

**From:** Charmaine Roth  
**To:** [fracking inquiry](#)  
**Subject:** response to Interim Report - Scientific Inquiry Hydraulic Fracturing NT  
**Date:** Monday, 4 September 2017 10:51:14 PM  
**Attachments:** [response to Interim Report, Fracking NT.pdf](#)  
[Gassy bore letter .pdf](#)

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Dear Panel Members of Scientific Inquiry in to Hydraulic Fracturing NT,

Please find attached my response to panel's presented Interim Report for your consideration. Please also find attached copy of letter sent by myself to NT Ministers, that I offer as evidence.

I give consent for my response, attached documented letter and name to be uploaded and published on Inquiry Web page with other submissions, but ask my address be withheld.

I thank you for the thorough work conducted and presented in Interim Report, and look forward to seeing the Panel's final report when released.

Kind regards,

Charmaine Roth

[REDACTED]

[REDACTED]  
[REDACTED]  
[REDACTED]

## Personal response to Interim Report: Scientific Inquiry into Hydraulic Fracturing in the Northern Territory

Dear Panel Members,

I would like to commend the Panel of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, on their released Interim Report and what appears to be a very thorough document, and would like to take the opportunity to make comment on a number of observations.

While the presented Interim Report looks to be comprehensive, and includes several new identified issues, it would appear that any conversation and indeed the scope of the inquiry stops at the stages of plugging and abandonment. Following abandonment, companies hand over responsibility of wells to the regulator, freeing themselves from any further concern or obligations. Unfortunately, history has shown us time and time again, is that steel corrodes and cement cracks and crumbles. Indeed, even the cement of Rome which the gas industry like to refer to as an example of longevity, has cracked and crumbled over time, and will not last forever.

Current NT regulations set out that wells are required to be plugged to specification, pipelines dismantled, water retention ponds and holding facilities pulled down and disposed of, and all associated infrastructure and waste removed. Well pads are leveled, what remains of the wells are cut off below ground and buried before top soil is bought back in and the area revegetated, the company receives its environmental bond back, and walks away wiping its hands. Eventually the trained eye will notice vegetation variations, but to most it will be hard to see where the industry once sprawled, and almost impossible to identify where individual wells were. Unfortunately, the effects of time, naturally occurring corrosive agents and geological pressures and movements do not stop once the unwanted asset is capped, plugged and buried below the surface.

It has been identified that the absolute responsibility of each and every one of these wells post abandonment rests with the regulator, and any ongoing monitoring and future remediation will be done at the expense of the public purse.

Acknowledgment is needed, of the large numbers of unconventionally drilled and hydraulically fractured wells required to successfully extract hydrocarbons from the shale. It also needs to be acknowledged that well integrity failure issues, can and will happen, and that wells are not simply going to disappear because they have been covered over with top soil and grass seeds.

It must be remembered, despite all of the hydrocarbon industry assurances and technical engineering, these are manmade structures, and like everything else, are subject to what is commonly referred to as Murphy's Law. What can go wrong, will go wrong, and therefore we must be prepared. It is blatantly obvious that the industry itself is avoiding this responsibility, and that the role of highlighting possible risks and areas where failure can occur, has been left to be shouldered by concerned constituents. Those people who voice their concerns hold the Northern Territory's future development and health in the highest degree. It is unfortunate that for their efforts they are quite often openly attacked, belittled, defamed and false claims made against by those who are in favor of onshore unconventional gas development.

It is disheartening when continuously people have made statements, and given evidence to this inquiry that suggests the 'other side of the story' (i.e. the risks involved) should not be told. The suggestion that 'left wing propagandists' change the opinions and the outcomes of proposals, sheds light on the very nature of the people that make these claims. Comments such as these indicate that many who stand and swear they are representing the best interest of the traditional peoples of the Northern Territory, are indeed representing their own possible financial gain. Furthermore, expressing a view that indigenous Australians should only receive the information that would lead to a favorable outcome, indicates a very severe understanding of International Laws.

## **For your consideration**

Simply being told the risk is minute, is not good enough. To dismiss potential failures as non-existent or minimal before regulations have been formulated, leaves any cause of environmental issues, economic impacts and human and animal health degradation, to be dealt with in a reactive and not a proactive manner. Without acknowledging the potential for risk, the protective framework cannot be developed let alone implemented.

When an industry hides truth and presents misleading information as fact, we need to ask what it is they are trying to mask. APPEA's submission to the Scientific Inquiry states that "Australia's first horizontal shale gas well was drilled by Santos in SA's Cooper Basin in 2013". However, Australia's first, second and third horizontal shale wells were drilled and fractured from 2011 under PetroFrontier in the Southern Georgina Basin in the Northern Territory. It is not hard to understand why APPEA does not want to acknowledge these earlier wells considering they are labeled as "operational & engineering failures". However, by failing to acknowledge the existence of these wells, their particular failures are overlooked are not taken into consideration.

The unconventional gas industry companies and the Australian Petroleum Production & Exploration Association (APPEA) give misleading information as they continue to portray that well integrity failure rate is low. However, despite the lobby group's claims, international reports refer to higher numbers of well failure and integrity issues, which appear to increase with a wells age. Considering horizontally drilled and hydraulically fractured shale wells are a relatively new development within the hydrocarbon extraction scene, it is difficult to establish failure rates of these particular wells, and almost impossible to determine rate of deterioration as the well ages, both during production and post abandonment.

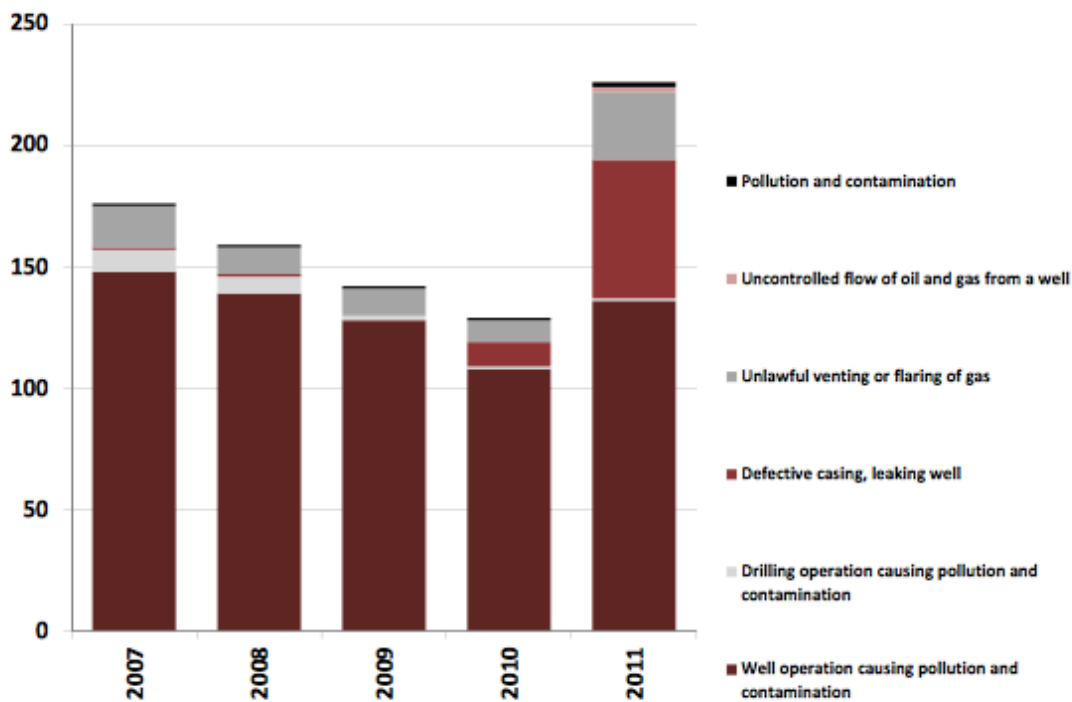
APPEA has used the figures of 0.03% of well failure rates in its shale gas development promotional materials: "An August 2011 report from the USA's Groundwater Protection Council examined more than 34,000 wells drilled and completed in Ohio between 1983 and 2007... It found only 12 incidents in Ohio that related to failures of (or graduate erosions to) casing or cement – a 0.03 per cent failure rate". However, these figures are merely misleading information, as the drilling and production of shale in Ohio began after 2007. As of April 2012, there were only 112 horizontal shale wells in Ohio. To further add to missing information, abandoned wells, resulted in more than 40 cases of private water supply contamination in Ohio between 1983 and 2007.

Furthermore, APPEA has not only continuously used figures collected from conventional wells to try justify the development of unconventional gas industry, it has referred to figures collected only from a very small part and single stage of a well's life, the drilling and preparing for production. Conventional wells do not necessarily need to be hydraulically fractured during completion stages, and are not exposed to the same geological challenges as with shale hydrocarbon extraction. The depth of shales dramatically increases external pressure and heat, and requires a considerable increase in Psi for hydraulic fracturing.

Looking at other credible and reliable sources, and the pollution from well violations (excluding oil and gas industry associated spills) saw a marked increase in Ohio in 2011, which coincides with the state's horizontal drilling shale boom, and includes sharp escalation in incidents of defective casing and leaking wells.

An April 2015 study which analyzed violation records from across three states from 2009 - 2013, revealed big oil and gas companies were found guilty for hundreds of violations. In this instance, it seems size company size bears no difference in capability of regulation violation. Chesapeake ranked at number one on the 'Top 10 Violators', ExxonMobil at 6, while Shell came in at number 9. Over the five-year period, Chesapeake was found to have committed 589 violations, out of 2,618 wells. Take the figures in consideration with oil and gas inspectors unable to visit and conduct inspection of an extremely large percentage of working wells, so exact numbers are unknown as many violations would not be reported.

**Pollution-related oil and gas violations in Ohio - (excluding spills)**  
Ohio Division of Oil and Gas Resources Management



Previous inquiries and reports have suggested that with robust regulatory regime, the industry can go ahead with reduced risk. APPEA’s own submission to the Scientific Inquiry states, “Robust regulations must be enforced to ensure the highest standards are maintained.” As previously detailed, an adequate protective framework can only be created if risks are identified and measures put in place to reduce threat and minimize impacts. However, there then remains the challenge of ensuring rules and regulations are being strictly adhered to. Self-regulation is not an option when there is so much at stake and when companies are eager to cut corners and reduce the massive costs associated with unconventional gas extraction. The oil and gas industry has proven in the US, even with a regulating body and teams of oil and gas inspectors, companies are violating rules and regulations, increasing risk and causing pollution.

The Northern Territory Government has continuously demonstrated inability of being an adequate regulator of the extractive industry. Furthermore, The NT Government has a proven track record of poor decision making when it comes to mining, other projects and sales of Territory assets. This has led to a severe lack of faith by the people of the Northern Territory in the Government as an able regulator. Regulatory blunders in the past may give companies the wrong impression, and in turn have a negative impact on best practice in the field.

As a regulator, and a representative of the people, the Northern Territory Government has to ask, and be able to answer in full, five basic questions before considering approval for unconventional gas industry:

1. What is it they want to do?
2. What is the risk?
3. Is it technically recoverable?
4. Is it economically recoverable?
5. Do the sums add up..what is it going to cost us?

### **What do they want to do?**

#### PRELIMINARY EXPLORATION & APPRAISAL

Establish if Northern Territory shale formations have proven potential to be developed into commercially viable productive unconventional shale gas operations:

Recognize and understand the many factors, some unique to marine shale, controlling deliverability and recovery as well as spatial variation from sweet spots to no-gas and extent to fracturing within the gas play/shale pool.

#### CONDITIONAL ON THE ABOVE, EXTENSIVE EXPLORATION & APPRAISAL

Drill a significant number of wells to further test various gas plays and establish an assessment of the accumulated estimated recoverable resource.

#### CONDITIONAL ON THE ABOVE, BANKABLE EXPLORATION & APPRAISAL

Additional exploration and appraisal, including further hydraulic fracturing to refine gas pool sizes and identify the recoverable resource range, assess deliverability, determine commerciality of production and possibly move the project towards full scale development and commercialization as seen in various shales across the US.

ELAPSED TIME FROM PRELIMINARY EXPLORATION & APPRAISAL TO COMMENCEMENT OF DEVELOPMENT 8-10 YEARS (NOT INCLUDING BOARD CONSIDERATION AND APPROVAL OF SIGNIFICANT INVESTMENT DECISION)

### **What is the risk?**

The purpose of this Inquiry is to help identify the areas of risk associated with onshore hydraulic fracturing of unconventional source rocks, and potential development of shale gas production facilities. Acknowledgment needs to be given that unconventional methods of hydraulic fracturing to extract hydrocarbons from source rocks such as shale, tight sands and coal seams, will open up development of an entire industry across the NT, and elevate areas of risk. Many of these areas have been identified within the Interim Report Scientific Inquiry into Hydraulic Fracturing in the Northern Territory.

Consideration needs to be given, that the ongoing exploration and appraisal of the NT shale formations, will also present possible identification of recoverable oil, leading to development of a separate industry, and further increase risk.

Risks of impact and threat from the unconventional hydrocarbon industry, must be identified from throughout the industry's lifespan including post abandonment. Risk and threat does not stop when wells are abandoned by the companies and the responsibility of their future integrity and ongoing maintenance is handed to the regulator. Risk must also be ascertained as to the effects and impacts of smashing the bedrock that has trapped and stored methane and other greenhouse gasses, effectively protecting groundwater systems and the atmosphere and preventing climatic catastrophe.

### **Is it technically recoverable?**

Technically recoverable resources represent the volumes of hydrocarbons that could be produced with technologies currently available, regardless of costs. It is essential to determine if current technologies can be applied to extract hydrocarbons from NT shales.

As of 2013, the US Energy Information Administration listed Australia as having 437tcf within potential shale formations, with 43tcf technically recoverable.

To date, assessment of Middle Velkerri shale pool within EP76, EP98 and EP117, calculates gas in place at 61tcf and the best estimated gross contingent gas resource is 6.6tcf

Currently the industry bases its asserted capabilities on the successes in various US shale plays. Each US shale formation has presented numerous variations and challenges, requiring refinement of technology in order to proceed. US shale formations are much younger than the NT shale, and produced under various evolutionary processes. Indeed, if Australia is successful in technological and economical ability to develop production level of hydrocarbons from shale, it will be from amongst some of the oldest shale in the world.

Evidence gathered from across the globe, highlights that differentiations in shale formation composition can render hydrocarbon reserves technically non recoverable. Due to the properties of clay, shale formations with a high amount of clay content is technically non recoverable. For this reason, both the Upper and Lower Velkerri formation of the Beetaloo Basin have zero prospectivity.

### **Is it economically recoverable?**

Economically recoverable resources are those that can be produced with profit under current market conditions. To date, with current exploration and appraisal in place, there is still no certainty that production of hydrocarbons from NT shale will be commercially viable.

The figure of 240tcf potential gas reserves has been used as promotion for further exploration and potential development, however, that is not what is proven available and projected figures cannot be based on this figure. It is technologically impossible to completely drain a sweet spot within a shale play, let alone the entire formation.

The economic recoverability of hydrocarbons from shale formations are influenced by three considerations:

- costs of drilling and completing wells
- amount of hydrocarbon produced over a well's lifetime
- prices received for the hydrocarbons produced

Evidence gained through the development of unconventional resources in the United States and other countries demonstrates economic recoverability is influenced by above-the-ground factors and not by geology alone.

In the United States and Canada, private ownership of subsurface rights and the royalties to landholders can provide an incentive for development; currently the NT faces a lack of social license for continued exploration and shale oil and gas industry development.

Other factors that require consideration by companies and shareholders when assessing commercial viability, and which currently could be providing uncertainty regarding estimates of capital and operating costs:

- lack of a developed service sector and workforce
- lack of supporting contractors with critical expertise and suitable drilling rigs
- lack of supporting infrastructure including water treatment facilities
- inadequate pipeline infrastructure
- inadequate road infrastructure
- possible non availability of water resources for use in hydraulic fracturing

The US experienced a revolutionized oil and gas production industry through the rapid development of shale hydrocarbon production which was made possible from the availability of existing infrastructure, workforce, critical expertise and suitable drilling rigs. The fact the Northern Territory

has poor above-the-ground conditions limited workforce and lacks the required infrastructure, presents a number of challenges to profitability and commercial viability.

Knowledge gained through the development of the unconventional oil and gas industry in the US has demonstrated that shale formations have vast heterogeneous composition, in which geophysical characteristics differ significantly over relatively short distances. Heterogeneity of shale can occur within a few hundred meters or less, meaning productivity can vary significantly between neighboring wells. Shale depth can also significantly affect the productivity of a formation.

The variations between US and NT shale formations in both geology and above-the-ground conditions can cause complexities, and the extent to which technically recoverable shale resources will prove to be economically recoverable, is as yet not known. As formations are further explored and appraised, spatial variation identified and the proven recoverable amounts are assessed and calculated, the Northern Territory Government will have a better idea of the amounts of expected royalties that will be received from the unconventional oil and gas industry.

Heterogeneity in shale causes significant variation of performance in hydrocarbon production across the fractured stages of a horizontal lateral of a well. Furthermore, shale heterogeneity can cause a number of fractured stages within the horizontal lateral to not produce any oil or gas, in some cases, almost half of the hydraulically fractured stages are not productive. This is one reason why long horizontal laterals are used, ensuring that sufficient hydrocarbon is produced along the horizontal section to make individual wells profitable.

#### **Do the sums add up..what is it going to cost us?**

As with any other major project development, there will be various levels of expenditure expected from the NT Government and without a doubt, this will have to be aided with contribution from Federal Government. It is essential to calculate the costs of contribution required from public purse, both in the lead up of exploration and appraisal phase, prior and during development and production phase, and for the duration of ongoing perpetual monitoring and remediation requirements post abandonment.

Identification of all areas where contribution is obliged to come from public funding, is critical in establishing estimated outgoing expenditure, these will include but are not be limited to:

- development and ongoing maintenance of essential infrastructure such as year round, all-weather public access roads for increased traffic and heavy vehicles,
- municipal controlled waste storage and water treatment facilities including such technologies as reverse or forward osmosis
- any rail links or sidings, connector pipelines and export facilities to be built in association with the development of the shale gas project

To get a realistic figure of costs, consideration must be given of other areas where public money will be used. These will include, but are not limited to, tasks of establishment of independent baseline data and monitoring and action covering both environmental, human and animal health, any further reports or scientific studies required for the identification of areas that need protection, the establishment of task force for the purpose of protective framework development and regulatory overseeing and inspections. Not forgetting the monetary requirements for perpetual monitoring and ongoing remediation of wells once the operator has released care and maintenance to the regulator following abandonment or orphaning; including associated costs of legacy and clean-up following industry procedures and requirements, accidental spill, human error or mechanical failure, which results in water contamination, air pollution or land degradation.

The total cost of expenditure from public monies, and the loss of income from other sectors that may be impacted due to requirements and activities of unconventional oil and gas development, need to be carefully weighed against any possible royalties to be received. These figures must be calculated

It should be noted that due to shale's nature, oil and gas production from individual wells declines rapidly, and is reason new wells are bought online in swift succession to ensure company profitability. Trends experienced within US shale boom, show that wells produce the most during the first year of life, followed by a sharp and rapid decline before stabilizing and gradually decreasing until commercially unviable to continue. Royalties received in the US start off high and very promising, giving way to landholder's acceptance, however the sharp downturn in production flow dictates a rapid decrease in royalty amounts, with only minimal royalties received after a few short years.

The US shale experience has shown that 'sweet spots' have displayed tendency to reduce flow at a much faster rate than was estimated. Reduced flow rates mean each additional well needed to successfully extract the oil or gas from the deposit becomes progressively more expensive as less hydrocarbons are produced. This

In APPEA's own submission to the scientific inquiry, their admittance was, "Of course, the economic benefits would be diminished if they came with negative environmental impacts but Territorian's can be confident that will not be the case."

However, due to poor decisions made in the past, a steadily increasing bill to the public due to the extractive industry legacy in the wake of mining across the Northern Territory, the majority local peoples are not confident that this will not be the case. Despite a lack in ability to act as proper regulator, and armed only with a set of flimsy guidelines and outdated regulations, the NT Government has continuously acted in a manner that shows a disregard for the magnitude of risk the unconventional gas industry brings.

Various Ministers and Department heads have previously made vital decisions without being fully educated across all areas of issue, relying heavily on the input from the lobby of the unconventional gas industry, and choosing to believe that anything less than praise is 'scaremongering'. Important recommendations from various experts and peak bodies have been overlooked, and unfortunately this is a trend that appears to have continued with new Ministerial portfolio holders.

In order to create an effective protective regulatory framework, a full and complete study of the land and environment must take place in order to understand the complete layout and identify where various risks can occur. Despite the ACOLA Report highlighting the quintessential importance of gaining intrinsic knowledge of the layout of land and environment, including naturally occurring faults and gas soaks, this seems to be overlooked. Departments are failing to communicate with one another, and Ministers are failing to understand the enormity of the task at hand.

In November 2016, a letter (attached) was sent to NT Ministers, highlighting areas of concerns in relation to a new water bore erupting with gas in proximity of shale exploration well within Pangaea Resources EPA 168. No acknowledgement was received from office of either Ministers Vowles or Fyles. The office of Chief Minister Michael Gunner replied that concerns had been passed to Lauren Moss, Minister for Primary Industry and Resources. The reply from Minister Moss included reference to a document the unconventional gas industry uses that acknowledges natural seepage can be encountered. Without any testing for formal identification of gas composition or origin, the gaseous water bore encounter on Gilnockie Station was dismissed as naturally occurring.



The decision to simply classify this gas as naturally occurring without conducting formal identification processes, and dismissing concerns without any monitoring or geological assessment, goes in total disregard of recommendations given by the Australian Chief Scientist. Ignoring recommendations and advice given by various experts which are aimed to minimize impacts, further increases distrust in the NT Government to be able to act as an adequate policy maker and incapable of being a totally independent and sufficient regulator.

## **Bonds**

With economic down turn, the US experienced a high number of orphaned wells as companies went bankrupt, leaving the tax payer to cover costs of well abandonment, site clean-up and landholder compensation payments.

An environmental and economic problem that Alberta announced will be facing for decades. In August 2016, it was acknowledged in the US that bonds were insufficient to cover costs incurred of plugging and clean up should wells be inadequately abandoned or outright orphaned. To decrease burden on public monies, Pennsylvania introduced a new bill, raising bonds to \$2million(US) per well, to ensure that costs of abandonment and clean up were sufficiently covered.

Economic downturn is not solely responsible for orphaned and poorly abandoned wells, shale gas booms are over relatively quickly, the bust comes sooner rather than later. The US experience has seen larger companies selling off assets to smaller companies as well productivity declines and oil and gas flow rate dwindle. The rapid bust following a shale boom, is associated with many thousands of wells being left to corrode as job numbers drop and people relocate in masses.

It is essential that NT held environmental bonds for the unconventional oil and gas industry are sufficient to meet costs of any plugging or clean up required. It must be acknowledged that the worst case scenario may happen, and down turn may see companies walk away, orphaning wells and sites. It should be a specification that bonds are required per well, per pad, and per field, and that a suitable estimated cost of field clean-up be determined per case.

Considering the nature of shale, the fact it is not fully drained, and the ever changing technologies within the industry, there is risk companies may 'temporarily' close and suspend shale wells, and fail to undertake proper decommissioning measures. Under the guise of possible future reopening, overseas regulators are allowing companies to 'temporarily' close wells, thus avoiding the cost and responsibility of undergoing proper abandonment processes. Temporary closure runs the risk of never actually reopening, which leads to major environmental risks including aquifer contamination and increased potent greenhouse emissions, along with huge economic drain to the public.

## **Post Abandonment Legacy**

Acknowledgment must be given that wells and shale deposits will never be pumped dry; production and hydraulic fracturing to increase and maintain flow, continues merely to a point where it becomes an economically unviable procedure. Once a well reaches non-viable commercial stage, it is abandoned (or orphaned) and handed into the trust of the regulator, freeing the extraction companies from any further responsibility or financial obligations.

It must be recognized that shale wells are exposed to great heat, extreme pressures, geological movements and naturally occurring corrosive elements such as hydrogen sulfide and high level salt in deep saline reservoirs. It cannot possibly be accepted, that these wells will stand the test of time and not corrode or crack from natural forces at some time in the future: be that 50, 100, 200 years.

Eventually all of these wells will suffer some form of structural integrity failure, at that point each well will become an open pathway for naturally occurring contaminants to migrate out of shale or saline aquifers, and into groundwater systems, or through to surface.

Acknowledgement must be given that the action of corrosion and structural failure due to natural causes and geological pressures will continue for perpetuity, threatening the water supply of future generations. People have lived in the Northern Territory for tens of thousands of years. It is of utmost importance that we consider the length of time people will continue to inhabit this land, and the importance of putting in to place protective measures to ensure future water supply is protected. Especially considering the current rising trend in global water contaminations and wastage. Water is set to become a very valuable resource in the near future.

For the purpose of future water protection, it must be calculated the costs of post abandonment perpetual monitoring and the remediation measures that will be required forever more. The costs of continuous monitoring of air and groundwater around each and every abandoned well, along with the ongoing repairs and any possible future clean-up, should not be financed from the public purse. Companies that are set to make profits from extensive numbers of wells which have an estimated approximate production life of twenty years' maximum, should not expect the tax payer to be financing their perpetual care. Therefore, it is recommended that a nonrefundable amount be paid per well and kept in trust, to cover all costs associated with post abandonment monitoring and remediation for perpetuity.

## **Conclusion**

While many issues have been identified in the interim report, they stop at abandonment when wells are handed to the regulator. Unfortunately for Territorian's, abandonment does not mean that the wells simply disappear, and as they age they will eventually deteriorate, or be damaged due to geological pressures and tremors, creating pathways for migration of contaminants out of shale and towards surface, or can lead to inter aquifer contamination, or uncontrolled flows. These are issues that can only be avoided by ongoing monitoring of ground water and air quality for perpetuity, which should not be funded from the public purse, but by those who are set to gain the most.

Consideration must be given into any actual benefits that Territorian's will receive, and weigh them carefully against the risk to existing and future environment, water, air, human and animal health, and economy. If the risk outweighs any possible benefit, then an outright ban on unconventional hydrocarbon extraction should be enforced.

I thank again the Panel for the work they are doing, and ask they take my comments and following recommendations into consideration as they move towards preparations for Scientific Inquiry final reporting.

I offer below a list of reference links and further reading points, and have attached above mentioned letter highlighting concerns in regard to gassy water bore.

Yours sincerely,  
Charmaine Roth

04 September 2017

## Recommendations

1. That an adequate length moratorium (seven years) be placed on all further exploration or appraisal activities for the shale extraction industry, to allow sufficient time for detailed and thorough study of the complete water system of the Northern Territory. This study should include but not be limited to:
  - rainfall patterns
  - sheet water flow
  - aquifer recharge
  - impacts and possible risk of rapid drawdown
  - impacts and possible risk on springs and river health
  - how any perceived impacts may negatively affect human and environment health
  - how any perceived impacts may negatively affect existing and future development and industry
  - identify areas that may be considered sensitive or are important to the recharge of aquifers and include those as 'no go zones'
  - recognize areas that are essential for the continued year round pumping of springs and subsequent river health, and identify these areas as 'no go zones'
  - acknowledging the spread of PFAS contamination within the Tindall Aquifer, consideration must be given to the risk and impacts of potential contamination associated with hydraulic fracturing and unconventional hydrocarbon extraction activities, and the extent of area that contamination could spread to
  
2. That during period of moratorium, detailed and thorough study of air and atmospheric quality of the Northern Territory be conducted. Study should include but not be limited to:
  - air composition, especially methane, butane, propane and other greenhouse gasses
  - identify areas of possible risk associated to increase in greenhouse gases both on a local and global level
  - identify impacts on vegetation and rainfall due to any associated localized weather disturbances due to increased greenhouse gasses
  - identify both human and animal health impacts of airborne pollutants, especially those associated with shale production
  - how any perceived impacts may negatively affect existing and future development and industry
  
3. That during period of moratorium, detailed and thorough study of effects of tectonic plate movement and consequent geological stresses within the Northern Territory be conducted. Study should include but not be limited to:
  - identification of areas onshore that may be subject to higher geological stress due to tectonic movement

- identification of areas and fault systems at risk of more frequent or higher magnitude earthquake due to increased geological stress caused by plate collision and the breaking of the Indo-Australian Plate
  - establish a timeframe of expected increase in earthquake and tremor frequency as geological pressure builds
  - identify any areas where surface infrastructure, or deep shale wells maybe impacted from risk of increased earthquake due to geological stresses and declare these as no go zones
4. A: That during period of moratorium, detailed and thorough study of effects of tectonic plate movement and consequent geological stresses within the Northern Territory be conducted. Study should include but not be limited to:
- identification of areas onshore that may be subject to higher geological stress due to tectonic movement
  - identification of areas and fault systems at risk of more frequent or higher magnitude earthquake due to increased geological stress caused by plate collision and the breaking of the Indo-Australian Plate
  - establish a timeframe of expected increase in earthquake and tremor frequency as geological pressure builds
  - identify any areas where surface infrastructure, or deep shale wells maybe impacted from risk of increased earthquake due to geological stresses and declare these as no go zones
5. That during period of moratorium a detailed economic impact study of associated costs to the Public be compiled. This study should include but not be limited to:
- cost from public purse to conduct necessary studies for the purpose of creating an effective protective framework and strengthening regulations
  - cost from public purse for the establishment of a specifically trained regulatory cadre who can conduct adequate inspection routine and ongoing monitoring
  - cost from public purse to upgrade and build necessary infrastructure to support the shale hydrocarbon extraction industry
  - cost from public purse to maintain necessary infrastructure
  - effects on existing workforce and the impacts this will have on other industries
  - impacts on existing and future industry and loss of revenue
  - financial impacts on other sectors such as health, education and environment
6. That during period of moratorium, a comprehensive study be conducted to identify associated costs to the Public following post abandonment or orphaning, and from this new environmental bonds be devised. This study should include but not be limited to:
- cost to public should a well or multiple well pad and other industry related infrastructure or waste be orphaned
  - cost to public for perpetual monitoring of air and groundwater surrounding individual wells
  - cost to public for perpetual remediation requirements for individual wells

7. Essential baseline data collection and collaboration, and the detailed results along with the findings of comprehensive studies, be made public and easily accessible on a user friendly central data system.
  
8. That collection of data and various comprehensive studies be conducted and compiled by independent and non-corruptible groups, or body who is not industry captured.

## REFERENCES AND SUGGESTED READING

### Southern Georgina Basin – Northern Territory

PetroFrontier – press release

<http://petrofrontier.com/assets/files/press-releases/2012-10-12.pdf>

Baraka Energy – Georgina Basin project review

<http://www.barakaenergy.com.au/projects.php>

Baraka Energy - Confirmation of Oil in the Southern Georgina Basin

<http://www.barakaenergy.com.au/pdfs/2012-10-15-012917Confirmation of Oil in the Southern Georgina Basin 15Oct2012.pdf>

Baraka Energy - Quarterly Activities and Cash Flow Report: 30 September

2012 <http://www.barakaenergy.com.au/pdfs/2012-11-11-235845Quarterly Activities and Cash Flow Report 31Oct2012.pdf>

Statoil to Withdraw from Permits EP127, EP128 in NT's Georgina Basin

[http://www.rigzone.com/news/oil\\_gas/a/135917/Statoil to Withdraw from Permits EP127 EP128 in NTs Georgina Basin](http://www.rigzone.com/news/oil_gas/a/135917/Statoil to Withdraw from Permits EP127 EP128 in NTs Georgina Basin)

PetroFrontier: History – End of Australian Activities

<http://petrofrontier.com/main/History>

### Beetaloo Basin – Northern Territory

Falcon Oil & Gas Ltd. ("Falcon"): Beetaloo Basin Drilling Results Indicate Material Gas Resource

<http://www.marketwired.com/press-release/falcon-oil-gas-ltd-falcon-beetaloo-basin-drilling-results-indicate-material-gas-resource-tsx-venture-fo-2196034.htm>

Dispelling APPEA's misleading information

APPEA – Well Integrity

<https://www.appea.com.au/industry-in-depth/technical-information/operations/well-integrity-2/q-a-well-integrity/>

Ohio Division of Oil and Gas Resources Management 2012 – Violations

<https://www.earthworksaction.org/files/publications/FINAL-OH-enforcement-sm.pdf>

Engineering Energy: Unconventional Gas Production – Recommendations

<http://www.chiefscientist.gov.au/wp-content/uploads/shalegas-recommendationsFINAL.pdf>

## Economic Considerations

Southern Georgina Basin Potential – inflated estimates

<http://www.asx.com.au/asxpdf/20101213/pdf/31vkg25kb9byls.pdf>

The Australia Institute - Economics of unconventional gas development

<http://www.tai.org.au/content/economics-unconventional-gas-development>

UK fracking may produce less fuel than claimed, says geologist

<https://www.theguardian.com/environment/2017/aug/17/uk-fracking-may-produce-less-fuel-than-claimed-says-geologist>

Ohio's 245 Utica shale wells producing at a rate of One Billion per year

<https://www.ohio.com/akron/business/ohio-s-245-utica-shale-wells-producing-at-a-rate-of-1-billion-a-year>

## Decline in Well Production

Shale Oil & Gas Production Costs Spiral Higher As Monstrous Decline Rates Eat Into Cash Flows

<https://srsroccoreport.com/shale-oil-gas-production-costs-spiral-higher-as-monstrous-decline-rates-eat-into-cash-flows/>

Mixed evidence from shale well decline rates

<http://www.ogfj.com/articles/print/volume-13/issue-8/features/mixed-evidence-from-shale-well-decline-rates.html>

Production and Royalty Declines in a Natural Gas Well Over Time

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

## Global Shale

Technically Recoverable Shale Oil and Shale Gas Resources: Australia

[https://www.eia.gov/analysis/studies/worldshalegas/pdf/Australia\\_2013.pdf](https://www.eia.gov/analysis/studies/worldshalegas/pdf/Australia_2013.pdf)

Technically Recoverable Shale Oil and Shale Gas Resources: Canada

[https://www.eia.gov/analysis/studies/worldshalegas/pdf/Canada\\_2013.pdf](https://www.eia.gov/analysis/studies/worldshalegas/pdf/Canada_2013.pdf)

A comparison of North American shale plays with emerging non- marine shale plays in Australia <http://v-scheiner.brunel.ac.uk/bitstream/2438/11921/1/Fulltext.pdf>

Shale gas handbook for Australia

[http://www.mondaq.com/article.asp?article\\_id=409972&signup=true](http://www.mondaq.com/article.asp?article_id=409972&signup=true)

## Well Integrity

Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation

<http://www.sciencedirect.com/science/article/pii/S0264817214000609>

Operators elevate well integrity priority

<http://www.offshore-mag.com/articles/print/volume-71/issue-1/subsea/operators-elevate-well-integrity-priority.html>

Energy Well Integrity: Nova Scotia Hydraulic Fracturing Independent Review and Public Engagement Process

<http://www.cbu.ca/wp-content/uploads/2015/10/hfstudy-energy-well-integrity.pdf>

King and King - Environmental Risk Arising From Well-Construction Failure—Differences Between Barrier and Well Failure, and Estimates of Failure Frequency Across Common Well Types, Locations, and Well Age

<http://shale.palwv.org/wp-content/uploads/2014/02/SPE-166142-PA-P2-copy.pdf>

Modeling Near Wellbore Leakage Pathways in Shale Gas Wells: Investigating Short and Long Terms Wellbore Integrity

<https://www.epa.gov/sites/production/files/documents/salehi.pdf>

Technical difficulties in the cementing of horizontal shale gas wells in Weyuan block and the countermeasures

<http://www.sciencedirect.com/science/article/pii/S2352854016300614>

Review and Analysis of DRAFT Supplemental Generic Environmental Impact Statement On The Oil, Gas and Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas

[https://www.nrdc.org/sites/default/files/ene\\_10092901d.pdf](https://www.nrdc.org/sites/default/files/ene_10092901d.pdf)

Corrosion in the Oil Industry

[https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=5&ved=0ahUKewiYtKn8s4vWAhVEfbwKHXhTB4wQFghJMAQ&url=https%3A%2F%2Fwww.researchgate.net%2Ffile.PostFileLoader.html%3Fid%3D57d87bf03d7f4b29da0bd248%26assetKey%3DAS%253A405982988521472%25401473805295454&usg=AFQjCNH5ITXBUcCb9jgmu-ASYe\\_ZU1UNzA](https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=5&ved=0ahUKewiYtKn8s4vWAhVEfbwKHXhTB4wQFghJMAQ&url=https%3A%2F%2Fwww.researchgate.net%2Ffile.PostFileLoader.html%3Fid%3D57d87bf03d7f4b29da0bd248%26assetKey%3DAS%253A405982988521472%25401473805295454&usg=AFQjCNH5ITXBUcCb9jgmu-ASYe_ZU1UNzA)

Abandoned Texas oil wells seen as "ticking time bombs" of contamination

<https://www.texastribune.org/2016/12/21/texas-abandoned-oil-wells-seen-ticking-time-bombs-/>

## Groundwater Contamination

State Oil and Gas Agency Groundwater Investigations And Their Role in Advancing Regulatory Reforms

[https://fracfocus.org/sites/default/files/publications/state\\_oil\\_gas\\_agency\\_groundwater\\_investigations\\_optimized.pdf](https://fracfocus.org/sites/default/files/publications/state_oil_gas_agency_groundwater_investigations_optimized.pdf)

Hydraulic fracturing in faulted sedimentary basins: Numerical simulation of potential contamination of shallow aquifers over long time scales

<http://onlinelibrary.wiley.com/doi/10.1002/2013WR014287/abstract>

Deteriorating Oil and Gas Wells Threaten Drinking Water Across the Country

<https://www.scientificamerican.com/article/deteriorating-oil-gas-wells-threatening-americas-drinking-water/>

## Bonds

‘We’re going to be dealing with this for decades’: Abandoned oil and gas wells skyrocket in Alberta

<http://business.financialpost.com/commodities/energy/were-going-to-be-dealing-with-this-for-decades-abandoned-oil-and-gas-wells-skyrocket-in-alberta>

Bill would raise shale well site bonds

<http://powersource.post-gazette.com/powersource/policy-powersource/2016/08/30/Bill-would-raise-oil-gas-well-site-bonds-Pennsylvania-Marcellus-shale/stories/201608300010>

When the Shale Runs Dry: A Look at the Future of Fracking

<https://www.desmogblog.com/2014/10/28/when-shale-runs-dry-look-future-drilling-fracking>

A Dynamic Model of Cleanup: Estimating Sunk Costs in Oil and Gas Production

<http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-DP-12-12-REV.pdf>

## Future Tremors

The Mw 6.0 Northern Territory earthquake of 21 May 2016

[https://riskfrontiers.com/rfwf/wp-content/uploads/2016/11/Briefing-Note-318\\_earthquake\\_NT\\_May-2016-1.pdf](https://riskfrontiers.com/rfwf/wp-content/uploads/2016/11/Briefing-Note-318_earthquake_NT_May-2016-1.pdf)

Earthquakes in Australia

<http://www.australiangeographic.com.au/topics/science-environment/2011/10/earthquakes-in-australia>

Quake start of Indo-Australia plate split

<http://www.abc.net.au/science/articles/2012/09/27/3599041.htm>



Hon. Michael Gunner MLA. Chief Minister, Minister for Trade, Business & Innovation  
Hon. Kenneth Vowles MLA. Minister for Primary Industry and Resources  
Hon. Lauren Moss MLA. Minister for Environment and Natural Resources  
Hon. Natasha Fyles MLA. Minister for Health

Dear Ministers,

I write to you with utmost concern.

On the 18th and 19th of July this year, a water bore was drilled on Gilnockie Station. Gilnockie is situated west of Larrimah (south of Katherine) and lies within the granted unconventional shale gas exploration permit number 168, held by Pangaea Resources.

Pangaea have been actively drilling the shale for exploration of unconventional gas in the region since 2014. There are 8 abandoned shale exploration wells within a 160km radius. The closest being approximately 30 km from the Gilnockie bore in question.

On the 19th of July, activity on the Gilnockie water bore registration number 39658 was halted due to an encounter with gas. The bore report states "left to observation due to gas smell". However, credible stories have surfaced that are linked back to the driller himself, which claim the gas ignited.

Upon receiving copy of the bore report stamped as 'Received 3/8/16', I contacted Department Land Resource Management and asked what testing had been undertaken to determine gas composition and origin. I was advised no testing had taken place, however the owner of the bore, Mr John Armstrong, had phoned a member of the Department on the day of the incident. The particular staff member dismissed it as gas, saying it was more likely a fuel or hydraulic fluid which had ignited due to the lack of gas holding capability of basalt and sand.

On Tuesday last week (November 8th December) ABC released a story: 'No link' between fracking and gas-emitting water bore on Northern Territory cattle station.

According to the article, a spokesperson from Department of Environment and Natural Resources claimed the interception of shallow gasses is not uncommon. Victoria Jackson from the Department of Mines and Energy claimed the distance between shale and water is too great to have been caused from shale exploration, and Professor Damian Barrett, CSIRO (and also Director of GISERA) added it was common for this type of occurrence to happen in Queensland.

However, after publication of the ABC Rural article, I contacted Dept. Environment & Natural Resources with the question, "How often has this type of incidence happened in the NT?" The answer I received was the only other incidence of this particular nature that is on record, occurred near Yuendumu when casting on a new bore was being cut, it ignited and exploded due to gas interception. From my understanding, this gas was not tested either, but became an OH&S issue. It was also confirmed during this conversation that while the NTG has two monitoring bores within this area, the only monitoring that occurs is for water depth. There is no ongoing testing of levels of naturally occurring contaminants such as gas, heavy metals, radioactive materials etc.

Victoria Jackson, was quick to defend the existing shale exploration wells in the area, citing distance between shale and aquifers is about 2km. What Ms Jackson failed to state is that shale (the source rock) is impermeable, while the layers between it and aquifers are not. Non permeability allows gas and fluids to migrate through to the surface. This is a phenomenon that has plagued the oil and gas industry, and shale is most certainly not immune to this. There are numerous scientific studies on integrity failure of shale wells, with inherent incorrectly designed, or poorly constructed wells being the main cause. A recent study found between 6-7% of new wells drilled in the Pennsylvania Marcellus shale suffered compromised integrity. Failure of well integrity after abandonment is acknowledged and discussed in the ACOLA report, from which recommendations have been made that monitoring continues after well abandonment. The Australian Chief Scientist recommended perpetual monitoring and testing of ground water and air quality around shale wells be carried out after abandonment to identify any changes in order to remediate the problem.

I have since written to Damian Barrett, CSIRO, to seek his opinion on the likelihood of basalt and sand having gas holding properties. I am still awaiting his reply. In the meantime, I have spoken to several water bore drillers who between them have drilled many thousands of bores across the Sturt Plateau and the NT. None have ever encountered methane, and do not believe that the geological formation in that particular area would naturally hold gas.

A well respected NT environmental consultant has agreed that “the geology of the Sturt Plateau is generally not the type of material that you would expect to find biogenic gas”. He added formal identification of the gas composition would be very useful information.

What is extremely alarming is the NT Government’s failure to act. To simply dismiss this incident as a natural and commonly occurring phenomenon without any form of evidence to back this claim is inexcusable. By failing to have this gas emitting water bore tested for proper identification of gas composition, the NT Government has demonstrated a severe lack of understanding in the complexity of the shale gas industry. Not only has this incident been dismissed without evidence, important baseline data has been neglected, and the NT Government has effectively set a precedent for any changes in air or water quality, to be simply dismissed as ‘naturally occurring’. This puts at risk any possible creation of an effective regulatory framework for the protection of water, air, existing and future land uses, environmental and public health.

This demonstration of lackluster response to a fledgling issue during the exploration stage of this industry demonstrates, quite alarmingly, that the NT government is in no position to monitor or adequately regulate this industry in it's production phase.

I ask that the NT Government have the Gilnockie bore independently tested for gas composition for the purpose of identification and collection of baseline data. Furthermore, I seek the perpetual testing of naturally occurring contaminants (eg methane, heavy metals, BTex chemical etc) in Government owned monitoring bores within the Wiso Basin. I request samples be collected and tested by independent consultants and laboratories.

I look forward to your response.

Yours sincerely,  
Charmaine Roth  
15 November 2016

ABC Rural story:

<http://mobile.abc.net.au/news/2016-11-08/gas-water-bore-northern-territory-gilnockie-station/7992524?pfmredir=sm>

Tuesday, 22 November 2016 2:01 pm

Dear Ms Roth

On behalf of the Hon Michael Gunner MLA, Chief Minister of the Northern Territory, I acknowledge receipt of your email dated 15 November 2016, raising concerns in relation to the Gilnockie water bore.

Your correspondence has been referred to the Office of the Hon Lauren Moss MLA, Minister for Environment and Natural Resources.

Thank you for writing to the Chief Minister about this matter.

Yours sincerely

  
Office of the Hon Michael Gunner MLA **Chief Minister** of the Northern Territory  
Northern Territory Government of Australia

Level 5, Parliament House, Darwin NT  
GPO Box 3146, Darwin NT 0801, Australia

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## Personal response to Interim Report: Scientific Inquiry into Hydraulic Fracturing in the Northern Territory

Dear Panel Members,

I would like to commend the Panel of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, on their released Interim Report and what appears to be a very thorough document, and would like to take the opportunity to make comment on a number of observations.

While the presented Interim Report looks to be comprehensive, and includes several new identified issues, it would appear that any conversation and indeed the scope of the inquiry stops at the stages of plugging and abandonment. Following abandonment, companies hand over responsibility of wells to the regulator, freeing themselves from any further concern or obligations. Unfortunately, history has shown us time and time again, is that steel corrodes and cement cracks and crumbles. Indeed, even the cement of Rome which the gas industry like to refer to as an example of longevity, has cracked and crumbled over time, and will not last forever.

Current NT regulations set out that wells are required to be plugged to specification, pipelines dismantled, water retention ponds and holding facilities pulled down and disposed of, and all associated infrastructure and waste removed. Well pads are leveled, what remains of the wells are cut off below ground and buried before top soil is bought back in and the area revegetated, the company receives its environmental bond back, and walks away wiping its hands. Eventually the trained eye will notice vegetation variations, but to most it will be hard to see where the industry once sprawled, and almost impossible to identify where individual wells were. Unfortunately, the effects of time, naturally occurring corrosive agents and geological pressures and movements do not stop once the unwanted asset is capped, plugged and buried below the surface.

It has been identified that the absolute responsibility of each and every one of these wells post abandonment rests with the regulator, and any ongoing monitoring and future remediation will be done at the expense of the public purse.

Acknowledgment is needed, of the large numbers of unconventionally drilled and hydraulically fractured wells required to successfully extract hydrocarbons from the shale. It also needs to be acknowledged that well integrity failure issues, can and will happen, and that wells are not simply going to disappear because they have been covered over with top soil and grass seeds.

It must be remembered, despite all of the hydrocarbon industry assurances and technical engineering, these are manmade structures, and like everything else, are subject to what is commonly referred to as Murphy's Law. What can go wrong, will go wrong, and therefore we must be prepared. It is blatantly obvious that the industry itself is avoiding this responsibility, and that the role of highlighting possible risks and areas where failure can occur, has been left to be shouldered by concerned constituents. Those people who voice their concerns hold the Northern Territory's future development and health in the highest degree. It is unfortunate that for their efforts they are quite often openly attacked, belittled, defamed and false claims made against by those who are in favor of onshore unconventional gas development.

It is disheartening when continuously people have made statements, and given evidence to this inquiry that suggests the 'other side of the story' (i.e. the risks involved) should not be told. The suggestion that 'left wing propagandists' change the opinions and the outcomes of proposals, sheds light on the very nature of the people that make these claims. Comments such as these indicate that many who stand and swear they are representing the best interest of the traditional peoples of the Northern Territory, are indeed representing their own possible financial gain. Furthermore, expressing a view that indigenous Australians should only receive the information that would lead to a favorable outcome, indicates a very severe understanding of International Laws.

## **For your consideration**

Simply being told the risk is minute, is not good enough. To dismiss potential failures as non-existent or minimal before regulations have been formulated, leaves any cause of environmental issues, economic impacts and human and animal health degradation, to be dealt with in a reactive and not a proactive manner. Without acknowledging the potential for risk, the protective framework cannot be developed let alone implemented.

When an industry hides truth and presents misleading information as fact, we need to ask what it is they are trying to mask. APPEA's submission to the Scientific Inquiry states that "Australia's first horizontal shale gas well was drilled by Santos in SA's Cooper Basin in 2013". However, Australia's first, second and third horizontal shale wells were drilled and fractured from 2011 under PetroFrontier in the Southern Georgina Basin in the Northern Territory. It is not hard to understand why APPEA does not want to acknowledge these earlier wells considering they are labeled as "operational & engineering failures". However, by failing to acknowledge the existence of these wells, their particular failures are overlooked are not taken into consideration.

The unconventional gas industry companies and the Australian Petroleum Production & Exploration Association (APPEA) give misleading information as they continue to portray that well integrity failure rate is low. However, despite the lobby group's claims, international reports refer to higher numbers of well failure and integrity issues, which appear to increase with a wells age. Considering horizontally drilled and hydraulically fractured shale wells are a relatively new development within the hydrocarbon extraction scene, it is difficult to establish failure rates of these particular wells, and almost impossible to determine rate of deterioration as the well ages, both during production and post abandonment.

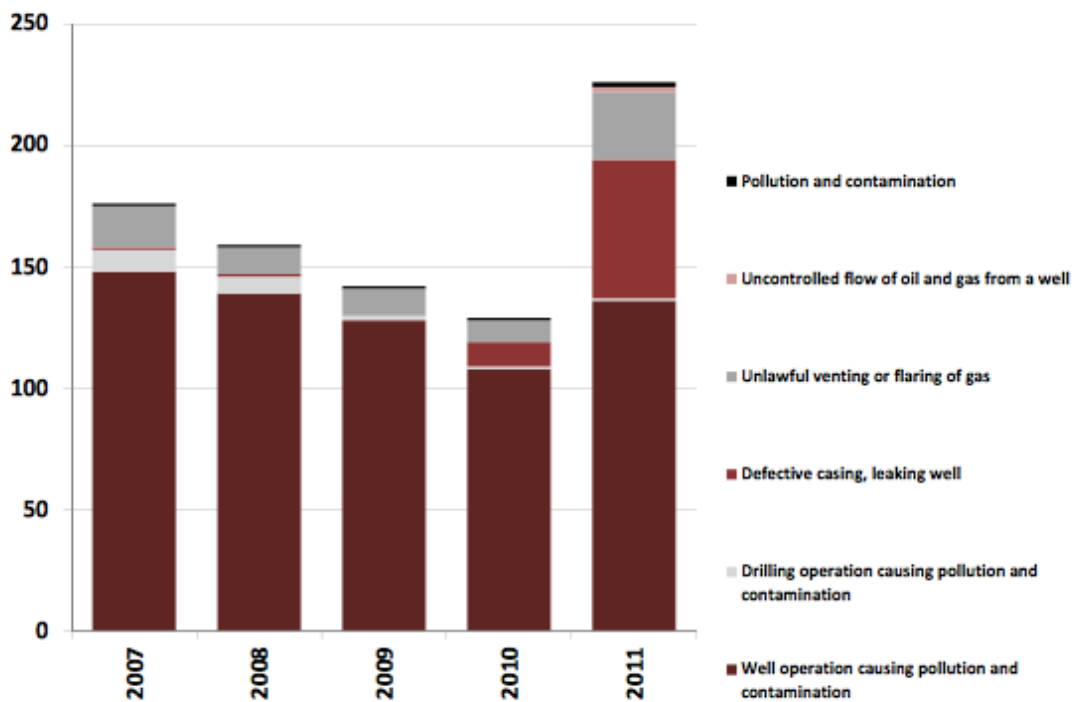
APPEA has used the figures of 0.03% of well failure rates in its shale gas development promotional materials: "An August 2011 report from the USA's Groundwater Protection Council examined more than 34,000 wells drilled and completed in Ohio between 1983 and 2007... It found only 12 incidents in Ohio that related to failures of (or graduate erosions to) casing or cement – a 0.03 per cent failure rate". However, these figures are merely misleading information, as the drilling and production of shale in Ohio began after 2007. As of April 2012, there were only 112 horizontal shale wells in Ohio. To further add to missing information, abandoned wells, resulted in more than 40 cases of private water supply contamination in Ohio between 1983 and 2007.

Furthermore, APPEA has not only continuously used figures collected from conventional wells to try justify the development of unconventional gas industry, it has referred to figures collected only from a very small part and single stage of a well's life, the drilling and preparing for production. Conventional wells do not necessarily need to be hydraulically fractured during completion stages, and are not exposed to the same geological challenges as with shale hydrocarbon extraction. The depth of shales dramatically increases external pressure and heat, and requires a considerable increase in Psi for hydraulic fracturing.

Looking at other credible and reliable sources, and the pollution from well violations (excluding oil and gas industry associated spills) saw a marked increase in Ohio in 2011, which coincides with the state's horizontal drilling shale boom, and includes sharp escalation in incidents of defective casing and leaking wells.

An April 2015 study which analyzed violation records from across three states from 2009 - 2013, revealed big oil and gas companies were found guilty for hundreds of violations. In this instance, it seems size company size bears no difference in capability of regulation violation. Chesapeake ranked at number one on the 'Top 10 Violators', ExxonMobil at 6, while Shell came in at number 9. Over the five-year period, Chesapeake was found to have committed 589 violations, out of 2,618 wells. Take the figures in consideration with oil and gas inspectors unable to visit and conduct inspection of an extremely large percentage of working wells, so exact numbers are unknown as many violations would not be reported.

**Pollution-related oil and gas violations in Ohio - (excluding spills)**  
Ohio Division of Oil and Gas Resources Management



Previous inquiries and reports have suggested that with robust regulatory regime, the industry can go ahead with reduced risk. APPEA’s own submission to the Scientific Inquiry states, “Robust regulations must be enforced to ensure the highest standards are maintained.” As previously detailed, an adequate protective framework can only be created if risks are identified and measures put in place to reduce threat and minimize impacts. However, there then remains the challenge of ensuring rules and regulations are being strictly adhered to. Self-regulation is not an option when there is so much at stake and when companies are eager to cut corners and reduce the massive costs associated with unconventional gas extraction. The oil and gas industry has proven in the US, even with a regulating body and teams of oil and gas inspectors, companies are violating rules and regulations, increasing risk and causing pollution.

The Northern Territory Government has continuously demonstrated inability of being an adequate regulator of the extractive industry. Furthermore, The NT Government has a proven track record of poor decision making when it comes to mining, other projects and sales of Territory assets. This has led to a severe lack of faith by the people of the Northern Territory in the Government as an able regulator. Regulatory blunders in the past may give companies the wrong impression, and in turn have a negative impact on best practice in the field.

As a regulator, and a representative of the people, the Northern Territory Government has to ask, and be able to answer in full, five basic questions before considering approval for unconventional gas industry:

1. What is it they want to do?
2. What is the risk?
3. Is it technically recoverable?
4. Is it economically recoverable?
5. Do the sums add up..what is it going to cost us?

### **What do they want to do?**

#### PRELIMINARY EXPLORATION & APPRAISAL

Establish if Northern Territory shale formations have proven potential to be developed into commercially viable productive unconventional shale gas operations:

Recognize and understand the many factors, some unique to marine shale, controlling deliverability and recovery as well as spatial variation from sweet spots to no-gas and extent to fracturing within the gas play/shale pool.

#### CONDITIONAL ON THE ABOVE, EXTENSIVE EXPLORATION & APPRAISAL

Drill a significant number of wells to further test various gas plays and establish an assessment of the accumulated estimated recoverable resource.

#### CONDITIONAL ON THE ABOVE, BANKABLE EXPLORATION & APPRAISAL

Additional exploration and appraisal, including further hydraulic fracturing to refine gas pool sizes and identify the recoverable resource range, assess deliverability, determine commerciality of production and possibly move the project towards full scale development and commercialization as seen in various shales across the US.

ELAPSED TIME FROM PRELIMINARY EXPLORATION & APPRAISAL TO COMMENCEMENT OF DEVELOPMENT 8-10 YEARS (NOT INCLUDING BOARD CONSIDERATION AND APPROVAL OF SIGNIFICANT INVESTMENT DECISION)

### **What is the risk?**

The purpose of this Inquiry is to help identify the areas of risk associated with onshore hydraulic fracturing of unconventional source rocks, and potential development of shale gas production facilities. Acknowledgment needs to be given that unconventional methods of hydraulic fracturing to extract hydrocarbons from source rocks such as shale, tight sands and coal seams, will open up development of an entire industry across the NT, and elevate areas of risk. Many of these areas have been identified within the Interim Report Scientific Inquiry into Hydraulic Fracturing in the Northern Territory.

Consideration needs to be given, that the ongoing exploration and appraisal of the NT shale formations, will also present possible identification of recoverable oil, leading to development of a separate industry, and further increase risk.

Risks of impact and threat from the unconventional hydrocarbon industry, must be identified from throughout the industry's lifespan including post abandonment. Risk and threat does not stop when wells are abandoned by the companies and the responsibility of their future integrity and ongoing maintenance is handed to the regulator. Risk must also be ascertained as to the effects and impacts of smashing the bedrock that has trapped and stored methane and other greenhouse gasses, effectively protecting groundwater systems and the atmosphere and preventing climatic catastrophe.

### **Is it technically recoverable?**

Technically recoverable resources represent the volumes of hydrocarbons that could be produced with technologies currently available, regardless of costs. It is essential to determine if current technologies can be applied to extract hydrocarbons from NT shales.

As of 2013, the US Energy Information Administration listed Australia as having 437tcf within potential shale formations, with 43tcf technically recoverable.

To date, assessment of Middle Velkerri shale pool within EP76, EP98 and EP117, calculates gas in place at 61tcf and the best estimated gross contingent gas resource is 6.6tcf

Currently the industry bases its asserted capabilities on the successes in various US shale plays. Each US shale formation has presented numerous variations and challenges, requiring refinement of technology in order to proceed. US shale formations are much younger than the NT shale, and produced under various evolutionary processes. Indeed, if Australia is successful in technological and economical ability to develop production level of hydrocarbons from shale, it will be from amongst some of the oldest shale in the world.

Evidence gathered from across the globe, highlights that differentiations in shale formation composition can render hydrocarbon reserves technically non recoverable. Due to the properties of clay, shale formations with a high amount of clay content is technically non recoverable. For this reason, both the Upper and Lower Velkerri formation of the Beetaloo Basin have zero prospectivity.

### **Is it economically recoverable?**

Economically recoverable resources are those that can be produced with profit under current market conditions. To date, with current exploration and appraisal in place, there is still no certainty that production of hydrocarbons from NT shale will be commercially viable.

The figure of 240tcf potential gas reserves has been used as promotion for further exploration and potential development, however, that is not what is proven available and projected figures cannot be based on this figure. It is technologically impossible to completely drain a sweet spot within a shale play, let alone the entire formation.

The economic recoverability of hydrocarbons from shale formations are influenced by three considerations:

- costs of drilling and completing wells
- amount of hydrocarbon produced over a well's lifetime
- prices received for the hydrocarbons produced

Evidence gained through the development of unconventional resources in the United States and other countries demonstrates economic recoverability is influenced by above-the-ground factors and not by geology alone.

In the United States and Canada, private ownership of subsurface rights and the royalties to landholders can provide an incentive for development; currently the NT faces a lack of social license for continued exploration and shale oil and gas industry development.

Other factors that require consideration by companies and shareholders when assessing commercial viability, and which currently could be providing uncertainty regarding estimates of capital and operating costs:

- lack of a developed service sector and workforce
- lack of supporting contractors with critical expertise and suitable drilling rigs
- lack of supporting infrastructure including water treatment facilities
- inadequate pipeline infrastructure
- inadequate road infrastructure
- possible non availability of water resources for use in hydraulic fracturing

The US experienced a revolutionized oil and gas production industry through the rapid development of shale hydrocarbon production which was made possible from the availability of existing infrastructure, workforce, critical expertise and suitable drilling rigs. The fact the Northern Territory



has poor above-the-ground conditions limited workforce and lacks the required infrastructure, presents a number of challenges to profitability and commercial viability.

Knowledge gained through the development of the unconventional oil and gas industry in the US has demonstrated that shale formations have vast heterogeneous composition, in which geophysical characteristics differ significantly over relatively short distances. Heterogeneity of shale can occur within a few hundred meters or less, meaning productivity can vary significantly between neighboring wells. Shale depth can also significantly affect the productivity of a formation.

The variations between US and NT shale formations in both geology and above-the-ground conditions can cause complexities, and the extent to which technically recoverable shale resources will prove to be economically recoverable, is as yet not known. As formations are further explored and appraised, spatial variation identified and the proven recoverable amounts are assessed and calculated, the Northern Territory Government will have a better idea of the amounts of expected royalties that will be received from the unconventional oil and gas industry.

Heterogeneity in shale causes significant variation of performance in hydrocarbon production across the fractured stages of a horizontal lateral of a well. Furthermore, shale heterogeneity can cause a number of fractured stages within the horizontal lateral to not produce any oil or gas, in some cases, almost half of the hydraulically fractured stages are not productive. This is one reason why long horizontal laterals are used, ensuring that sufficient hydrocarbon is produced along the horizontal section to make individual wells profitable.

#### **Do the sums add up..what is it going to cost us?**

As with any other major project development, there will be various levels of expenditure expected from the NT Government and without a doubt, this will have to be aided with contribution from Federal Government. It is essential to calculate the costs of contribution required from public purse, both in the lead up of exploration and appraisal phase, prior and during development and production phase, and for the duration of ongoing perpetual monitoring and remediation requirements post abandonment.

Identification of all areas where contribution is obliged to come from public funding, is critical in establishing estimated outgoing expenditure, these will include but are not be limited to:

- development and ongoing maintenance of essential infrastructure such as year round, all-weather public access roads for increased traffic and heavy vehicles,
- municipal controlled waste storage and water treatment facilities including such technologies as reverse or forward osmosis
- any rail links or sidings, connector pipelines and export facilities to be built in association with the development of the shale gas project

To get a realistic figure of costs, consideration must be given of other areas where public money will be used. These will include, but are not limited to, tasks of establishment of independent baseline data and monitoring and action covering both environmental, human and animal health, any further reports or scientific studies required for the identification of areas that need protection, the establishment of task force for the purpose of protective framework development and regulatory overseeing and inspections. Not forgetting the monetary requirements for perpetual monitoring and ongoing remediation of wells once the operator has released care and maintenance to the regulator following abandonment or orphaning; including associated costs of legacy and clean-up following industry procedures and requirements, accidental spill, human error or mechanical failure, which results in water contamination, air pollution or land degradation.

The total cost of expenditure from public monies, and the loss of income from other sectors that may be impacted due to requirements and activities of unconventional oil and gas development, need to be carefully weighed against any possible royalties to be received. These figures must be calculated

It should be noted that due to shale's nature, oil and gas production from individual wells declines rapidly, and is reason new wells are bought online in swift succession to ensure company profitability. Trends experienced within US shale boom, show that wells produce the most during the first year of life, followed by a sharp and rapid decline before stabilizing and gradually decreasing until commercially unviable to continue. Royalties received in the US start off high and very promising, giving way to landholder's acceptance, however the sharp downturn in production flow dictates a rapid decrease in royalty amounts, with only minimal royalties received after a few short years.

The US shale experience has shown that 'sweet spots' have displayed tendency to reduce flow at a much faster rate than was estimated. Reduced flow rates mean each additional well needed to successfully extract the oil or gas from the deposit becomes progressively more expensive as less hydrocarbons are produced. This

In APPEA's own submission to the scientific inquiry, their admittance was, "Of course, the economic benefits would be diminished if they came with negative environmental impacts but Territorian's can be confident that will not be the case."

However, due to poor decisions made in the past, a steadily increasing bill to the public due to the extractive industry legacy in the wake of mining across the Northern Territory, the majority local peoples are not confident that this will not be the case. Despite a lack in ability to act as proper regulator, and armed only with a set of flimsy guidelines and outdated regulations, the NT Government has continuously acted in a manner that shows a disregard for the magnitude of risk the unconventional gas industry brings.

Various Ministers and Department heads have previously made vital decisions without being fully educated across all areas of issue, relying heavily on the input from the lobby of the unconventional gas industry, and choosing to believe that anything less than praise is 'scaremongering'. Important recommendations from various experts and peak bodies have been overlooked, and unfortunately this is a trend that appears to have continued with new Ministerial portfolio holders.

In order to create an effective protective regulatory framework, a full and complete study of the land and environment must take place in order to understand the complete layout and identify where various risks can occur. Despite the ACOLA Report highlighting the quintessential importance of gaining intrinsic knowledge of the layout of land and environment, including naturally occurring faults and gas soaks, this seems to be overlooked. Departments are failing to communicate with one another, and Ministers are failing to understand the enormity of the task at hand.

In November 2016, a letter (attached) was sent to NT Ministers, highlighting areas of concerns in relation to a new water bore erupting with gas in proximity of shale exploration well within Pangaea Resources EPA 168. No acknowledgement was received from office of either Ministers Vowles or Fyles. The office of Chief Minister Michael Gunner replied that concerns had been passed to Lauren Moss, Minister for Primary Industry and Resources. The reply from Minister Moss included reference to a document the unconventional gas industry uses that acknowledges natural seepage can be encountered. Without any testing for formal identification of gas composition or origin, the gaseous water bore encounter on Gilnockie Station was dismissed as naturally occurring.

The decision to simply classify this gas as naturally occurring without conducting formal identification processes, and dismissing concerns without any monitoring or geological assessment, goes in total disregard of recommendations given by the Australian Chief Scientist. Ignoring recommendations and advice given by various experts which are aimed to minimize impacts, further increases the distrust of the public towards the NT Government's ability to act as an adequate policy maker. Furthermore, these actions give the public little faith the NT Government is able to remain an independent and sufficient regulator.

## **Bonds**

With economic down turn, the US experienced a high number of orphaned wells as companies went bankrupt, leaving the tax payer to cover costs of well abandonment, site clean-up and landholder compensation payments.

An environmental and economic problem that Alberta announced will be facing for decades. In August 2016, it was acknowledged in the US that bonds were insufficient to cover costs incurred of plugging and clean up should wells be inadequately abandoned or outright orphaned. To decrease burden on public monies, Pennsylvania introduced a new bill, raising bonds to \$2million(US) per well, to ensure that costs of abandonment and clean up were sufficiently covered.

Economic downturn is not solely responsible for orphaned and poorly abandoned wells, shale gas booms are over relatively quickly, the bust comes sooner rather than later. The US experience has seen larger companies selling off assets to smaller companies as well productivity declines and oil and gas flow rate dwindle. The rapid bust following a shale boom, is associated with many thousands of wells being left to corrode as job numbers drop and people relocate in masses.

It is essential that NT held environmental bonds for the unconventional oil and gas industry are sufficient to meet costs of any plugging or clean up required. It must be acknowledged that the worst case scenario may happen, and down turn may see companies walk away, orphaning wells and sites. It should be a specification that bonds are required per well, per pad, and per field, and that a suitable estimated cost of field clean-up be determined per case.

Considering the nature of shale, the fact it is not fully drained, and the ever changing technologies within the industry, there is risk companies may 'temporarily' close and suspend shale wells, and fail to undertake proper decommissioning measures. Under the guise of possible future reopening, overseas regulators are allowing companies to 'temporarily' close wells, thus avoiding the cost and responsibility of undergoing proper abandonment processes. Temporary closure runs the risk of never actually reopening, which leads to major environmental risks including aquifer contamination and increased potent greenhouse emissions, along with huge economic drain to the public.

## **Post Abandonment Legacy**

Acknowledgment must be given that wells and shale deposits will never be pumped dry; production and hydraulic fracturing to increase and maintain flow, continues merely to a point where it becomes an economically unviable procedure. Once a well reaches non-viable commercial stage, it is abandoned (or orphaned) and handed into the trust of the regulator, freeing the extraction companies from any further responsibility or financial obligations.

It must be recognized that shale wells are exposed to great heat, extreme pressures, geological movements and naturally occurring corrosive elements such as hydrogen sulfide and high level salt in deep saline reservoirs. It cannot possibly be accepted, that these wells will stand the test of time

and not corrode or crack from natural forces at some time in the future: be that 50, 100, 200 years. Eventually all of these wells will suffer some form of structural integrity failure, at that point each well will become an open pathway for naturally occurring contaminants to migrate out of shale or saline aquifers, and into groundwater systems, or through to surface.

Acknowledgement must be given that the action of corrosion and structural failure due to natural causes and geological pressures will continue for perpetuity, threatening the water supply of future generations. People have lived in the Northern Territory for tens of thousands of years. It is of utmost importance that we consider the length of time people will continue to inhabit this land, and the importance of putting in to place protective measures to ensure future water supply is protected. Especially considering the current rising trend in global water contaminations and wastage. Water is set to become a very valuable resource in the near future.

For the purpose of future water protection, it must be calculated the costs of post abandonment perpetual monitoring and the remediation measures that will be required forever more. The costs of continuous monitoring of air and groundwater around each and every abandoned well, along with the ongoing repairs and any possible future clean-up, should not be financed from the public purse. Companies that are set to make profits from extensive numbers of wells which have an estimated approximate production life of twenty years' maximum, should not expect the tax payer to be financing their perpetual care. Therefore, it is recommended that a nonrefundable amount be paid per well and kept in trust, to cover all costs associated with post abandonment monitoring and remediation for perpetuity.

## **Conclusion**

While many issues have been identified in the interim report, they stop at abandonment when wells are handed to the regulator. Unfortunately for Territorian's, abandonment does not mean that the wells simply disappear, and as they age they will eventually deteriorate, or be damaged due to geological pressures and tremors, creating pathways for migration of contaminates out of shale and towards surface, or can lead to inter aquifer contamination, or uncontrolled flows. These are issues that can only be avoided by ongoing monitoring of ground water and air quality for perpetuity, which should not be funded from the public purse, but by those who are set to gain the most.

Consideration must be given into any actual benefits that Territorian's will receive, and weigh them carefully against the risk to existing and future environment, water, air, human and animal health, and economy. If the risk outweighs any possible benefit, then an outright ban on unconventional hydrocarbon extraction should be enforced.

I thank again the Panel for the work they are doing, and ask they take my comments and following recommendations into consideration as they move towards preparations for Scientific Inquiry final reporting.

I offer below a list of reference links and further reading points, and have attached above mentioned letter highlighting concerns in regard to gassy water bore.

Yours sincerely,  
Charmaine Roth

04 September 2017

## Recommendations

1. That an adequate length moratorium (seven years) be placed on all further exploration or appraisal activities for the shale extraction industry, to allow sufficient time for detailed and thorough study of the complete water system of the Northern Territory. This study should include but not be limited to:
  - rainfall patterns
  - sheet water flow
  - aquifer recharge
  - impacts and possible risk of rapid drawdown
  - impacts and possible risk on springs and river health
  - how any perceived impacts may negatively affect human and environment health
  - how any perceived impacts may negatively affect existing and future development and industry
  - identify areas that may be considered sensitive or are important to the recharge of aquifers and include those as 'no go zones'
  - recognize areas that are essential for the continued year round pumping of springs and subsequent river health, and identify these areas as 'no go zones'
  - acknowledging the spread of PFAS contamination within the Tindall Aquifer, consideration must be given to the risk and impacts of potential contamination associated with hydraulic fracturing and unconventional hydrocarbon extraction activities, and the extent of area that contamination could spread to
  
2. That during period of moratorium, detailed and thorough study of air and atmospheric quality of the Northern Territory be conducted. Study should include but not be limited to:
  - air composition, especially methane, butane, propane and other greenhouse gasses
  - identify areas of possible risk associated to increase in greenhouse gases both on a local and global level
  - identify impacts on vegetation and rainfall due to any associated localized weather disturbances due to increased greenhouse gasses
  - identify both human and animal health impacts of airborne pollutants, especially those associated with shale production
  - how any perceived impacts may negatively affect existing and future development and industry
  
3. That during period of moratorium, detailed and thorough study of effects of tectonic plate movement and consequent geological stresses within the Northern Territory be conducted. Study should include but not be limited to:
  - identification of areas onshore that may be subject to higher geological stress due to tectonic movement

- identification of areas and fault systems at risk of more frequent or higher magnitude earthquake due to increased geological stress caused by plate collision and the breaking of the Indo-Australian Plate
  - establish a timeframe of expected increase in earthquake and tremor frequency as geological pressure builds
  - identify any areas where surface infrastructure, or deep shale wells maybe impacted from risk of increased earthquake due to geological stresses and declare these as no go zones
4. A: That during period of moratorium, detailed and thorough study of effects of tectonic plate movement and consequent geological stresses within the Northern Territory be conducted. Study should include but not be limited to:
- identification of areas onshore that may be subject to higher geological stress due to tectonic movement
  - identification of areas and fault systems at risk of more frequent or higher magnitude earthquake due to increased geological stress caused by plate collision and the breaking of the Indo-Australian Plate
  - establish a timeframe of expected increase in earthquake and tremor frequency as geological pressure builds
  - identify any areas where surface infrastructure, or deep shale wells maybe impacted from risk of increased earthquake due to geological stresses and declare these as no go zones
5. That during period of moratorium a detailed economic impact study of associated costs to the Public be compiled. This study should include but not be limited to:
- cost from public purse to conduct necessary studies for the purpose of creating an effective protective framework and strengthening regulations
  - cost from public purse for the establishment of a specifically trained regulatory cadre who can conduct adequate inspection routine and ongoing monitoring
  - cost from public purse to upgrade and build necessary infrastructure to support the shale hydrocarbon extraction industry
  - cost from public purse to maintain necessary infrastructure
  - effects on existing workforce and the impacts this will have on other industries
  - impacts on existing and future industry and loss of revenue
  - financial impacts on other sectors such as health, education and environment
6. That during period of moratorium, a comprehensive study be conducted to identify associated costs to the Public following post abandonment or orphaning, and from this new environmental bonds be devised. This study should include but not be limited to:
- cost to public should a well or multiple well pad and other industry related infrastructure or waste be orphaned
  - cost to public for perpetual monitoring of air and groundwater surrounding individual wells
  - cost to public for perpetual remediation requirements for individual wells

7. Essential baseline data collection and collaboration, and the detailed results along with the findings of comprehensive studies, be made public and easily accessible on a user friendly central data system.
  
8. That collection of data and various comprehensive studies be conducted and compiled by independent and non-corruptible groups, or body who is not industry captured.

## REFERENCES AND SUGGESTED READING

Southern Georgina Basin – Northern Territory

PetroFrontier – press release

<http://petrofrontier.com/assets/files/press-releases/2012-10-12.pdf>

Baraka Energy – Georgina Basin project review

<http://www.barakaenergy.com.au/projects.php>

Baraka Energy - Confirmation of Oil in the Southern Georgina Basin

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Baraka Energy - Quarterly Activities and Cash Flow Report: 30 September

2012 [http://www.barakaenergy.com.au/pdfs/2012-11-11-235845Quarterly Activities and Cash Flow Report 31Oct2012.pdf](http://www.barakaenergy.com.au/pdfs/2012-11-11-235845Quarterly%20Activities%20and%20Cash%20Flow%20Report%2031Oct2012.pdf)

Statoil to Withdraw from Permits EP127, EP128 in NT's Georgina Basin

[http://www.rigzone.com/news/oil\\_gas/a/135917/Statoil to Withdraw from Permits EP127 EP128 in NTs Georgina Basin](http://www.rigzone.com/news/oil_gas/a/135917/Statoil%20to%20Withdraw%20from%20Permits%20EP127%20EP128%20in%20NTs%20Georgina%20Basin)

PetroFrontier: History – End of Australian Activities

<http://petrofrontier.com/main/History>

Beetaloo Basin – Northern Territory

Falcon Oil & Gas Ltd. ("Falcon"): Beetaloo Basin Drilling Results Indicate Material Gas Resource

<http://www.marketwired.com/press-release/falcon-oil-gas-ltd-falcon-beetaloo-basin-drilling-results-indicate-material-gas-resource-tsx-venture-fo-2196034.htm>

Dispelling APPEA's misleading information

APPEA – Well Integrity

<https://www.appea.com.au/industry-in-depth/technical-information/operations/well-integrity-2/q-a-well-integrity/>

Ohio Division of Oil and Gas Resources Management 2012 – Violations

<https://www.earthworksaction.org/files/publications/FINAL-OH-enforcement-sm.pdf>

Engineering Energy: Unconventional Gas Production – Recommendations

<http://www.chiefscientist.gov.au/wp-content/uploads/shalegas-recommendationsFINAL.pdf>

## Economic Considerations

Southern Georgina Basin Potential – inflated estimates

<http://www.asx.com.au/asxpdf/20101213/pdf/31vkg25kb9byls.pdf>

The Australia Institute - Economics of unconventional gas development

<http://www.tai.org.au/content/economics-unconventional-gas-development>

UK fracking may produce less fuel than claimed, says geologist

<https://www.theguardian.com/environment/2017/aug/17/uk-fracking-may-produce-less-fuel-than-claimed-says-geologist>

Ohio's 245 Utica shale wells producing at a rate of One Billion per year

<https://www.ohio.com/akron/business/ohio-s-245-utica-shale-wells-producing-at-a-rate-of-1-billion-a-year>

## Decline in Well Production

Shale Oil & Gas Production Costs Spiral Higher As Monstrous Decline Rates Eat Into Cash Flows

<https://srsroccoreport.com/shale-oil-gas-production-costs-spiral-higher-as-monstrous-decline-rates-eat-into-cash-flows/>

Mixed evidence from shale well decline rates

<http://www.ogfj.com/articles/print/volume-13/issue-8/features/mixed-evidence-from-shale-well-decline-rates.html>

Production and Royalty Declines in a Natural Gas Well Over Time

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## Global Shale

Technically Recoverable Shale Oil and Shale Gas Resources: Australia

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Technically Recoverable Shale Oil and Shale Gas Resources: Canada

[https://www.eia.gov/analysis/studies/worldshalegas/pdf/Canada\\_2013.pdf](https://www.eia.gov/analysis/studies/worldshalegas/pdf/Canada_2013.pdf)

A comparison of North American shale plays with emerging non- marine shale plays in Australia <http://v-scheiner.brunel.ac.uk/bitstream/2438/11921/1/Fulltext.pdf>

Shale gas handbook for Australia

[http://www.mondaq.com/article.asp?article\\_id=409972&signup=true](http://www.mondaq.com/article.asp?article_id=409972&signup=true)



## Well Integrity

Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation  
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Operators elevate well integrity priority  
<http://www.offshore-mag.com/articles/print/volume-71/issue-1/subsea/operators-elevate-well-integrity-priority.html>

Energy Well Integrity: Nova Scotia Hydraulic Fracturing Independent Review and Public Engagement Process  
<http://www.cbu.ca/wp-content/uploads/2015/10/hfstudy-energy-well-integrity.pdf>

King and King - Environmental Risk Arising From Well-Construction Failure—Differences Between Barrier and Well Failure, and Estimates of Failure Frequency Across Common Well Types, Locations, and Well Age  
<http://shale.palwv.org/wp-content/uploads/2014/02/SPE-166142-PA-P2-copy.pdf>

Modeling Near Wellbore Leakage Pathways in Shale Gas Wells: Investigating Short and Long Terms Wellbore Integrity  
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Technical difficulties in the cementing of horizontal shale gas wells in Weiyuan block and the countermeasures  
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Review and Analysis of DRAFT Supplemental Generic Environmental Impact Statement On The Oil, Gas and Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas  
[https://www.nrdc.org/sites/default/files/ene\\_10092901d.pdf](https://www.nrdc.org/sites/default/files/ene_10092901d.pdf)

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## Bonds

'We're going to be dealing with this for decades': Abandoned oil and gas wells skyrocket in Alberta

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Bill would raise shale well site bonds

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When the Shale Runs Dry: A Look at the Future of Fracking

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