Scientific Inquiry into Hydraulic Fracturing In the Northern Territory

Public submission by Charmaine Roth, given as Feedback on Background and Issues Paper.

I would like to thank the Scientific Panel for the opportunity to be able to submit concerns on the matter of hydraulic fracturing and comment on various issues associated with the development of unconventional gas industry in the Northern Territory. The Inquiry website and email updates reflect a Panel who seeking transparency and stakeholder engagement, and for this I am thankful too.

I am a third generation Territorian, with children of my own who are now working, investing in the NT and bringing forth a new generation. I was born and have lived in the Northern Territory my entire life, and while I am currently away on an extend adventure, my heart is definitely back home with the countryside, weather and people I love and adore.

My grandparent's ashes are both scattered on the McDonald Ranges in the central desert. I had family members die during the bombing of Darwin. And while they fought to defend our people and lands from foreign invasion back then, it seems today not only are we defending the land and the people, but we are fighting for the future as well.

I understand fully that the necessity for the NT to 'develop', but I believe that any future development needs to be thoroughly studied and well planned to avoid any potential disasters, and to ensure sustainability.

A lack of adequate planning has been previously highlighted by Darwin rural residents facing water restrictions. Further demonstrated when local Katherine springs pumped dry and rural residents began losing bore water following landscape changes and the introduction of mango and sandalwood plantations. A lack of forethought was demonstrated in the fairly recent handing out of excessive Water License in the Mataranka region, which was then used as a sales pitch to a sandalwood company. The company conducted mass clearing and sunk large bores in order to establish an expansive sandalwood plantation, and all without any sort of EIS. There was no study into what impact the required drawdown on groundwater would have on natural springs nor the effect of chemical sprays on native birds and wildlife, or the impact this could have on tourism and existing industries.

In the rush to develop the Territory, important information, essential baseline data and much needed forward planning is missing.

I understand the need for development, but this should be undertaken in a sustainable manner. It is inevitable that the Northern Territory be developed and that it will transition away from the 'last frontier', but industrialization and urbanization should not be at the detriment of our beautiful landscapes, our pristine ancient wilderness, our iconic image and envied lifestyle, nor to existing industries and the future of Territorians.

The Northern Territory sits in a unique position. The extractive industry see us as ripe for the picking, an uncontested land filled with mineral riches and ores for the taking. However, the Northern Territory remains the home of the world's oldest living culture. The traditional aboriginal peoples of the Northern Territory are alive and well, and to damage that living culture would be a crime against humanity.

Any development of the Territory, must be done in a manner that is protective of all that we hold dear. The Territory may need development, but it needs sustainable industries, and long term jobs for local people, not another boom and bust extractive industry that is going to make all the promises in the world, while delivering little apart from a very expensive and dangerous legacy.

Thanks where thanks is due

I acknowledge our new Labor Government, who romped in with a landslide victory on the 'fracking vote', honored their election promise by placing a moratorium on unconventional hydraulic fracturing across the NT and appointing a Scientific Inquiry into the processes.

The Draft Terms of Reference were somewhat disappointing, reflecting very little of the motion that was voted on and passed during their Labor NT Conference 2016.

The released final Terms of Reference displayed somewhat marked improvement, however underlined the NT Government's continued failure to recognize the scope of threat the unconventional gas industry poses. The ToR indicate the NT Government does not understand the complex nature and multi stages of unconventional shale hydrocarbon wells, nor the risk that are well documented against each stage.

The changes made to the ToR, while far from perfect, hinted the possibility of an investigation into a wider scope of issues associated the shale gas industry activities and requirements.

However, the Inquiry Background and Issues Paper presents the reader with what can only be described as industry spin and polishing. The Panel will deliver its final report in December this year, giving less than 12 months from start to finish for the Inquiry to collect and collaborate evidence and data, and to present it along with any recommendations. It should be noted that other countries and regions have undertaken lengthy and extensive scientific inquiries for the purpose of creating an effective regulatory framework, or condemning the industry altogether.

This is of great concern considering the NT Government's decision to identify the Interconnector Pipeline as a high priority project. Furthermore, this pipeline is being pushed ahead at a time that companies have committed gas supply to Asia, conventional reservoirs are dwindling, and the Federal Government is urging states to drop their delays and move ahead with the development of unconventional gas resources. People are afraid, and rightly so, that the Pipeline is a precursor for 'fracked gas'. This is further cemented when politicians such as Queensland Premier, Anastasia Palaszczuk make claims the only way to solve the 'crisis' is to pipe gas from the Territory.

Meanwhile understanding is still lacking in four essential areas:

- exactly what the unconventional shale gas industry means for the Northern Territory
- exactly what is at risk from the unconventional shale gas industry
- exactly what threats the unconventional shale gas industry poses
- exactly what entails as an effective regulatory frame work for minimal impact from the introduction of the shale gas industry

The possibility of properly understanding the issues has been severely hamstrung by varying levels of confusion when it comes to recognizing what the shale gas industry is and what this implements.

Justice Pepper herself noted people are confused between CSG and Shale, but that is just the tip of the iceberg.

In an effort to gain understand of the requirements of shale hydraulic fracturing, members witnessed what was initially described as a 'shale' well in Moomba. However, as was corrected in the following update, the area in question is not targeting shale but conventional and tight sands deposits.

I have to ask why the panel did not actually attend the hydraulic fracturing of a shale well? While Justice Pepper defends the incident by saying "the processes are very similar" it must be noted there are huge differences in water and chemical requirements between vertical and horizontal fracturing.

While Justice Pepper has stressed in the media that there are differences between CSG and shale, it must be recognized there are vast differences between conventional and unconventional methods, and also between shale and tight sands deposits.

There are also perceived differences in the actual meaning of the word fracking, this creates confusion in itself. In order for a full and proper conversation with the public to take place, this confusion must be recognized and clarified.

Clarifying the Fracking Word

Over the past few years the term 'fracking' has become almost a household word. It is a word that is harsh, and can incite concern even to those who are unfamiliar with it. It is also a word that has created confusion, conflict and mistrust between opposing parties. It is unfortunate, but important to understood, that the word fracking has different meaning to different groups.

Industry refers to fracking (or fraccing as it is sometimes spelt) as the single act of hydraulically fracturing a target area, be it conventional or unconventional. Whereas, the majority of those opposed use the word fracking as a blanket term that covers all associated risk areas of an industry which is targeting unconventional oil and gas only.

Those in opposition to the industry say “Don’t Frack” in an attempt to protect water and land from the impact of a new technology and new industry. This in turn prompts a response from the oil and gas companies claiming they have been conducting fracking for 60 years in Australia without incident. Those opposed claim ‘fracking’ leads to water contamination, and the petroleum industry retaliates saying there is no documented evidence fracking has led to contamination. However, as we can clearly see now, the two parties are not necessarily arguing about the same thing.

This confusion results in industry accusing those opposed as being misinformed and misguided, while it leaves those who have concerns feeling that they are being manipulated and lied to.

The truth is, there are companies who have been hydraulically fracturing to speed up oil and gas flow for a large number of years, but is this quite simply not the same beast that is about to be unleashed across much of Australia. The fracturing itself is not the same, the preparations before fracturing are not the same, the requirements are not the same, the risks are not the same. And this is due to the fact that the hydrocarbon reservoirs are not the same.

Defining Shale

The existence of shale has been known for quite some time by petroleum companies who realized its potential as an oil and gas supply. However, the technology has been lacking in order to unlock it. Shale has eluded us for decades, keeping its bounty locked safely away. These deep reservoirs have become more alluring to petroleum companies as conventional pockets of oil and gas begin to run dry. Shale is not sandstone pockets, nor is it coal seam or tight sand, it holds on protectively of its precious hoards and refuses give it up easily.

Shale is old. The Beetaloo Basin Valkyrie Formation in the Northern Territory dates from the Proterozoic and Cambrian periods. 2,500 to 570 million years ago, when the earliest forms of life began to evolve and primitive seas covered much of the land. Shale is also extremely hard, and non-permeable. As the early life forms broke down, gas was created and became trapped in the hardening silt and mud. Over time the shale was compressed, heated and hardened into its present day form.

Most recently in the oil and gas recovery timeline, companies have been working to enhance ‘technology’ to beat the shale into submission. The process of extracting from shale is not only relatively new, it is brutal and savage. The shale is pulverized and destroyed so that the prized fossil fuels can be dragged from its clutches and bought to the surface.

For decades the methods of extracting shale hydrocarbons made it unviable, but with recent developments and refining of technology, extraction is now commercially worthwhile. Companies are now in a position to make vast riches from the oil and gas that the shale has guarded so well. However, due to costs to develop wells and the necessary infrastructure, shale gas is not a cheap alternative.

Despite the fact other oil and gas deposits do not necessarily require hydraulic fracturing in order to establish gas flow, shale has to be fractured. This is a process that is repeated again and again until the oil or gas flow becomes commercially unviable. At this time the well is then subject to be killed off, abandoned and forgotten.

These shale wells, due to their depth and length, are exposed to extreme heats and pressures, both from natural forces, and from the continuous ruthless pulverizing of source rock in order for hydrocarbon extraction. Conventional, CSG and tight sand petroleum wells are not subject to the same extensive punishment that shale wells are expected to endure.

Referring back to word meanings, the call from opposition to 'ban fracking' has given industry the ability to manipulate the argument to focus the attention on the act of hydraulic fracturing itself. However, when we begin breaking the industry down, looking at it piece by piece, we will see it for the vicious beast that it is.

In order to truly understand something, we need to carefully look at it from all angles and in minute detail, and then it must be dissected. Before any doctor or scientist wields the scalpel, he takes a close look at what is about to be studied.

Before beginning to peel back the layers of the shale oil and gas industry in order to better understand it, three identified points must be acknowledged:

1. Due to advancements in technology shale can now be viably targeted
2. The extraction method and requirements for shale differs to conventional and CSG
3. The extraction of shale hydrocarbons in Australia is in its infancy and at experimental stage

The Issues

Reading through the released Scientific Inquiry background and issues paper, my first impression is that the Australian Petroleum Production and Exploration Association kindly offered their services to write it. This paper, is somewhat an insult to those people who have labored long to have an inquiry established. So I thank Panel members for the opportunity to make comment on it for the purpose of open discussion and to highlight areas that the Panel should include in their focus.

The author has failed to identify a number of issues that are presented by this fledgling industry. This paper demonstrates the NT Government are continuing to fail the people by not acknowledging various potential risks of the unconventional oil and gas industry. In doing so are quite possibly steering the conversation away from important issues that need careful consideration if the creation of any effective regulatory framework is to be attempted and carried through.

The ACOLA Report was written with the objective of developing the shale gas industry across Australia and presented in May 2013 as, Engineering Energy: Unconventional Gas Production – A study of shale gas in Australia. The report discusses at length the need to acknowledge

and identify all areas of risk in order to create a protective regulatory framework that will mitigate impacts. Regulations need to be proactive rather than reactive in order to be effective.

The unconventional gas industry has extracted a few cleverly chosen lines from that report and run with them saying that fracking can be done safely. The Industry's intent is to repeat these lines as often as possible with the hope that eventually they will stick in people's minds and the industry will be accepted with open arms.

The truth is, the ACOLA report highlights the complexity of the introduction of shale gas industry. Its advice is to learn what the issues are, and identify what is at risk. It recommends that the layout of land, the water, the air, the natural formations be intimately understood. It suggests that every angle of land use, both present and future be intrinsically viewed to recognize any conflicts or areas of risk. The ACOLA Report advises to learn every aspect, look in fine detail at each step and stage of industry activity requirement, in order to recognize and understand the risks and possible impacts.

One thing I will give to the Industry, they have not lied. However, they have continuously handed out misleading information time and time again. With that, their cherry picked lines, and seemingly clever tactics deployed to try show they have gained a social license, we really have to be asking why. We have to ask the question, if the truth is not so bad, if this industry is as harmless as they would have us believe, why do they employ these strategies?

BACKGROUND

I have no doubt that others have already pointed out the numerous flaws contained in the Background and Issues Paper, but I am compelled not to simply skip over them as I find the background filled with misleading and incorrect information. And the back ground forms the basis from where all questions arise.

I will make comment from Point 3. Some basic facts..page 4

3.1..What is the difference between conventional and unconventional gas?

It is important to establish the differences between conventional and unconventional gas extraction methods:

- Conventional refers to gas that has escaped the source only to become trapped in geological faults and pockets. Gas can be successfully drained with a limited number of wells, and hydraulic fracturing is not a necessary factor and is generally used for the purpose of speeding up flow
- Unconventional refers to any type of gas that cannot be extracted with conventional methods, this includes CSG, tight sands and shale. Due to the nature of the deposits unconventional reservoirs require the use of hydraulic fracturing to free the gas, well

numbers are drastically increased and the industry has a far larger footprint

- The use of words such as 'improved' and 'refined' technology gives a false sense of security. The reality is the technologies have been upgraded and made more powerful enabling once inaccessible deposits to now be targeted. These target areas present an increased degree of difficulty and are accompanied with increased risk factor
- Deeper and harder to reach unconventional gas deposits, come with a drastically increased price tag
- With increased well depth, comes increased stresses both internally due to extraction processes and requirements, and also from geological heat, pressures and naturally occurring corrosive elements such as brine and hydrogen sulfide
- Increased depth also means increased water requirements for drilling and fracturing
- The final line in 3.1 is misleading: "horizontal drilling and hydraulic fracturing have been used for decades on conventional reservoirs". True, however as discussed, this is not the same method, requirements or risk as unconventional shale
- Conventional deposits require fewer wells that are drilled over a longer timeframe
- Unconventional shale reservoirs require hundreds, sometimes thousands, of wells, which are drilled during in a much shorter campaign
- Unconventional gas wells have a far shorter lifespan than conventional wells
- Conventional wells can be successfully drained, whereas shale wells can still hold a large volume of gas and other contaminates at time of being killed off

3.2 What is the difference between coal seam gas and shale gas?

While there are numerous differences between shale and CSG, there are also considerable similarities. 3.2 contains misleading, incorrect and missing information.
Please note the following:

- CSG is pure methane, Shale contains around 90% methane, and also ethane and propane and other greenhouse gases
- CGS does not necessarily require fracking, whereas shale needs continual fracturing to release gas
- While CSG produces larger quantities of waste water, Shale requires and excessive quantity for fracking purposes, both processes require the capture and storage of large amounts of contaminated water
- Toxic waste water has to be captured and stored, this is usually done in liner ponds
- Faulty liners can lead to groundwater contamination
- Shale wells are deeper than drinking water aquifers, however saline aquifers are heavier than drinking water and can be very deep. Some saline groundwater systems have extended deeper than shale
- Shale wells can come into contact with these deep aquifers. As happened with the Petrofrontier wells horizontally drilled and hydraulically fractured in the Southern Georgina Basin, NT 2012
- The hydraulic fracturing of shale returns between 30 and 80 percent of fracking fluid known as 'produce water'

- Produce water contains not only fracking chemicals, but also returns to the surface with high salt content, heavy metals, volatile organics, and naturally occurring radioactive materials
- Shale gas extraction has a bigger footprint and more wells required than CSG
- There are conflicting reports on which has higher gas recovery, however Queensland CSG reservoirs have not been as productive as initially projected, and thus companies are struggling to meet contract requirements and pushing Australia into 'gas crisis'
- CSG is easier to drill, is cheaper and presents less risk than shale
- Each particular industry claims to be the good guy, saying opponents are confused with the other. I.e. CSG says shale is the bad one, while shale says CSG are the bad guys
- Both shale and CSG are targeted by the same companies

3.3 The extraction of shale gas

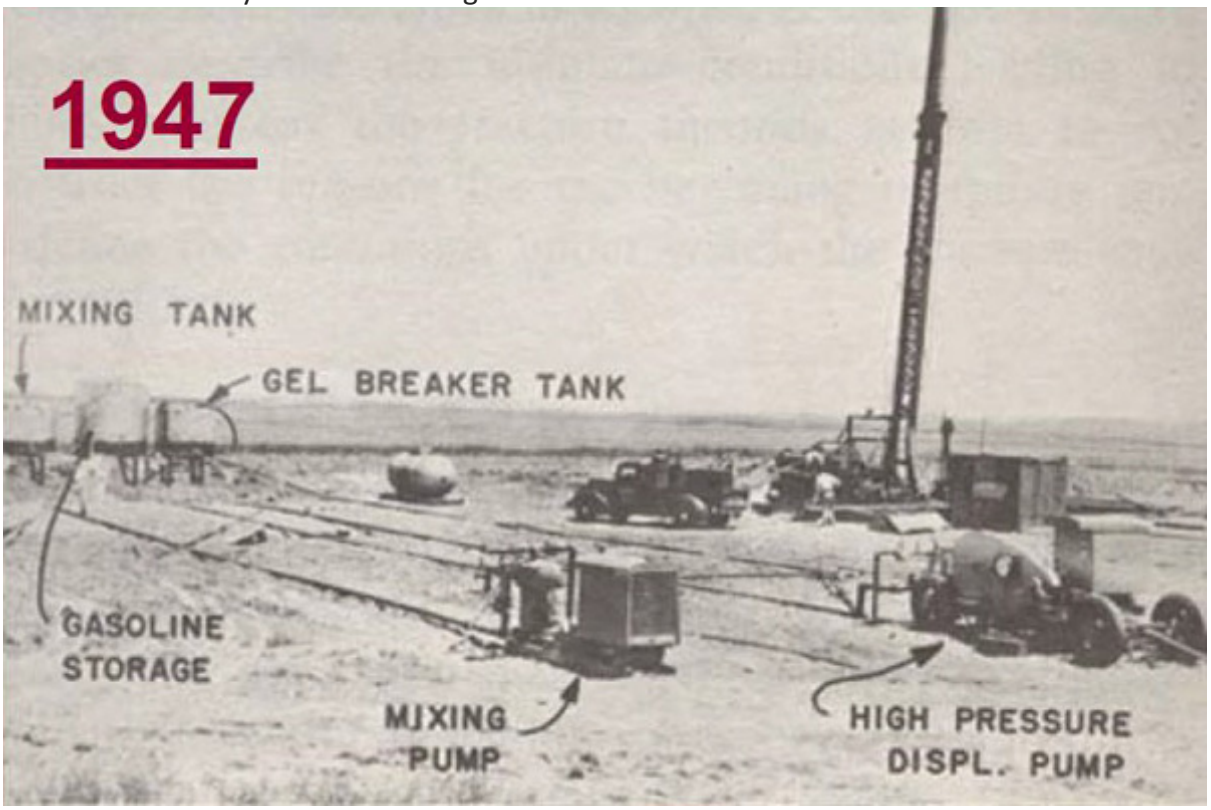
- Shale gas is made up or roughly 90% methane, and 10% ethane/propane meaning production costs are higher
- Ethane and propane content make shale gas far more volatile in the atmosphere
- Shale gas is trapped in the highly non-permeable source rock, this is where the gas was created, it is known as wet gas, can contain various compounds such as Btex chemicals which consist of benzene, toluene, ethylbenzene and xylene
- Shale may also contain radioactive materials, volatile organics, heavy metals, and corrosive substances such as hydrogen sulfide which are also bought to the surface and must be captured and disposed of
- Brine solution that is retrieved is around 5 times saltier than the ocean
- Horizontal drilling makes the wells commercially viable, the drill-bit direction is controlled through electromagnetic cabling, it is a relatively recent development the oil and gas industry
- The horizontal section is not drilled in a nice straight line as depicted
- Steel and cement casings cannot be guaranteed
- Fracturing is a multistage process
- Perforation by numerous extreme powerful explosions along the entire horizontal section of the well
- Perforation guns can include spent uranium in the detonation
- Acid spearhead cleans out the perforations and cracks and removes perforation residue
- Hydraulic fracturing completed in multiple stages
- Fracturing is required several times throughout a well's life, until it becomes commercially unviable to do so, and is then 'killed off'
- Well integrity can fail during stimulation stages
- Wells are put under stress during perforation and fracturing, and due to natural pressures and earth movements
- Wells exposed to high pressures both in and out

- Hydrogen sulfide is highly corrosive, as is salt water
- Numerous fracking chemicals, and acid spearhead are highly corrosive
- Each well passes through aquifers and has potential to eventually corrode through, or be crushed, and cause migration pathways to aquifers and through to surface
- Hydraulic Fracturing has been documented as causing migration pathways into drinking ground water and wells.

3.4 'What is Hydraulic Fracturing?'

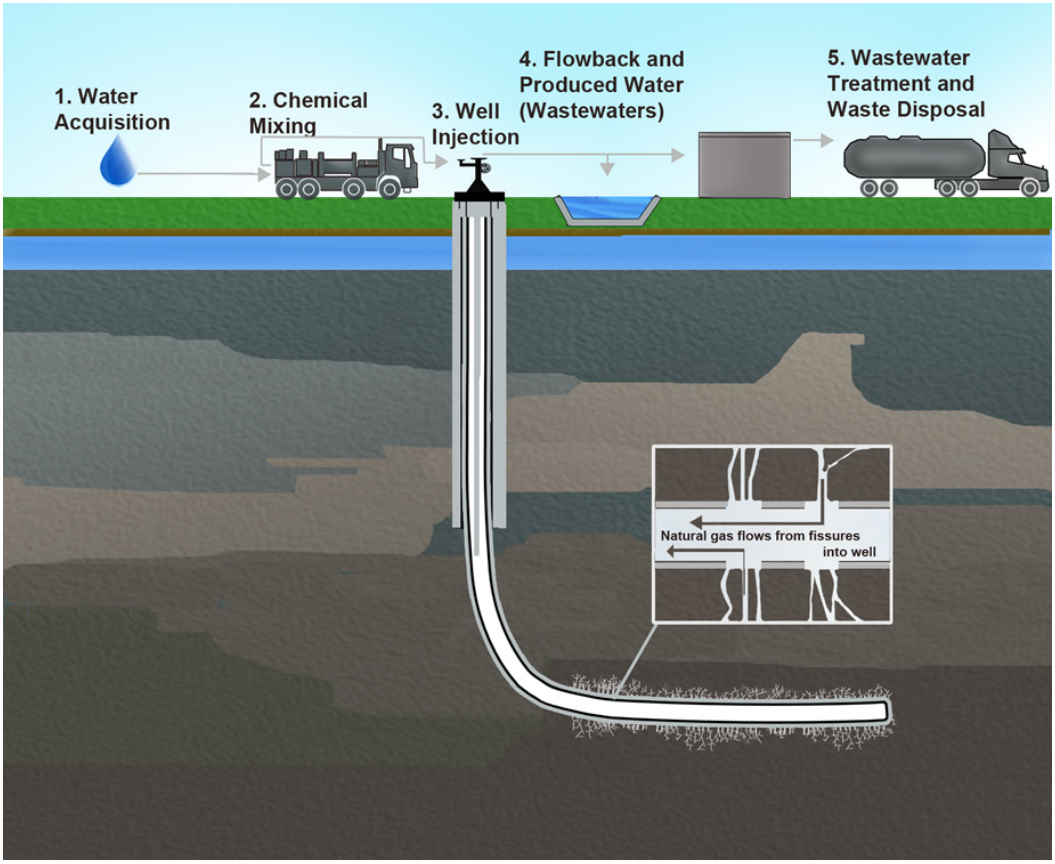
- part of a multistage process used in the extraction of oil and gas
- a mixture of water, proppant and various chemicals pumped down at high pressure to crack rocks in effort to release hydrocarbons
- an ever changing technology and industry as conventional supply is running out and hydrocarbons are becoming harder to reach
- techniques and requirements vary between conventional and unconventional wells
- an essential step in the extraction of oil and gas from shale
- to extract oil and gas from shale, hydraulic fracturing must occur multiple times
- hydraulic fluid consists of high percentage of water, proppant and various chemicals
- due to depth and length of shale wells, water requirements are high
- due to excessive amount of water required, the relatively small percentage of chemicals are high volumes
- hydraulic fracturing is done under high pressure
- increased depth and length has led to massive increase in psi required for hydraulic fracturing
- pictures portraying hydraulic fracturing of shale are very often misleading
- after fracturing, a percentage of fluid is returned to the surface (between 30%-80%) this is known as flowback
- flowback water contains naturally occurring contaminants such as heavy metals, volatile organic compounds, BTEX chemicals, radioactive materials
- flowback water, known as produce water, must be captured and collected
- produce water cannot be released into the natural environment
- chemicals are released into the air during fracturing stages
- hydraulic fracturing of shale requires a large number of heavy machinery and generators, and creates large amounts of noise

The evolution of hydraulic fracturing looks like this…

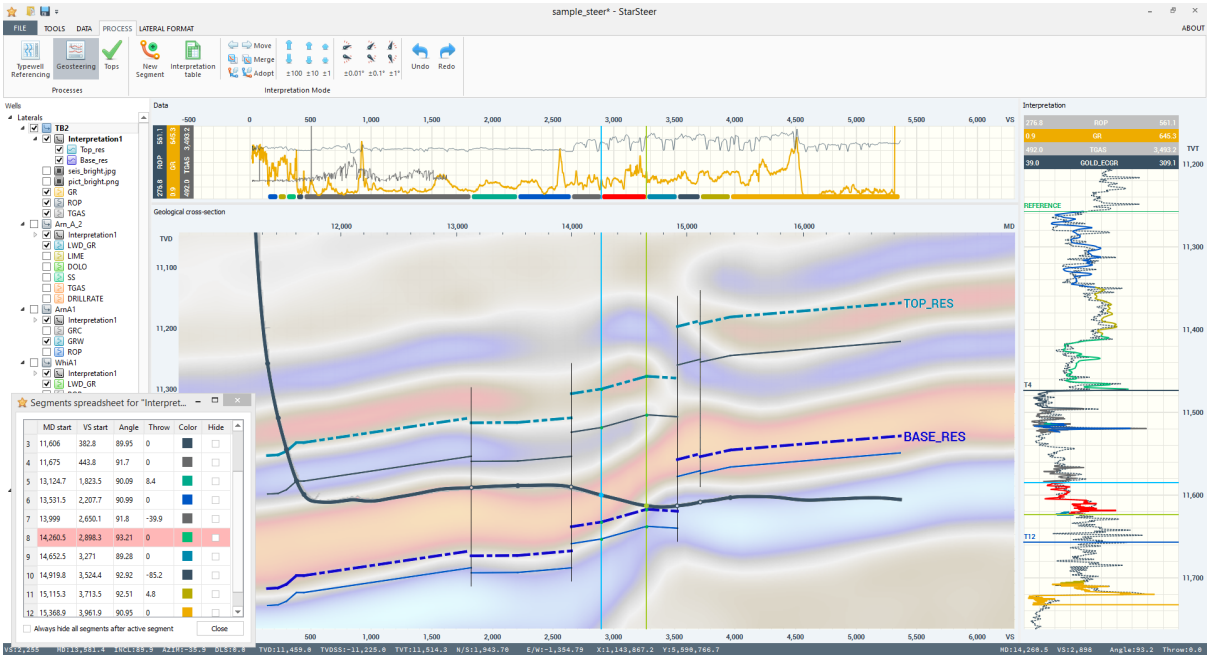


From the early and relatively simply process of conventional fracturing to increase oil and gas flow, through to the high-tech drilling techniques, extensive water and chemical requirements and the massive pressures of unconventional methods applied to pulverize and extract from the shale..

The industry uses simple and misleading imagery:



The reality is horizontal drilling is highly technical and difficult maneuver. The horizontal section is not a simple straight line through the shale..



and the fracturing process is no longer a simple operation.

3.5 Chemicals used in hydraulic fracturing

- Various chemicals make up between 0.5% and 2.5% of total volume of hydraulic fracturing liquid
- Chemical usage will depend on the company and the particular geology
- Between the steps of perforation and hydraulic fracturing is the step known as 'acid spearhead' which cleans out any residue caused during perforation, this is hydraulic acid
- Chemicals in hydraulic fracturing are often misleadingly portrayed as harmless food and makeup additives or common cleaning products found under kitchen sink
- Many of the chemicals used in hydraulic fracturing are corrosive
- Many of the chemicals are not well studied
- The reaction to the combination of these chemicals along with naturally occurring elements is not understood
- Chemicals reacting within shale can produce hydrogen sulfide
- Many of the chemical data sheets specify these chemicals should not be exposed to long term heat
- Many of the chemical data sheets specify these chemicals should not be released into water or soil
- Many of the chemical data sheets specify these chemicals cause a wide range of health impacts

Origin Energy Chemical Disclosure Submission – Amungee Well

Name	Compound	Purpose		Compound pictogram
Hydrocloric Acid		Pre-fracture	Corrosive to metal	
F112	Poly(oxy-1,2-ethanediyl), a,hexyl-w-hydroxy-)	Surfacant		
J609W	Ammonium sulfate	Friction Reducer	Corrosive of steel. At high temperatures creates Carbon Oxides and Sulphur Oxide	
L065	Ethylene glycol and Calcium chloride	Scale Inhibitor	Toxic. Causes increased corrosion.	

L071	Cholinium chloride	Temporay Clay Stabilizer	Causes pitting corrosion in steel	
M275	5-chloro-2 methyl-4 isothiazolin-3-one		Corrosive, acidic. Reactive of non-compatible with oxidizing materials	
L128	Sodium Hydroxide	Active gelling agent	Corrosive. Avoid extreme temperatures	
J604	Ethylene glycol, Sodium tetraborate, Boric acid	Crosslinker	Extremely toxic.	
J580	Carbohydrate polymer	Water gelling agent		
J481	Sodium bromate	Breaker	Oxidizer	
LPVEG	quartz	'sand'	Contains respirable crystalline silica in the form of quartz	

4 . Shale deposits in the Northern Territory

- The location of shale deposits in the Northern Territory coincide with major water basins and groundwater systems
- The location of shale deposits in the Northern Territory coincide with existing and identified potential growing areas, pastoral land, rural living areas, culturally significant and environmentally pristine areas
- Stating that the NT has experience with hydraulic fracturing in the Mareenie and Dingo fields is misleading and irrelevant as these are conventional gas fields
- Amungee NW1H was NOT the first horizontal well in the Northern Territory to be stimulated with multistage hydraulic fracturing
- Petrofrontier horizontally drilled and multi-stage hydraulically fractured three wells in the southern Gerorgina Basin, (NE Alice Springs) in 2011/2012
- The first suffered shallow casing failure
- The second two were drilled into faults, communicated with highly permeable water source and produced biogenic hydrogen sulfide
- All three have been abandoned

4. Prior Reports relating to Hydraulic fracturing in the Northern Territory

- (the 2011 Hunter Report was in fact for WA)
- 2012, Dr Tina Hunter conducted review of NT Petroleum (Environmental) Regulations and made a list of 26 recommendations
- 2014, Hawk Report - Independent Inquiry into Hydraulic Fracturing in the Northern Territory
- 2015, Hawke Report – Review of environmental and approval process
- 2016, Dr Tina Hunter commissioned to independent assessment of draft Petroleum Regulations – found regulations were improved, but needed further work

Reports and Studies that are lacking and otherwise essential for regulatory framework:

- impact of shale gas development, associated activities and requirements and risk to NT natural environments
- impact of shale gas associated activities and infrastructure requirements development on surface and sheet water flow and risk to aquifer recharge
- impact of shale gas associated activities and requirements on hydrogeology, the effect of quick and massive drawdown on groundwater systems and risk to water supply and flow to spring fed creeks and rivers
- impacts of shale gas associated activities, requirements, infrastructure and risk to water quality
- impacts of shale gas associated activities, requirements, infrastructure and risk to air quality
- impact of shale gas associated activities and requirements on increased seismicity and risk to faults, natural gas flows and cavernous lime stone systems
- impact of shale gas associated activities, requirements and risk on existing and future land uses
- impacts of shale gas associated activities, requirements and risk to human and animal physical and mental health
- impact of shale gas associated activities, requirements and risk on small and isolated communities
- impact of shale gas associated activities, requirements and risk on cultural and spiritual aspects of Aboriginal society and philosophy
- impact of shale gas associated activities, requirements and risk on existing and future industry

6. The current regulatory framework

- Petroleum Act 1984 (NT) - principle piece of legislation for regulation of petroleum industry (conventional and unconventional) in the Northern Territory
- Petroleum (Environmental) Regulations 2016
- Schedule of Onshore Petroleum Exploration and Production Requirements 2016

- Administrator and regulator is the Department of Primary Industries and Fisheries
- Conflicts can be found with one Minister holding portfolio of both primary industries and fisheries along with mineral and energy mining
- Other more suitable Departments are omitted from regulatory framework of mining and petroleum impacts
- The NT Government 'Mines Department' has a proven poor track record of being an effective regulator of the extractive industry
- Current regulations and requirements leave petroleum operators to be basic self-regulators
- The Mining and Petroleum Extraction industries are exempt from the NT Water Act
- Current regulations are reactive rather than protective based

7. The possible risks or issues associated with hydraulic fracturing

There will be impact of varying degrees.

Missing essential independently gathered baseline data covering:

- Widespread water quality
- Widespread air quality
- Widespread soil quality
- Widespread noise pollution
- Clear and precise native flora counts
- Clear and precise native fauna counts
- Clear and precise weed infestation data
- Widespread human health in particular mental, respiratory, dermal and nosebleeds (especially in younger and older populations, and those with compromised immune system)

The unconventional gas industry activities and requirements pose varying levels of risk, and these too need to be identified and acknowledged.

Hypothesis can be generalized into expected risk categories, however, without full and proper study into what we have, and extensive modelling to understand the risk, full understanding and recognition of type of risk and projected impacts will not be gained.

Without extensive and independent baseline data collection from across the Northern Territory and covering geological, hydrogeological, geographical, ecological, atmospheric, economic and public health…

1. a proper assessment of current conditions cannot be conducted, nor can any changes be properly identified in order to remedify or compensate
2. fail to arrive at a target of agreed levels of acceptable impact
3. failure to estimate levels of risk and therefore fail to be able to develop and implement an effective protective regulatory regime
4. an effective regulatory framework cannot be constructed and implemented

Summary and Further Considerations

There are two types of gas extraction, conventional and unconventional. Conventional refers to gas that has escaped its original source and is trapped in a pocket or fault. Australia has been extracting oil and gas from conventional deposits for decades. During this time, the procedure known as hydraulic fracturing has been used to increase well flow. Due to the nature of conventional gas, hydraulic fracturing is not a necessary component of the extraction process, however increased flow means increased revenue.

Unconventional oil and gas is that which requires more than the traditional methods of extraction. Unconventional gas can be broken into three types: Coal Seam Gas, Tight Sands and Shale. The deeper the gas, the more expensive it is to extract, there is an increase in level of difficulty and increased associated risk.

On average between 10-40% of CSG require hydraulic fracturing, whereas 100% of shale wells will need to receive fracturing stimulation.

The shale gas exploration industry is in infant stages in Australia and therefore remains in an experimental stage as the technique is refined to suit our particular geology. Therefore, we can expect to see a large number of failures while geology is understood and technology is tweaked.

Petroleum companies in Australia have had previous experience with hydraulic fracturing of conventional oil and gas deposits, however, the technology to drain these unconventional deposits is only relatively new, and in its infancy in Australia. Shale gas extraction requirements differ substantially to those of conventional gas when comparing volumes and numbers. The shale gas industry footprint and water and chemical requirements are far greater than that of conventional gas deposits.

The Brakken Shale of North Dakota, US, was discovered 75 years ago, however it took 60 years for the technology to catch up to be able to extract the gas. The past 15 years have seen companies refining their techniques in an effort to bring the costs down.

Cost saving advances have meant shale reservoirs have become commercially viable. Technology to detect the resources has improved, meaning better deposits (also known as ‘sweet spots’) can be targeted. Drilling time has been shortened by almost half. Horizontal drilling increases wellbore exposure to shale formation thus reducing well numbers. Multiple wellheads reduce surface infrastructure and man hours, and therefore reduces company costs.

Due to their depth, shale wells can be drilled through unknown or inactive faults. Technology can help to identify these pre drilling, but not always, as was demonstrated with two of the Petrofrontier wells in the Southern Georgina Basin. Drilling into faults can result in the encounter of deep aquifers as consequence the well may ‘communicate’ with water source. The effect of this interaction with deep aquifers, and any subsequent impact on overlaying groundwater must be understood before any further drilling of shale wells can continue.

Hydraulic fracturing of shale can lead to increased seismicity. The risk of earthquake more than 0.5 and less than 3.0 M_L tremor is likely. The effect of increased seismic activity on faults, natural gas soaks, cavernous limestone, surface environment and communities is unknown.

Drilling, shockwaves, pressures and seismicity can result in the increased flow of naturally occurring gas soaks. The geological layout of the land must be intimately studied to ensure preventative actions are in place to prevent the increase of biogenic methane into the atmosphere as a result of shale gas extraction activities.

Shale wells are much deeper than conventional gas wells, and that combined with an average 1km long horizontally drilled section, means that internal and external pressures are significantly increased and water and chemical requirements are far greater than the conventional wells we are accustomed to.

Shale wells waste water volume is less than that of CSG wells. However, shale formation produce water may be very saline (upwards of seven times saltier than seawater) and may contain varying levels of heavy metals, volatile organics, naturally occurring radioactive materials such as barium. Formation water bought to the surface contains a range of harmful chemicals and naturally occurring elements will limit treatment and reuse possibilities.

Large volumes of hydrochloric acid are required during 'acid spearhead' to clean and remove debris and residue from holes purposely created in steel and cement and subsequent cracks in the shale during the perforation stage. Following this flush out of explosive's residue and debris, multiple stages of hydraulic fracturing take place, an average of ten fracks per well. Hydraulic fracturing fluid is largely made of water and a proppant. A small percentage (and yet large volume in weight/volume) is made of chemicals. Many of these chemicals are corrosive, toxic to aquatic environments and detrimental to human health.

A notable increase in geological heat and pressure due to depth, along with the powerful shockwaves experienced during perforation, the high internal pressures created during hydraulic fracturing, and corrosive elements both naturally occurring and chemically induced, all put well integrity at risk.

Shale wells experience a rapid decline in flow rate, being most productive within the first few years of their producing life. Shale requires re-fracturing, during its lifespan each well will receive an average of three hydraulic fracturing treatments. Each stage of fracturing and re-fracturing puts strain on steel and cement casing. Unconventional shale wells have a higher percentage of well casing failure then conventional wells.

At such time the flow has reduced to a commercially unviable level, steps are taken to kill the well and abandonment procedure takes place. Typically, the well is plugged, cut off below ground and surface environmental remediation takes place. Companies have two years to comply to set regulations and then receive in full any environmental bond that was previously paid.

Wells will deteriorate over time, eventually leading to the formation of pathways for contaminates to migrate in to ground water and through to surface and into atmosphere. Remediation of well bore integrity is a costly exercise, and can only occur if leaks are detected. The remote and out of way locations of majority of proposed NT shale wells, would result in non-detection of groundwater, surface and air contamination.

Shale wells and associated infrastructure release varying levels of fugitive emissions. While industry predictions say these emissions are low, studies of unconventional gasfields show that the amounts of fugitive emissions of gasses into atmosphere are much larger than expected. NASA imagery and thermal imaging have revealed large plumes of methane discharging from fracked shale gasfields.

Atmospheric scientists in the Swiss Alps have recorded a significant, and alarming increase in greenhouse gasses. Levels of methane, ethane and propane have spiked after what was a downward trend after scientist announced the climate changing nature of these gases and the use as propellants were banned. The recent marked increase in global emissions of these planet warming gases has been directly related to the swift development of American shale gasfields.

Methane is promoted as a cleaner burning fossil fuel than coal and oil. However, methane itself is far greater greenhouse gas than Co2. Pound for pound, methane is almost 100 times more potent than Co2 over a 30 year period. Ethane is even more potent. Meaning that any benefits of burning methane as a power source, are quickly lost through fugitive emissions from wells, pipelines, transport, holding facilities, and other processes, infrastructure and human error. Coupled with the added threat to water, environmental and human health, unconventional gas is far from the clean and green image the industry would have us believe.

Water requirements for a developed shale gasfield are very high, yet the mining and extractive industries remaining outside of the NT Water Act. Approximately one million liters of water is required to initially drill each shale well, along with requirements for vertical test fracturing, pad and road building, pipelines, dust suppressant and worker's camp site domestic use. This is on top of the tens of millions of liters of water used during fracturing of each horizontally drilled shale well. Considering the high water requirements of the oil and gas industry in the Northern Territory, in an effort to prevent draining of aquifers, the industry should be bought in line with the NT Water Act.

Shale gas industry promoters try to downplay their water requirements by comparing the needs of an individual shale well to other industries. For example, "to fracture a shale well takes 30,000,000 liters, whereas the almond industry requires…." However, they are failing to make clear that during ramp-up of industry, hundreds of wells can be drilled in the same water basin in a single year. Unlike other industries such as the cattle production where water usage is drawn out over a full year, the drawdown of water from aquifers for hydraulic fracturing of a horizontal shale well is sudden.

The northern section of the Georgina and Wiso Basins flow in a northward direction and feed numerous springs on route to their major exit points in the Katherine and Flora Rivers.

The Katherine and Flora junction with and feed into the Daly River. Both Katherine and Flora River play an important role in cultural identity of indigenous populations, sustaining ecological balance, domestic water supply, tourism, recreational fishing, and various existing industries that are set to grow as demand from Asia market increases. Any disruption to dry season spring flow into these and other Top End NT rivers, will be of dire consequence to river health, domestic use and existing industries.

Water that is returned to surface after hydraulic fracturing of shale contains explosives residue, fracking chemicals, and also varying levels of heavy metals, volatile organics, hydrocarbons and naturally occurring radioactive materials. There are currently no adequate water treatment facilities in the Northern Territory to handle the large volumes of waste water that will be created from the industry. Currently the only available alternatives is to truck the water out the NT to facilities in Queensland, or to store waste until time that wells are due to be abandoned and then reinjected below ground. However, both alternatives effectively remove excessive amounts of water from the natural system. The successful treatment of water in specialized facilities is questionable due to the nature of natural contaminates. The reinjection of water to be plugged into abandoned wells increases volume of contaminates that will eventually make way through migration pathways into groundwater and surface.

Water collected in the (Beetaloo) Georgina and Wiso basins, eventually makes its way through to the ocean through various river systems. This finally balanced natural system creates the ideal breeding grounds for barramundi, crabs and other estuarine species and is vital in river health and support of tourism, recreational fishing and seafood industry of the NT, along with recreational fishing, tourism and aboriginal culture.

Yearly water requirements during ramp-up of shale gasfields are being ignored and the impacts of quick massive drawdown from aquifers, along with the removal of excessive volumes of water from natural systems are unknown. Independent baseline data to establish water quality and quantity are lacking, as is a full and proper study into water basins, aquifers and groundwater systems. The impact of reduced or contaminated spring flow on domestic supply, existing and future industries and land uses, natural environments ecological communities and cultural belief has not been properly assessed.

Fully developed shale gasfields rapidly ramp up to production mode and require extensive supportive infrastructure that must also be established quickly. Thousands of wells are required to successfully drain the shale basin, along with a vast array of connecting roads and pipelines, well pads, campsites, water holding ponds and gas processing facilities. Infrastructure associated with the industry will industrialize natural landscapes and carve up existing cattle station paddocks. The development of shale gasfields brings a significant increase in traffic and heavy vehicles through regional centers, cattle stations and pristine natural environments. Heavy vehicle flow is round the clock, and throughout the entire year. Roads would be required to be built up and sealed for year round and wet season access.

Many cattle stations in the Northern Territory are home to pristine areas that have been diligently protected from development. One particular example can be found on Vermelha

Station, which is situated around 180 kilometers south of Katherine and lies within Jacaranda tenement for oil and gas exploration.

Vermelha is situated at the start of the 'spring country' and it, along with other similar areas, are important to the existence of the NT's living rivers. The Strangways River runs through Vermelha, and while much of the river is subject to a seasonal flow, there are permanent waterholes, lagoons and springs. The area was important to the traditional peoples due to the availability of ground water, and the abundance of native food supply that this water provided for. There are numerous sites of cultural significance including rock and cave art and grinding stones situated around natural stone wells. The availably of year round surface water made Vermelha an important area for traditional Aboriginal people's, and as such, these are known as areas of Cultural Significance.

Culturally significant areas such as those found on Vermelha, are also significant in the ongoing existence of numerous animal species, many of whom numbers are declining and unknown. The Northern Territory is home to numerous Australian animals who have managed to survive the drying of the continent through climate change, seasonal burning, the onset of human development, and the introduction of feral and domesticated animals. There are numbers of vulnerable, endangered and critically endangered species spread across the entirety of the NT. Several critically endangered species, including the Golden-Backed Tree-Rat and the Northern Quoll, along with endangered and vulnerable birdlife such as the Australian Painted Snipe and Gouldian Finch have been identified within the Beetaloo Basin.

These species will be exposed to industrialization of landscapes, vegetation fragmentation, excessive noise, increased traffic, changed fire regime and loss of habitat and natural water supply. There is also risk of chemical exposure through fugitive emissions and air pollution, spills due to accident, faulty infrastructure and human error, and also via the waste water ponds.

The proposed development of shale gasfields within the Wiso and northern Georgina Basins, would effectively industrialize the Sturt Plateau, which happens to be part of the world's most pristine remaining savannahs. Full and proper study is required to identify all plant and animal species that are found within areas that will be exposed to unconventional gas development. Species identification and numbers are needed to implement successful protection strategies and to help identify the need of any establish 'no go zones' for species protection.

The industrialization of landscapes and increased noise pollution has potential to disrupt existing industry practices, and will impact on both native wildlife, herd animals, and residential areas that may be in close proximity. The introduction and spreading of weeds is a threat to native grasses, small ground dwelling animals and various bird species, along with added burden and cost to the cattle and farming industries.

The industrialization of land and high water use by unconventional gas industry will be in direct competition with not only the cattle industry and existing farmers and

horticulturalists, but also future agricultural developments. The Northern Territory is actively promoting itself as the 'Asian Delicatessen' as the Asian demand for quality food steadily increases. While Asia remains rapidly shifting from the developing nation status into a consumer society, demand for superior foods will continue to rise. Technological advancements and global pressure sees energy sources transitioning away from fossil fuels, towards the more environmentally friendly renewable energy solutions, however, human populations will always require food. The image of a clean environment for growing quality foods would be greatly tarnished with a fracked gasfield sitting within the vegetable patch, and thus exclusion from all growing and identified future growing areas must be identified and clearly marked for exclusion from fracking.

The Northern Territory is referred to as the 'Last Frontier' and promoted as 'Nature Territory', it has remained relatively intact and free from the destructive nature of development. The Territory boasts large swathes of natural and pristine environs. This has enabled the local indigenous culture to continue to survive in excess of 40,000 years. The indigenous people of the Northern Territory have a deep and intimate relationship with the environment. The natural landscapes form the songlines which are central to Aboriginal culture.

An extensive genomic study conducted by the University of Cambridge testing has confirmed that outside of Africa, the Australian Aboriginal peoples are the oldest living population on Earth.

- A singular out of Africa exit occurred at around 72,000 years ago.
- Australian and Papua New Guinean aborigines diverged from the main 'out of Africa' group approximately 52,000 years ago
- At around 50,000 years ago group arrived in the supercontinent 'Sahul', a landmass which included New Guinea, Australia and Tasmania
- Papuans and Australian Aborigines diverged at around 37,000 years ago, possibly due to early flooding of the Carpentaria Basin, with the remaining strip of land connecting Australia to New Guinea becoming uninhabitable
- Australian aboriginal communities became genetically isolated from each other, from about 31,000 years ago, most likely due to environmental barriers caused by changes in climate and the development of large impassible deserts in the center of the continent
- Rising sea levels caused the separation of Sahul, creating the islands of New Guinea, Australia and Tasmania around 10,000 years ago
- Ancestors of today's Australian Aboriginal communities remained isolated until contact was made by Indonesian fishermen a few thousand years ago, and then European explorers in the 18th Century which led to colonization

Aboriginal way of life has been impacted by European settlement, however, traditional peoples of the Northern Territory have not been forcibly dispossessed with many choosing to live as they have done for thousands of years. Anthropologists and social workers understand the associated negative impacts of dispossession and cultural identity loss, it is

important that Aboriginal peoples of the Northern Territory are encouraged to stay connected to their land, traditions and beliefs. The indigenous people of the Northern Territory may have adapted to specific introduced lifestyle changes, but their traditional songs, dances, stories, art, plant knowledge and ceremonies are alive and well. There are many documented benefits of maintaining a strong cultural identity and is recognized as an important factor of Aboriginal health and wellbeing.

Visitors to the Northern Territory are intrigued by Aboriginal culture, this creates opportunity for development of Aboriginal owned and operated Tourism ventures. Sharing of culture with both national and international visitors, will create sustainable employment and inject money into local communities and benefit the NT economy. Sharing of cultural experience will not only bring understanding between different groups, but will also strengthen individual identity and purpose.

The landscapes, environs, ideal winter climate, reactional fishing, and traditional cultural experiences draw thousands of national and international visitors each year. During the summer months, backpackers replace the traveling families and 'grey-nomads' and flock to the NT for seasonal work and the cheaper warmer weather deals. Tourism is a large economic driver in the Northern Territory, having an impact on numerous industries and generating significant numbers of jobs across a broad sector of employment areas.

The unconventional gas industry promises thousands of jobs for Territorians. However, quoted figures produced from Deloitte Access Economics are over estimated and do not identify the short term nature of employment for majority of positions during construction period. According to Deloitte's own report, Economic Impact of Shale and Tight Gas Development in the NT, that was commissioned by APPEA, estimated figures are based on the best case scenario of the best case scenario. Ultimately, these figures are imaginary.

The shale gas industry in the USA showed a rapid boom and bust cycle for workers and regional towns, and this same scenario was reproduced in Queensland with CSG development.

The shale gas industry needs to drill numerous wells and then test them for at least two years in order for companies to decide if they will invest in the billions of dollars required to develop a full production gasfield. Once the go-ahead is given, companies borrow huge amounts of money to build roads, pipelines, workers camps, well pads, and other infrastructure, along with the drilling and fracturing of thousands of wells. The nature of shale wells and the fact companies have to pay back large debts while creating a profit means development is swift. Major construction project phase is completed within a few short years, and with it ends the thousands of jobs that were created during the ramping up of the boom.

Following the initial construction phase, comes the drilling, fracturing and extraction of thousands of wells. These positions are technical and require specific training and experience. The majority of these positions will be filled with Fly-In-Fly-Out workers from the oil and gas sector from interstate and overseas. Local jobs for local people will be short lived during construction phase, and will be limited during production.

The Northern Territory has been promised high royalty payments by the unconventional shale gas industry. It has been suggested that the development of this industry will take the NT through to the 'next level' with huge financial gain. These suggested royalties and gains are highly questionable. In recent times there have been reports that highlight the taxes being avoided by oil and gas companies, and showing that revenue will be delayed by a decade. After that time, gas flow slows and the royalties trickle out as the wells life comes to an end.

Development of the unconventional gas industry poses significant risk to environment, water, air, existing and future land uses, existing and future industry, human and animal health. We need to ask serious questions and ensure that the gains will outweigh the risk. The only way to ensure that we have full understanding of exactly what is at risk and how it can be threatened is to conduct full and proper investigations across a wide sector.

Full and proper investigation and study is the only way to determine what level of detrimental impact the unconventional gas development will have on various existing and future aspects of the Northern Territory.

Full and proper investigation and study is the only way in which to acknowledge what needs protecting, and identifying what must be implemented to prevent detrimental impact. Be that through a strict regulatory framework, or with implemented bans or no go zones.
A protective regulatory framework designed to minimize impacts, can only be developed once this study and investigation has been completed.

Full and proper investigation, in this case, means individual expert organizations who are able to conduct independent study. This study should not come from the pockets of Territorians or Australian tax payers, instead Gas companies be required to pay a non-refundable deposit controlled by an independent body tasked to designate various organizations to implement investigations.

For the future of the Northern Territory it is important to not be swept up in the promises of a fledgling high risk industry that continuously presents misleading information and cannot give any guarantees. To protect the Territory and ensure a viable future for upcoming generations, difficult questions need to be asked. We should be prepared to accept nothing less than absolute assurance against environmental mismanagement and wide scale industrial damage to our unique environment and ecosystems.

Societies have shown they can recover from economic downturns. Australia has proven she can prosper after depressions. However, history has repeatedly shown that societies cannot survive without the simplest of needs, water. Indeed, entire civilizations have collapsed and disappeared when a loss of water has meant the loss of ability to grow food.

I would urge our decision makers to take heed of the requests of the people and advice given through various reports and studies, and tread this particular path of development very carefully. Getting it right will minimize impacts and possibly see prosperity for a few, but getting it wrong will have very dire and far reaching consequences that will impact every Territorian for generations to come.

Considering the factors above, and others that I have failed to mention due to the broad scope of possible impact, my personal recommendations that I ask the Panel to consider when making their decisions are as follows:

Recommendations

That the Panel recognizes that hydraulic fracturing is merely a single part in a complex extraction process, that belongs to an industry that poses varying levels of risk.

That the Panel recommend the Northern Territory Government acknowledge hydraulic fracturing is one step in a complex procedure, and that the entire shale gas industry poses element of risk, and as such a full and proper investigation be carried out to extensively study possible impacts of the development of this industry in the NT.

That a seven-year moratorium be placed on any further development of unconventional gas exploration or extraction in the Northern Territory, including shale, tight sand or any possibility of CSG. During this time, full and proper study is to be conducted by independent organizations. The unconventional gas companies will transfer non-refundable deposit to an independent agent, who is tasked to oversee the employment of various independent research organizations.

During seven-year moratorium vital baseline data be collected, including but not limited to, surface and ground water quantity and quality, air, seismicity, faults and natural soaks, sheetwater flow and aquifer recharge, flora and fauna counts, human and animal health, economics, existing and future land use.

Due to the misleading information that the unconventional gas industry has continued to hand out while trying to win government support and gain social license, that any form of compensation that companies may seek be dismissed and marked null and void.

Due to the fact that companies are in the earliest infant stages and deposits have not yet been properly tested and proven, that any claims of possible future loss by the unconventional gas industry be dismissed and marked null and void.

Perpetual independent monitoring of groundwater and air quality surrounding each individual abandoned well is a necessary requirement to detect any changes and should come at a cost to the companies who owned the well, not the tax payer. At such time that structure remedial action is required for abandoned wells, this ought to be paid for out of an eternal insurance fund set in place by the companies for each and every single well, so as Australian tax payers are not confronted with the cost of industry legacy. The industry companies and share-holders ought to be held indefinitely monetarily responsible for the structure of each and every well.

Faulty wells, infrastructure on ground, human error and spills can lead to surface and ground water contamination. Insurances should be in place to cover the cost of any loss of land use be it residential, recreational, cultural, environmental or separate existing or future

industry due to water contamination. Companies and shareholders should be held financially responsible for any losses, due to Shale Gas Industry associated activities or infrastructure.

Shale Gas Industry activities and infrastructure can lead to varying levels of fugitive emissions including methane, ethane, propane and other gases. These gases are known potent greenhouse gas, and as such will contribute to climate change and localized weather variations. Any damaging effect to temperatures and rain, will detrimentally impact the NT environment and economy. The Shale Gas Industry and its shareholders should be held monetarily responsible for any impact due to gas emissions to existing or future land uses, be they residential, recreational, cultural, environmental or separate industry.

To prevent future migration pathways for contaminates into aquifers due to well integrity failure caused by corrosion and natural pressures, drilling through and fracturing below bodies of ground water be banned.

To prevent interruption to sheet water flows and ground water recharge, that any activity associated with the unconventional shale gas industry, be banned from water catchment basins.

To prevent over extraction of aquifers, damage to existing and future industries and land uses, and threat to springs, natural environments and ecological communities, the oil and gas industry be bought in line with the NT Water Act and required to apply for water licensing, and monitored by an independent authority.

To prevent over extraction of aquifers, damage to existing and future industries and land uses, and threat to springs, natural environments and ecological communities, the ramp-up period of shale gas industry be slowed down, and well completion and fracturing be reduced to a maximum number per year set by Water Authority to ensure adequate yearly aquifer recharge, and monitored by an independent authority.

To prevent detrimental impact on threatened or endangered species of plant or animal, all activities and requirements for shale gas be banned in areas where vulnerable species have been recorded and identified.

The unconventional gas industry be held monetarily responsible for all public access roads. The upkeep of roads for year round access for extensive amounts of trucks and other vehicles, shall not come from the public purse, but will be funded in whole by the industry.

The unconventional gas industry be held monetarily responsible for all losses to already existing industries.

The unconventional gas industry be held monetarily responsible for all detrimental impacts on land prices and residential water.

FURTHER READING

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"Hydraulic fracturing and water policy were among the key issues for regional voters as they delivered a landslide election to the Northern Territory Labor Party at the weekend."
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Natural-Gas Boom and Coming Bust in America
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