuk, T., Krynock, R., Bricker, M., Rutter, J. K., Bain, D. J., & Stolz, J. F. (2015). Well water contamination in a rural community in southwestern Pennsylvania near unconventional shale gas extraction. *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering*, 50, 516-528. doi: 10.1080/10934529.2015.992684

⁴⁰ Long, J. C. S, Birkholzer, J. T., & Feinstein, L. C. (2015, July 9). Summary report. In: An Independent Scientific Assessment of Well Stimulation in California. California Council on Science and Technology, Sacramento, CA. <http://ccst.us/publications/2015/2015SB4summary.pdf>

In the Northern Territory, Origin Energy has used unlined pits for the storage of waste water, and then has failed to responsibly remove all contaminants, leaving polluted water in areas that then flooded.

These photos show the state that a shale gas pad was left in after gas fracking activities stopped in mid December 2015.



December 2015, photo supplied



December 2015, photo supplied



December 2015, photo supplied

Water testing from the site showed results common of water associated with the unconventional gas industry: high barium, aluminium, iron & bromine. Please find the spreadsheet of results in **Attachment D**.

The entire area was underwater during the flooding event which stretched from Mataranka to Elliot in late December 2015: <http://www.abc.net.au/news/2015-12-29/stuart-highway-closure-flood-elliott-mataranka/7057992>

Head of NT Department of Mines and Energy gave evidence to a Senate Inquiry in 2016, where he answered questions in relation to shale gas activities. Here, he gave the impression that ponds did not overflow and that the ponds would have been lined. This provided the current Inquiry Panel insights in to the recent behaviour and attitude to date of the shale gas regulatory system in the Northern Territory.

Transcript: Tuesday, 12 April 2016 Senate Page 1 SELECT COMMITTEE ON UNCONVENTIONAL GAS MINING

BACON, Dr Rachel, Deputy Chief Executive, Department of the Chief Minister

KELLY, Mr Ron, Chief Executive, Department of Mines and Energy Committee met at 8:03

CHAIR (Senator Lazarus):

Senator PERIS: Do you know if you have had shale gas drilling ponds overflowing already in the Territory, from the gas wells that have been drilled?

Mr Kelly: No, Senator.

Senator PERIS: Are the ponds that have been drilled lined to avoid seepage into the groundwater underneath?

Mr Kelly: In the current regime of drilling—because there have not been any wells drilled in the southern part of Australia for some time—in all the new work that is being done, any ponds that may have been or are constructed are certainly lined, but they are only temporary. With regard to the wastewater, or the processed water, that resulted from exploration wells that were drilled last year, we required that all of that processed water be captured, sealed into appropriate containers and trucked away to an approved water treatment processing facility. The reason for that is that, until we have the actual chemical constitution of that water—as it has come back out of the ground, if it has picked up any other elements—and we know exactly what that water looks like, we are unable to approve an appropriate treatment process on-place. So we take the precautionary principle in that regard, and we are not going to let it sit there in an evaporation pond, if you like, while we figure out the best way of treating it. We make sure that it is treated appropriately from the start.

Senator PERIS: Okay. Has the Department of Mines and Energy done water samples of what pollution is present in the shale gas drilling ponds across the Sturt Plateau and the Daly Waters?

Mr Kelly: We have water samples from any of those operations, but I think you would have to tell me which ponds you are looking at, because I am not aware of anything other than what may be there as temporary, protective, storage type measures. There are no long-term dams that are unlined or untested in the Northern [Territory]. (Full transcript available, **Attachment E**)

Spills – a risk to surface and groundwater

New analysis, published Feb. 21 2017 in the journal *Environmental Science & Technology*, revealed 6,648 spills from the fracking industry from just the four states that they studied alone—Colorado, New Mexico, North Dakota and Pennsylvania—in 10 years⁴¹. The researchers determined that up to 16 percent of fracked oil and gas wells spill hydrocarbons, chemically laden water, fracking fluids and other substances. They found that 75% to 94% of spills occurred within the first three years of well life when wells were drilled, completed, and had their largest production volumes. Across all four states, 50% of spills were related to storage and moving fluids via flowlines. The team also designed an interactive spills data visualization tool (<http://snappartnership.net/groups/hydraulic-fracturing/webapp/spills.html>) to illustrate the value of having standardized, public data.

In Australia, during the exploration phase of coal seam gas development in NSW, there have been a number of recorded contamination events around the state. Santos' CSG operations in the Forest region of NW NSW recorded at least 20 coal seam gas waste water spills and continuing leaks from evaporation ponds. Santos' records show spills and leaks from all parts of the operations, from evaporation ponds, pipelines, the wastewater treatment facilities and at well sites⁴².

Pollution offences occurred under the former site operator Eastern Star Gas. The NSW EPA issued the following statement, "The EPA issued two penalty notices with fines of \$1,500 each to Eastern Star Gas for discharging polluted water containing high levels of salt into Bohena Creek in March and November 2010; offences under section 120 of the Protection of Environment Operations Act 1997."⁴³

⁴¹ Patterson, L. K. Konschnik, K. Wiseman, H... (2017) Unconventional Oil and Gas Spills: Risks, Mitigation Priorities, and State Reporting Requirements, *Environ. Sci. Technol.*, 2017, 51 (5), pp 2563–2573, DOI: 10.1021/acs.est.6b05749 <http://pubs.acs.org/doi/abs/10.1021/acs.est.6b05749?journalCode=esthag>

⁴² Santos Ltd Energy NSW (2014) Report into Eastern Star Gas Limited prepared for Government of New South Wales

⁴³ NSW EPA (2012) Eastern Star Gas fined for pollution in the Pilliga, <http://www.epa.nsw.gov.au/epamedia/EPAMEDIA12070601.htm>

In 2014, Santos was found guilty of polluting an aquifer in the Pilliga Forest⁴⁴ with radioactive uranium 20 times safe levels as well as toxic heavy metals⁴⁵.

A spill in June 2011 in the Pilliga resulted in 10,000 litres of untreated toxic coal seam gas wastewater containing a mix of heavy metals (including arsenic, lead and chromium), salts and petrochemicals that killed vegetation and wildlife. Santos was found guilty in the NSW Land and Environment Court and fined \$52,000⁴⁶.

Well integrity failure risks

Issues surrounding well integrity failure pose specific risks across many themes, including surface and groundwater, landscapes, air quality and greenhouse gas emissions and health.

The industry has been arguing for years that they are improving their practice, and science and industry papers have been calling for improvements for decades, yet the problems persist. Well failures have not improved with time – the industry has not engineered a way out of well casing failure and annular flow.

In the spoken presentation to the NT Fracking Inquiry Panel, the Lock the Gate Alliance provided specific insights from 2003 Oilfield Review, published by Schlumberger (**Attachment F**). Here, the industry paper admits, *“Techniques for locating, exploiting and transporting natural gas to our homes and industries have had huge advances since the early days. Despite these advances, many of today’s wells are at risk. Failure to isolate sources of hydrocarbon either early in the well construction process or long after production begins has resulted in abnormally pressured casing strings and leaks of gas into zones that would otherwise not be gas-bearing.”*

They also admit, *“Since the earliest gas wells, uncontrolled migration of hydrocarbons to the surface has challenged the oil and gas industry. Gas migration, also called annular flow, can lead to sustained casing pressure (SCP)... The presence of SCP indicates that there is communication to the annulus from a sustainable pressure source because of inadequate zonal isolation. Annular flow and SCP are significant problems affecting wells in many hydrocarbon-producing regions of the world... By the time a well is 15 years old, there is a 50% probability that it will have measurable SCP in one or more of its casing annuli. However, SCP may be present in wells of any age.”*

⁴⁴ <http://www.epa.nsw.gov.au/epamedia/EPAMedia14021802.htm>

⁴⁵ <http://www.smh.com.au/environment/water-issues/epa-defends-its-actions-over-natural-uranium-in-contaminated-aquifer-20140309-34fhp.html>

⁴⁶ <http://australianresources.com.au/1833/santos-fined-pilliga-spill>

A 2014 study published in the Proceedings of the National Academy of Sciences of the United States of America provides a useful and more recent overview of the industry and scientific data produced to that date, specifically considering unconventional extraction.

In a technical sense, “well integrity” refers to the zonal isolation of liquids and gases from the target formation or from intermediate layers through which the well passes. In a practical sense, it means that a well doesn’t leak. Drilling companies emphasize well integrity because a faulty well is expensive to repair and, in the rarest of cases, costs lives, as in the Deepwater Horizon disaster in the Gulf of Mexico. Drillers use steel casing (pipes), cement between nested casings and between the outside casing and rock wall, and mechanical devices to keep fluids inside the well.

Faulty casing and cementing cause most well integrity problems. Steel casing can leak at the connections or corrode from acids. Cement can deteriorate with time too, but leaks also happen when cement shrinks, develops cracks or channels, or is lost into the surrounding rock when applied. If integrity fails, gases and liquids can leak out of the casing or, just as importantly, move into, up, and out of the well through faulty cement between the casing and the rock wall.⁴⁷

Risk of biogenic hydrogen sulfide gas

The 2012 media release from Petrofrontier in relation to their Georgina Basin fracking program also states: *A successful hydraulic stimulation was performed on the MacIntyre-2H well over nine open-hole stages. However, after recovering approximately one-third of the hydraulic stimulation fluid, traces of biogenic hydrogen sulfide gas, produced from naturally occurring organisms in the completion fluid, were detected and the well had to be suspended.⁴⁸*

According to a 2007 paper, hydrogen sulfide gas (H₂S) is a toxic and corrosive gas and a precursor to the formation of sulfuric acid, H₂SO₄, which causes the destruction of metal and concrete substrates. This bacterially induced process of forming hydrogen sulfide gas and the subsequent conversion to sulfuric acid that attacks concrete and steel within wastewater environments is known as biogenic sulfide corrosion⁴⁹.

Biogenic sulphide corrosion of shale gas infrastructure could have major implications for risks to NT water supplies into the future. It is problems rarely admitted by the industry when they talk up their three layers of cement and steel. However, the natural bacterial corrosion of well

⁴⁷ Jackson, R. (2014) The integrity of oil and gas wells, [Proc Natl Acad Sci U S A](https://doi.org/10.1073/pnas.1410786111). 2014 Jul 29; 111(30): 10902–10903. Published online 2014 Jul 9. doi: [10.1073/pnas.1410786111](https://doi.org/10.1073/pnas.1410786111), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4121783/>

⁴⁸ Ibid.

⁴⁹ O’Dea, V. (2007) Understanding biogenic sulfide corrosion, <https://www.environmental-expert.com/articles/understanding-biogenic-sulfide-corrosion-36635>

casings into the future creates a very difficult risk to ignore and is difficult to measure what impact it could have, particularly in the long term after wells are abandoned.

Conoco Phillips authored a paper in 2012 that states:

Internal pipeline corrosion in the presence of hydrogen sulfide has become a major issue for both oil and gas industries. Problems resulting from hydrogen sulfide corrosion have started to draw attention to the oil and gas industry since the 1940's. Since then, researchers have done a tremendous amount of work, studying the mechanism of hydrogen sulfide corrosion. However, the corrosion mechanisms initially proposed are still not fully understood and well acceptable around the world. Although the corrosion mechanism is still confusing, many attempts have been made by the industry to mitigate hydrogen sulfide corrosion problems.⁵⁰

Further, and for broader Northern Territory perspective, the below text is a direct excerpt from the International Association of Hydrogeologists (NT) 2015 Submission to the Hawke Inquiry (**Attachment C**).

Deterioration and failure of improperly decommissioned wells will, over time, result in long term release of oil and/or gas into the environment. Pathways in the annulus may develop that would allow oil, gas, and brine to move vertically across geologic formations and contaminate groundwater. Substances dissolved in the brine may include those that occur naturally in the shale formations and others injected during the hydraulic fracturing process.

Also upwardly migrating gas, known as stray gas, represents an explosion hazard if not properly vented away from buildings and drinking water wells.

The risk that annular pathways will develop increases over time as chemical, mechanical, and thermal stresses causes deterioration of well structures and components. Failure modes of improperly abandoned wells include the formation of cracks in the cement casing or packers, corrosion of steel production casing, faulty valves, and leaking temporary plugs or surface caps. A key paper on the causes of well failure (Dusseault et al, 2000) discusses cement shrinkage as the principle cause of well failure, particularly long after wells have been plugged and abandoned.

⁵⁰ Conoco Phillips (2012) Investigation of Effects of Iron Sulfide On Corrosion And Inhibition of Carbon Steel In H₂S Containing Conditions, <https://www.onepetro.org/conference-paper/NACE-2012-1651>

Estimates of well failure rates vary although the more conservative well failure rates found in the literature are between 4.6% and 8.9%. Further, a study from Alberta, Canada of more than 315,000 oil, gas and injection wells of various ages, (Watson and Bachu, 2009), shows that 'injection wells' into which liquids or gasses are pumped are 2-3 times more likely to leak than conventional 'production wells'.

The same study found that horizontal or inclined wells are observed to have significantly higher failure rates than vertical wells. It is universally acknowledged that problems with casing centralisation and cement slumping in horizontal or inclined wells may contribute to the increased incidence of leakage.(Council of Canadian Academies, 2014, Watson and Bachu, 2009).

A well-documented example of groundwater contamination caused by fracking operations from the USA occurred in Pennsylvania, USA (Osborn et al, 2011). It found that about 75% of wells sampled within 1 kilometre of gas drilling in the Marcellus shale in Pennsylvania were contaminated with methane from the deep shale formations. Isotopic fingerprinting of the methane indicated that the deep shale was the source of contaminations, rather than biologically derived methane. In addition, fracking-return fluids have also been known to contaminate drinking water, although the evidence is not as strong as for methane contamination (Horvath & Illgraffea, 2011).

Well integrity is of concern in the NT because some groundwater environments in the NT are naturally corrosive. An example of the effect of corrosive water on cementing and casing in the NT is provided by deep oil exploration wells (McDills and Dakota) drilled in the Perdika/Great Artesian Basin in the 1960s. (The Perdika Basin is one of the prospective unconventional shale gas areas of the NT). Now, some fifty years later, the steel casing has almost entirely corroded away, resulting in inter-aquifer contamination. This well required expensive rehabilitation works to stem artesian flow (Humphreys and Kunde, 2004). This single bore cost the Territory and Commonwealth Governments \$500,000 to plug as the company responsible for the well was insolvent. This example highlights the issue of operator insolvency due to the boom and bust cycles of oil and gas development which complicate efforts to hold liable parties responsible and provide for timely environmental reclamation.

7.2 Land

In assessing the rehabilitation of land that has been hydraulically fractured, the European Commission report⁵¹ on fracking notes: “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.” A recent US study documents the failure of plant and soil systems disturbed by drilling and fracking activities to return to pre-drilling conditions following rehabilitation- even after 20 to 50 years⁵².

An interdisciplinary study published in *Science* 2015 demonstrated that the accumulating land degradation has resulted in continent-wide impacts of the unconventional gas industry in the United States, as measured by the reduced amount of carbon absorbed by plants and accumulated as biomass. This is a robust metric of essential ecosystem services, such as food production, biodiversity, and wildlife habitat, and its loss “is likely long-lasting and potentially permanent.” The land area occupied by well pads, roads, and storage facilities built during this period is approximately three million hectares, roughly the land area of three Yellowstone National Parks. The authors concluded that new approaches to land use planning and policy are “necessary to achieve energy policies that minimize ecosystem service losses.”⁵³

Many of the ecosystem services of the Northern Territory have not yet been adequately mapped to understand what the impacts of degrading this resource will be, and the negative impacts that could flow from that.

The gaps in baseline understanding are exemplified by a recent 11 April 2017 media release from the Northern Territory Government, announcing the release of its new \$9.935 million *Mapping the Future* program. The project will support scientific teams to identify potential productive land for future use in regional areas and improve natural resources information.

According to the release: “Minister for Environment and Natural Resources said the program would map the soil, water and biodiversity assets in regional parts of the NT.

⁵¹ European Commission: DG Environment (August 2012) Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe

⁵² Minnick, T. J. & Alward, R. D. (2015). Plant–soil feedbacks and the partial recovery of soil spatial patterns on abandoned well pads in a sagebrush shrubland. *Ecological Applications* 25(1), 3-10.

⁵³ Allred, B. W., Kolby Smith, W., Tridwell, D., Haggerty, J. H., Running, S. W., Naugle, D. E., & Fuhlendorf, S. D. (2015). Ecosystem services lost to oil and gas in North America. *Science*, 348 (6233), 401-402.

The mapping that takes place over the five year period will;

- Provide data to underpin land use plans for regional growth areas, which will identify areas that are highly suitable for land uses such as agriculture.
- Allow regional communities to make informed decisions on the location of natural resource-based economic development opportunities and local community-based land use planning.
- Attract private investment in natural resources industries based on accurate scientific data.
- Inform the long term management, protection and health of community drinking supplies, while ensuring sustainability of natural and cultural assets such as ground water-dependent ecosystems.

The first year of the program involves extensive planning and consultation with industry and community stakeholders from across the NT to identify prospective areas for mapping.

Scientific teams will be deployed from July 2018 once priority areas have been identified and land access agreements secured. When active, the Department of Environment and Natural Resources will;

- Use drill rigs and corers to obtain soil samples for analysis.
- Measure the flow, quality and quantity of both surface and ground water in or near study areas.
- Use a range of techniques to survey study areas to describe the distribution of native plants and animals, including threatened species.⁵⁴

This is exactly the type of baseline information collection that is required. There is a fair amount of information on where shale gas reserves are most likely found, but data regarding other land uses is scant. Final decision making on the acceptability or otherwise of the shale gas industry and its associated damaging impacts, water use and landscape impacts should only be undertaken after this regional mapping project is completed.

Fragmentation and Biosecurity

There is very little empirical data available on the ecological impacts of fragmentation from unconventional gas development, nor on the biosecurity threats it poses or the actual contribution its development has made to date to the spread of invasive weeds and feral animals.

⁵⁴ NT Government (2017) <http://newsroom.nt.gov.au/mediaRelease/23051>

Research that is available identifies significant ecological impacts arising from landscape fragmentation. A thesis on the landscape consequences of unconventional gas development in Pennsylvania's old growth forest found that gas development increased edge length and the number of forest patches and decreased interior forest cover⁵⁵. A 2012 study in Pennsylvania found that shale gas development would fragment forest cover and entail intensive disturbance of core forests where headwater streams occur⁵⁶.

One of the few studies available on individual species impacts from the US, shows marked alterations in deer habitat selection patterns in response to unconventional gas development in Colorado⁵⁷. Deer were forced to alter habitat use to avoid gas activities and infrastructure, leading to a 50% variation during the day time within their critical winter range.

Ecological experts in Australia have identified that *'fragmentation and loss of native vegetation resulting from the considerable surface footprint of CSG infrastructure represent a serious threat to biodiversity, threatened species and landscape function'*⁵⁸. They suggest that, "Evidence from CSG developments to date indicates that severe effects are possible. Potential impacts include direct clearing of bushland, fragmentation of important remnant vegetation, spread of invasive species and increased fire risk".

Similarly, the sheer scale of proposed shale production, including the number of likely gas wells and the extent of associated infrastructure, presents genuine risks for the unique natural landscapes of the Northern Territory.

In Queensland, farmers have reported serious invasions of weeds following CSG development. One cattle farmer has initiated legal action against a CSG company after he had to destock his property at Dalby after a sudden infestation of the noxious African lovegrass weed following CSG activities⁵⁹.

Lawyers in Queensland representing farmers dealing with the CSG industry consider that weeds may ultimately be one of the biggest legacies of the CSG industry. Shine Lawyers have spoken

⁵⁵ Bernau, Jeremiah. 2013. [Landscape Consequences of Pennsylvania Natural Gas Development: Fragmentation effects of unconventional gas development upon the future of Pennsylvania's old growth forests.](#)

⁵⁶ Drohan, P. J., Brittingham, M., Bishop, J., & Yoder, K. (2012). Early trends in landcover change and forest fragmentation due to shale gas development in Pennsylvania: A potential outcome for the northcentral Appalachians. *Environmental Management*, 49(5), 1061 - 1075

⁵⁷ Joseph M. Northrup, Charles R. Anderson Jr. and George Wittemyer, "Quantifying Spatial Habitat Loss from Hydrocarbon Development through Assessing Habitat Selection Patterns of Mule Deer," [Global Change Biology](#), 12 August 2015.

⁵⁸ Williams J., Stubbs T. & Milligan A. (2012) An analysis of coal seam gas production and natural resource management in Australia. A report prepared for the Australian Council of Environmental Deans and Directors by John Williams Scientific Services Pty Ltd, Canberra, Australia

⁵⁹ <http://www.abc.net.au/news/2014-08-23/farmer-claims-csg-companies-spread-weeds-on-southern-qld-propert/5661016>

out against the weaknesses of biosecurity measures, stating that: *'We are informed by a leading expert that current washdown procedures have difficulty removing more than 10% of the weed or pathogen load from machinery. If correct, no amount of insistence upon constant monitoring of access and the production of weed hygiene declarations (washdown certificates) will truly protect a landholder. Furthermore, having companies or subcontractors able to self-monitor and write the certificates themselves is hardly of comfort'*.⁶⁰

Seismic Activity

Evidence arising in just the past 18 months has had a significant impact on our understanding the links between fracking and waste fluid reinjection with increased seismicity and earthquakes.

January 2016: An international research team investigated a swarm of earthquakes in California's Central Valley that occurred in 2005. Using hydrogeological modeling, the researchers concluded that the underground injection of wastewater from oil drilling operations had contributed to seismicity via changes in localized pressures along an active fault.⁶¹

February 2016: An article in the Texas Journal of Oil, Gas, and Energy Law exhaustively reviewed the literature on earthquake activity in areas of six states (Arkansas, Colorado, Kansas, Ohio, Oklahoma, and Texas) where fracking takes place or drilling wastes are disposed underground and concluded that courts should impose strict liability for earthquake damage caused either by fracking itself or by the underground injection of fracking fluids. "Earthquakes sometimes occur when subsurface formations are properly fractured. Likewise, the risk of earthquake damage is not substantially mitigated by the exercise of due care when frack fluids are injected into the ground."⁶²

March 2016: A summary of the evidence linking drilling and fracking activities to earthquakes appeared in Scientific American. Emerging data suggests that pressure changes caused by fracking wastewater injection can migrate for years before encountering a geological fault and altering stresses in ways that allow for slippage. In this way, earthquake risks can spread out over both time and space—traveling for miles beyond the disposal well and persisting for a

⁶⁰ <https://www.shine.com.au/blog/coal-seam-gas-law/weeds-csg-insidious-legacy/>

⁶¹ Goebel, T. H. W., Hosseini, S. M., Cappa, F., Hauksson, E., Ampuero, J. P., Aminzadeh, F. & Saleeby J. B. (2016). Wastewater disposal and earthquake swarm activity at the southern end of the Central Valley, California. *Geophysical Research Letters*, 43. doi: 10.1002/2015GL066948

⁶² Watson, B. A. (2016). Fracking and cracking: strict liability for earthquake damage due to wastewater injection and hydraulic fracturing. *Texas Journal of Oil, Gas and Energy Law*, 11(1). <http://ssrn.com/abstract=2735862>

decade or more as injected fluids travel underground. In spite of increasing scientific clarity about these mechanisms, regulators have been slow to respond.⁶³

May 2016: In a study that has “far-reaching implications for assessment of induced seismicity hazards,” a Canadian team of researchers determined that hydraulic fracturing itself is linked to earthquake swarms in western Canada, in contrast to the central United States where disposal of fracking waste is the cause of most induced seismicity. Furthermore, lowering the volume of injected fluid may not be sufficient to prevent quakes.⁶⁴

Further study is needed to assess the impact of this increased seismicity and earthquakes with contamination to groundwater. The damage from the increased earthquakes must also be considered as a risk across other areas of interest for the NT Fracking Inquiry.

7.3 Air

A 2012 study detected 44 hazardous air pollutants at unconventional gas well sites⁶⁵, whilst other recent US studies⁶⁶ show that drilling and fracking emissions often contain strikingly high levels of benzene. The NYS Dept. of Health Public Health Review (the NYS Review) noted that “studies provide evidence of uncontrolled methane leakage, emissions of other volatile organic chemicals, and particulate matter from well pads and natural-gas infrastructure [as well as]... intermittently high dust and benzene concentrations.”

Exposure to a range of harmful substances associated with unconventional gas operations constitutes a serious health hazard to those working on and living adjacent to or surrounded by UG development. The NYS Review⁶⁷ states that emissions from UG operations have the potential to contribute to community odour problems and respiratory health impacts such as asthma exacerbations.

A less discussed impact on air quality is raising ethane levels. According to University of Michigan researchers, the Bakken shale emits 250,000 tons of ethane per year.⁶⁸ They found,

⁶³ Kuchment, A. (2016, March 28). Drilling for earthquakes. Scientific American. Retrieved from <https://www.scientificamerican.com/article/drilling-for-earthquakes/>

⁶⁴ Atkinson, G. M., Eaton, D. W., Ghofrani, H., Walker, D., Cheadle, B., Schultz, R. ... Kao, H. (2016). Hydraulic fracturing and seismicity in the Western Canada Sedimentary Basin. *Seismological Research Letters*, 87(3). doi: 10.1785/0220150263

⁶⁵ NTN: Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources

⁶⁶ See footnotes 3–8, 12, 57, 174 in Fracking Compendium, Vol. 2

⁶⁷ A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development: http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf

⁶⁸ Kort, E. A., Smith, M. L., Murray, L. T., Gvakharia, A. Brandt, A. R., Peischl, J., . . . Travis, K. (2016). Fugitive emissions from the Bakken shale illustrate role of shale production in global ethane shift. *Geophysical Research Letters*, 43, 4617–4623. doi: 10.1002/2016GL068703

“emissions we observed in this single region are 10 to 100 times larger than reported in inventories. They directly impact air quality across North America. And they’re sufficient to explain much of the global shift in ethane concentrations.”⁶⁹ Ethane is a gas that affects climate and decreases air quality. Ethane contributes to ground-based ozone pollution as it breaks down and reacts with sunlight to create smog. This surface-level ozone is linked to respiratory problems, eye irritation, and crop damage. Global ethane levels were decreasing until 2009, leading the researchers to suspect that the U.S. shale gas boom may be responsible for the global increase in levels since 2010.

Climate Change

Methane is a more powerful greenhouse gas than carbon dioxide – 86 times more powerful when considered over a 20-year timeframe and 34 times more over a 100-year timeframe. The near term consequences of methane emissions are very important in the context of the risks of climate tipping points and near term temperature thresholds over the coming two decades.

A recent report by the Melbourne Energy Institute (MEI) reviewed the latest research on methane fugitive emissions from unconventional gasfields in the US⁷⁰. It found that:

1. Actual measurements above US gasfields have recorded fugitive emissions of up to 17% of production. For comparison, the unconventional gas industry in Australia claims that its fugitive emissions amount to only 0.1% of production⁷¹.
2. ‘Top down’ methods of measuring fugitive emissions, such as satellite imagery and aerial borne surveys, have revealed methane emissions that are many orders of magnitude greater than emissions recorded from ‘bottom up’ surveys using ground measurements’.

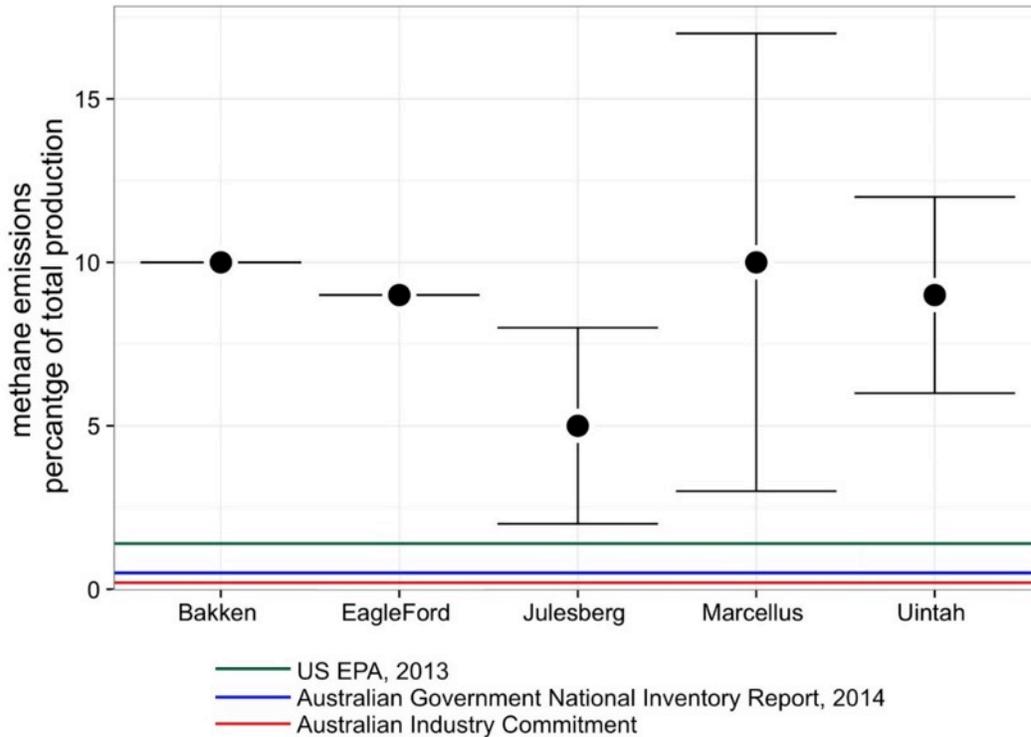
It is widely recognized that at more than about 3% leakage, gas is actually more polluting than coal when used to generate electricity⁷².

⁶⁹ Moore, C. S. & Human K. (2016, April 26). One oil field a key culprit in global ethane gas increase. Michigan News. <http://ns.umich.edu/new/multimedia/videos/23735-one-oil-field-a-key-culprit-in-globalethane-gas-increase>

⁷⁰ Lafleur, D., Forcey, T., Saddler, H., and Sandiford. M. (2016) A Review of Current and Future Methane Emissions from Australian Unconventional Oil and Gas Production. Melbourne Energy Institute.

⁷¹ Clark, T., R. Hynes, P. Mariotti, A. P. Production and E. Association (2011). Greenhouse gas emissions study of Australian CSG to LNG, Australian Petroleum Production & Exploration Association Limited.

⁷² See, for example, Hardisty, P. E., T. S. Clark and R. G. Hynes (2012). "Life cycle greenhouse-gas emissions from electricity generation: A comparative analysis of Australian energy sources." *Energies* 5(4): 872-897.



Measured fugitive emissions at US gas fields compared to Australian industry and government reporting.

Comparison of emission estimates and measurements (Table 11 from MEI 2016)

Reported oil and gas-related methane-emission estimates and top-down measurements				
		Basis	% of production	Reference
Australia	Oil and gas industry media release	limited well-pad measurements	0.02%	Footnote ⁷³
	Fugitive emissions reported in Queensland CSG-LNG environmental impact statements	factor-based estimates	0.1%	Clark, Hynes et al. (2011), Prior (2011), Hardisty, Clark et al. (2012)
	Australian Government reported (for the year 2014)	largely factor-based estimates	0.5%	See Section 5.3 MEI report
U.S.	U.S. EPA (for the year 2013, latest revision)	largely factor-based estimates	1.4%	See Section 4.6 MEI report

⁷³ APPEA (2014) http://www.appea.com.au/media_release/csiro-report-points-to-environmental-benefits-of-csg/

U.S. Denver-Julesberg basin	aircraft measurements	2 to 8%	Petron, Karion et al. (2014), see Table 2 MEI report
U.S. Eagle Ford Basin (Texas)	satellite-based measurements	9%	Schneising, Burrows et al. (2014), see Table 2 MEI report
U.S. Bakken Basin (North Dakota)	satellite-based measurements	10%	Schneising, Burrows et al. (2014), see Table 2 MEI report
U.S. Uintah Basin (Utah)	aircraft-based measurements	6 to 12%	Karion, Sweeney et al. (2013), see Table 2 MEI report
U.S. Marcellus Basin (southwestern Pennsylvania)	aircraft-based measurements	3 to 17%	Caulton, Shepson et al. (2014), see Table 2 MEI report

Emissions Factors Used in Australia

The MEI report found that in Australia to date, there has been almost complete reliance on pre-determined emission ‘factors’ in reporting of unconventional gas emissions to the UNFCCC. It also noted that actual measurements of emissions have been almost non-existent (confined only to extremely limited bottom up studies), and that there have been no baseline measurements in Australia.

Therefore, it is currently not possible to accurately assess emissions from Australian gasfields, but evidence from the US points to the fact that our emissions reporting, based as it is on factors, is likely to significantly understate the true level of emissions. Specifically, methane leakage rates recorded in the atmosphere at US unconventional gas fields are 10-25 times higher than those the Australian government reports to the UNFCCC (see Figure above).

The report highlighted one particularly notable area of likely underestimation in the use of emissions factors. The emission factor used for reporting methane leaked during the production phase of gas extraction for UNFCCC reports; categorized as “*fugitive emissions-general leaks*” – which is very low at just 0.0058% of production. Within that production

category, emissions are set to zero for the following sources of emissions, despite the likelihood that emissions from these sources are very large:

1. In field compressor stations
2. Water and gas gathering lines and associated venting
3. Water treatment facilities
4. Migratory emissions

The 'production' emissions factor relies on a CSIRO 2014⁷⁴ report that claims to have validated the 0.0058% factor, but that report:

- Was artificially restricted to well head emissions only
- Ignored leaks from the large network of gathering lines, compressors and pumps connecting gas wells to the transmission pipeline.
- Noted far larger leaks in the pipeline system outside wellheads that overwhelmed well head measurements, but didn't measure them
- Relied on a very small sample of 43 wells selected by the gas industry

The CSIRO 2014 report, however, gives some insight into the scale of production emissions that were outside its study and that are currently set to zero in Australian reporting, as follows:

"We found a significant CH₄ emission point from a water gathering line near Well B13. Methane was being released from two vents ... at a rate sufficient rate to be audible a considerable distance from the vents. ... Based on the prevailing wind speed, we estimate that the CH₄ emission rate from the two vents was at least 130 [grams per minute].... This is a factor of three more than the highest emitting well examined during this study."

Recorded Methane Venting in Australia

The substantial nature of emissions from vents has been verified recently with the deployment of a FLIR GF-320 infrared camera in the Queensland coal seam gasfields. An independent energy advisor, Tim Forcey, deployed the camera in February 2017 near Chinchilla and found⁷⁵:

1. Continuous releases of methane from "high-point vents" on water-gathering pipelines
2. Intermittent releases of methane from other gas field equipment
3. Methane bubbling from the Condamine River and Wambo Creek.

Given the very large number of high point vents and other gas field equipment vents which are located throughout the Queensland CSG fields, if the scale of venting detected by the FLIR camera was replicated, it would represent a potentially vast, unmeasured contribution to global warming.

⁷⁴ Day, S., M. Dell'Amico, R. A. Fry and H. Javanmard Tousi (2014). Field Measurements of Fugitive Emissions from Equipment and Well Casings in Australian Coal Seam Gas Production Facilities, CSIRO, Australia.

⁷⁵ Tim Forcey. 2017. Infrared Video Recording Methane Emissions in the Queensland Coal Seam Gas Fields. February 2017.

Estimates of Emissions and Implications for Paris Targets

Whilst the paucity of data makes it difficult to assess the likely scale of emissions from unconventional gas in Australia, the Melbourne Energy Institute utilised recorded 'top down' measurements from the US to derive a set of estimated emission scenarios for the Australian context and associated liabilities should there be a price on carbon⁷⁶.

Table 12 from MEI 2016

Liabilities for differing scenarios for methane emissions from Australian unconventional oil and gas production, in terms of lost value and potential carbon impost.					
Column	A	B	C	D	E
Case	Unconventional gas production rate	Methane emissions rate	Methane greenhouse-gas emissions (100 yr – 20 yr GWP)	Sales value of lost gas (at \$A 10 / gigajoule)	Carbon impost (\$A 25/tonne CO ₂ -e; 100 yr – 20 yr GWP)
	PJ/yr	% of gas production	million tonnes CO ₂ -e/yr	million \$A/yr	million \$A/yr
1	1,500 (*)	0.5	5 - 12	75	115 - 290
2	"	2	18 - 46	300	459 - 1,162
3	"	6	55 - 139	900	1,367 - 3,485
4	"	10	92 - 232	1,500	2,296 - 5,808
5	"	15	136 - 348	2,250	3,443 - 8,712
6	3,000	0.5	9 - 23	150	230 - 581
7	"	2	37 - 93	600	918 - 2,323
8	"	6	110 - 279	1,800	2,755 - 6,969
9	"	10	184 - 465	3,000	4,590 - 11,615
10	"	15	275 - 697	4,500	6,887 - 17,423

* 1,500 PJ/yr is approximately equal to current or near-term (2016, 2017) CSG production capacity.

⁷⁶ Lafleur, D., Forcey, T., Saddler, H., and Sandiford, M (2016) A Review of Current and Future Methane Emissions from Australian Unconventional Oil and Gas Production. Melbourne Energy Institute.

As the table above shows, MEI concluded that a 10% methane leakage rate for the production of 1,500 PJ/annum of gas would lead to fugitive emissions of 92MtCO₂-e/yr using the 100 year global warming potential of methane, or to 232MtCO₂-e/yr using the 20 year GWP.

This means that if the Northern Territory industry were to develop to a similar size as the existing CSG industry in Queensland, which seems likely, then we could estimate a similar level of 92MtCO₂-e/yr based on 10% leakage. This would equate to emissions equivalent to fuel combustion from Australia's entire transport sector emissions which were 93MtCO₂-e in the last reporting year.

Australia's Paris commitment is to reduce emissions by 26-28% on 2005 levels by 2030. In a recent fact sheet, the Australian Government estimates this will require 900Mt CO₂-e of total abatement from 2020 to 2030⁷⁷. Therefore, over a 10 year period, estimated emissions at 10% leakage from 1,500PJ gas production would effectively double our national abatement task.

If the Northern Territory were to increase its production of unconventional gas any further, then our abatement task will become even more unattainable. However, if unmeasured emissions from existing CSG production in Queensland has already effectively doubled our abatement task, then any NT shale gas production makes that task even more unobtainable.

If the 20 year global warming potential of methane is considered, then leakage rates of 10% represent an even more serious threat given the near-term impacts of methane emissions on climate tipping points. This is particularly disturbing as climate records continue to tumble globally. We argue that is a risk that is inconsistent with both NT and Federal Government policy and entirely unnecessary given the competitiveness of renewable energy alternatives.

It is also notable that the conversion of unconventional gas to LNG and transport offshore adds even further to overall life-cycle emissions from exported gas.

In light of the serious risks of large-scale fugitive emissions identified by the MEI 2016 report, they recommended that:

- Reported methane-emission measurements should be independently verified by a regulatory body funded by a levy on the industry.
- Methane emissions volumes should be explicitly limited by regulation.
- Independently collected and analysed methane-emissions baseline data should be established for any area being considered for oil and gas development.
- Piloted and unpiloted aircraft should be used for top-down emission investigations
- Real time, top down methane emissions monitoring should be made publicly available on a website.

⁷⁷ Lafleur, D., Sandiford, M. (2016) The risk of migratory methane emissions resulting from the development of coal seam gas in QLD. Melbourne Energy Institute.
http://www.tai.org.au/sites/default/files/Migratory_emissions_20170417-LowerRes.pdf

- A widespread network of ground based air quality monitoring towers should be establish.
- Sedimentary basin management plans should be developed.

Other Australian work

Another report released this year by the Melbourne Energy Institute explores the risks of methane gases from a coal seam migrating to the surface as a result of coal seam dewatering and depressurisation for coal seam gas production⁷⁸. It identifies that such migratory emissions are a potentially significant source of greenhouse gases from unconventional gas extraction, but concludes that there is very limited data available to assess the full scale of the risk.

It finds that migration of methane along existing natural faults and fractures is possible and may increase with continued depressurization by unconventional gas mining. It notes that presence of free methane in water bores can be the direct consequence of depressurisation of the coal seams.

It finds that due to a lack available data the likelihood of migratory emissions occurring as a result of gas extraction is difficult to assess, and highlights that to date the presence or scale of such emissions has been completely un-measured. It finds that there is an urgent need for holistic sedimentary basin management plans and integrated geological-hydrological models to allow for a thorough analysis of the risks of gas migration.

The Climate Council has also recently released a report titled 'Pollution and Price: The Cost of Investing in Gas' (**Attachment G**). It concluded that old gas power plants in Australia, such as Torrens Island, are as polluting as coal fired power stations. It also concluded that whilst new gas power plants are less polluting than coal when the entire supply chain of gas production is considered, gas is not significantly less polluting than coal.

It found that overall current levels of reliance on gas power in Australia must be reduced to play our role in limiting global temperature below 2°C. Expanding gas usage is inconsistent with tackling climate change as it locks in emissions for decades into the future.

It also noted that new renewable energy is now cost competitive with new gas. The cost of renewable power and storage, particularly solar, wind and batteries, continues to fall and has no associated fuel costs. This contrasts with rising and volatile gas prices. It also highlighted that the most economic and accessible unconventional gas reserves are being exported now, and that further gas expansion will drive increased reliance on unconventional gas, which is expensive.

⁷⁸ Lafleur, D., Sandiford, M. (2016) The risk of migratory methane emissions resulting from the development of coal seam gas in QLD. Melbourne Energy Institute.
http://www.tai.org.au/sites/default/files/Migratory_emissions_20170417-LowerRes.pdf

Technologies such as solar thermal, hydro and biomass plants can meet demand for electricity at all times of the day as well as meeting technical requirements for grid stability according to the Climate Council. Combining these technologies with wind, solar PV, and large-scale energy storage, can meet electricity demand round-the-clock.

7.4. Public Health

Drilling and fracking chemicals

A 2017 peer reviewed study has only just been released and provides some very useful evidence for this inquiry in relation to risks and impacts of chemical use of the UG industry outside of just the fracking process itself.

The study found that evaluations for chemicals used in other routine oil and gas development activities, such as maintenance acidizing, gravel packing, and well drilling, have not been previously conducted, in part due to a lack of reliable information concerning on-field chemical-use. Through their extensive research, the results of the 2017 study indicate regulations and risk assessments focused exclusively on chemicals used in well-stimulation activities may underestimate potential hazard or risk from overall oil field chemical use⁷⁹.

The National Toxics Network identifies a range of issues in relation to the chemicals used in fracking and their regulation. These include:

- Many chemicals used in fracking operations in Australia have not been assessed for their toxicity to the environment and humans. “The mixtures used in drilling and fracking fluids are also not assessed for toxicity or persistence and can form new compounds when exposed to sunlight, water, air, radioactive elements or other natural chemical catalysts.”
- Large numbers of hazardous products were identified in US fracking operations.
- There is a reliance on industry reporting of fracking chemicals in the US, with many potentially toxic chemicals not being reported as they are classed as ‘trade secrets’.⁸⁰

As part of the NT Fracking Inquiry Public Hearing process on 10 March 2017, we heard from Halliburton in relation to drilling and fracking chemicals. Halliburton made the claim that, “Any

⁷⁹ Stringfellow WT, Camarillo MK, Domen JK, Shonkoff SBC (2017) Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development. PLoS ONE 12(4): e0175344. <https://phys.org/news/2017-04-hazardous-chemicals-unregulated-routine-oil.html>

⁸⁰ National Toxics Network, 2013, Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources http://www.ntn.org.au/wp/wp-content/uploads/2013/04/UCgas_report-April-2013.pdf

fracking chemicals being brought into Australia goes through a rigorous process with NICNAS before it can be used.”

Lock the Gate sought further information on this statement from a member of the Australian Government’s Department of Health National Industrial Chemicals Notification and Assessment Scheme (NICNAS) Advisory Board and the National Toxics Network.

The feedback we received brought to light the following points:

Under the *Industrial Chemicals (Notification and Assessment) Act 1989* (the Act), chemicals that are already listed on Australian Index of Chemical Substances (AICS) may be used for any industrial purpose (subject to conditions of use, if any), including for purposes related to CSG or shale fracking, without further assessment by NICNAS.

If an ingredient is already on the AICS (this Index includes around 38,000 chemicals) then it can be used with no further assessment. The vast majority (around 85%) of those chemicals have never been assessed, as they were grandfathered into the scheme.

Supposedly new chemicals must be assessed, however there is not evidence it is a ‘rigorous’ process. Importantly, the assessment only relates to individual chemicals, and not the chemical combination ‘products’ used by the fracking companies. One problem with fracking chemicals is they are often imported as a ‘product’ and NICNAS doesn’t investigate the entire product ingredients.

It is also worth noting there is no assessment of the interactions between chemicals used in the fracking process and the chemicals released naturally from the coal or shale seams.

NICNAS has established the Inventory Multi-tiered Assessment and Prioritisation (IMAP) framework to accelerate the assessment of existing chemicals on the AICS. Specifically, NICNAS was given the task back in 2012 of assessing the safety or otherwise of fracking chemicals under their IMAP program.

However the Federal Minister for the Environment has not released a public outcome of that investigation to date. It is also important to remember it is only for coal seam gas extraction chemicals and not for shale. Plus, the chemicals used in the fracking process are likely to have changed since 2012, and it is not clear (even to those sitting on the NICNAS advisory board) whether newer chemicals have been assessed under IMAP or not.

The investigation will not deal with the impacts on groundwater aquifers nor will it look at the mixture of chemicals released to the environment, which has been highlighted as a serious issue by the EU.

Further, under future reforms proposed by NICNAS, if an individual chemical is deemed to be low-medium risk, then the industry will essentially self regulate and self assess the risks of that

chemical. It is only when a chemical ingredient (NB ingredient, not a product) is a high risk that NICNAS will do any assessment. Again, the chemical combination risks are not considered.

There are a number of very significant impacts on the mental, emotional and physical well-being of communities facing and experiencing the rapid industrialization of their local area for UG development. These impacts are outlined in the following paragraphs.

Health Impacts Associated with Air and Water Pollution

Studies increasingly show that air pollution associated with drilling and fracking operations is a grave concern with a range of impacts, with researchers documenting dozens of air pollutants from drilling and fracking operations that pose serious health hazards⁸¹. Hazardous air pollutants are released from a range of processes in UG operations. These include: the burning of diesel in machinery, generators, construction equipment and chemical, water, and waste transport vehicles; off-gassing from wastewater holding ponds; flaring and venting at wellheads; and emissions and leaks from wells, pipelines, processing plants and compressor stations.⁸²

Importantly, the risks of exposure to harmful substances occur not only as a result of drilling and fracking stages of gas operations but throughout the life time of UG operations from emissions from infrastructure and other processes including silica and sand mining activities, compressor stations, pipelines and wastewater holding ponds. Exposure to harmful substances can also occur through direct skin contact with fracking chemicals and wastes; drinking or bathing in contaminated water and through contaminated dust particulates⁸³.

The Compendium notes that “among residents living near drilling and fracking operations, documented indicators variously include increased rates of hospitalization, self-reported respiratory problems and rashes, motor vehicle fatalities, trauma, drug abuse, and low birth weight among infants,” Some of the public health effects of UG development that researchers have documented, outlined in the Compendium of Fracking Risks, include:

- increased rates of hospitalization for cardiological complaints, cancer, skin conditions, and urological problems;
- increase in frequency of health symptoms reported by residents as distance between households and gas wells decreased; with rashes and upper respiratory problems more prevalent among persons living less than one kilometre from drilling and fracking operations;

⁸¹ Concerned Health Professionals of New York & Physicians for Social Responsibility. (2015, October 14). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (3rd ed.). <http://concernedhealthny.org/compendium/>

⁸² NTN: Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources

⁸³ Ibid.

- increases in commercial vehicle accidents;
- a sharp rise in ambulance calls and emergency room visits for drug related cases and oilfield related injuries and accidents;
- increase in infant deaths to six times the normal rate over three years;
- congenital heart defects, and possibly neural tube defects in newborns, associated with the density and proximity of natural gas wells within a 10-mile radius of mothers' residences;
- elevated rates of low birthweight among infants born to mothers living near drilling and fracking operations during their pregnancies;
- reductions in average birthweight and length of pregnancy as well as increased risk for low birthweight and premature birth associated with proximity to fracking operations.⁸⁴

In a 2013 US study, surface and groundwater near areas experiencing high levels of unconventional gas activity in Colorado were shown to contain endocrine-disrupting chemicals (EDC) with moderate to high levels of EDC activity.⁸⁵ The concentrations of chemicals detected in surface and ground water were in high enough concentrations to interfere with the response of human cells to male sex hormones and estrogen. Samples taken from sites with little drilling showed little EDC activity. Exposure to EDCs can increase the risk of reproductive, metabolic, neurological, and other diseases, especially in children and young organisms.

Hydrocarbons and BTEX

A team of researchers established that petroleum-based hydrocarbons can break down underground in ways that promote the leaching of naturally occurring arsenic, a known human carcinogen that causes bladder, lung, and skin cancer, into groundwater.⁸⁶

⁸⁴ Concerned Health Professionals of New York & Physicians for Social Responsibility. (2015, October 14). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (3rd ed.). <http://concernedhealthny.org/compendium/>

⁸⁵ Kassotis et al (2013) Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region, *Endocrinology* doi: 10.1210/en.2013-1697 <http://www.endo.endojournals.org>

⁸⁶ U.S. Geological Survey (2015, January. 26) Natural breakdown of petroleum underground can lace arsenic into groundwater. http://www.usgs.gov/newsroom/article.asp?ID=4110&from=rss&utm_source=dlvr.it&utm_medium=facebook#.VavGXIsqdyA

A 2015 routine monitoring at AGL's (now abandoned) Waukivory CSG Project at Gloucester detected elevated levels of toxic BTEX (Benzene, Toluene, Ethylene, Glycene) chemicals in flowback water from wells following hydraulic fracturing. Given that the fracking chemicals and raw water used both tested negative for these chemicals, it was assessed that the likely source of BTEX was the coal seams and that the chemicals were mobilized as a result of the fracking process.⁸⁷

Mental Health and Wellbeing

The social stressors associated with the large-scale heavy industrial activities that accompany UG development take a heavy toll on the mental and emotional health of rural families and communities impacted by UG development. Doctors for the Environment Australia note that “water and air pollution, water shortages, permanent degradation of productive agricultural land and loss of livelihood and landscape... all have mental health consequences for communities living in a gas field.”⁸⁸

A 2013 study investigating the impacts of mining and CSG operations on the mental health of landholders in south west Queensland established that these operations placed rural communities “under sustained stress”.⁸⁹ The study conducted twelve workshops within the region, asking community members, among other things, about the issues, which were affecting their mental health. Study participants reported that mining and CSG operations “significantly impacted or exacerbated issues such as the health, social fabric and economy of the community”, and the authors noted that local health services faced “unsustainable pressure”. A 2014 article in the Medical Journal of Australia notes that “gas developments can have numerous and considerable social and psychological effects, which may exacerbate more direct health risks.”⁹⁰

⁸⁷ EPA NSW (2015) <http://www.epa.nsw.gov.au/resources/licensing/150311-agl-gloucester.pdf>

⁸⁸ Doctors for the Environment Australia, Submission to the NSW Parliamentary Inquiry into Coal Seam Gas, 16/09/2011

⁸⁹ Hossain D. et al. Impact of the mining industry on the mental health of landholders and rural communities in southwest Queensland (2013). *Psychiatry*, 21:32-37

⁹⁰ Coram, Moss and Blashki (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 <https://www.mja.com.au/journal/2014/200/4/harms-unknown-health-uncertainties-cast-doubt-role-unconventional-gas-australias>

A 2014 CSIRO study⁹¹ noted that local farmers perceived the nature of CSG development in South West Queensland to date as an “invasion” or “occupation”, whilst a previous study in Chinchilla found residents describing a ‘tsunami of change’.⁹²

Interacting and engaging with CSG companies has also been reported⁹³ as having a significant negative impact on farmer’s wellbeing. The interactions between farmers and CSG companies resulted in issues of stress, conflict and disconnection.

More recently, researchers assessed the contribution of coal seam gas extraction in Queensland to the global stress burden and mental health of Australian farmers. Dr. Methuen Morgan surveyed 378 Australian farmers, predominantly from Queensland and NSW, on the factors associated with their work that can impact mental health and wellbeing⁹⁴.

The study, reported in the *Journal of Environmental Psychology* in 2016, found that farmers concerned about the impacts of coal seam gas on their health, community and the environment, were more likely to report symptoms of depression and decreased levels of wellbeing. It found that farmers who were classified as ‘CSG-stressed’ exhibited clinically significant levels of psychological morbidity.

7.5 Aboriginal People and their culture

The Lock the Gate congratulates the Fracking Inquiry for taking the time to visit many Aboriginal communities across the NT. We have received feedback through our networks that many of the visits have been too short, not fitting in with local practices that allow time for a larger and more representative group from a community to participate. We have been told that interpreters not been used to their full capacity. We appreciate there is a second round of remote consultations mid 2017 and aim for this quick feedback to help plan even more effective future communications.

Land Ownership

⁹¹ Huth N.I., Cocks B., Dalgliesh N., Poulton, P., Marinoni O., Navarro J. (2014) Farmers’ perceptions of coexistence between agriculture and a large scale coal seam gas development: working paper, June 2014, CSIRO, Australia.

⁹² Walton, A.M., McCrear, R., Leonard, R., Williams, R., 2013. Resilience in a changing community landscape of coal seam gas: Chinchilla in Southern Queensland. *Journal of Economic and Social Policy* 15, Article 2

⁹³ Huth N.I., Cocks B., Dalgliesh N., Poulton, P., Marinoni O., Navarro J. (2014) Farmers’ perceptions of coexistence between agriculture and a large scale coal seam gas development: working paper, June 2014, CSIRO, Australia.

⁹⁴ Morgan, M., Hine, D., Bhullar, N., Dunstan, D., and Bartik, W. Fracked: Coal Seam Gas Extraction and Farmers Mental Health. *Journal of Environmental Psychology* 47 (2016), 22-32.

Many Aboriginal people across the Northern Territory have been outspoken in their concerns around the impacts of fracking gasfields on their country, around their rivers and across their cultural landscape.

Traditional Owners from Watarrka (Kings Canyon) National Park worked with the Central Land Council and the EDO NT to build a legal and political campaign over several years to prevent the NT Government from granting Palatine Energy Pty Ltd an exploration licence over the park⁹⁵. After travelling to Canberra to lodge a heritage application, traditional owners were eventually successful in preventing oil and gas development in the Park⁹⁶.

In Elliot, an area targeted for shale gas exploration fracking, a local family with Traditional Country across that region wrote a song '*No Mining In Our Land*' in language and released it on You Tube in 2016 to help spread their message.

The You Tube description reads: *Watch this film clip from me - Ethan Dixon - and my mum - Janey Dixon. It is sung in our language Mudburra and filmed on location at Marlinja - 25kms from Elliott, Northern Territory. We don't want fracking on our land.*

The full song with captions is available at: <https://www.youtube.com/watch?v=-hscad3Sl68>

Across Arnhem Land, a group of Traditional Owners formed a local action group, Protect Arnhem Land, in response to fracking applications covering their Land and Sea Country. Their website: <http://www.protectarnhemland.org/> provides video and interviews where you can hear first hand from Traditional Owners on the issue of oil and gas fracking applications in their communities. Their Facebook page *Protect Arnhem Land* has thousands of followers from across the world. One family from Maningrida worked with a documentary maker to produce a song about their life and battle, titled, *Stingray Sisters*. This documentary was featured on *ABC Lateline* in August 2016 and their five-minute overview is available here: <http://www.abc.net.au/lateline/content/2016/s4518129.htm>

In Mataranka, Traditional Owners from the region including Jilkminggan, across Mangarrayi and Alawa Land Trusts and out to Ngukurr led a rally through the main street of Mataranka in 2016 calling for protection for the Roper River Catchment from Fracking.

⁹⁵ Central Land Council (2014) <http://www.clc.org.au/media-releases/article/kings-canyon-traditional-owners-reject-mining-in-watarrka-national-park>

⁹⁶ Akerman, A. (2015) The Australian <http://www.theaustralian.com.au/business/mining-energy/nt-bows-to-traditional-owners-watarrka-fracking-protests/news-story/223024db0d2da968835c656abc739cd8>



Photo credit: Jeff Tan, 2016

To better understand what the on ground impacts of shale gasfields on Aboriginal people could be, we have to look to other parts of the world where it has been developed. The First Nations people of Canada have been experiencing the on ground impacts of gas development, first for conventional gas, and then for shale gas requiring hydraulic fracturing for many decades. Their experiences offer lessons that could be considered in this context.

A 2014 Powerpoint presentation from the Fort Nelson First Nation group from Canada covers insights and issues similar to those that have been raised as risks by Aboriginal people in the Northern Territory.

For example, their presentation reads:

Fort Nelson First Nation (FNFN) rights, interests and lands

- *FNFN's experience with hydraulic fracturing*
 - *Significant adverse impacts on land, water, air and treaty rights*
 - *BC LNG export poses tremendous risk to FNFN Inadequate regulatory framework*
 - *Inadequate consultation and accommodation*
 - *FNFN bearing greater burden than benefit*

Over the past ten years there has been enormous oil and gas development in FNFN territory, with more anticipated.

- *Hydraulic fracturing and horizontal drilling technologies have brought rapid change to FNFN territory*
- *Regulated by the Province of BC (Oil and Gas Commission) on an incremental basis, with little or no attention to cumulative impacts*
 - *Habitat fragmentation & loss (caribou, grizzly bear, bison)*
 - *Increased predation (caribou, moose)*
 - *Populations of furbears decline with industrial development (lynx, marten, fisher, beaver)*
 - *Introduction of invasive Species*
 - *Reduction in plant and ecotype diversity*
 - *Contamination*
 - *Rare plants lost*
 - *Fragmentation of forested lands reduces ecological vitality*

As of June 2013, the OGC had approved the use of up to 2,623,000 m³ /day or 20,405,000 m³ /year (equivalent to +8,000 Olympic swimming pools) for fracking in FNFN territory

- *Significant hydrologic impacts (reduced stream flow, drought vulnerability, degraded fisheries habitats and wetlands)*

Please see the full presentation here: http://www.legassembly.gov.yk.ca/pdf/rbhf_FNFN-Presentation.pdf

Fort Nelson First Nation also have uploaded a useful time lapse video of the industrialisation of their lands over the decades, first from conventional gas, and more recently from shale gas fracking.

http://lands.fnnation.ca/sites/default/files/industry_activity_2.mp4

7.6. Social Impacts

Infrastructure - onshore unconventional gas led to a degradation of public resources in QLD

In 2013, the University of QLD published in depth research into the impacts of mining and onshore gasfields across the regional QLD communities where they were operating. The research team interviewed people from across all sectors of the local communities to gather a broad range of evidence and feedback on the impacts⁹⁷.

⁹⁷ Everingham, J., Collins, N., Rodriguez, D. Cavaye, J., Vink, S., Rifkin, W. & Baumgartl, T. (2013) Energy resources from the food bowl: an uneasy co-existence. Identifying and managing

Their detailed research found that while those working in the coal seam gas industry in the Darling Downs region had a positive view of the impact of the industries, people working in local businesses, agriculture, government and the community sector consistently believed UG development and mining had led to a deterioration of:

- Financial capital- revenue streams and economic resources.
- Built capital- local infrastructure including buildings, transport, equipment and communications.
- Human capital- skills, knowledge, abilities and good health.
- Social capital- organisations, networks and relationships, based on shared values, mutual trust and reciprocity.

The main reasons for these social and financial impacts are the loss of skilled staff to the gas industry and the increased cost of labour, rent, transport and goods and services for local businesses.

The outcomes of discussions are summed up in the below table. It is worth noting that even stakeholders representing the mining and gas sector conceded that built capital such as roads in the area were made worse due to the operations of mining and gas in the area.

Stakeholders groups	Financial capital	Human capital	Built capital	Social capital	Natural capital
Gas	Better	Better	Worse	Better	Better
Mining	Better	Better	Worse	Better	Better
Agriculture	Worse	Worse	Worse	Worse	Worse
Local business	Worse	Worse	Worse	Worse	Worse
Local government	Worse	Better	Worse	Same	Same
Community	Worse	Better	Worse	Worse	Worse
Advocacy	Worse	Worse	Worse	Worse	Worse

Table sourced from report by The Australia Institute (2015) *Be careful what you wish for*⁹⁸.

Community cohesion and wellbeing:

The Queensland and NSW experience with the expansion of coal seam gas operations has shown that when this industry is forced upon communities against their wishes, there is potential for significant conflict and social upheaval and disruption as a result, even at the exploration phase of the industry. Lock the Gate members and local community groups report a range of impacts from proposed and actual UG development on their mental and emotional wellbeing. These include:

- A sense of injustice that they do not have the right to refuse access to companies for UG activities and that this industry is being forced on an unwilling population.
- Fear and anxiety about the impacts of the UG industry on their family's health and the quality of the air and water they rely upon.
- Concern about the impact of UG development on the economic viability of their farms and property values.
- A sense of anger and betrayal that governments are supporting industry rather than communities in the development of the UG industry.

⁹⁸ Ogge, M. (2015) *Be careful what you wish for*. Report for The Australia Institute

- A sense of anger that the industry is being pushed ahead rapidly without proper consideration of the impacts and before proper scientific studies have been done and baseline data collected.

In discussing the broader social impacts of UG development, Doctors for the Environment Australia note: “Informed consent of landholders is often lacking in the contract process when mining companies first approach landholders about unconventional gas extraction.... The injustice and powerlessness that this engenders contributes to solastalgia and poorer mental health outcomes.” Overall, DEA maintain that UG development can “divide previously close-knit rural communities, increasing tension and disharmony.”

The lack of a veto right for landholders in relation to UG development, the stress involved in dealing with UG companies (often against their will), the lack of full information and disclosure on the realities of UG development, and the often underhanded tactics employed by companies contributes to a sense of powerlessness, betrayal and frustration amongst landholders and affected communities. According to DEA, in eastern Australia, “the stress and disruption caused to farmers has already been shown to force some of them to leave a CSG drilling area, allowing once productive lands to lapse into disuse,” whilst in the US “longtime residents are moving, unable to bear the changes the gas industry has wrought on their landscape and community.”

In their submission to the 2015 Victorian Parliamentary Inquiry⁹⁹ DEA note:

“The migratory, boom and bust nature of UG developments can carry significant social and psychological effects for those who live in communities near operations and on those who may travel to work at these developments. A study¹⁰⁰ of impacts of mining and unconventional gas operations on landholders in Queensland found that these operations placed rural communities “under sustained stress”, with study participants describing significant impacts on the health, social fabric and economy of local communities.”

The health and social impacts of UG development will necessarily have a flow on negative impact on the overall wellbeing of rural communities, as well as the functionality of other industries in which rural residents are engaged. This impact will be magnified due to the fact that farming and rural communities are the very same communities who are already at most risk from the adverse health effects of drought, climate change and the degradation and depletion of Australia’s river systems and groundwater resources.¹⁰¹

⁹⁹ Doctors for the Environment Australia (2015) http://www.parliament.vic.gov.au/images/stories/committees/EPC/Submission_416_-_Doctors_for_Environment_Australia_.pdf

¹⁰⁰ Hossain D. et al. Impact of the mining industry on the mental health of landholders and rural communities in southwest Queensland (2013). *Psychiatry*, 21:32-37.

¹⁰¹ Doctors for the Environment Australia, Submission to the Inquiry into Coal Seam Gas, 16/09/2011

The impacts of the use of fly-in, fly-out and drive-in, drive-out workforces, used extensively in existing unconventional gas developments in Australia, also has a range of negative social impacts which were documented in a recent Parliamentary Inquiry¹⁰². The use of FIFO and DIDO workforces have come under scrutiny for their negative influence on community cohesion, increased rents and other living expenses, and their association with elevated levels of alcohol and drug use, as well as mental health issues and violence.

Crime – risk of increase:

A recently release paper from the Journal of Environmental Economics and Management shows that the energy boom in the United States has affected regional crime rates throughout the country. Researchers found positive effects on rates of various property and violent crimes in shale-rich counties. In 2013, the cost of the additional crimes in the average treatment county was roughly \$2 million¹⁰³.

The Western Criminological Review Journal found in 2013 that law enforcement and human service personnel reported that the rapid growth in oil and gas producing areas and communities leads to increased crime and other social ills. Researchers made a comparison of 2012 crime rates in a matched sample of counties revealed that crime rates were higher in oil impacted counties. A pre-post analysis found that violent crime in boom counties increased 18.5% between 2006 and 2012 while decreasing 25.6% in a matched sample of counties that had no oil or gas production¹⁰⁴.

A Multi-State Shale Research Collaborative published a report in December 2014 on the relationship of the shale drilling to crime, traffic fatalities, STDs and rents. Researchers found that communities with the highest intensity of natural gas drilling have seen increased rate of crime, motor vehicle fatalities and sexually transmitted diseases. While the influx of

¹⁰² House of Representatives Standing Committee on Regional Australia. Cancer of the bush or salvation for our cities? Fly-in, fly-out and drive in, drive-out workforce practices in regional Australia. Canberra: Commonwealth of Australia, 2013.
<http://trove.nla.gov.au/work/176479103?selectedversion=NBD50509223>

¹⁰³ James, Smith et al, 2017, There will be blood: Crime rates in shale-rich U.S. counties, Journal of Environmental Economics and Management Volume 84, July 2017, Pages 125–152,
<http://dx.doi.org/10.1016/j.jeem.2016.12.004>,
<http://www.sciencedirect.com/science/article/pii/S0095069616305459>

¹⁰⁴ Ruddell, Rick, Dheeshana S. Jayasundara, Roni Mayzer, and Thomasine Heitkamp. 2014. "Drilling Down: An Examination of the Boom-Crime Relationship in Resource Based Boom Counties" Western Criminology Review 15(1):3-17
(<http://wcr.sonoma.edu/v15n1/Ruddell.pdf>).

energy workers hasn't significantly increased population figures, it coincided with a surge in rental prices across the Marcellus Shale region¹⁰⁵.

Employment – risk that jobs projections from onshore unconventional gas are overstated by industry

The 2015 APPEA commissioned Deloitte Access Economics report clearly states in the executive summary on page four that the jobs figures were modeled in an “aspirational scenario” and “they do not necessarily represent expected outcomes”, requiring “upper bound assumptions to materialise”. Page five reveals their jobs figure is not due to eventuate until the year 2040¹⁰⁶.

Their report not only relied on a high international gas price that no longer exists, but also on the opening up of six onshore gas basins across the Territory, which would require thousands of gas wells across tourism regions and important water basins.

Independent modeling of realistic figures, based on a realistic oil price and volumes of shale gas that are appropriate to bring to market is required.

We applaud the approach of the Panel in obtaining independent economic analysis to feed into the inquiry. We trust this will be based on a true cost benefit analysis of industry impacts and realities of the sector, plus acknowledgment of any economic ‘externalities’ that could be factored in.

Onshore gas jobs have a negative impact on agricultural jobs

The Office of the Chief Economist’s 2015 Review into the Socioeconomic Impacts of Coal Seam Gas in QLD revealed that researchers produced “evidence that agricultural jobs have been affected negatively: 1.8 agricultural jobs lost correlating with every CSG job created.”¹⁰⁷

That means that for every 10 unconventional gas jobs created in QLD, 18 agricultural jobs were measured to be lost. This negative jobs figure for agriculture was measured and reported in a peer-reviewed paper by Fleming and Measham in 2015¹⁰⁸.

¹⁰⁵ Multi-State Shale Research Collaborative, 2016: http://www.pennlive.com/midstate/index.ssf/2014/12/fracking_brought_spikes_in_vio.html

¹⁰⁶ Deloitte Access Economics, 2015: https://www.appea.com.au/wp-content/uploads/2015/08/APPEA_Deloitte-NT_Unconv_gas_FINAL-140715.pdf

¹⁰⁷ Office of the Chief Economist, 2015, Review of the socioeconomic impacts of coal seam gas in QLD, <https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/coal-seam-gas/Socioeconomic-impacts-of-coal-seam-gas-in-Queensland.pdf>

Boom Bust

The scale of the ‘bust’ after the short unconventional gas construction period ends is severe, and long-term job opportunities are extremely limited. Queensland Treasury figures reveal that more than 10,000 FIFO/DIDO jobs have been lost in the Surat Basin since the CSG construction boom peaked in 2014. In June 2014 there were 14,490 non-resident jobs in the region, and by June 2016 that had reduced to just 3,820 jobs¹⁰⁹, similar to pre-CSG levels.

Long-term employment is low because the oil and gas industry is highly capital intensive. The Office of the Chief Economist estimates that the entire oil and gas industry in Australia employed just 29,000 people in 2015/16¹¹⁰, which is less than a quarter of the Australian workforce. That is an extraordinarily low employment given that Australia is set to become the world’s largest exporter of gas.

The gas industry frequently also makes claims about delivering substantial flow-on jobs in regional communities, particularly in the services industry, and job multipliers are frequently used to derive large job estimates. However, research into the local economic impacts of CSG in Queensland provides evidence, which disputes those claims. Specifically, research by Fleming and Measham for GISERA found that job spillovers into non-mining employment in the Surat Basin were negligible¹¹¹. The table below provides a summary of their findings.

Table 4.2. CSG employment spillovers over different sectors

	Elasticity	Additional job for each new CSG job
Local goods sector		
Construction	0.832 (0.426) *	1.412
Professional services	0.704 (0.259) **	0.412
Retail trade	0.011 (0.140)	0.024
Services [†]	-0.205 (0.230)	-0.732
Traded sector		
Manufacturing	0.068 (0.199)	0.160

Notes: Elasticity values are 2SLS estimations for coefficient ψ in equation (2). The number of CSG wells in an SLA is used as instrument for the log change of mining employment. Values estimated using sample 3 (n = 48). F-stat first-stage = 10.74. Robust clustered std. errors at LGA levels in parentheses. *p < .10. **p < .05. [†]Services sector include employment in accommodation, rental agencies, transport and ‘other services’.

¹⁰⁸ Fleming and Measham, (2014) Local economic impacts of an unconventional energy boom: the coal seam gas industry in Australia, *The Australian Journal of Agricultural and Resource Economics*, 59(1), pp. 78–94, <http://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12043/full>

¹⁰⁹ <http://www.qgso.qld.gov.au/products/reports/surat-basin-non-resident-pop-proj/surat-basin-non-resident-pop-proj-2017-2023.pdf>

¹¹⁰ <https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Resources-and-energy-quarterly.aspx>

¹¹¹ Fleming, D. and Measham, T. (2013) Local economic impacts of an unconventional energy boom: the coal seam gas industry in Australia. [Report to the Gas Industry Social and Environmental Research Alliance \(GISERA\)](#). June 2013. CSIRO, Canberra.

Amenity – risk of adverse impacts on those living on the land

A recent CSIRO study¹¹² examining farmers' perceptions of coexistence between agriculture and a large scale coal seam gas development in Queensland found that "issues regarding atmospheric pollution (dust, light, noise) has a significant impact on many aspects of farmers' lives." The impact of significantly increased traffic, both on and off the farm, was also a significant concern to farmers.

The expansion of CSG production in Queensland has demonstrated the potential for UG developments to severely disrupt virtually every aspect of agricultural production and potentially even remove the land from production.

In the course of its work supporting landholders and communities facing the impacts of unconventional gas developments, Lock the Gate Alliance hears firsthand about the myriad effects these developments are having on the livelihoods, health and well-being of Australian farming families living adjacent to and surrounded by gas activities. These harmful impacts include: intimidation, coercion and bullying by UG companies; intolerable noise and light pollution from flaring, traffic and UG infrastructure; contamination and depletion of water in farm bores; rivers bubbling with methane; bores running dry; stock losses associated with pipeline construction and water contamination; costly and time consuming interruptions to farming operations; huge trucks and heavy machinery on small local roads affecting lifestyle, safety and road infrastructure; dust impacts on pasture; increases in weed infestation; industry workers leaving mess from pipeline construction in farm paddocks; workers destroying fences and leaving gates open; properties not able to be sold; mental health impacts resulting from dealing with companies and the impacts of industry development; and physical health symptoms including respiratory ailments, headaches, rashes, nausea and vomiting, and nose, throat and eye irritations.

For many affected landholders, these impacts affect all facets of life and are making their living situation untenable. Personal testimonies of a number of affected landholders can be viewed in a series of short films compiled by the Lock the Gate Alliance talking about the impacts on them: https://www.youtube.com/watch?v=4OG9JkzB_3M

In relation to the cattle industry, there have been measured impacts of exposure to fracking related spills in the United States. A 2012 study by Bamberger and Oswald cited the following example:

Two cases involving beef cattle farms inadvertently provided control and experimental groups. In one case, a creek into which wastewater was allegedly dumped was the

¹¹² Huth N.I., Cocks B., Dalgliesh N., Poulton, P., Marinoni O., Navarro J. (2014) Farmers' perceptions of coexistence between agriculture and a large scale coal seam gas development: working paper, June 2014, CSIRO, Australia.

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 and 16 failed to produce calves the following spring. Of the 36 that were not exposed, no health problems were observed, and only one cow failed to breed. At another 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.¹¹³

A follow-up study published in 2015 by the same authors further investigated 21 case studies from five states. They found that the distribution of symptoms in animals and humans affected by nearby fracking operations was, since 2012, unchanged for humans and companion animals. In food animals, reproductive problems decreased over time while respiratory problems and growth problems increased. Researchers also found, “More than half of all exposures were related to drilling and hydraulic fracturing operations; these decreased slightly over time. More than a third of all exposures were associated with wastewater, processing and production operations; these exposures increased slightly over time.”¹¹⁴

Cumulative risks – Gaps between company promotion and on ground impacts

The question of well spacing and impact on the landscape has played a role in discussions in the NT Fracking Inquiry to date. Some industry proponents argue that the landscape impacts will be less than the real-life invasive gasfield images that are available from satellite images via Google Maps, or aerial photographs taken by local residents in gasfield areas.

Of interest to the Panel is this 2010 video released by Australian unconventional gas driller Santos. The short video, titled *CSG Multi well pad drilling: reducing our impact*, features discussion of how Santos will reduce impacts on local roads from 5 wells on one well pad.

The two minute video is available online here:

<https://www.youtube.com/watch?v=NCdkybhPb6w>

¹¹³ Bamberger, M. and Oswald, R (2012). IMPACTS OF GAS DRILLING ON HUMAN AND ANIMAL HEALTH, NEW SOLUTIONS, Vol. 22(1) 51-77, 2012, http://www.psehealthyenergy.org/data/Bamberger_Oswald_NS22_in_press.pdf

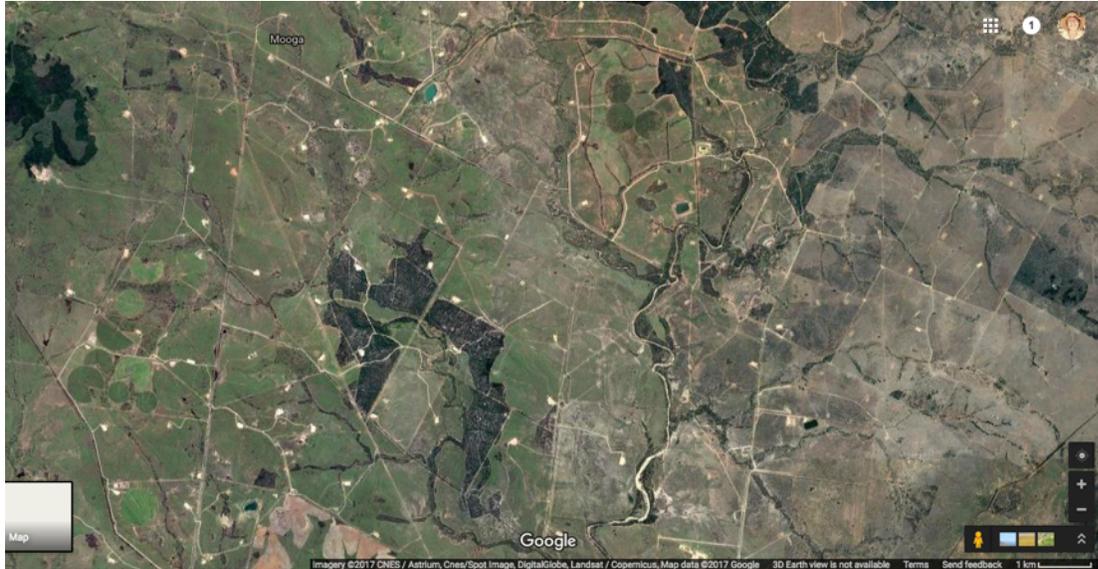
¹¹⁴ Bamberger, M. & Oswald, R. E. (2015). Long-term impacts of unconventional drilling operations on humans and animal health. *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering*, 50, 447-59. doi: 10.1080/10934529.2015.992655

Screenshot from the Santos video:



However, this technology has not been widely used by Santos in QLD. Or if it has, it has had limited impact on reducing surface impacts. Over six years since this video was released, Santos has cleared thousands of CSG pads across QLD, and has recently gained Federal approval for a further 6100 CSG wells in QLD.

Please note these more recent images of Santos unconventional gasfields in QLD that form part of their GLNG gas project. You can note by the scale that the cleared gas pads are at approximately 1 km spacing.



And below is a photo taken while travelling through the QLD Arcadia Valley in 2015, where flare stacks from wells looked to be just hundreds of metres apart. The middle flare is closest and most obvious. Please note the other flares, one on the far left of the shot and the other on the far right of the shot.



The aim in showing photos of coal seam gas fields in QLD is not to say that on ground impacts of shale gasfields will be exactly the same (although as noted there are many similarities). These photos help demonstrate the clear gap between what the Santos promotional video said in 2010, and the reality that has played out across a larger scale in the years following. In this case, the company had a promotional position that was not necessarily implemented widely or the lived experience of those impacted by the industry.

7.7 Economic Impacts

Energy Security

Based on the experience of UG extraction in QLD, evidence shows that there is a risk that energy security in the Northern Territory will be jeopardised if shale gas *is* developed.

The advent of UG in QLD was designed to fuel export liquefied natural gas (LNG) terminals in Gladstone. The demand from those gas terminals is around three times the demand of the East Coast domestic market and has led to gas shortages and price hikes across the East Coast of Australia. With the commissioning of LNG export terminals from Darwin, and proposed gas pipelines from the NT to QLD and/or SA, the NT is not immune to the energy security risks faced in other jurisdictions in Australia that have risen from an expectation of high yields of unconventional gas.

Currently, the Northern Territory has a secure contract for plentiful, affordable offshore conventional gas until 2032¹¹⁵.

The following statements from economists Acil Tasman in 2013 give further information on the current conventional gas available to the NT:

The Blacktip field is located in shallow water 110km off the northern coast of Australia in the Timor Sea's Bonaparte Basin. The field is 100% owned and operated by Eni. The gas produced at Blacktip is transported through a 108km long, 18in diameter subsea pipeline to an onshore gas processing facility at Wadeye. It is then transported via the 286 km Bonaparte Gas Pipeline which connects to the Amadeus Gas Pipeline at Ban Ban Springs.

Blacktip commenced production in 2009, delivering gas to the Northern Territory's Power and Water Corporation (PWC) under a 25 year supply contract with supply rising to 18,000 boe/day (about 38 PJ/a) over the life of the contract. According to a notification by PWC to the Australian Competition & Consumer Commission in 2006, the supply of gas under the Blacktip Gas Supply Agreement (GSA) represented all of PWC's forecast demand for gas from 2012 until 2032. The same notification pointed out that the total contract quantity under the GSA exceeded Eni's then-current proved (P1) gas reserves in the Blacktip field, but also noted that there was potential for further recoverable gas to be found in prospects in Eni's tenements in and around Blacktip. The field has proven and probable (2P) reserves of around 900 bcf (960 PJ) of which about 625 PJ are committed under the PWC 25-year contract.¹¹⁶

A re-negotiation of that Eni contract with Power Water to allow for unconventional gas to enter the NT domestic market would lead to price risks, supply uncertainty risks and would have a destabilizing impact on the Territory's economy.

Other Industries

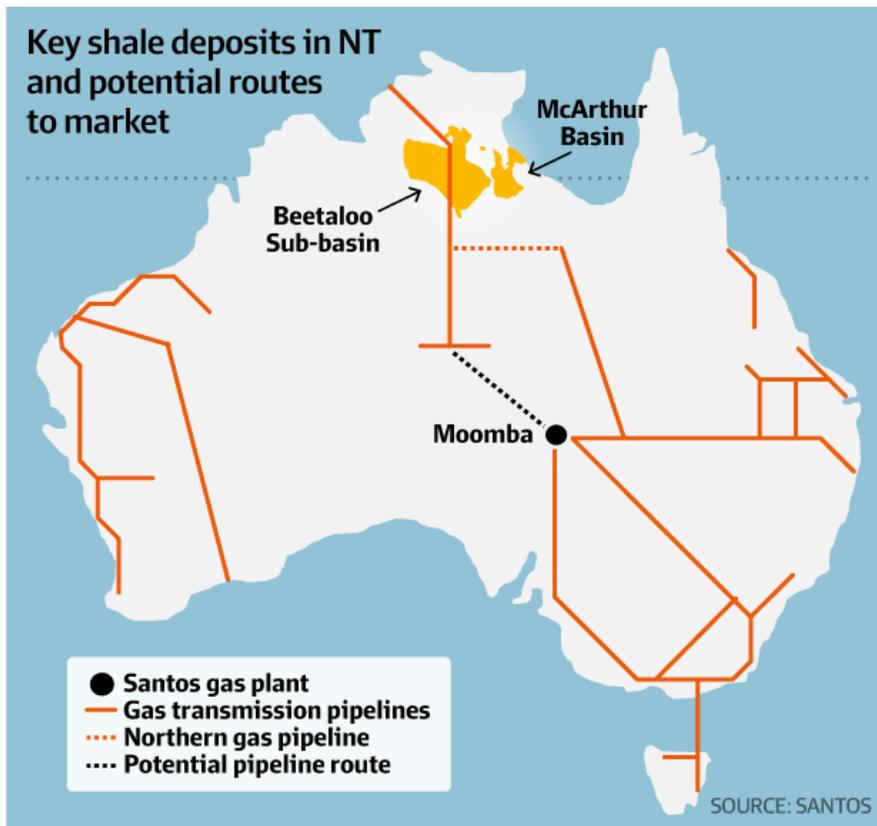
On Friday 31 March, the Australian Financial Review released a map of where gas producers would like to be able to access in the NT by the end of 2017¹¹⁷.

¹¹⁵ Australian Competition and Consumer Commission, <http://registers.accc.gov.au/content/index.php/itemId/750462/fromItemId/729985/display/notification>

¹¹⁶ Acil Tasman (2013) Economic impacts of Katherine to Gove Gas Pipeline, Prepared for Pacific Aluminium, https://ntepa.nt.gov.au/_data/assets/pdf_file/0003/287535/Appendix-A-Economic-Evaluation.pdf

¹¹⁷ Australian Financial Review, 2017, <http://www.afr.com/business/energy/gas/beetaloo-emerges-as-beacon-for-east-coast-gas-20170329-gv9add>

The map, inserted here and supplied to the Australian Financial Review by Santos, includes significant tourism areas of the NT including Mataranka thermal springs and large tracts of the Roper River catchment in the proposed gasfield region.



There are further economic risks that we recommend are added to the risk tables in the Paper.

Credit Availability – risk of loan problems for landholders

In a submission to the NSW Legislative Council *Inquiry into the Management of the Murray-Darling Basin – Impact of Mining Coal Seam Gas*, Rabobank, the world’s leading specialist in food and agribusiness banking, listed the risks from unconventional gas mining to include reductions in farm productivity, efficiency, land values and credit availability. Further Rabobank states, “Should the trend toward concurrent CSG mining and agricultural activities continue on agricultural land ... problem loans or defaults will rise”¹¹⁸.

¹¹⁸ Rabobank (2011) Submission to the Senate Inquiry into the management of the Murray-Darling Basin – impact of mining coal seam gas <http://www.aph.gov.au/DocumentStore.ashx?id=5bfff958-7e81-41e7-94d3-c1f463ce8c26>

This prediction has already begun to become a reality for some landholders in QLD who have hosted unconventional gas mining on their properties. For example, in 2016 it was revealed that a QLD family were unable to obtain a bridging loan using their property for equity, on the grounds that the QLD property has four coal seam gas wells on it.

The email from the Commonwealth bank stated, “Long form valuation has revealed coal seam gas wells on the land, making the security unacceptable for residential lending purposes.”

A copy of the refusal email is embedded here, supplied by the journalist Joshua Robertson via Twitter, who uncovered the story in September 2016¹¹⁹.

¹¹⁹ <https://www.theguardian.com/environment/2016/sep/30/commonwealth-bank-coal-seam-gas-makes-property-unacceptable-as-loan-security>

From: Retail Credit Decisioning
Sent: 01/07/2016
To: [REDACTED]
SUBJECT: [REDACTED]
Date: 01/07/2016

[REDACTED]

Customer Name: [REDACTED]
Facility: [REDACTED]
Product/s: 2 Year Fixed Rate Home Loan (TP)
Account No:
Loan Amount: \$500,000.00

If not already provided to the Bank, please supply supporting documents as soon as possible clearly identifying with the application Bank Reference Number. Supporting documents are required for the application to progress further.

Unfortunately, we are unable to provide assistance with the above application at the present time as the application does not meet the Banks approval conditions. If application details change please resubmit the application.

We provide the following comments:

The Application fails to meet the Bank's lending criteria due to the follow reasons: Security unacceptable

1) Long form valuation has revealed 4 gas wells on the land, making the security unacceptable for residential lending purposes.

Application is declined, and this decision supersedes any former decisions.

[REDACTED]

If you would like to discuss this please contact your local Mortgage Services.

Further information can be obtained on <http://www.commbroker.com.au> using the Bank Reference Number above or contact your local Mortgage Services centre.

Commonwealth Bank
Retail Credit Decisioning

Royalties – risk that onshore gas royalties are likely to be far less than forecast

The Northern Territory can look to QLD for actual figures on the onshore gas industry and contribution to the economy through royalty payments. The uncomfortable reality is that QLD has reaped very little of the economic royalties that it was promised and that QLD Treasury forecast.

The QLD Treasury mid-year review in 2013-14 forecasted \$482M for petroleum royalties to flow during 2015-16¹²⁰.

However, the reality shows that in Queensland, the Mid Year Fiscal and Economic Review reported actual royalties from onshore oil and gas were \$36M in total from all CSG and conventional gas in 2015-16¹²¹. That equates to only 7.5% of projected royalty payments, compared to what was expected just three years earlier. The reality is down by \$446M.

A deeper look shows that those royalty payments were made from 5,127 coal seam gas wells that were producing that year¹²².

Origin Energy has taken the QLD Government to the Supreme Court challenging the entire system of royalties and the rights of the QLD Government to levy them.

Furthermore, as reported in the Australian Financial Review on 28 April 2016, the royalty spat between the Queensland government and a major gas consortium flared up with a petroleum exploration company claiming big liquefied natural gas producers used transfer pricing to reduce their royalties bill.¹²³

Taxation – risk that UG extraction companies will not pay their fair share of corporate tax in Australia

In late 2016, the Australian Tax Office revealed large companies in Australia that paid no corporate tax in the 2014/15 financial year, these included:

- Origin Energy Ltd, total taxable income \$12,200,600,757, paid zero corporate tax,

¹²⁰ QLD Treasury, 2014, <https://www.treasury.qld.gov.au/publications-resources/mid-year-review/mid-year-review-2013-14.pdf>

¹²¹ Queensland Government's [Mid Year Fiscal and Economic Review](https://www.treasury.qld.gov.au/publications-resources/mid-year-review/mid-year-review-2016-17.pdf#mid-year) 2016-17, <https://www.treasury.qld.gov.au/publications-resources/mid-year-review/mid-year-review-2016-17.pdf#mid-year>

¹²² Queensland Government data: [CSG Production, 6 Monthly Statistics](https://data.qld.gov.au/dataset/petroleum-gas-production-and-reserve-statistics/resource/63a8a6cc-7fb6-4040-b4e7-9d453b14d3ed) <https://data.qld.gov.au/dataset/petroleum-gas-production-and-reserve-statistics/resource/63a8a6cc-7fb6-4040-b4e7-9d453b14d3ed>

¹²³ AFR 2016, <http://www.afr.com/news/politics/origin-Ing-consortium-used-transfer-pricing-to-cut-taxes-20160426-gofb0q>

- Santos Ltd, total taxable income \$3,389,399,798, paid zero corporate tax¹²⁴.

Unprofitable – risk that NT shale gas is not profitable, leads to bankruptcies

In shale gasfields of the United States, Bloomberg reported that many fracking companies were losing money on shale drilling. A damning case study of shale drilling in Oklahoma revealed that the drilling was financed on cheap debt, with drillers spending \$2 for every \$1 they made from shale.

The Bloomberg report includes: *As Stanley Druckenmiller, an investor with one of the best long-term records in money management, said of Texans in January 2015: “Those guys know how to gamble, and if you let them stick a hole in the ground with your money, they’re going to do it.” Shale wasn’t sustaining the frenzy; cheap debt was.*¹²⁵

A 2016 Reuters report revealed a wave of bankruptcies across the United States that year¹²⁶. One question for the Northern Territory Fracking Inquiry might be: who pays the clean up bill if these shale gas drilling and fracking companies go bankrupt? How do these economic risks relate to regulatory risks and failure to protect the environment and local communities?

The United States examples are particularly relevant to the Territory, due to the high cost of proposed shale gas operations here. In October 2016, Core Energy Group provided an Outlook Report to the SA Government and industry round table. The report includes the below table, outlining that NT Unconventional gas is the most expensive gas to extract in all of Australia¹²⁷.

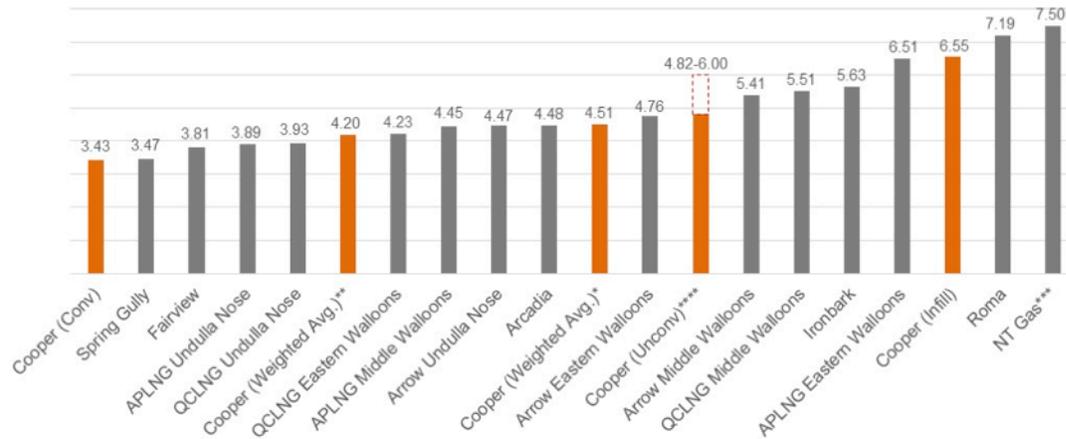
¹²⁴ ABC report based on ATO data, December 2016, <http://www.abc.net.au/news/2016-12-09/tax-data-transparency-ato/8106178>

¹²⁵ Bloomberg, 2016, <https://www.bloomberg.com/news/articles/2016-03-10/the-shale-reckoning-comes-to-oklahoma>

¹²⁶ Reuters, 2016, <http://www.reuters.com/article/us-usa-shale-telecoms-idUSKCN0XV07V>

¹²⁷ Core Energy Group, 2016, Cooper-Eromanga Basin Outlook | 2035

Figure 1.9 Comparison of Cooper Basin and Competitor Marginal Cost of Supply (ex-field) | AUD/GJ



* Represents the weighted average of the CBJV Conventional gas and the CBJV infill program, under the assumption that infill gas would meet the existing horizon contract shortfall.

** Represents the weighted average of the CBJV Conventional gas and unconventional plays, under the assumption that gas from unconventional reservoirs would meet the existing horizon contract shortfall and the contestable market.

*** NT Gas is estimated to have a range of AUD6/GJ (Blacktip ex-field) to AUD7.50/GJ for the higher cost unconventional plays.

Social Licence to Operate

While the NT Government deemed the matter of 'social licence to operate' outside the formal terms of the Panel's deliberations, the phrase has arisen both during presentations from the gas industry and community representatives throughout the inquiry, as it is a widely used concept. While not a legal concept, the Lock the Gate Alliance sought information from researchers at the EDO NSW on its meaning and how a social licence to operate might be applicable in relation to the Fracking Inquiry.

Please see **Attachment H** for a detailed overview and referenced research on this matter.

7.8. Land Access

Compensation

Landholders lose millions every year by hosting unconventional onshore gasfields

In 2016, the CSIRO released a report into the total losses to gross revenues incurred by farmers who host unconventional gasfields on their properties. The new spatial modeling, using a methodology developed by CSIRO after years of research, found that the alienation of

productive farmland for CSG infrastructure in Queensland results in losses in gross economic returns of up to 10.9%¹²⁸.

The research, published in the Land Use Policy Journal, found that in relation to the chosen study area in the Western Downs: “In the scenario assessment the total losses to gross revenues incurred by the existence of CSG infrastructure per property varied between \$1.32 m and \$3.29 m and averaged \$2.17 million... Access tracks and lease areas contribute most to economic losses”.

The Lock the Gate Alliance notes that the methodology was estimating economic losses based solely on reduction in land area and did not attempt to quantify losses resulting from disruption to operations, dust generation, spills and leaks of wastewater or the spread of weeds. Therefore, total losses to landholders will undoubtedly be far higher.

We understand that the UG industry in the Northern Territory is claiming that the surface impacts of a shale gas industry will be very different to the QLD CSG reality, however that is yet to be seen, with all exploration wells so far demonstrating the same one well one pad technology that is utilized around the world.

While farmers do receive some compensation for hosting gas mining companies on their land, landholders have been suggesting that access agreements and compensation payments should be made publicly available and must also be agreed to by the Territory Government. This would help ensure there can be no confusion as to the impacts the industry is having on landholders’ assets as they host gas companies on the Northern Territory Government’s behalf.

Consultation

I have been provided the written information that was used in a negotiation meeting with the Garawa Traditional Owners from around Borroloola in 2012 (**Attachment I**).

This is a useful overview that provides insights into what companies are disclosing (and failing to disclose) to Land Councils and Traditional Owners through their bid for land access in the Northern Territory.

While the presented materials give some good insights, the benefit of hindsight now shows that there was a failure to disclose any chemical use and there was a failure to explain in any form what the ultimate development outcome would look if exploration was approved, which then led to production. In short, there is no mention that a gasfield in the region could entail hundreds or even thousands of wells drilled and fracked, truck movements, extensive

¹²⁸ [O. Marinoni, J. Navarro Garcia, 2016, A novel model to estimate the impact of Coal Seam Gas extraction on agro-economic returns, Land Use Policy, Volume 59, 31 December 2016, Pages 351–365, http://www.sciencedirect.com/science/article/pii/S026483771630076X](http://www.sciencedirect.com/science/article/pii/S026483771630076X)

associated infrastructure, roads and associated scale of workers living in the area, as has occurred across the world with this industry.

In this case, it is my understanding that the Traditional Owners in this case exercised their veto right, however it is unknown what the materials provided in other negotiations have been in cases where Traditional Owners have provided their consent.

For insights into the consultation process, Lock the Gate has sought further examples from landholders in QLD.

This 14-minute video provides very useful insights into the gap between what a landholder thought would take place based on the negotiation phase, and what his lived experience of dealing with the industry has been. He signed an access agreement for unconventional gas extraction by Origin Energy (one of the major gas companies seeking to access unconventional gas in the Northern Territory).

I have obtained permission from the video maker to share this video with the Panel:

<https://vimeo.com/212700855/70d67dbd16>

This screen shot from the video shows of one of the high point vents (venting methane) on this property:



Video credit: Brian Monk

Please note that this landholder raises many similar concerns to those landholders interviewed in short videos mentioned earlier in this submission. Again, these impacts of a coal seam gas operation are important when considering the impacts of shale gas extraction, as the

companies, the company practises, the overseeing regulation and the land based impacts share similarities worthy of serious consideration by the Panel.

The Lock the Gate Alliance argues these information gaps are unacceptable. The misleading picture that onshore unconventional gas companies provide to landholders and Traditional Owners in order to obtain a signature on an access agreement is unacceptable. The fullest possible disclosure of all impacts to property, to the landscape, to health, to Traditional landscapes, Aboriginal dreaming sites and songlines, and to waterways that will result of an onshore unconventional gasfield in full production must be put clearly on the table as part of the negotiations. Information must be public. Landholders must have access to lawyers that are independent of gas company appointed lawyers.

Due to the evidence of large information gaps that have aided the sign off of exploration licences and access agreements to date, the Lock the Gate Alliance recommends that the panel consider whether already granted exploration licences should be revoked and the process restarted. This would offer landholders and Traditional Owners the benefit of the information that the Panel is collecting. This would allow landholders to make informed decisions for the future of their land. This should be accompanied with the right of veto, again to provide fair options and full information.

Insurance

Farmers and other landholders have raised major concerns about the likelihood that they may ultimately be liable for any negative impacts caused by hydraulic fracturing. In 2014, the NSW Chief Scientist released a report, which concluded that the CSG industry there was markedly under-insured and that landholders were likely to bear a substantial risk as a result¹²⁹.

Meat and Livestock Australia has provided general guidance for livestock producers in regard to CSG operations on livestock property. It notes that there is a genuine risk that landholders may ultimately be responsible for liabilities arising from unconventional gas activities if they lead to:

1. Someone being injured on the property
2. Damage to the property
3. Damage to a neighbouring property
4. Livestock or produce is injured, damaged or contaminated¹³⁰

It notes that landowners need to be fully informed about the terms and scope of gas companies insurance cover, and need to be included in any policy as an interested party. It highlights particularly the liability that may accrue to a landowner with CSG operations on their property

¹²⁹ NSW Chief Scientist and Engineer, 2014 <http://www.chiefscientist.nsw.gov.au/latest-news/chief-scientist-and-engineer-calls-for-tougher-insurance-regime-for-csg-industry>

¹³⁰ Meat and Livestock Australia. (2014) Coal Seam Gas Operations on Livestock Property: General Information for Livestock Producers.

if any harm is caused to adjacent properties, stating that *'Contamination of soil, pasture or groundwater could also result in contamination of neighbouring properties as well as livestock which, if then processed and consumed, could breach Australian food standards or importing country requirements for meat. While a landowner may have some recourse against a CSG operator, the landowner may still have primary responsibility'*.

It also notes that landowners may be forced to cover the costs of the clean-up of contamination, stating that *'Environmental regulatory authorities may also exercise statutory powers to impose clean-up obligations on the landowner if contamination occurred. These costs may not always be recoverable from the CSG operator under the relevant legislation.'*¹³¹

Notably, the Rural Industries Research and Development Corporation cite a case study in QLD where a landowner was advised by their supply chain partners that they would be liable for any contamination caused by CSG activities. Neither the CSG company nor the insurer would agree to indemnify the landholder against that risk¹³².

Legal advice received by the landholder was that the Conduct and Compensation Agreement on offer from the CSG company 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 through the Courts.

The major implications for landholders and livestock producers in particular, are that:

1. The onus of proof in any contamination event is almost certain to reside with the landholder.
2. The inadequacies of baseline monitoring by companies and the prohibitive costs of monitoring for landholders, means that proving contamination is likely to be extremely difficult.
3. Farmers who sign National Vendor Declarations for livestock that may have been contaminated by contact with UG waste are likely to be liable for any harm incurred.
4. UG companies are refusing to include provisions in access agreements to accept liability for any contamination that may occur.
5. UG companies in Australia are under-insured and do not have adequate insurance to cover the types of risks that CSG activities bring.
6. Some graziers have reported that insurers have examined the risk to them of UG contamination and found it too high to offer insurance.

¹³¹ Ibid.

¹³² Clarke, M. (2013) Principles for Negotiating Appropriate Co-existence Arrangements for Agricultural Landholders, Rural Industries Research and Development Corporation
<https://rirdc.infoservices.com.au/items/12-114>

7.9. Regulatory framework

Current onshore petroleum statutes were typically developed to manage historical conventional gas operations, which, as outlined in this submission, are very different in their scale and intensity than conventional operations, with correspondingly far greater potential for impacts on land, water and air. Consequently, the roll out of the unconventional gas industry across Australia has taken place within a regulatory environment that is grossly inadequate to the task of managing this spatially intensive industry and the new and often experimental processes and methods that it employs.

In the NT, the current legislation under which the UG gas industry is operating fails to address a whole range of factors. Government has been playing policy catch up as this industry is rolled out without proper consideration of the possible or likely impacts. Some of the issues that current legislation fails to adequately address include: impacts that occur during the exploration phase of development; cumulative impacts across multiple projects; use of untested chemicals and chemical cocktails in fracking processes; treatment, storage and disposal of unprecedented volumes of saline wastewater (that also contains fracking chemicals and other toxic substances present in the rock substrates such as heavy metals and radionuclides); leaking methane emissions and air pollution impacts and resultant human health risks. In addition to the failure to properly address the risks, there is also an absence, across both Federal and Territory jurisdictions, of legislated mechanisms to ensure that adequate baseline data relating to air, water and soil systems is gathered prior to commencement of UG activities. Without proper baseline data, there is no way to measure and quantify impacts that do occur, let alone manage or mitigate those impacts.

Recent findings from the US show that regulations are simply not capable of preventing harm¹³³ and relying on regulatory frameworks alone to manage the risks associated with fracking is not a viable solution for governments.

Regulation is ineffective both because the number of wells and attendant infrastructure in unconventional gas operations is so large and keeps increasing and, more importantly, because some of the shale gas fracking industry's many component parts, which include the subterranean geological landscape itself, are simply not controllable.

For instance, a new study on fracking-related air pollution in northeastern Colorado shows that even though the volume of toxic emissions per well might be decreasing, overall air quality in

¹³³ Concerned Health Professionals of New York & Physicians for Social Responsibility. (2016, November 17). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (4th ed.). http://concernedhealthny.org/wp-content/uploads/2016/12/COMPENDIUM-4.0_FINAL_11_16_16Corrected.pdf

the shale field continues to deteriorate as the rapid, continuing increase in the number of wells cancels out improvements to air quality brought about by more stringent regulations. Similarly, the *Compendium of Fracking Risks* details the results of a new study from Texas which raises the possibility that methane can migrate into aquifers through *unseen* cracks and fissures in the rock surrounding the wellbore in ways that no cementing and casing protocols, however strictly applied, can prevent. Additionally, new findings from West Virginia show how previously abandoned wells can become re-pressurized during nearby fracking operations and serve as conduits for the contamination of drinking water. The *Compendium* notes that, “no set of regulations can obviate these problems”.

Water and Regulation – US EPA Report

Perhaps the most notable finding of the US EPA Investigation into the impacts of hydraulic fracturing on water resources was that it simply did not have sufficient data to actually properly assess impacts. The EPA concluded that ‘*data gaps and uncertainties limited EPA’s ability to fully assess the potential impacts on drinking water resources both locally and nationally*’. That is an extraordinary admission of the failure of proper baseline assessments and of systematic monitoring¹³⁴.

Despite being limited only to considering the impacts on drinking water resources, and not looking further at impacts on agricultural water supplies, the study found that there were certain conditions under which the impacts can be more frequent or severe. Top of that list of conditions was fracking water demand in times or areas of low water availability, particularly in areas of limited or declining groundwater resources. It seems likely that those conditions would apply equally to agricultural water supplies as they do to drinking water, and it raises serious alarm bells about the likely risks to vital groundwater resources in the Territory.

Self Regulation Risks

In addition to the regulatory issues outlined from the US, the scale of unconventional gas operations make regulatory enforcement and monitoring a difficult and expensive undertaking which is not economically feasible for governments within existing funding priorities and frameworks. In existing UG operations such as those in Queensland, and even across the relatively small footprint of the conventional gasfields in the Northern Territory, the role of monitoring has largely been left to the industry if it is done at all. Typically enforcement agencies are under resourced and under staffed. The fact that there has been little baseline monitoring of existing water, air and soil parameters prior to the roll out of the UG industry in Australia also means that impacts will not be measurable, if and when they occur.

¹³⁴ EPA USA (2017) “Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources”. <https://www.epa.gov/hfstudy>

Non-Compliance Allegations from QLD

A Statement of Claim filed by whistleblower, Ms Sally McDow, in a civil case against Origin Energy, makes a number of allegations pertaining to the APLNG CSG project in Queensland, including that potential gaps in the monitoring equipment which is used to calculate petroleum royalties payable to the Queensland Government may have led to the potential loss of ‘tens of millions of dollars’ to taxpayers, but was not reported to authorities¹³⁵.

Other specific APLNG allegations include ‘multiple water containment breaches’ and failure in pipeline maintenance¹³⁶. More broadly, in relation to Origin activities, there are additional allegations pertaining to hundreds of gas wells that had not been properly maintained for 10 years or more and that had not been plugged and abandoned¹³⁷ and other instances of aquifer contamination and leaking of gas and oil¹³⁸.

A most disturbing allegation is that Origin was engaged in a deliberate strategy of non-reporting of breaches in order to minimise costs, and that hundreds of incidents were going unreported to relevant authorities and regulators¹³⁹. More specifically, it is alleged that senior management were opposed to reporting the true state of compliance with the APLNG project until the project was finished and producing income ‘in 2017’¹⁴⁰.

This fair work case has now been discontinued¹⁴¹, and it is likely that the serious potential non-reporting and non-compliance matters which it exposed will never be properly investigated or brought to light.

NT Context: lessons from offshore conventional gas in relation to regulation

We can look to past investigations into oil and gas operations in the Territory to learn more about where the weaknesses are likely to be into the future. While there has not been a comprehensive independent investigation into the onshore conventional gas operations in Central Australia, there was a fairly recent investigation of the offshore practices.

On 5 November 2009, the then Hon Martin Ferguson AM MP, Minister for Resources and Energy, announced a commission of inquiry into the uncontrolled release of oil and gas from the Montara Wellhead Platform in the Timor Sea. The commission of inquiry was established

¹³⁵ Page 22 of the Amended Statement of Claim filed on 23rd January 2017

¹³⁶ Page 22

¹³⁷ Page 26

¹³⁸ Page 27

¹³⁹ Page 21

¹⁴⁰ Page 21, Amended Statement of Claim filed on 23rd January 2017

¹⁴¹ <https://www.comcourts.gov.au/file/Federal/P/VID920/2015/3744249/event/28905029/document/945311>

under Part 9.10A of the Offshore Petroleum and Greenhouse Gas Storage Act 2006, and had nearly all the powers of a Royal Commission.

The Commissioner David Borthwick AO PSM provided the Montara Commission of Inquiry Report to Minister Ferguson on 17 June 2010.

The Montara Commission of Inquiry found that the company, PTTEP Australasia (PTTEPAA), “Did not come within a bull’s roar of sensible oilfield practice”. It also found major issues with the regulation of the site by the Northern Territory’s Department of Resources. The Commission of Inquiry issued a scathing critique of the NT Government’s regulatory role, with Commissioner Borthwick pointing particularly to the amount of revenue received by the NT Government, vis-à-vis the amount it spent on regulation.

The Commission specifically recommended that the Federal Government remove the regulatory powers from the NT Government and give them to a single national regulatory body.

The following statements of the Commissioner in the formal report to the Federal Government¹⁴² highlight the major issues with the regulators approach:

- *The NT DoR did not do its job by ensuring the company’s WOMP or the Phase 1B Drilling Program complied with good oilfield practice. In short, the NT DoR did not take adequate steps to ensure that PTTEPAA actually complied with the requirement of good oilfield practice.*
- *The inquiry finds that the NT DoR’s regulatory regime was totally inadequate, being little more than a ‘tick and flick’ exercise. In particular, the inquiry does not agree with the Northern Territory’s characterisation (before the Inquiry’s public hearing) that the approach the NT DoR adopted followed ‘contemporary regulatory practice’. The information provided to the inquiry indicates that, in contrast to the approach adopted by the NT DoR, the Victorian regulator undertakes monitoring, inspection, audit and compliance regime.*
- *The relationship between the NT DoR and PTTEPAA had become far too comfortable. Indeed, one contributory factor to PTTEPAA’s own lax standards was the minimalist approach to regulatory oversight by the NT DoR.*
- *The inquiry formed the view that the resources and expertise that the NT DoR devoted to its task as delegate of the DA were inadequate (effectively only one person, who appeared to have a limited ability to fulfil this task). The Minister should consider removing this delegation from the NT DoR.*

¹⁴² Commissioner David Borthwick AO PSM (2010) Report of the Montara Commission of Inquiry, <http://www.iadc.org/wp-content/uploads/2016/02/201011-Montara-Report.pdf>

Summary of initial regulation recommendations

The Lock the Gate Alliance looks forward over the course of the inquiry to ongoing and productive discussions in regards to whether this industry should proceed in the Northern Territory, and if it were to proceed in any form, what potential regulatory mechanisms should apply.

Based on the evidence of known, deleterious impacts from unconventional gas identified in this submission and the additional major risks it poses to water resources, public health and the social fabric of communities, we believe that there is currently no sound basis to proceed with the industry in the Northern Territory.

In particular, the land use intensification, the risks to groundwater and the potential scale of fugitive emissions, all represent strong reasons why the industry should not proceed in any form at present. These problems are intensified by the evidence that substantial liabilities will accrue to landholders and that major legacy issues will continue long after gas companies have packed up and gone.

In terms of intergenerational equity, there are perhaps no two issues as fundamental as water resources and climate, and unconventional gasfields will genuinely threaten both. The precautionary principle dictates that we do not proceed with damaging activities when there is so much uncertainty about their impacts. There is enough evidence presented in this submission to make an extraordinarily strong argument against any unconventional gas development until all of these uncertainties have been fully resolved. The burden of proof must fall on the unconventional gas industry to prove that it will not cause the harms identified in this submission, and until it can do so, it should not be given approval to operate in the Northern Territory.

Some initial recommendations are listed below:

1. A continuation of a moratorium on any new unconventional shale gas mining or exploration should be continued across the Northern Territory until further important research has been completed. This must include the completion of proper baselines assessments for water quality, quantity and flow rates, geological data, health impact assessments for target communities, ecological values and air quality data including methane concentrations.
2. These baseline assessments must be transparent, legally verifiable and publicly available. If unconventional gas developments are to proceed in any areas of the Territory into the future, these publicly held baseline assessments will be critical for ensuring any future pollution can be quantified and responsible companies can be held to account. The Lock the

Gate Alliance does not support any continuation of shale gas extraction activities in the Territory before these baseline assessments have been completed.

3. Baseline assessments must be accompanied by systematic monitoring of each of the attributes listed above to assess change against baseline. All baseline assessments and monitoring should be conducted independently, be made publicly available, and be paid for by a levy imposed on the industry.
4. Due to the inherent and measured risks and impacts associated with shale gas extraction wherever it has been undertaken, exclusion zones are required to protect land, water and communities from the impacts of the industry. We recommend exclusion zones and buffer areas around agricultural land, all significant groundwater and surface water resources, identified cultural landscapes and tourism icons, national parks and other ecologically important areas, and residential dwellings from shale gas exploration and extraction impacts.
5. We acknowledge the growing body of evidence related to high methane emissions from unconventional gas extraction and processing activities. To prevent methane emissions from unconventional gas in the Territory making a major contribution to global warming, laws must be amended to set strict allowable limits on methane emissions and to mandate that operations that do not meet those limits will not be allowed to operate. The laws must also mandate strict independent measurement and accounting of greenhouse gas emissions from shale gas operations. All of the recommendations made by the Melbourne Energy Institute, and reproduced above, in relation to fugitive emissions, should be implemented.
6. Requirement for full hazard assessments and compulsory disclosure of all chemicals used in unconventional gas mining, and prohibition of the use or production of chemicals or chemical mixtures that are harmful to human health or the environment.
7. Amend the laws to prevent UG companies using the threat of the Land Court to intimidate and coerce landholders and Native Title holders into signing access agreements, and implement powers to create legislation to give landholders, Traditional Owners and communities the right to say “NO” to unconventional gas operations at both an exploration and production proposal stage of development.
8. Include a requirement that all gas companies who seek to operate in the NT must hold comprehensive environmental insurance to cover all risks, and legislate to make gas companies responsible for any downstream impacts or impacts to neighbouring landholders.
9. Put in place world’s best practice rehabilitation requirements that include:
 - Requirement for payment of upfront cash bonds to cover the full cost of rehabilitation
 - Rigorous estimation of bonds based on best practice calculations, the use of a mandatory government calculator, strong contingencies and no discounts
 - A mandated progressive annual rehabilitation ratio of 1:1 disturbance to rehabilitated area

- Prior to any approvals being given gas companies must be required to provide a fully-costed gasfield closure plan which has been subject to stakeholder engagement and sign-off.
10. Amend laws to create a strict liability for gas companies for any spread of weeds or feral animals or any impacts on biosecurity or farm operations, and to create a strong fit and proper person test which precludes the granting or transfer of licences to financially inadequate companies or any companies with a record of non-compliance with environmental or company laws.
 11. A fully independent Ombudsman should be created to act as an umpire in disputes between landholders, Traditional Owners or communities and gas companies. The Ombudsman should have wide powers to compel gas companies to provide information and to act responsibly and prevent harm to people and businesses affected by their operations.
 12. To address negative social impacts of FIFO workers, new QLD state legislation bans 100% FIFO workers for projects¹⁴³. Despite having many shortcomings, the Queensland legislation is at least a start and it would be worthwhile for the Northern Territory Government to investigate this matter further and look to improve on it.

¹⁴³ Minister for State Development and Minister for Natural Resources and Mines
The Honourable Anthony Lynham, November 2016,
<http://statements.qld.gov.au/Statement/2016/11/8/queensland-government-moves-to-deliver-choice-for-resource-communities-workers>