The Scientific Inquiry into Hydraulic Fracturing in the Northern Territory

Background and Issues Paper

Submission

Dear Justice Pepper and Panel,

Please accept this as my submission of comments in reply to the Issues Paper.

Introduction

My name is Pauline Cass and I have lived in the Northern Territory since my teens, raised my family here, and built our home on our property in Darwin's rural area. My love of the Territory led me to study Environmental Science at Charles Darwin University, which in turn led me to begin my Master of Environmental Management through the University of Queensland. It is this study which taught me about the catastrophic consequences the shale gas industry will have for our environment, society, health and future. Please see Appendix 1, 'What environmental, social, and economic impacts will hydraulic fracturing (fracking) for shale gas have on the Northern Territory?', which I wrote as an assessment for UQ (and has 15 pages of referencing to support it).

To Territorians the Northern Territory is home. It is a place we love, where we live, work, and raise our families. We are not no-one and this is not nowhere.

The Northern Territory is uniquely beautiful and of great intrinsic value. It is rich in wild natural places which tourists flock to visit, and our fragile environments are vital to our existing industries such as tourism, agriculture, horticulture, and fisheries. The NT's sustainability must be protected for future generations.

A tiny cohort of powerful people from elsewhere want to destroy our home by converting the Territory into an industrialised gas facility. This will irreparably change the landscape, contaminate our environment, and alter the fabric of our society, for little or no benefit to Territorians, just so they can line their pockets by exporting our gas overseas. This must not be allowed to happen.

The plethora of scientific evidence in peer-reviewed, published reports irrefutably demonstrates the extensive, negative consequences the unconventional shale gas industry (fracking) will have on the Northern Territory. This evidence clearly shows fracking and all its associated activities must be banned in the NT.

Response to Issues Paper

The Scientific Inquiry into Hydraulic Fracturing in the Northern Territory's Background and Issues Paper (2017, p. 13) lists the possible risks that may be associated with the hydraulic fracturing of onshore unconventional shale reservoirs and its associated activities in the Northern Territory. The risks have been organised into the following nine themes which this submission will follow:

1. Water; 2. Land; 3. Air; 4. Public health; 5. Impacts on Aboriginal people and their culture; 6. Social impacts; 7. Economic impacts; 8. Land access; and 9. Regulatory framework.

But first I will address the issues of:

a) The majority of Territorians don't want unconventional shale gas mining to occur in the NT; b) Integrity of Reports and Research; c) Well Integrity; and d) Short Production Life of Wells. I have also added issues where required under the 9 themes.

a) The majority of Territorians don't want unconventional shale gas mining to occur in the NT.

Majority rule should apply in a true democracy.
There are countless examples of Territorians opposing the shale gas industry in the NT, below are just 3 of many.

On 06 April 2016, Mix 104.9 Darwin conducted a survey asking, 'Do you feel environmental standards are being met when it comes to fracking?', 89.23% of respondents said 'No". http://www.mix1049.com.au/katie-home/latest-from-katie/48881-do-you-feel-environmental-standards-are-being-met-when-it-comes-to-fracking

I personally collected 1388 signatures in the Darwin rural area calling for fracking to be banned in the Northern Territory. My petition was submitted to NT Parliament in May 2016.

A call for a show of hands at the recent NT Fracking Inquiry's Community Consultations, overwhelmingly showed almost all Territorians oppose fracking.

b) Integrity of Reports and Research

Gas Industry reports and research are not independent nor peer reviewed, are rarely publicly published, and are written with the intention of acquiring financial gain. Their credibility and accuracy are rarely questioned by politicians and the media, and they are stated as facts despite the lack of rigor.

For example, a water bore driller noticed gas coming from a new water bore he was drilling on Gilknocky Station, which has 8 petroleum exploration wells nearby. This was duly reported by the water driller but nothing was done until community awareness of a water

bore releasing gas lead to a public statement on ABC Country Hour on 8 November 2016 (http://www.abc.net.au/news/2016-11-08/gas-water-bore-northern-territory-gilnockie-station/7992524). In the interview, Dr Damian Barrett from the CSIRO/GISERA said the gas in the water well was not caused by fracking, despite the gas not being tested to determine its origin. As the statement came from GISERA, it was blindly accepted as fact, despite there being no facts to support the statement. It was also claimed that the "intersection of gas at shallow depths is not uncommon in the Northern Territory", something I have never heard of before and could find no data to substantiate (nor my many acquaintances in the area). I find it incredulous that this response to a possible aquifer contamination was deemed acceptable by the Government and media. Why wasn't the gas tested?

On the other hand, published, peer reviewed, scientific reports identifying negative consequences of hydraulic fracturing are treated with the utmost scrutiny, distrust, and dismissal by gas company representatives, media and many politicians, despite the authors having no hidden agendas or investment in the outcome.

c) Well Integrity

Well integrity is of enormous concern, not only while the well is productive, but for the rest of eternity. Drilling a well creates a permanent conduit between what lays kilometres underground and the surface. It is impossible to permanently plug this conduit. The quotes about well integrity below are from published peer-reviewed scientific reports and represent just a few of the many reports available.

"We need much more information on the structural integrity of older producing wells and abandoned wells. A new analysis suggests there are between 280,000 and 970,000 abandoned wells in Pennsylvania alone, most of them unaccounted for in the state database. How many of these wells leak fluids into groundwater or the atmosphere? A random survey of 19 (a small sample) showed that all of these older wells leaked methane to the air, mostly at low rates, but could be responsible for 4–13% of methane emissions from human activities in the state."
Jackson, RB 2014, 'The integrity of oil and gas wells', *Proceedings of the National Academy of Sciences of the United States of America (PNAS),* National Center for Biotechnology Information (NCBI), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4121783/

"In a technical sense, "well integrity" refers to the zonal isolation of liquids and gases from the target formation or from intermediate layers through which the well passes. In a practical sense, it means that a well doesn't leak. Drilling companies emphasize well integrity because a faulty well is expensive to repair and, in the rarest of cases, costs lives, as in the Deepwater Horizon disaster in the Gulf of Mexico. Drillers use steel casing (pipes), cement between nested casings and between the outside casing and rock wall, and mechanical devices to keep fluids inside the well.
Faulty casing and cementing cause most well integrity problems. Steel casing can leak at the connections or corrode from acids. Cement can deteriorate with time too, but leaks also

happen when cement shrinks, develops cracks or channels, or is lost into the surrounding rock when applied. If integrity fails, gases and liquids can leak out of the casing or, just as importantly, move into, up, and out of the well through faulty cement between the casing and the rock wall."
Jackson, RB 2014, 'The integrity of oil and gas wells', *Proceedings of the National Academy of Sciences of the United States of America (PNAS),* National Center for Biotechnology Information (NCBI), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4121783/

"Pennsylvania state inspection records show compromised cement and/or casing integrity in 0.7–9.1% of the active oil and gas wells drilled since 2000, with a 1.6- to 2.7-fold higher risk in unconventional wells spudded since 2009 relative to conventional well types. Hazard modeling suggests that the cumulative loss of structural integrity in wells across the state may actually be slightly higher than this, and upward of 12% for unconventional wells drilled since January 2009."
Ingraffea, AR, Wells, MT, Santoro, RL & Shonkoff, SB 2014, 'Assessment and risk analysis of casing and cement impairment in oil and gas wells in Pennsylvania, 2000–2012', *Proceedings of the National Academy of Sciences of the United States of America (PNAS),* National Center for Biotechnology Information (NCBI), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4121786/

Here are 2 more examples of the many well integrity articles stating the risks:

Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation
http://www.sciencedirect.com/science/article/pii/S0264817214000609

Wellbore Integrity: Failure Mechanisms, Historical Record, and Rate Analysis
https://www.epa.gov/sites/production/files/documents/ingraffea.pdf

d) Short Production Life of Wells

The short production life of wells is another issue to be considered when assessing the viability of hydraulic fracturing.

"Shale gas plays developed by hydraulic fracturing have the interesting characteristic that they are very productive initially but have rapid decline rates. The estimated ultimate recovery per well (EUR) may be in the billions of cubic feet but 50–75% is usually recovered in the first year of production. A typical well in the Haynesville, for example, has a EUR of 6.5 Bcfe but an initial decline rate of 85%. The Barnett (2.65 Bcfe, 70%), and Fayetteville (2.4 Bcfe, 68%) are comparable. The early production rates for Marcellus wells indicate a EUR of 4.4 Bcfe and a first year decline rate of 75%. Thus the wells will finish their productive stage in 3 to 5 years. In order for companies to keep their production level constant, they need to keep drilling and fracking."
Lampe, DJ & Stolz, JF 2015, 'Current perspectives on unconventional shale gas extraction in the Appalachian Basin', *Journal of Environmental Science and Health*, Taylor and Francis, http://www.tandfonline.com/doi/full/10.1080/10934529.2015.992653?scroll=top&needAccess=true

1. Water

"Four potential risks for water resources are identified: (1) the contamination of shallow aquifers with fugitive hydrocarbon gases (i.e., stray gas contamination), which can also potentially lead to the salinization of shallow groundwater through leaking natural gas wells and subsurface flow; (2) the contamination of surface water and shallow groundwater from spills, leaks, and/or the disposal of inadequately treated shale gas wastewater; (3) the accumulation of toxic and radioactive elements in soil or stream sediments near disposal or spill sites; and (4) the overextraction of water resources for high-volume hydraulic fracturing that could induce water shortages or conflicts with other water users, particularly in water-scarce areas. Analysis of published data (through January 2014) reveals evidence for stray gas contamination, surface water impacts in areas of intensive shale gas development, and the accumulation of radium isotopes in some disposal and spill sites."
Vengosh, A, Jackson, RB, Warner, N, Darrah, TH & Kondash, A 2014, 'A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States', *Environmental Science and Technology*, American Chemical Society (ACS) Publications, http://pubs.acs.org/doi/full/10.1021/es405118y

Water quality Groundwater / Surface Water

There are numerous international examples of ground water and surface water contamination as a result of shale gas activities.

"Analyses revealed that arsenic, selenium, strontium and total dissolved solids (TDS) exceeded the Environmental Protection Agency's Drinking Water Maximum Contaminant Limit (MCL) in some samples from private water wells located within 3 km of active natural gas wells. Lower levels of arsenic, selenium, strontium, and barium were detected at reference sites outside the Barnett Shale region as well as sites within the Barnett Shale region located more than 3 km from active natural gas wells. Methanol and ethanol were also detected in 29% of samples. Samples exceeding MCL levels were randomly distributed within areas of active natural gas extraction, and the spatial patterns in our data suggest that elevated constituent levels could be due to a variety of factors including mobilization of natural constituents, hydrogeochemical changes from lowering of the water table, or industrial accidents such as faulty gas well casings."
Fontenot, BE, Hunt, LR, Hildenbrand, ZL, Carlton, DD, Oka, H, Walton, JL, Hopkins, D, Osorio, A, Bjorndal, B, Hu, QH & Schug, KA 2013, 'An Evaluation of Water Quality in Private Drinking Water Wells Near Natural Gas Extraction Sites in the Barnett Shale Formation', *Environmental Science and Technology*, American Chemical Society (ACS) Publications, http://pubs.acs.org/doi/full/10.1021/es4011724

"As part of the report, EPA identified certain conditions under which impacts from hydraulic fracturing activities can be more frequent or severe, including:

- Water withdrawals for hydraulic fracturing in times or areas of low water availability, particularly in areas with limited or declining groundwater resources;

- Spills during the management of hydraulic fracturing fluids and chemicals or produced water that result in large volumes or high concentrations of chemicals reaching groundwater resources;
- Injection of hydraulic fracturing fluids into wells with inadequate mechanical integrity, allowing gases or liquids to move to groundwater resources;
- Injection of hydraulic fracturing fluids directly into groundwater resources;
- Discharge of inadequately treated hydraulic fracturing wastewater to surface water resources; and
- Disposal or storage of hydraulic fracturing wastewater in unlined pits, resulting in contamination of groundwater resources."

United States Environmental Protection Agency 2016*, EPA Releases Final Report on Impacts from Hydraulic Fracturing Activities on Drinking Water*
https://www.epa.gov/newsreleases/epa-releases-final-report-impacts-hydraulic-fracturing-activities-drinking-water

Water supply and distribution (quantity)

There have been reports of towns running out of water due to shale gas fracking in America and Canada.

"Fracking boom sucks away precious water from beneath the ground, leaving cattle dead, farms bone-dry and people thirsty."
Goldenberg, S 2013, 'A Texan tragedy: ample oil, no water', *The Guardian,*
https://www.theguardian.com/environment/2013/aug/11/texas-tragedy-ample-oil-no-water

"The area has become rife with tension. Not between the oil and gas companies and environmentalists, but between the companies and local residents, many of them oil and gas workers themselves, and all of them dependent on the industry. Both sides are jostling for rights to what is becoming an increasingly scarce resource in the area: fresh water. The oil and gas companies are eager to stake their claims on water sources as they rush to exploit the wealth of natural resources underground. And to do that they need water. Lots of water. That has locals fearing the disappearance of surface and ground water sources that not only act as drinking water but are also the lifeblood of hunting, fishing and recreational activity in the region."
Hames, E 2016, Is Fracking Behind This Town's Dry Water Well?, *Alberta Venture*,
http://albertaventure.com/water/towns-in-albertas-industrial-heartland-ran-out-of-water-last-summer-is-fracking-to-blame/

I find the use of produced water to augment town water supplies particularly worrisome: Chinchilla "weir has the dual purpose of providing supply of irrigation water along the alluvial flats of the Condamine River and of augmenting the water supply to the town of Chinchilla." "The release of treated (CSG) water into Chinchilla Weir is regulated under Beneficial Use Approval ENBU02701811."
Sunwater n.d., *Chinchilla Weir*, http://www.sunwater.com.au/schemes/chinchilla-weir

Aquatic ecosystems and biodiversity

NT reliant on aquatic ecosystems for tourism as well as profitable fishing, crabbing and crocodile industries. Many rivers are also used for irrigation and as domestic water supply for rural and remote households.

"Generally, the closer geographical proximity of the susceptible ecosystem to a drilling site or a location of related industrial processes, the higher the risk of that ecosystem being impacted by the operation. The associated construction of roads, power grids, pipelines, well pads, and water-extraction systems along with increased truck traffic are common to virtually all HVHF operations. These operations may result in increased erosion and sedimentation, increased risk to aquatic ecosystems from chemical spills or runoff, habitat fragmentation, loss of stream riparian zones, altered biogeochemical cycling, and reduction of available surface and hyporheic water volumes because of withdrawal-induced lowering of local groundwater levels."
Burton, GA, Basu, N, Ellis, BR, Kapo, KE, Entrekin, S & Nadelhoffer, K 2014, 'Hydraulic "fracking": are surface water impacts an ecological concern?', *Environmental Toxicology and Chemistry*, Wiley Online Library, https://deepblue.lib.umich.edu/bitstream/handle/2027.42/108102/etc2619.pdf?sequence=1&isAllowed=y

We have already experienced several contaminating spills in our rivers due to truck accidents and train derailments. A spill of fracking chemicals or waste water has the potential to be much worse.
Schubert, S 2012, 'Environmental damage for Edith River still unknown after derailment', *ABC Rural*, http://www.abc.net.au/site-archive/rural/content/2012/s3410442.htm

Amenity values

Under this heading, the Issues Paper says, "There may be a risk that there will be adverse impacts on amenity values such as national parks and rangelands due to gaseous emissions and flaring."

This list should also include smelly, discoloured water from discharges/leaks/spills, increased traffic, noise from gas infrastructure, fish kills, and more, impacting on amenity for tourism and enjoyment by locals camping, bush walking and fishing.

Another concern is restricted access to favourite fishing, hunting and camping spots due to gas activities. Many Territorians like to do these activities in private, off the track locations away from tourists, eg. I take my family camping at a 'secret' hot spring for peace and privacy.

Public health

Many people rely on bores or river water for household water supply.

Economic

Existing industries are unable to co-exist with shale gas activities and infrastructure, despite what the gas industry says.

Tourism relies on unpolluted waterways; fishing, mud crabbing, crocodile industries rely on healthy aquatic ecosystems; horticulture relies on uncontaminated water for irrigation; agriculture requires potable water for stock; and the NT population requires adequate clean, fresh water for drinking and bathing. People and businesses will leave the Territory if these needs are not met.

Added Issue: Our heavy rainfalls. For example, Noonamah received 129.0mm of rain in the 24 hours before 9am on the 20th of March 2017, with almost all the rain falling in one early morning storm (http://www.bom.gov.au/places/nt/palmerston/observations/noonamah/). How will the waste water ponds, etc, cope with such an influx of rainwater? The NT EPA's table of 'Pollution Incidents Reported' highlights the problem of managing wet season overflows (https://ntepa.nt.gov.au/waste-pollution/compliance/pollution-incidents)

2. Land

Australia's Chief Scientist found that "natural gas production from shale will likely have a larger footprint than production from coal seam"
http://www.chiefscientist.gov.au/wp-content/uploads/shalegas-recommendationsFINAL.pdf

Terrestrial ecosystems and biodiversity

Shale gas development causes habitat loss and fragmentation.

Pipelines and roads act as barriers to native species movement, and increased traffic will result in higher road kill rates.

"Loss of natural forest in the gas field was significantly higher compared to areas outside the gas field. The creation of edge habitat, roads, and developed areas was also greater in the gas field." "Considering the large number of wells drilled in other parts of the eastern U.S. and projections for new wells in the future, shale gas development will likely have substantial negative effects on forested habitats and the organisms that depend upon them."
Habitat Loss and Modification Due to Gas Development in the Fayetteville Shale
https://link.springer.com/article/10.1007%2Fs00267-014-0440-6

"We conclude that species and habitats most at risk are ones where there is an extensive overlap between a species range or habitat type and one of the shale plays (leading to high

vulnerability) coupled with intrinsic characteristics such as limited range, small population size, specialized habitat requirements, and high sensitivity to disturbance."
Ecological Risks of Shale Oil and Gas Development to Wildlife, Aquatic Resources and their Habitats
http://pubs.acs.org/doi/full/10.1021/es5020482

"Canaport LNG has pleaded guilty to federal charges under the Migratory Birds and Species at Risk Act in relation to the 2013 deaths of thousands of songbirds. The birds were drawn to a 10-to-15 meter gas flare during a period of fog and low cloud."
Canaport LNG pleads guilty in bird kill case
http://www.cbc.ca/news/canada/new-brunswick/irving-canaport-bird-kill-plea-1.3305351

Amenity values

Due to the short lifespan of shale gas wells, many wells will need to be drilled. While multi-well pads have helped relieve the impact slightly, our NT landscape will still be greatly impacted by the number of wells, pipelines, roads, and infrastructure required to support a shale gas industry. This blight on the landscape will not only deter tourists, but will also make farming activities such as mustering or ploughing extremely difficult.

Cumulative risks

"There is a close density of well operations needed to fully develop a play, as has been seen in places like Garrett County CO, Green River Basin WY, and DISH TX. The industry can move very quickly as has been demonstrated in Washington County, where since 2005 over 756 wells have been drilled, with the associated well pads, impoundments, compressor stations, and other gas facilities. In 2008 the PA DEP granted 519 Marcellus well permits and 196 were drilled; in 2009, there were 1985 permits and 763 wells drilled; and in 2010, 3,314 permits and 1,386 wells drilled (matching the number of conventional wells drilled). Over 700,000 acres of Pennsylvania state forest land are leased or available for gas production, with approximately 50% sitting above the Marcellus Shale formation. It has been estimated that 80,000 to 200,000 acres could be lost if the Marcellus Shale is fully developed. The effects are already being seen with increased forest fragmentation and edge communities."
Current perspectives on unconventional shale gas extraction in the Appalachian Basin
http://www.tandfonline.com/doi/full/10.1080/10934529.2015.992653?scroll=top&needAccess=true

"Worldwide shale-gas development has the potential to cause substantial landscape disturbance. … Agricultural land conversion suggests that drilling is somewhat competing with food production. … The intensity of core forest disturbance, where many headwater streams occur, suggests that such streams should become a focus of aquatic monitoring."
Early Trends in Landcover Change and Forest Fragmentation Due to Shale-Gas Development in Pennsylvania: A Potential Outcome for the Northcentral Appalachians
https://link.springer.com/article/10.1007%2Fs00267-012-9841-6

Added Issue: Earthquakes

While there is evidence that hydraulic fracturing can cause earthquakes, the NT also experiences natural earthquakes. Earthquakes can impact well integrity, damage pipelines, pits, ponds and tanks, creating spills, leaks and emissions from a wide variety of gas industry infrastructure, leading to water, air and soil contamination, health risks to people and animals, and possibly lead to an area becoming uninhabitable.

"Geoscience Australia senior seismologist Jonathan Bathgate said it is the second earthquake greater than magnitude 3.0 to hit Tennant Creek this year (2017), with a 3.1 recorded on January 5. He said the town recorded five earthquakes of that kind last year and nine in 2015."
Earthquake rocks Tennant Creek
http://www.ntnews.com.au/lifestyle/earthquake-rocks-tennant-creek/news-story/632f661d5c820d86ef34507bafc5074b

A gas pipeline is repaired after the 1988 Tennant Creek earthquake. Photo: Geoscience Australia in ABC News article: http://www.abc.net.au/news/2016-05-12/northern-territory-1988-quake-now-rated-australias-biggest/7406988

3. Air

Air pollution caused by shale gas activities has many sources including, leaking wells, leaking pipelines, venting, flaring, evaporative waste water ponds, and increased truck traffic.

Climate change

"Our conclusion was that for the 20-year time period, shale gas had a larger GHG than coal or oil even at our low-end estimates for methane emission." "At best, using natural gas rather than coal to generate electricity might result in a very modest reduction in total greenhouse gas emissions, if those emissions can be kept below a range of 2.4–3.2%. That is a big "if," and one that will require unprecedented investment in natural gas infrastructure and regulatory oversight. For any other foreseeable use of natural gas (heating, transportation), the GHG is larger than if society chooses other fossil fuels, even with the most stringent possible control on methane emissions, if we view the consequences through the decadal GWP frame. Given the sensitivity of the global climate system to methane, why take any risk with continuing to use natural gas at all? The current role of methane in global warming is large, contributing 1.0 watts m-2 out of the net total 2.29 watts m-2 of radiative forcing."
A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas
http://www.eeb.cornell.edu/howarth/publications/Howarth_2014_ESE_methane_emissions.pdf

"Shale is likely to be economically important but may also generate significant emissions of ozone precursors … Ozone increases due to Haynesville Shale emissions can affect regions outside Northeast Texas and Northwest Louisiana due to ozone transport. This study evaluates only near-term ozone impacts, but the emission inventory projections indicate that Haynesville emissions may be expected to increase through 2020."
Ozone Impacts of Natural Gas Development in the Haynesville Shale
http://pubs.acs.org/doi/full/10.1021/es1021137

Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4280601/

Cumulative risks

The more wells, pipelines, etc, the greater the air pollution impacts.

4. Public health

Protecting the health of Territorians is vital, not only to save medical expenses, but also because people will leave the NT if their family's health is threatened. Queensland is already experiencing the phenomena of 'gasfield refugees' who have been forced from their homes due to the CSG industry there.

Drilling and fracking chemicals

Gas companies tell us that they only use a small percentage of chemicals in their fracking fluids, but neglect to tell us that this equates to a large volume in total. They also neglect to say that this small percentage of chemicals contaminates the entire volume of water that they use to frack.

It is not just the chemicals used to frack that is of concern, but also the chemicals which are brought to the surface in the flow back (produced) water.

"All substances are poisons; there is none that is not a poison. The right dose differentiates a poison from a remedy." "All chemicals, from whatever source – human manufacture or natural – are potentially toxic at some dose."
https://www.sciencelearn.org.nz/resources/365-all-in-the-dose

Radioactive substances

NORMS or naturally occurring radioactive materials are brought to the surface in fracking flowback (produced) water as well as drilling debris.

"In North Dakota's Bakken region, the fracking boom has generated nearly 10,000 wells for unconventional oil and gas production—and along with them, almost 4,000 reported wastewater spills resulting from the activity. A new study shows that these spills have left surface waters in the area carrying radium, selenium, thallium, lead, and other toxic chemicals that can persist for years at unsafe levels (Environ. Sci. Technol. 2016, DOI: 10.1021/acs.est.5b06349). Soils and sediments at spill sites also harbored long-lasting radium contamination, the study found."
http://cen.acs.org/articles/94/web/2016/05/Toxic-chemicals-fracking-wastewater-spills.html

Mental health and wellbeing

I have already witnessed my friends who own properties which have petroleum exploration applications over them in the Northern Territory suffering from extreme stress due to the threat of having their homes and livelihoods fracked. This is impacting their mental health and the wellbeing of their entire families.

Physical safety

"Animals, especially livestock, are sensitive to the contaminants released into the environment by drilling and by its cumulative impacts. Documentation of cases in six states strongly implicates exposure to gas drilling operations in serious health effects on humans, companion animals, livestock, horses, and wildlife. Although the lack of complete testing of water, air, soil and animal tissues hampers thorough analysis of the connection between gas drilling and health, policy changes could assist in the collection of more complete data sets and also partially mitigate the risk to humans and animals. Without complete studies, given the many apparent adverse impacts on human and animal health, a ban on shale gas drilling is essential for the protection of public health." (p. 72)
Impacts of Gas Drilling on Human and Animal Health
http://www.psehealthyenergy.org/data/Bamberger_Oswald_NS22_in_press.pdf

"In summary, hydraulic fracturing as determined by well number or density had a significant association with cardiology inpatient prevalence rates, while well density had a significant association with neurology inpatient prevalence rates."
Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4503720/

"It is clear that Australia must quickly move beyond its reliance on coal for health and environmental reasons. However, when taking into consideration the uncertainties over health risks, the unfavourable comparisons with other energy options, the climate risks associated with fugitive emissions, the moral obligations Australia faces as a gas exporter, the potential displacement of renewables and doubts raised over the claim that gas will prove to be a cheap energy option, the scale is firmly tipped against the further development of unconventional gas."
Harms unknown: health uncertainties cast doubt on the role of unconventional gas in Australia's energy future
https://www.mja.com.au/journal/2014/200/4/harms-unknown-health-uncertainties-cast-doubt-role-unconventional-gas-australias

There is also increased likelihood of traffic accidents due to increased gas related traffic on the roads.

Cumulative risks

Health risks of contaminants entering the food chain. We have already seen the 'Gasfields Free' label introduced in Australia. This article (while not peer-reviewed science) raises valid issues and highlights the lack of scientific research and data available. It provides examples of contaminants entering our food chain through air, water and soil, and impacting the health of people and animals.
Fracking Our Food Supply
https://www.thenation.com/article/fracking-our-food-supply/

5. Impacts on Aboriginal people and their culture

8 Traditional Owners from Mataranka, Borroloola, Maningrida, and Arnhem Land told the Senate Select Committee on Unconventional Gas Mining, Darwin Hearing, 12 April 2016, about the impacts they were already suffering from gas companies and their fears for the future.
The transcript for their joint presentation is available here:
http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;db=COMMITTEES;id=committees%2Fcommsen%2Fb11b69b9-6cc2-4be2-890e-4b4da4eaa521%2F0007;query=Id%3A%22committees%2Fcommsen%2Fb11b69b9-6cc2-4be2-890e-4b4da4eaa521%2F0000%22

While not necessarily identifying as aboriginal, almost all long term Territorians have an affinity with the bush and spend a large portion of their holidays fishing. camping, and 'going bush'. I believe this Territory culture (not just Aboriginal culture) is also worth protecting.

Land ownership

Land ownership implies having the right to determine what occurs on the land. This right is terminated by gas companies once they gain access to a property, as in reality the gas companies control what happens where and when on the land, despite what the access agreement might say.

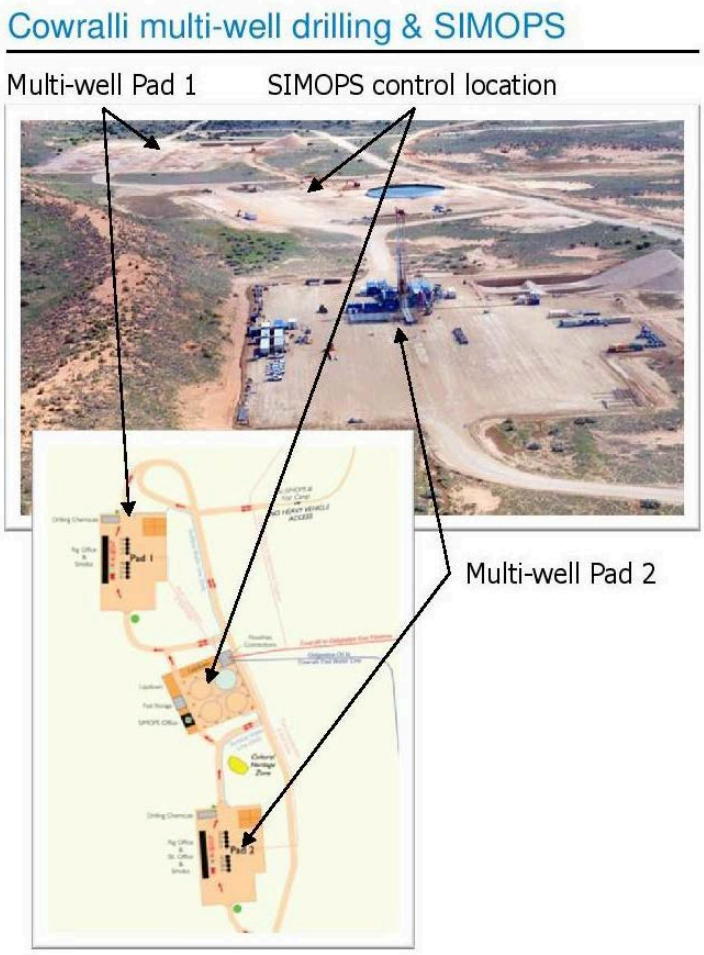
A group of Indigenous people told the Senate Select Committee on Unconventional Gas Mining in Darwin in April 2016 that they had had fences cut and mustered cattle released by gas companies accessing their land.

Culture, values and traditions

This is how Santos respects Indigenous culture.

The first image (below) is of Santos' Cowralli 3 well in the Cooper Basin.
http://www.abc.net.au/news/2013-10-03/cowralli-3-field-in-the-outback-cooper-basin.jpg/4995338

The 2nd photo shows there is a 'cultural heritage zone' between the rectangular ponds and round ponds.
https://www.santos.com/media/1863/2013_05_28_-appea_investor_briefing.pdf



Aquatic and terrestrial ecosystems

Regulations can't protect us from fracking contamination, as evidenced in other mining breaches such as this example from McArthur River Mine.

“Cattle with elevated lead levels have been found wandering near the site, sparking fears for human health, and there have been persistent claims the mine is affecting fish and shellfish eaten by Aborigines who hunt and forage in nearby rivers.”
Authorities oblivious to toxic mine breaches
http://www.theaustralian.com.au/national-affairs/authorities-oblivious-to-toxic-mine-breaches/news-story/d95f1a9f66542b4d65e10663d69d8c4c

Added Issue:

Many people do not realise that giving permission to explore means permission to frack.

English is a 2nd, 3rd, or more language for many Indigenous people. This necessitates the use of an interpreter to ensure the discussions are fully understood by all parties, despite what Pangaea NT speaker, Tim Radburn, said at the NT Fracking Inquiry Hearing in Darwin on 10 March 2017.
https://www.youtube.com/watch?v=iRxj7mCY_AE&feature=youtu.be&list=PLHnnuC-2E7-S6sW2215knMKgH0NRPlcgv

6. Social impacts

Insurance

I have been told by friends who own properties which have petroleum exploration applications over them, that they have been unable to find any insurance companies willing to insure them against gas industry activities.

We heard from Haliburton at the NT Fracking Inquiry in Darwin on 10 March 2016, that they don’t know who would be responsible for any adverse effects of their gas operations. Did Diana Grantham ever “get back to you on that”?
https://www.youtube.com/watch?v=dM80bpoDg2U&feature=youtu.be&list=PLHnnuC-2E7-S6sW2215knMKgH0NRPlcgv

Health services

See 4. Public Health

Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0131093

Education

Population may increase with workers but families will leave as no-one wants to live in a gas field, this may impact schools due to loss of students.

Many of the skills taught by the gas industry are useless in any other industries.

Infrastructure

Roads built by and for gas companies will have heavy truck traffic which degrades roads. Who will be responsible for maintaining these roads? Eg. In Litchfield Council municipality, new roads are built by the developers then handed over to the local council for maintenance.

While on the subject of trucks and transport, they will need to transport materials long distances to wells, increasing carbon emissions, fossil fuel use and the risk of traffic accidents.

Livelihoods

It is fantasy to think the gas industry will provide Territorians with long term jobs. We have witnessed many short term booms in the past, such as the building of East Arm Wharf, the construction of the Alice Springs - Darwin Railway, Inpex, and numerous mines. They all promised hundreds of jobs, yet employed workers from interstate (many FIFO) who left Darwin once the job was completed.

The shale gas industry will negatively impact the livelihoods of graziers, farmers, fishermen, and those working in tourism, especially if the 'Gasfield Free' labelling gains popularity. These are long term, sustainable industries which provide long term employment to Territorians.

"Farmers and businesses can add value to their produce and protect their regions by labelling their farm, products and services - Gasfield Free."
http://www.gasfieldfree.com.au/

"farmers on the Surf Coast in south-west Victoria described the importance of the ban to maintain land to grow clean and safe food, and support sustainable agriculture."
The Member for Eastern Victoria Harriet Shing said, "We promised to ban fracking and we're getting it done – the livelihoods of thousands of Victorians and the reputation of their world-class produce depend on it."
Protecting Our Agricultural Heartland From Fracking
http://www.premier.vic.gov.au/protecting-our-agricultural-heartland-from-fracking/

Long term benefits

I can think of no long term benefits for Territorians. The negative impacts of the shale gas industry will negate any short term benefits which may exist, especially if the water is depleted or contaminated, or the environment is polluted, as people/families won't live in such conditions.

The Blacktip Gas Field in the Bonaparte Basin, Timor Sea, Australia, has ample gas reserves and the infrastructure required to meet the needs of Territorians.
http://www.offshore-technology.com/projects/blacktip-gas-field-timor/

Community cohesion

"There was also a small though significant decline in perceptions of community cohesion from its high level in 2014."
The 2016 CSIRO Community Wellbeing and Responding to Change survey: Western Downs region, Queensland
https://gisera.org.au/wp-content/uploads/2017/01/community-wellbeing-survey-2-report_final.pdf

Crime

There are numerous reports of increased crime rates in gas fields.
"For instance, a report prepared for the Sublette County, Wyoming Attorney's Office, titled 'Sublette County Statistics on Drug and Crime Rates', discusses how oil and gas development has affected drug and crime rates the last 7 to 10 years in Sublette County, Wyoming. The report indicated that crimes and arrests correlate highly to oil and gas field activity and increase with mineral development. These crimes and arrests consist of drug, burglary, domestic violence, and petty crimes."
Montana Statewide Oil and Gas and Proposed Amendment of the Powder River and Billings Resource Management Plans: Environmental Impact Statement, Volume 2, Part 1, p. 58

Employment

"Satisfaction with employment and business opportunities declined significantly from being favourable in the construction phase in 2014 to being dissatisfied on average in the post-construction phase in 2016. This dimension was now the least favourable of the 15 community wellbeing dimensions"
The 2016 CSIRO Community Wellbeing and Responding to Change survey: Western Downs region, Queensland
https://gisera.org.au/wp-content/uploads/2017/01/community-wellbeing-survey-2-report_final.pdf

In defence of Victoria's ban against fracking, Victoria's Premier, Daniel Andrews said renewable energy is "Good for industry, good for skills and good for jobs... and it just

happens to be good for the planet as well", on ABC's Q&A on Monday 6 February 2017. A video is available at: https://www.facebook.com/abcqanda/videos/10154082456966831/

The Climate Council also found renewable energy provides long term employment. "The modelling finds accelerated uptake of renewable electricity is a scenario for overall employment generation" (p. 30), "Renewable power generators are long-term assets that require ongoing staffing" (p. 31)
https://www.climatecouncil.org.au/uploads/7b40d7bbefbdd94979ce4de2fad52414.pdf

Amenity

One of the things I love about living in the Northern Territory is the warm, friendly community and sense of belonging. This will be lost if shale gas fracking occurs.

Cumulative risks

"The report provides a valuable snapshot of the range of views that exist in a CSG community and how these have changed over time. Attitudes and feelings towards CSG activities in the region change were less favourable in 2016. They were lukewarm or neutral during the construction phase in 2014 but were unfavourable on average in 2016 after the end of the construction phase. "
The 2016 CSIRO Community Wellbeing and Responding to Change survey: Western Downs region, Queensland
https://gisera.org.au/wp-content/uploads/2017/01/community-wellbeing-survey-2-report_final.pdf

7. Economic impacts

"Several reports sponsored by the gas industry have estimated the economic effects of the shale gas extraction on incomes, employment, and tax revenues. None of these reports has been published in an economics journal and therefore have not been subjected to the peer review process. Yet these reports may be influential to the formation of public policy. This commentary provides written reviews of several studies purporting to estimate the economic impact of gas extraction from shale beds. Due to questionable assumptions, the economic impacts estimated in these reports are very likely overstated."
Kinnaman TC, 2011, 'The economic impact of shale gas extraction: A review of existing studies', *Ecological Economics*, Elsevier,
http://www.sciencedirect.com/science/article/pii/S0921800911000590

"Economic and environmental impacts may also arise from the "boomtown" phenomenon, where local areas facing shale development see increases in population, employment, business activity, and government revenues. However, boomtowns may also suffer from

negative social, economic, and environmental consequences such as increased crime rates, housing rental costs, and air pollution (Lovejoy 1977; Albrecht 1978; Freudenburg 1982). Furthermore, the "boom" may be followed by a "bust" if benefits from shale gas development are only temporary. Local public goods might be expanded during the boom at considerable cost only to be later left underutilized, and sectors with better growth potential could contract during the boom, leaving the area worse off in the long run."
The Housing Market Impacts of Shale Gas Development, American Economic Review 2015
http://pubs.aeaweb.org/doi/pdfplus/10.1257/aer.20140079

Distribution

Cost of importing clean water for drinking, bathing and stock if water is contaminated.

Property values

Rex Tillerson, chairman and chief executive of Exxon Mobil Corp, joined a lawsuit to fight construction of tower that would provide water for fracking. The lawsuit states the project would create "a noise nuisance and traffic hazards", as trucks would be needed to haul and pump water. (This is so ironic I have referenced it twice and added a picture)

Exxon CEO Joins Suit Citing Fracking Concerns, The Wall Street Journal, 20 Feb 2014
http://www.wsj.com/articles/SB10001424052702304899704579391181466603804

Exxon CEO Profits Huge As America's Largest Natural Gas Producer-But Frack In His Own Backyard And He Sues!, Forbes, 22 Feb 2014
http://www.forbes.com/sites/rickungar/2014/02/22/exxon-ceo-profits-huge-as-americas-largest-natural-gas-producer-but-frack-it-in-his-own-backyard-and-he-sues/#474ec3db3337

The Commonwealth Bank turned down an owners' application for a $500,000 bridging loan on grounds that Queensland property has four coal seam gas wells on it.
"Long form valuation has revealed coal seam gas wells on the land, making the security unacceptable for residential lending purposes," the bank said.
"We can't sell it, we can't lend against it. It's useless to us," the owner said.
Commonwealth Bank: coal seam gas makes property 'unacceptable' as loan security
https://www.theguardian.com/environment/2016/sep/30/commonwealth-bank-coal-seam-gas-makes-property-unacceptable-as-loan-security

"We estimate the local impacts on groundwater dependent homes to be large and negative, which is not surprising given the attention the media has been placing on this potential risk. As groundwater contamination can cause severe economic hardship on homes without access to piped water, the perception that a nearby shale gas well will cause irreversible harm to an aquifer can have significant effects on nearby property values. These forces are beginning to show up in the way housing markets located on shale plays operate—e.g., recent evidence that major national mortgage lenders are refusing to make loans for properties in close proximity to shale gas wells, and that insurance providers are refusing to issue policies on those houses."
The Housing Market Impacts of Shale Gas Development, American Economic Review 2015, p 3656
http://pubs.aeaweb.org/doi/pdfplus/10.1257/aer.20140079

Other industries

A 2016 "report, commissioned by the Northern Territory Farmers' Association, states that the gross value of production for the plant industries sector is $244.4million." "The $244 million also does not include forestry businesses such as the high value and extensive sandalwood plantations that have come online in the NT in recent years."
Report reveals the true value of NT farming
https://www.ruralweekly.com.au/news/report-reveals-the-true-value-of-nt-farming/3121676/

Who compensates for loss of income due to fracking activities, eg less land for cattle/crops, less water availability, water contamination, cattle losses due to accidental poisoning, etc?

Who will pay the legal costs of negotiating with gas companies and seeking compensation for eg loss of income due to gas activities or contamination of land, air or water? Currently the legal costs for negotiating or preventing gas company access must be paid for by the land holder. This is a huge and unwanted impost on their finances.

Energy security

Australia is not facing a gas shortage.
Despite what companies wanting to frack the NT say, we have more than ample off-shore reserves to meet Australia's needs without fracking.

BHP petroleum chief Mike Yeager told the APPEA conference in Adelaide in 2012 that the Bass Strait could supply east coast markets “indefinitely”.

In 2014-15, Power and Water sourced close to 100% of its natural gas from Eni Australia BV’s Blacktip gas field in the Joseph Bonaparte Gulf, which lies some 110km off the Territory’s northwest coast (page 31 of PAWA 2014-2015 Annual Report). Eni currently have a 25 year agreement to provide our gas.
https://www.powerwater.com.au/__data/assets/pdf_file/0008/127673/PWC_Annual-Report_Web-2_-_FINAL_as_of_15_July_2016.pdf

The Blacktip Gas Field in the Bonaparte Basin, Timor Sea, Australia, has ample gas reserves and the infrastructure required to meet the needs of Territorians.
http://www.offshore-technology.com/projects/blacktip-gas-field-timor/

Australia is a leading exporter of gas, any shale gas from the NT is likely to be exported, not increase domestic energy security.
Developing the Territory’s onshore gas potential, Santos 2014, p. 7
https://transport.nt.gov.au/__data/assets/pdf_file/0020/240419/SANTOS-NT-gas-potential.pdf

Net impacts

"Until the market rebalances, investment returns for developers of Australian projects will be weak and US LNG offtakers will struggle to recover all of their liquefaction costs"
Global LNG prices to remain capped beyond 2020 on supply/demand imbalance, Moody’s Investors Service, 22 Feb 2017
https://www.moodys.com/research/Moodys-Global-LNG-prices-to-remain-capped-beyond-2020-on-PR_362435?WT.mc_id=AM~RmluYW56ZW4ubmV0X1JTQl9SYXRpbmdzX05Id3NfTm9fVHJhbnNsYXRpb25z~20170222_PR_362435

Farmers lose $2m on average when CSG arrives: CSIRO
https://m.chinchillanews.com.au/news/farmers-lose-2m-average-when-csg-arrives-csiro/3123400/

Management

Santos has a 48% Probability of Bankruptcy.
Santos wants to frack the Territory.
Who will clean up their mess when they go bust???

"Santos Limited Probability Of Bankruptcy = Normalized Z-Score = 48 %"
Macroaxis investment management service, 17 March 2017
https://www.macroaxis.com/invest/ratio/STO.AX--Probability-Of-Bankruptcy

No wonder Santos are struggling to find investors!
Santos' share offer comes up well short, The West Australian, 2 February 2017
https://thewest.com.au/business/energy/santos-share-offer-comes-up-well-short-ng-b88377724z

Added Issue:

The economic impact of rehabilitating land or water contaminated by shale gas activities, not only during the productive life of the well, but 30 - 50 years after its abandonment and long into the future, as eventually all shale gas wells fail.

8. Land access

Pangaea NT speaker, Tim Radburn, said at the NT Fracking Inquiry Hearing in Darwin on 10 March 2017, that giving landholders the right to veto was not necessary, when asked by Justice Pepper if this means a right to veto would not impact fracking access to property, the spokesman's only response was that a veto was not required. I felt this evasiveness to Jestice Pepper's questioning demonstrated the fact that gas companies don't want landholders to have a right to veto, as they know landholder's will refuse permission to access or frack their properties.
https://www.youtube.com/watch?v=iRxj7mCY_AE&feature=youtu.be&list=PLHnnuC-2E7-S6sW2215knMKgH0NRPlcgv

Consultation

As access agreements are mandatory for landholders, consultation is really just 'box ticking' for gas companies.

Consent

Access agreements are mandatory in the NT, meaning landholders can't say no. They have to agree to access, if they don't a panel will force an agreement.
"All resources (minerals, oil and gas) are owned by the Territory and the Territory has the right to authorise the exploitation of those resources"
New process for land access agreements for mining and petroleum exploration activities, Adam Giles 2015
http://www.newsroom.nt.gov.au/mediaRelease/17031

Conditions

"Mr Anderson : I am also a pastoralist, at Manangoora station, pastoral lease 685, portion 0408. Besides being a traditional owner I am the chairman of a committee we made in Boroloola through the Northern Land Council."

"Mr Anderson : Sorry, I forgot to tell you this. As a pastoralist, what happened on Maningrida station is that the gas company came through our property without any formal written letter to get permission. They have made roads, and the worst thing they have done is driven and smashed our fences down. We have cattle and horses and our calves and foals in there. I am trying to explain that they did not ask us permission for what they did, and we did not know that because we were busy working in other areas, because we were having a bad drought. What happened was that our foals and calves were getting that weak, and there were dingoes. But we did not know that, because we were looking after here and there, because we breed our own stock horses as well for working purposes and for gymkhanas, rodeos and the pony club for kids. Then we came back and saw our fences gone and all our cattle scattered all over the place. We had to remuster them and redo our fences. There was not even a thankyou. That is reality. Our animals are outside getting eaten by dingoes, but the dingoes are not doing anything wrong; they are just looking for a feed. What hurt us is that they should have asked us first, and they did not have permission."
Mr Robert Anderson, Traditional Owner, to Senate Select Committee on Unconventional Gas Mining, Darwin Hearing, 12 April 2016
http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;db=COMMITTEES;id=committees%2Fcommsen%2Fb11b69b9-6cc2-4be2-890e-4b4da4eaa521%2F0007;query=Id%3A%22committees%2Fcommsen%2Fb11b69b9-6cc2-4be2-890e-4b4da4eaa521%2F0000%22

Compensation

There is no guarantee of safety and no insurance against losses caused by fracking activities.

Santos has a 48% probability of bankruptcy according to Macroaxis, who will clean up the mess if they go bust?
Macroaxis investment management service, 17 March 2017
https://www.macroaxis.com/invest/ratio/STO.AX--Probability-Of-Bankruptcy

Cumulative risks

Rod Dunbar, owner of 'Nutwood Downs' cattle station, has been told by Origin that they want to put 400 wells on his station. How can he muster cattle and conduct his profitable cattle business with all these wells and associated infrastructure on his property?

Due to mandatory access agreements, he will eventually be forced to have them on his land. The risks to his property, business and mental health are extreme.

Added Issue:

While the right to veto access to shale gas companies would improve the situation for landholders, it won't fully protect them from bullying or pressure from gas companies for

access. Also, as air and water are not constrained by property boundaries, landholders refusing to allow fracking must still be protected from contamination and damages caused by any wells or gas activities on neighbouring properties. This protection is especially crucial, now people such as Gina Reinhardt are purchasing cattle properties in prime gas areas.
Gina Rinehart buys another Northern Territory cattle property, Aroona Station, ABC Rural 2017
http://www.abc.net.au/news/rural/2017-03-06/gina-rinehart-buys-aroona-cattle-station-in-northern-territory/8326516

9. Regulatory framework

We have been told by the 2014 Hawke Report and Dr Tina Hunter's recommendations that regulations will protect us from the risks of shale gas exploration and production. However, regulations are not a guarantee of safety. If regulations were truly effective, then Australia would have a zero road death toll due to the strict regulation of drivers, vehicles, road laws and policing.

Australia is a signatory to the Rio Declaration on Environment and Development (1992), Agenda 21. Principle 15, The Precautionary Principal, states: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." I believe Principle 15 is grounds for banning hydraulic fracturing in the Northern Territory.
http://www.unesco.org/education/pdf/RIO_E.PDF

"Fracking is the headstand of democracy and a logical progression of unrestrained corporate power—a systemic invocation of Government against its people. It violates numerous universally accepted human rights as contained in the International Bill of Rights (the UDHR, the International Covenant on Civil and Political Rights and the International Covenant on Economic, Social and Cultural Rights*)* including, but not limited to, the following.

- The right:
    - to life (Art 6 ICCPR; Art 6 UDHR);
    - to the enjoyment of the highest attainable standard of physical and mental health (Art 12 ICESCR; Art 12 UDHR);
    - to a healthy environment (a "new generation right" without which we cannot fully realise the right to health and the right to life);
    - to an effective legal remedy (Art 8 UDHR);
    - to not be arbitrarily deprived of property (Art 17 UDHR);
    - of self-determination (Art 1 UDHR; Art 1 ICCPR; Art 1 ICESCR);
    - to the equal protection of the law (Art 26 ICCPR);
    - for (indigenous) peoples to enjoy their own culture (Art 27 ICCPR) (See also Declaration on the Rights of Indigenous Peoples);

- to safe and healthy working conditions (Art 7(b) ICESCR);
- to an adequate standard of living including adequate housing (Art 11 ICESCR);
- to legal protection against arbitrary or unlawful interference with privacy, family, home (Art 17 ICCPR);
- to equal access to the public service (Art 25 ICCPR) (i.e., Environmental Protection Authorities and regulators)."

http://www.humansandnature.org/how-the-dash-to-frack-harms-rights-ful-humans

Failure to protect the environment

Shale gas in remote areas will be at risk of substandard compliance and enforcement.

Regulations can't protect us from fracking contamination, as evidenced in other mining breaches such as McArthur River Mine.

"Cattle with elevated lead levels have been found wandering near the site, sparking fears for human health, and there have been persistent claims the mine is affecting fish and shellfish eaten by Aborigines who hunt and forage in nearby rivers."
"Data from the mine's own air-quality monitor show that on 31 occasions between September and last month, atmospheric sulphur dioxide concentrations averaged over a one-hour period exceeded the National Environment Protection Measure standard. That standard says there should be no more than one such breach in any given year."
"The data show maximum allowable levels were not only breached but, on some occasions, exceeded by as much as fourfold."
Authorities oblivious to toxic mine breaches
http://www.theaustralian.com.au/national-affairs/authorities-oblivious-to-toxic-mine-breaches/news-story/d95f1a9f66542b4d65e10663d69d8c4c

The NT EPA's table of 'Pollution Incidents Reported' highlights the Northern Territory's inability to protect the environment.
https://ntepa.nt.gov.au/waste-pollution/compliance/pollution-incidents

"Regulation of offshore petroleum activities:
While the Montara Commission of Inquiry found that the company, PTTEP Australasia (PTTEPAA), "did not come within a bull's roar of sensible oilfield practice" it found major issues with the regulation of the site by the Northern Territory's Department of Resources. The Commission of Inquiry issued a scathing critique of the NT Government's regulatory role, with Commissioner Borthwick pointing particularly to the amount of revenue received by the NT Government, vis-à-vis the amount it spent on regulation. The Commission specifically recommended that the Federal Government remove the regulatory powers from the NT Government and give them to a single national regulatory body. The following statements of the Commissioner highlight the major issues with the regulators approach:

• The NT DoR did not do its job by ensuring the company's WOMP or the Phase 1B Drilling Program complied with good oilfield practice. In short, the NT DoR did not take adequate steps to ensure that PTTEPAA actually complied with the requirement of good oilfield practice.
• The inquiry finds that the NT DoR's regulatory regime was totally inadequate, being little more than a 'tick and flick' exercise. In particular, the inquiry does not agree with the Northern Territory's characterisation (before the Inquiry's public hearing) that the approach the NT DoR adopted followed 'contemporary regulatory practice'. The information provided to the inquiry indicates that, in contrast to the approach adopted by the NT DoR, the Victorian regulator undertakes monitoring, inspection, audit and compliance regime.
• The relationship between the NT DoR and PTTEPAA had become far too comfortable. Indeed, one contributory factor to PTTEPAA's own lax standards was the minimalist approach to regulatory oversight by the NT DoR.
• The inquiry formed the view that the resources and expertise that the NT DoR devoted to its task as delegate of the DA were inadequate (effectively only one person, who appeared to have a limited ability to fulfil this task).
The Minister should consider removing this delegation from the NT DoR."
Environmental Defenders Office Northern Territory 2016, *Health Check of Our Top End Coasts*, Australian Marine Conservation Society, p. 28

Land access

If fracking is banned in the Northern Territory, land access will no longer be an issue.

At the very least, landholders must be given the right to veto, and offered protection from fracking on nearby properties.

Public health

Health is a real issue and must be made a priority. Compensation may pay for medical bills, but money can't buy back health. The only way to absolutely protect our health is to ban fracking.

Economic impacts

If fracking is to go ahead, legislation must be enacted to force gas companies to pay upfront bonds which will truly reflect the cost of land and water rehabilitation, and cover the costs of compensation and rehabilitation when decommissioned wells leak and contaminate land and water 30 - 50 years after the well has been abandoned. It is unjust to expect the landholder or tax payer to meet these eventually unavoidable costs.

Compliance and enforcement

Self monitoring and reporting by gas companies puts Territorians at risk of suffering unscrupulous and dishonest behaviour from gas companies, and allows cover-ups to occur.

There is a long history of non-compliance in NT, for example, Port Melville was built without an EIS, and Mt Todd Gold Mine, Ranger Uranium Mine, McArthur River Mine, and others have all had accidents and spills.

A report of gas in a new water bore being drilled on Gilknocky Station didn't warrant Government or regulatory body testing to determine the source of gas, despite petroleum exploration wells drilled in the area.
ABC Country Hour, 8 November 2016
http://www.abc.net.au/news/2016-11-08/gas-water-bore-northern-territory-gilnockie-station/7992524

The NT EPA is powerless. The NT EPA Act has no offences so the EPA can't prosecute. The EPA can only make recommendation's which can be over-ridden by the Responsible Minister.

The NT Petroleum (Environment) Regulations 2016, do not detail minimum acceptance levels.

One Final Quote:

Unconventional shale gas mining is not safe and must be banned.

"Casing and cement impairment in oil and gas wells can lead to methane migration into the atmosphere and/or into underground sources of drinking water. An analysis of 75,505 compliance reports for 41,381 conventional and unconventional oil and gas wells in Pennsylvania drilled from January 1, 2000–December 31, 2012, was performed with the objective of determining complete and accurate statistics of casing and cement impairment. Statewide data show a sixfold higher incidence of cement and/or casing issues for shale gas wells relative to conventional wells."
Ingraffea, AR, Wells, MT, Santoro, RL & Shonkoff, SBC 2014, 'Assessment and risk analysis of casing and cement impairment in oil and gas wells in Pennsylvania, 2000–2012', *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*
http://www.pnas.org/content/111/30/10955.full

Concerned Territorians

There are many Territorians concerned by the potential consequences of Hydraulic Fracturing for shale gas. As the scientific evidence provided in this submission shows, these concerns are absolutely valid and justified. I have categorised their main concerns below:

Farmers and station owners.

Imposition of wells and infrastructure interfere with their businesses activities. They need fresh, clean water for stock and irrigation, and uncontaminated soil for growing pasture or crops. Gas extraction activities and infrastructure eg flaring, could impact helicopter mustering. Pipelines also present an issue as they block movement when above ground and can trap cattle if buried pipelines subside. As viable and sustainable business owners, farmers and station owners deserve the right to say no to fracking on their land.

Tourism operators.

Tourists come to NT for fishing and nature, not to see an industrialised shale gas field. Fracking applications have been approved (by Adam Giles for Gina Reinhart) around Mataranka Hot Springs. Fish kills due to spills and truck accidents are also of concern.

Darwin Rural Residents.

1388 signatures have been collected (mostly by me personally at the Humpty Doo shopping centre), calling for fracking to be banned.

Application EPA224 is in Darwin's rural area (Litchfield). Rural residents rely on aquifers for all their water needs, and Darwin's water supply is supplemented by bore water. Despite repeated requests to have EPA224 removed, and constant assurances that they won't frack in the Litchfield municipal area, the application still stands (it has been withdrawn by MBS Oil, but is still available for acquisition by another company). Residents are also concerned about health issues, loss of amenity and lifestyle, climate change, traffic increases and other impacts on community. Gamba grass fires lit by flaring are another valid concern.

Property Owners.

We have seen the Commonwealth Bank decline loan applications in Queensland due to CSG wells on property. This renders land valueless as it can't be borrowed against or sold.

Appendix 1.

"What environmental, social, and economic impacts will hydraulic fracturing (Fracking) for shale gas have on the Northern Territory?"

Literature Review

by Pauline Cass

10 May 2016

Figure 1. An aerial view of hydraulic fracturing for shale gas in Wyoming, USA. Source: Bagilet 2015.

Pauline Cass Email: territoryfun@yahoo.com.au

Table of Contents.

"What environmental, social, and economic impacts will hydraulic fracturing (Fracking) for shale gas have on the Northern Territory?"

Literature Review by Pauline Cass

10 May 2016

Introduction to the Northern Territory and Hydraulic Fracturing.

The Northern Territory of Australia has a total area of 1,349,129 square kilometres (Geoscience Australia n.d.) which is home to 244,500 people (Australian Bureau of Statistics 2015). The 'Onshore Petroleum Titles and Developments' map (Appendix 1), shows over 90% of the Northern Territory (NT) is currently either approved or under application for onshore oil and gas exploration and production (Styles 2016), with prospective onshore gas resource estimates of more than 200 trillion cubic feet (Department of Minerals and Energy 2015c, p. 3). Onshore gas is found in a variety of matrixes or plays, such as shale, tight sands, coal seam (CSG), and conventional plays, with each requiring different methods of extraction (Department of Economic Development, Jobs, Transport and Resources 2015). Shale gas is mostly methane, is colourless and odourless, and can be used in homes, industry, and to generate electricity (Santos Ltd 2016). The NT's onshore gas is predominantly shale gas trapped in shale rock, so will need hydraulic fracturing to extract it (Department of Minerals and Energy n.d; Hawke 2015, p. ii).

Hydraulic fracturing shale gas is a form of unconventional gas mining. It is also known as fracking, fraccing, hydrofracturing, hydrofracking, fractious stimulation, and onshore natural gas production. The term 'fracking' is used in this review to describe all aspects of the hydraulic fracturing processes and industry. Shale gas in the NT requires horizontal fracking (Figure 2), where a well is drilled down vertically for an average of 2.5 kilometres (Northern Territory Government 2016), before turning horizontally in the shale rock and continuing <2 kilometres (Northern Territory Government 2015c). The well is then cased and cemented (Northern Territory Government 2015b), before being perforated at the production site. Fracking fluid consisting of water, proppants and chemicals, is then injected in large quantities at high pressure to force and hold fractures open, stimulating gas flow, and resulting in vertical fissures which "can extend several hundred feet away from the wellbore" (EPA 2015b). The gas then flows to the surface where it is collected and processed (Figure 4). Compared to other gas types, shale's production rate declines rapidly once fracked, necessitating the constant drilling and fracturing of new wells to maintain a play's productivity (Cook et al. 2013, p. 23), often resulting in 'octopus' or multi-well pads (Figure 3).

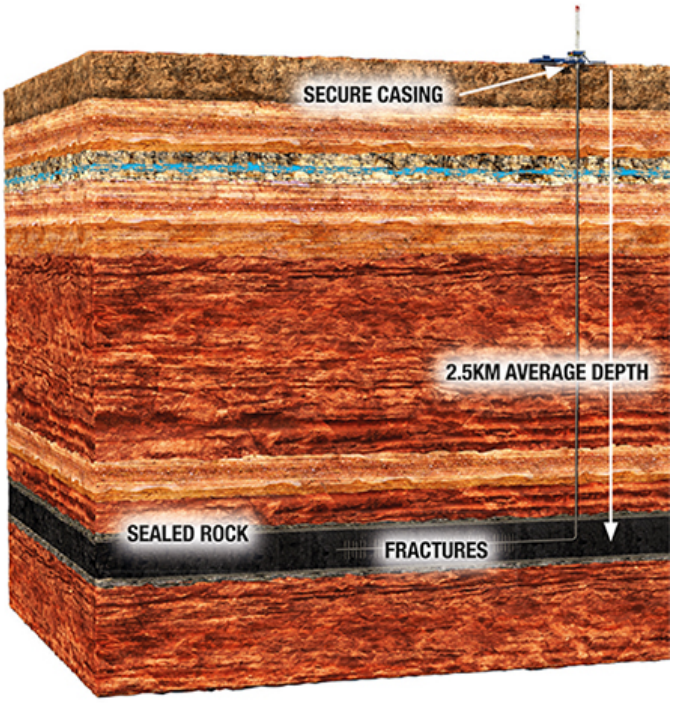


Figure 2. Diagram of horizontal drilling and hydraulic fracturing for shale gas. Source: Northern Territory Government 2016.

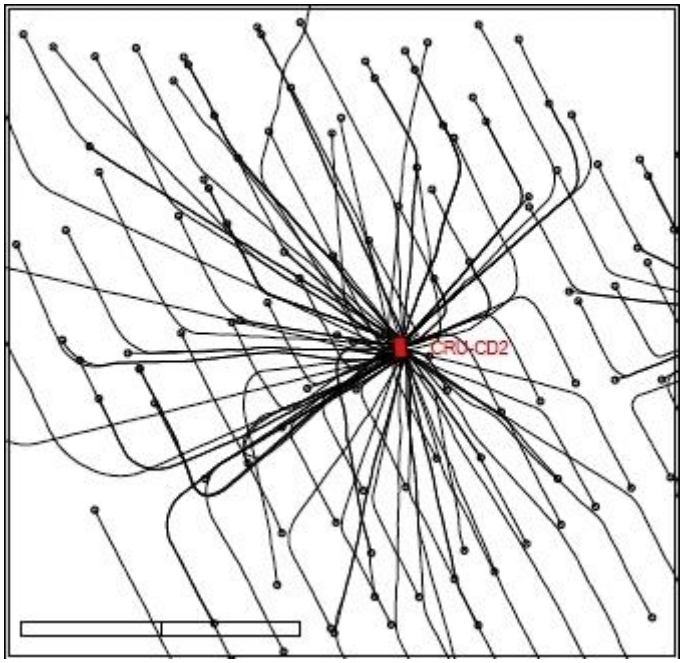


Figure 3. An octopused multi-well pad. The surface multi-well pad is shown in red with the wells (Black lines) radiating out underground. 2,000 acres of shale reservoirs can be fracked from one 7 acre pad. Source: Hicks 2012.

Situation Analysis:

Fracking is a divisive issue. Internationally, some countries like the USA (EIA n.d.) frack, though it is banned in some US States (Kaplan 2014); some like South Africa (Bagilet 2015) have a moratorium on fracking; while others such as Italy (DLA Piper 2016), Wales (Schaps 2015), and France (Members Research Service 2014, p. 5), have banned fracking due to environmental concerns. The Northern Territory Government (NTG) promotes and supports fracking as a clean energy (Jackson 2016). In 2015 it released the 'Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory' (Hawke Report), which states "This Inquiry's major recommendation, consistent with other Australian and International reviews, is that the environmental risks associated with hydraulic fracturing can be managed effectively subject to the creation of a robust regulatory regime" (Hawke 2015, p. x). The Hawke Report's finding that a moratorium is unjustified, despite over half the submissions calling for one (Hawke 2015, p. 46), was questioned by NT politicians (Manison 2015), lawyers (ABC News 2015), and environmentalists (Zillman 2015), and applauded by industry (Macdonald-Smith 2016; Curtain 2015).

2016 is a Territory election year and fracking has become a political issue. The current NTG (Country Liberal Party) asserts it will frack (Giles 2016), Territory Labour promises a moratorium if elected (Coates 2016), 1Territoy publicises they are 'anti-fracking' (Earley 2015), and an independent candidate has called for a fracking referendum (Bardon 2016a). There are numerous anti-fracking groups in the NT, such as Protect Arnhem Land, Don't Frack the Territory, Environment Centre NT, Arid Lands Environment Centre, and NT Frack Free Alliance, which has groups in many areas. A recent Mix FM Darwin survey found 89.1% of respondents opposed fracking (Woolfe 2016), and another poll in the NT News reported 83% of Territorians were concerned by the effects of fracking (Walsh 2016).

This literature review aims to inform NT stakeholders such as politicians, local businesses, Indigenous communities, and the general public about the impacts of unconventional gas mining for NT shale gas, and provide an extensive, relevant bibliography. It will investigate shale gas fracking literature, in order to answer the question 'What environmental, social, and economic impacts will hydraulic fracturing (Fracking) for shale gas have on the Northern Territory?'

Figure 4.

Santos' Moomba gas plant, South Australia, has approximately 5,600 kilometres of pipelines and flowlines, field boost compressors, and 24 oil and gas satellite facilities.

Source: Foster & McGee 2015

Literature Review:

Impacts of Hydraulic Fracturing for Shale Gas in the NT.

This literature review will explore fracking impacts pertinent to the Northern Territory, using recent Australian peer-reviewed literature whenever possible. There is a plethora of information available on horizontal hydraulic fracturing for shale gas, with many international and national government and private sector inquiries, discussion panels, scientific reports, scientific journals, websites, magazine and newspaper articles, and anecdotal reports on social media. A recently published literature review (Hays & Shonkoff 2016) found 685 peer-reviewed scientific papers addressing the impacts of fracking had been published between 2009 and 2015.

Figure 5. 3600 kilometres of seismic lines cleared in preparation for fracking operations near Broome, WA. Source: Frack Free Kimberley Community 2016

Figure 6. Well pads, access roads, pipeline corridors and other fracking infrastructure in Green River Valley, Wyoming, USA. Source: Hoffman 2012.

Environmental Impacts:

The Hawke Report (2015) found environmental impacts can potentially result from many shale gas fracking processes but that the risks can be managed with robust regulations. The Australian Academy of Technological Sciences and Engineering's (ATSE) submission to the Hawke Inquiry (Finkel 2014, p. 2) warns that if management is inadequate, the NT's ecosystems, sedimentary basins, water resources, and landscapes may be detrimentally impacted.

The key environmental findings of the European Parliament's study 'Impacts of Shale Gas and Shale Oil Extraction on the Environment and on Human Health' were:

- Unavoidable impacts are area consumption due to drilling pads, parking and manouvering areas for trucks, equipment, gas processing and transporting facilities as well as access roads. (Figures 5 & 6)

- Major possible impacts are air emissions of pollutants, groundwater contamination due to uncontrolled gas or fluid flows due to blowouts or spills, leaking fracturing fluid, and uncontrolled waste water discharge. (Figures 10 & 11)

- Fracturing fluids contain hazardous substances, and flow-back in addition contains heavy metals and radioactive materials from the deposit. (Appendix 2)

- Experience from the USA shows that many accidents happen, which can be harmful to the environment and to human health. The recorded violations of legal requirements amount to about 1-2 percent of all drilling permits. Many of these accidents are due to improper handling or leaking equipments. (Appendix 3)

- Groundwater contamination by methane, in extreme cases leading to explosion of residential buildings, and potassium chloride leading to salinization of drinking water is reported in the vicinity of gas wells. (Figures 7 & 8)

- The impacts add up as shale formations are developed with a high well density (up to six wells per km²). (Tables 1 & 3)

(Lechtenböhmer et al. 2011)

In 2013 the European Commission Directorate-General for Environment commissioned environmental risk assessments for both individual wells, and multiple installation's cumulative effects, for each stage of shale gas well development. The results are shown in Table 1 and demonstrate that risks to water, air and biodiversity increase with multiple wells.

Table 1. Summary of shale gas well environmental risk assessments for an individual site and cumulative sites. This table demonstrates that risks to air, water and biodiversity increase with well accumulation.

Environmental Aspect	Site identification and preparation	Well design drilling, casing, cementing	Fracturing	Well Completion	Production	Well abandonment and post-abandonment	Overall rating across all phases
Groundwater Contamination Individual Site	Not Applicable	Low	Moderate – High	High	Moderate – High	Not Classifiable	High
Groundwater Contamination Cumulative	Not Applicable	Low	Moderate – High	High	High	Not Classifiable	High
Surface water Contamination Individual Site	Low	Moderate	Moderate – High	High	Low	Not Applicable	High
Surface water Contamination Cumulative	Moderate	Moderate	Moderate – High	High	Moderate	Not Applicable	High

Water Resources Individual Site	Not Applicable	Not Applicable	Moderate	Not Applicable	Moderate	Not Applicable	Moderate
Water Resources Cumulative	Not Applicable	Not Applicable	High	Not Applicable	High	Not Applicable	High
Release to Air Individual Site	Low	Moderate	Moderate	Moderate	Moderate	Low	Moderate
Release to Air Cumulative	Low	High	High	High	High	Moderate	High
Risk to Biodiversity Individual Site	Not Classifiable	Low	Low	Low	Moderate	Not Classifiable	Moderate
Risk to Biodiversity Cumulative	Not Classifiable	Low	Moderate	Moderate	High	Not Classifiable	High
Seismicity Individual Site	Not Applicable	Not Applicable	Low	Low	Not Applicable	Not Applicable	Low
Seismicity Cumulative	Not Applicable	Not Applicable	Low	Low	Not Applicable	Not Applicable	Low

Adapted from: Broomfield 2013.

Fracking Chemicals:

The Northern Territory Government (2015c) tells us fracking requires "pumping a mixture of sand, water and a low concentration of chemicals (up to 3%)" into a well. 3% sounds innocuous until the volume of water used is considered. It is unclear which chemicals will be used in the NT (Department of Minerals and Energy n.d.). Appendix 2 summarises the fluids and particles used in hydraulic fracturing fluid in Australia. Elsner & Hoelzer (2016) discuss the over 1,000 reported fracking substances used in America and found they range from non-toxic to extremely toxic (deadly).

Water:

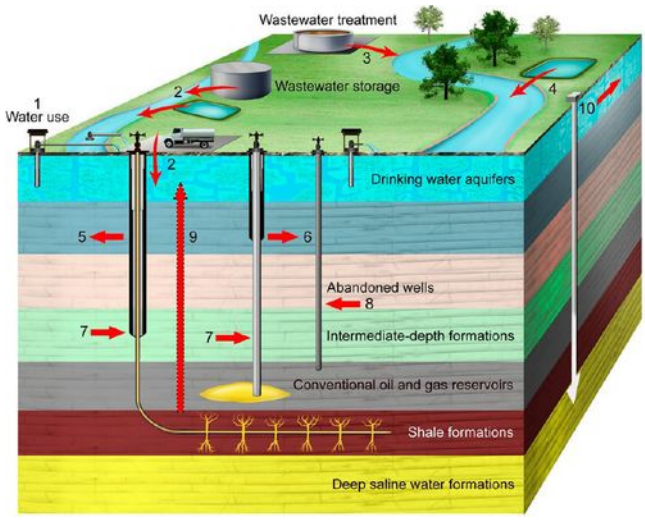
The main concern people have with fracking is its impacts on water (Hawke 2015, p. 31). Water resource impacts include contamination and depletion (Table 1). Shale gas production uses a higher input of water than CSG production, but it also creates less waste water (Australian Council of Learned Academies 2013, p. 2). A shale gas well can use over 10 million litres of water to frack (Grafton 2012, p. 16).

The media often shows flammable water as examples of water contamination (Figures 7 & 8). Osborn et al. (2011, p. 8172) found "methane concentrations in drinking water wells increased with proximity to the nearest gas well" and were "a potential explosion hazard" in active fracking areas. Drilling fluids, flow back fluids, fracking chemicals, and naturally occurring contaminants migrating into drinking water and rivers due to fracking have also been found (Broomfield 2012). Fracking fluids containing heavy metals and acids have

harmed Kentucky fish species (Papoulias & Velasco 2013). Wildlife and animals suffer similar impacts to humans (Centre for Biological Diversity, n.d.; Kelly 2011). 'Fracking Can Contaminate Drinking Water' (Vaidyanathan 2016), explains why older reports refuted fracking caused water contamination. Figure 9 demonstrates possible sources of water contamination from fracking shale gas.

Figure 7. Tap water on fire after water contamination from fracking. Source: Beament 2015.

Figure 8. CSG fracking is blamed for methane in the Condamine River. Source: Water Career 2016.



Schematic illustration (not to scale) of possible modes of water impacts associated with shale gas development reviewed in this paper: (1) overuse of water that could lead to depletion and water quality degradation particularly in water-scarce areas; (2) surface water and shallow groundwater contamination from spills and leaks of wastewater storage and open pits near drilling; (3) disposal of inadequately treated wastewater to local streams and accumulation of contaminant residues in disposal sites; (4) leaks of storage ponds that are used for deep-well injection; (5) shallow aquifer contamination by stray gas that originated from the target shale gas formation through leaking well casing. The stray gas contamination can potentially be followed by salt and chemical contamination from hydraulic fracturing fluids and/or formational waters; (6) shallow aquifer contamination by stray gas through leaking of conventional oil and gas wells casing; (7) shallow aquifer contamination by stray gas that originated from intermediate geological formations through annulus leaking of either shale gas or conventional oil and gas wells; (8) shallow aquifer contamination through abandoned oil and gas wells; (9) flow of gas and saline water directly from deep formation waters to shallow aquifers; and (10) shallow aquifer contamination through leaking of injection wells.

Figure 9. Potential sources of shale gas fracking impacts on water.

Source: Avner et al. 2014, p. 8337.

Irreversible water impacts include: depleting fossil aquifers (eg. Australia's Great Artesian Basin), large volume water extraction causing aquifer compaction, artesian aquifers losing pressure, fracking creating new connections between aquifers, groundwater contamination, and loss of biodiversity and groundwater-dependent ecosystems (Nelson 2012, p. 31).

Air Pollution:

Sources of air pollution associated with fracking, including methane, are illustrated in Figure 12. Styles (2014) found that flaring gas containing high percentages of hydrogen sulfide results in SO_x emissions which affects local and regional air quality, and Tumuluri et al. (2016) found acidic gases produced by fracking, including CO_2, SO_2, and NO_x, have adverse environmental and health effects. Fracking air pollutants and their health impacts are described in Table 2.

Figure 10. Venting shale gas containing toxic H_2S, Franklin, Texas. Source: Wilson 2012.

Figure 11. Shale gas flare, burning off excess gas, Nordheim, Texas. Source: Tedesco & Hillier 2014.

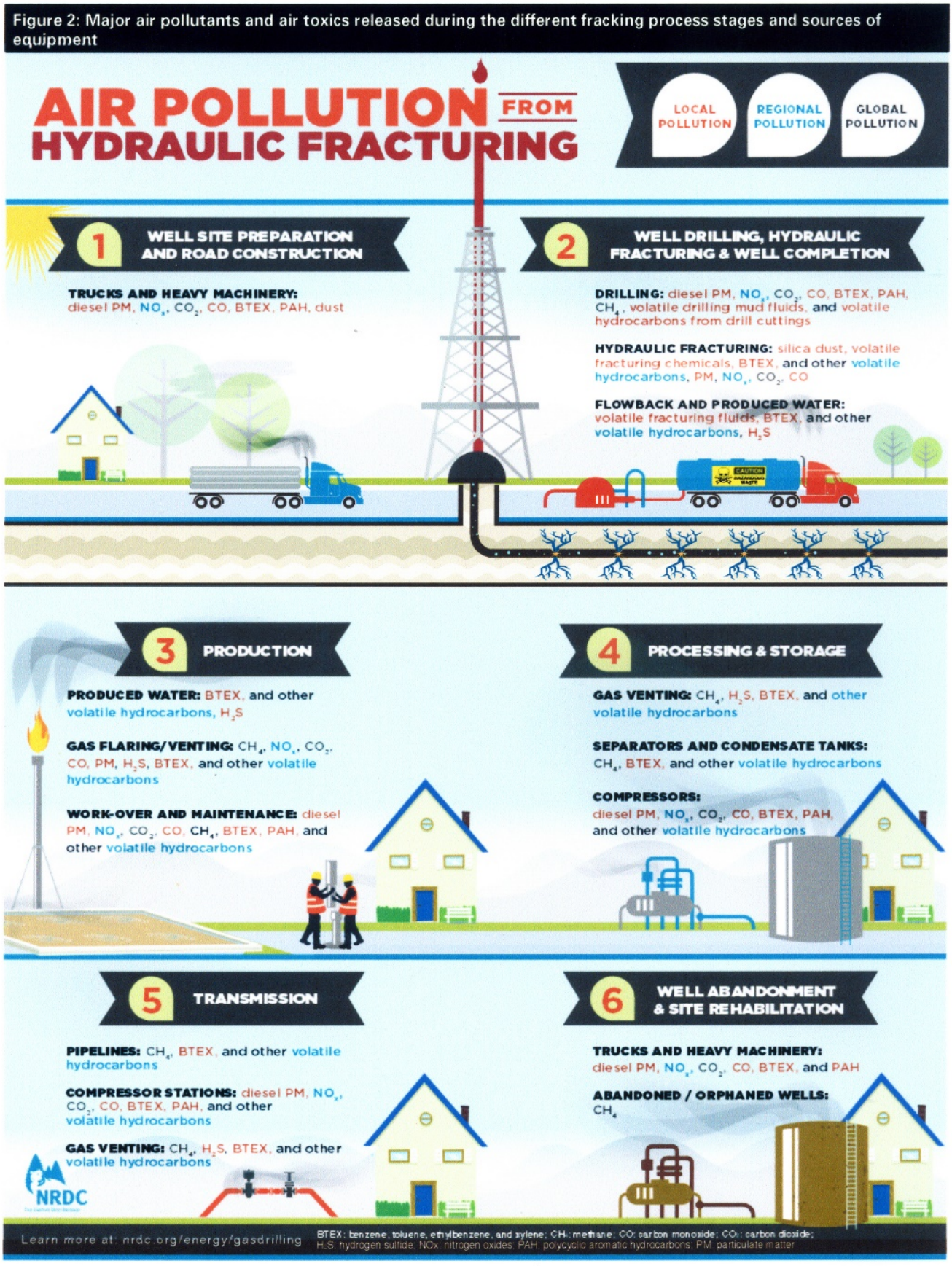


Figure 12. The major air pollutants released during the different stages of fracking. Source: Srebotnjak & Rotkin-Ellman 2014.

Table 2. The Health Impacts of Air Pollution from Hydraulic Fracturing.

Air Pollutant Type		Affected Body Organ/System	Carcinogen
Particulate Matter (PM)			
Diesel PM		Respiratory system; Cardiovascular system	✓
PM_{10} and smaller *		Respiratory system; Cardiovascular system, Dermal	
Volatile Organic Compounds (VOCs)			
B T E X	Benzene	Immune system; Blood; Foetal development, Neurologic System	✓
	Toluene	Brain and nervous system; Respiratory system; Foetal and child development; Reproductive system	
	Ethylbenzene	Foetal and child development; Liver; Kidney; Endocrine system; Auditory system	✓
	Xylene	Brain and nervous system; Foetal and child development	
Other VOCs (incl. Formaldehyde, Methanol)		Immune system; Respiratory system; Brain and nervous system; Dermal; Liver; Kidneys; Endocrine system; Foetal and child development	✓
Other Air Pollutants			
Hydrogen sulphide (H_2S)		Respiratory system; Dermal, Pulmonary system, Brain and nervous system; Gastrointestinal system	
Nitrogen oxides (NO_x)		Pulmonary, Respiratory system	
Ozone (O_3)		Respiratory system; Cardiovascular system	
Carbon Monoxide (CO)		Neurologic, Reproductive system	
Respirable Silica		Respiratory system; Kidneys; Immune system	✓
Polycyclic aromatic hydrocarbons (PAHs)		Immune system; Reproductive system; Brain and nervous system; Foetal and child developmental effects	✓

* PM_{10}: particulate matter of 10 micrometres or smaller in diameter.

Adapted from: Srebotnjak & Rotkin-Ellman 2014; & Spear 2015.

Climate Change:

Methane (CH_4) is 84 times more damaging to the atmosphere than CO_2 for the first twenty years after its release (Climate and Clean Air Coalition n.d.; EDF n.d.). Venting methane into the atmosphere during fracking contributes greatly to greenhouse gas emissions (Figure 10). Gas flaring (Figure 11) also accelerates climate change, though it releases 28-84 times less methane than venting (Styles 2014). The US EPA is proposing to limit methane release from fracking due to climate change concerns (EPA 2015a; EDF n.d.).

Seismic Activity:

A Miami University, Ohio study has directly linked hydraulic fracturing to earthquakes (Skoumal et al. 2015). Waste water injection from fracking has also been linked to seismic activity (Walsh & Zoback 2015). Oil and gas operations have been tied to earthquake surges in eight US states, including, Arkansas, Kansas, Ohio, Oklahoma and Texas (Kuchment 2016).

Oklahoma's earthquakes have dramatically risen since 2008 (Figure 13) when Oklahoma increased its oil and gas production (Rusinow n.d.). Studies have also found fracking wells have caused earthquakes in Canada (Hirji 2016).

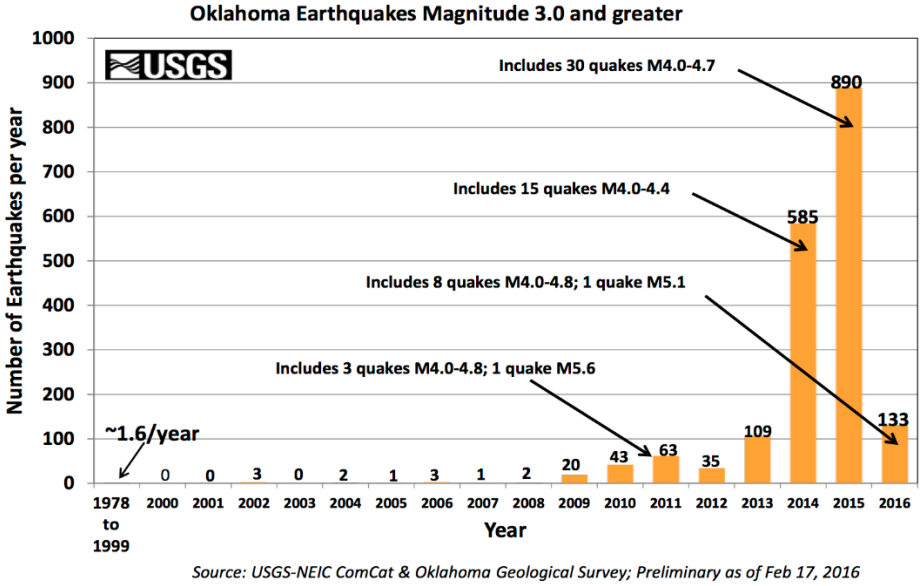


Figure 13. Oklahoma's earthquake incidence has increased dramatically since 2009. 2016 only includes January and early February figures. Source: USGS 2016.

Socio-Economic Impacts:

Lifestyle:

Fracking has many social impacts on communities. The most influential in rural towns being demographic change, with an influx of single males employed by the fracking industry, mostly as fly in - fly out (FIFO) workers (Hawke 2015, p. 63), and an exodus of families (Everingham et al. 2013, p. 40).

Fracking impinges on people's lifestyles. Numerous US communities are reliant on bottled drinking water provided by the fracking companies, as their water supplies have been contaminated or depleted by fracking (Jerolmack & Berman 2016; O'Connor 2014). They "shower with the windows open, to prevent a build-up of explosive gas", and some have had their "water wells explode" (Fenton 2016). Territorians rely on bore water so this is a serious concern.

National Geographic (Dobb 2013) describes "Streets clotted with noisy, exhaust-belching … trucks. More crime, more highway accidents, more medical emergencies. People on fixed incomes forced to move because they can't afford steep rent hikes. Overtaxed water and sewer systems. Prostitution…". Then there's the noise, lights, odours, dust, traffic, and other excessive nuisances (Goldberg et al. 2015; Nicholson 2014).

Landowners have no legal right to refuse a gas company access to their land if it owns the mineral rights (Dairy Australia 2015). This impacts privacy and ability to conduct routine activities (Figure 14). The 'Lock the Gate Alliance' has become a vocal, anti-fracking movement, nationally attracting and uniting a diverse range of people concerned about fracking issues. Members' voice concerns, which are shared internationally, such as environmental impacts, health, climate change (de Rijke 2013, p. 2), social dynamics, and people's rights to protect their water, land and livelihoods from fracking (Figure 20).

Broomfield's (2013) risk assessments commissioned by the European Commission Directorate-General for Environment are shown in Table 3. They demonstrate that traffic, noise, visual, and land-take impacts increase with multiple wells (Figures 14 & 15).

Table 3. Risk Assessment Results for an Individual Site and Cumulative Risks. This shows the risks and impacts of fracking increase with multiple (cumulative) wells, especially in regards to traffic and land-take.

Environmental Aspect	Site identification and preparation	Well design drilling, casing, cementing	Fracturing	Well Completion	Production	Well abandonment and post-abandonment	Overall rating across all phases
Traffic Individual Site	Low	Low	Moderate	Low	Low	Not Applicable	Moderate
Traffic Cumulative	High	High	High	Moderate	Low	Not Applicable	High
Noise Impacts Individual Site	Low	Moderate	Moderate	Not Classifiable	Low	Not Applicable	Moderate – High
Noise Impacts Cumulative	Low	High	Moderate	Not Classifiable	Low	Not Applicable	High
Visual Impact Individual Site	Low	Low	Low	Not Applicable	Low	Low – Moderate	Low – Moderate
Visual Impact Cumulative	Moderate	Moderate	Moderate	Not Applicable	Low	Low – Moderate	Moderate
Land-Take Individual Site	Moderate	Not Applicable	Not Applicable	Not Applicable	Moderate	Not Classifiable	Moderate
Land-Take Cumulative	Very High	Not Applicable	Not Applicable	Not Applicable	High	Not Classifiable	High

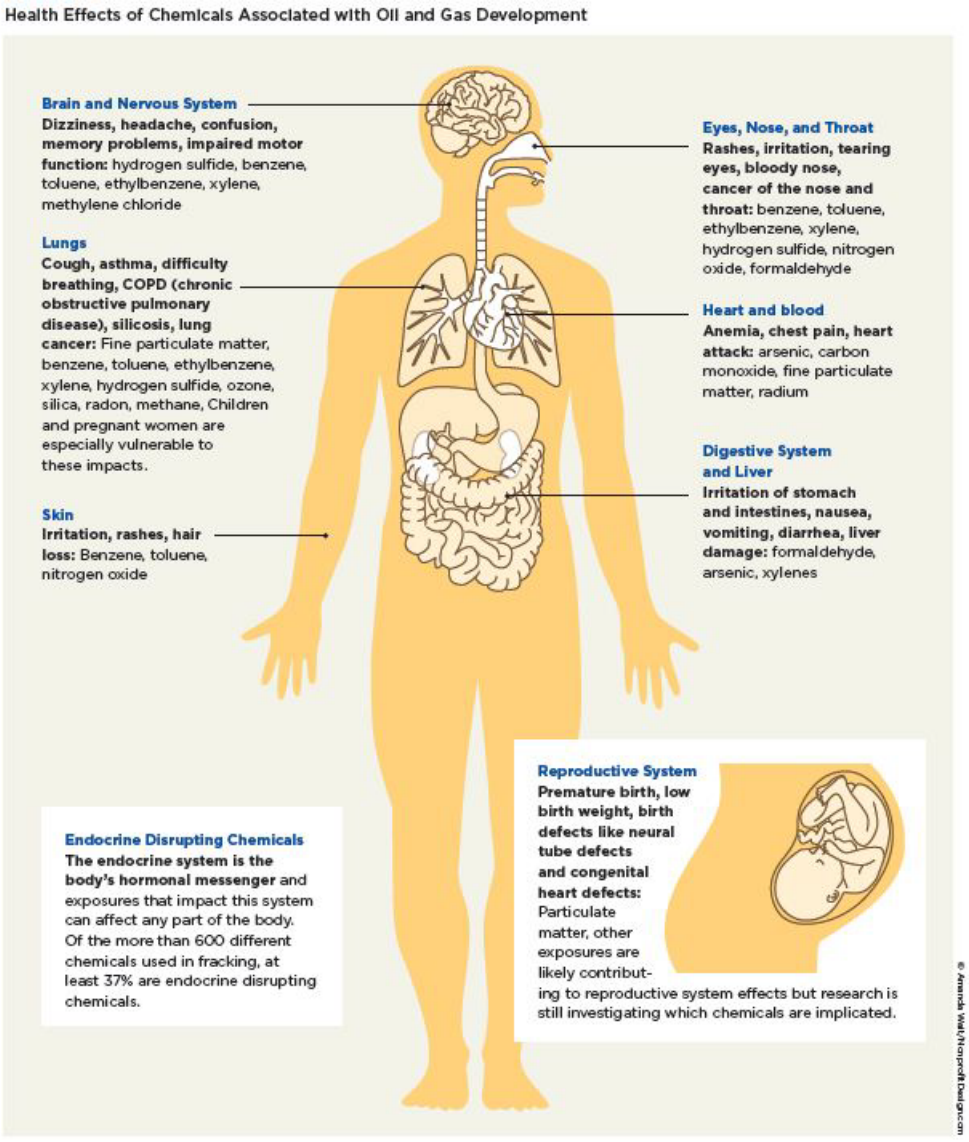
Adapted from: Broomfield 2013.

Figure 14. Land-take, air pollution and visual impacts of shale gas fracking in North Dakota, USA. Source: Dawson 2014.

Figure 15. Visual, noise, air pollution, and traffic impacts. Fracking truck traffic in Watford City, North Dakota. Source: Lee 2013.

Health:

Risks for neurological and respiratory problems, and birth defects increase with proximity to active wells (Spear 2015). New York State banned fracking after 'A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development' identified significant health risks (Zucker & Dreslin 2014; Kaplan 2014). 'Symptomatology of a Gas Field - An independent health survey in the Tara rural residential estates and environs' (McCarron 2013) 'found a pattern of symptoms which is extremely concerning' (p. 1). Berke discusses fracking toxicology and its serious health effects (Berke 2016). Wildlife and domestic animals also suffer these health issues (Centre for Biological Diversity, n.d.; Kelly 2011). Figure 16 illustrates the health effects associated with fracking chemicals, and Table 2 addresses air pollution health impacts.



This image indicates the common symptoms and health impacts known to be linked to chemicals associated with unconventional oil and gas development, including some of the chemicals captured in air samples as part of this project.

NOTE: For a description of health symptoms associated with specific chemicals, see the Agency for Toxic Substances and Disease Registry at http://www.atsdr.cdc.gov/substances/ToxOrganSystems.asp.

Figure 16. Health effects of chemicals associated with fracking. Source: CEH 2013.

Local Economy:

The Australian Business Review and Wall Street Journal have been reporting the risks of fracking (Berke 2016; Hutchinson 2015; Dawson 2014; de Rijke 2013). Land-take, water contamination, water depletion, air pollution, and health effects will likely be detrimental to the tourism, real estate, agriculture, horticulture, aquaculture, fisheries, crocodile, and manufacturing industries in the NT. A reduction of production in these industries can lead to a decrease in exports, and increased imports and food prices (GISERA 2013). NT tourism currently attracts over 1.5 million tourists each year (Tourism NT 2016), a reduction in tourist numbers will greatly affect many small businesses.

Initially, hotels, motels, bakeries, restaurants, car sales, and coach charters will flourish as a result of fracking, but many other small businesses will perish. "There's more small businesses for sale at the moment in Roma than almost any town in western Queensland. And they can't sell." (Everingham et al. 2013, p. 40). This is partly due to the exodus of families (GISERA 2013) and influx of single, male, FIFO workers, and exacerbated by the difficulties in retaining staff as small businesses can't compete with the wages offered by fracking companies (Everingham et al. 2013, p. 39; GISERA 2013).

The NTG tells us fracking "will create more jobs, boost the economy, improve local infrastructure and could lead to cheaper electricity which in turn stimulates further business activity" (Northern Territory Government 2016b). While this may initially be true during the short term, establishment phase, the CSG experience in Queensland shows employment and expenditure in mining is now declining (Figure 17), and almost 50% of mining town homes are now selling at a loss (Hutchinson 2015).

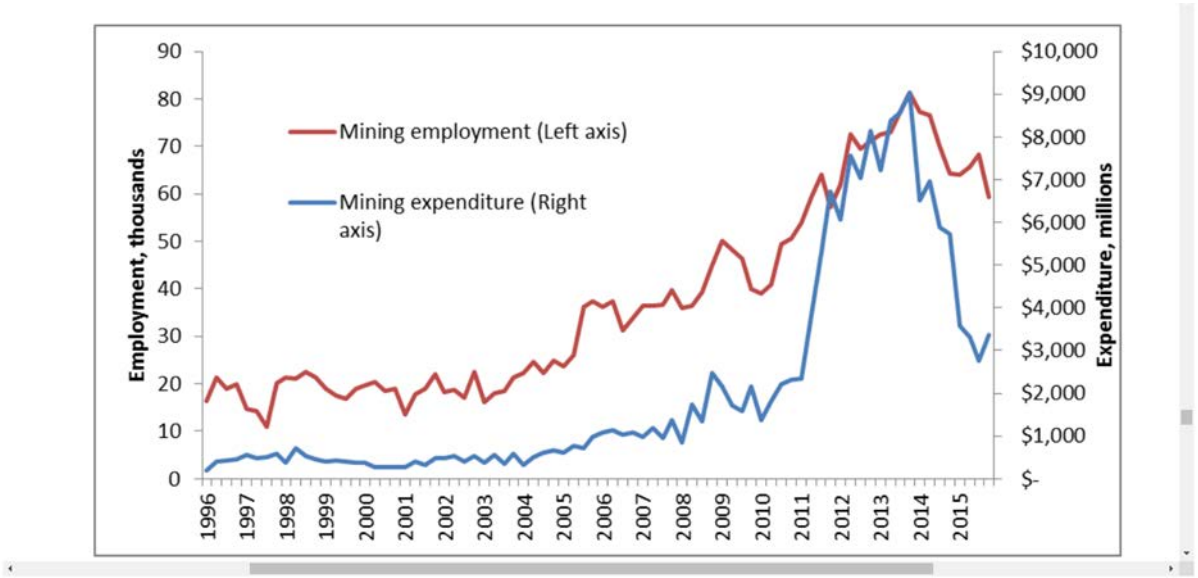


Figure 17. Mining expenditure and employment is declining in Queensland. Source: Swann et al. 2016, p. 41.

Economics and Legalities:

Fracking is labelled as petroleum mining and controlled by the Northern Territory Petroleum Act (AustLII n.d.b; EDONT n.d.). Gas pipelines are regulated under the Northern Territory Energy Pipelines Act (AustLII n.d.a; EDONT n.d.). Litigation against fracking companies is on the rise in the US. (Goldberg et al. 2015; Nicholson 2014). This trend is now occurring in Queensland with the Nothdurft family challenging QGC and four other respondents in the Brisbane Land Court, seeking compensation for fracking impacts under Queensland's Petroleum and Gas Act (Smail 2016).

The NTG has “cut the red tape” for oil and gas corporations by “Reforming as necessary, the Northern Territory Government’s regulatory and other practices” to "accelerate land access and approvals processes" (Department of Minerals and Energy n.d.b, p. 21).

The NTG also lowered “the cost of assessing the prospectivity of Northern Territory gas resources” for fracking corporations by committing “nearly $8 million over four years to specifically target improved knowledge about the Territory’s shale gas resources. The CORE program, totalling $23.8 million, is the largest investment to support the exploration industry made by a Territory Government" (Department of Minerals and Energy n.d.b, p. 17). The NTG is also financing an elaborate advertising campaign (Figure 18), and $800 million to construct a gas pipeline from Tennant Creek to Mount Isa (Giles n.d.).

A Deloitte Access Economics report for the Australian Petroleum Production & Exploration Association (APPEA) modelled a “success scenario” which found “the cumulative addition to GSP over the two decades from 2020 to 2040 would be about $17 billion, and government coffers would collect an extra $680 million” based on the most ambitious future demand predictions from the Australian Energy Market Operator (AEMO) (Aikman 2015).

America’s oil and gas corporations are struggling, with “at least 15 companies” having their credit cut, and lenders preparing to lose billions of dollars on oil and gas loans (Loder & Klein 2016).

Accidents Happen:

There have been 43 pollution incidents which threatened or caused ‘serious environmental harm’ reported to the NT EPA since 11 May 2006 (NT EPA 2016), see Appendix 3. Interestingly, the copper concentrate spill at East Arm Wharf, Darwin Harbour (Ascend 2015, p. 105), and water contamination incidents at McArthur River Mine (Bardon 2016b) are not listed. This does not foster confidence that the NTG can successfully manage fracking risks if proposed unconventional shale gas plans were to eventuate.

The Hakwe Report (2015, p. 85) acknowledges that robust regulatory regimes can not fully prevent accidents from occurring, stating “the risks cannot be reduced to zero and some areas of uncertainty remain, particularly the very long-term integrity of wells”. Appendix 4 has several images of shale gas fracking accidents from America and Canada.

Potential Limitations of This Literature Review:

The high proportion of literature detailing negative impacts of fracking in this review led to concerns of author bias. This review's findings are supported by Hays and Shonkoff's, 'Toward an Understanding of the Environmental and Public Health Impacts of Unconventional Natural Gas Development: A Categorical Assessment of the Peer-Reviewed Scientific Literature, 2009-2015' (2016, p. 1) which found:

- 84% of public health studies contain findings that indicate public health hazards, elevated risks, or adverse health outcomes;
- 69% of water quality studies contain findings that indicate potential, positive association, or actual incidence of water contamination; and
- 87% of air quality studies contain findings that indicate elevated air pollutant emissions and/or atmospheric concentrations. (Hays & Shonkoff 2016, p. 1)

The prevalence of recent scientific evidence decrying unconventional gas maybe due to the development of new testing methods (Vaidyanathan 2016), and fracking impacts being accumulative (Broomfield 2013), so only becoming documented now.

Figure 18. Northern Territory advertisement. Oil & Gas it's for the future.
Source: Northern Territory Government 2015d

Figure 19. Tanker trucks hauling water and fracking fluids line up near a gas flare in Williston, North Dakota. Source: Berke 2016

Figure 20. 16 April 2016, Our Land is Our Life March in Katherine, NT.
Source: Don't Frack the Territory 2016

Conclusion:
What environmental, social, and economic impacts will hydraulic fracturing (Fracking) for shale gas have on the Northern Territory?

This literature review discovered onshore shale gas is a multibillion dollar industry, which booms and busts, and comes at great cost and risk to the environment and general public.

Hydraulic fracturing for gas is opposed by the majority of people in the NT. With over 90% of the Northern Territory granted or under application for unconventional gas mining it will potentially impact everyone in some way. Fracking poses a very real threat to the people, places and activities we love, and risks our health, lifestyles and livelihoods. These are things which money can not replace.

Tax payer funded advertising designed to influence the public into accepting unconventional gas extraction, portrays onshore natural gas as a clean energy. This review found that the land clearing, infrastructure, machinery, water usage, chemicals required, waste water produced, and gases leaked during fracking debunk this claim.

Scientific evidence shows horizontal hydraulic fracturing for shale gas poses many environmental risks, some with irreversible consequences, and each new report further confirms this. Fracking has destroyed aquifers and rivers through contamination and over extraction, killing wildlife, fish, and aquatic ecosystems. It has caused air pollution, health issues and seismic activity, and it contributes to climate change by releasing greenhouse gases such as methane. Countless reports list these risks, including the 'Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory', which concluded that the risks can be managed by regulation. While regulation might offer some protection, accidents do occur. Human error, mechanical failure, unforeseen circumstances, waste water ponds flooding, trucks of fracking fluid crashing, wells leaking, and well heads catching fire, can and have happened. And the repercussions can be catastrophic for the affected area and its inhabitants.

Clean water is critical for economic growth, public health, and the environment. Our aquifers, lakes and rivers provide water for households, irrigation for crops, water for livestock, support our crocodile industry, and our pristine waterways attract over 1.5 million tourists and fisherman to the Northern Territory each year. Our agriculture, horticulture, aquaculture, real estate and tourism industries will be impacted if our water is accidently contaminated or depleted.

These industries are also impacted by the resources and infrastructure required by the gas industry. Employees leave their local jobs to go work for mining companies. Frack pads and production water ponds require large areas of land. Pipelines and roads require land clearing which will deter tourists who come to see the untamed wilderness of the outback, not a gas field with heavy truck traffic or polluted hot springs. Fracking risks these industries, the revenue they generate, and the jobs they provide.

At the conclusion of this literature review we must ask ourselves, is fracking worth the risk? Just because we can do something, doesn't mean we should. We can live without gas but we can't survive without clean air and water. This review suggests that the Northern Territory Government ceases spending tax payers' money to support and promote an industry which is detrimental to Territorians, and that it hold a referendum on fracking. In view of the mounting legitimate health and environmental concerns, this review highly recommends that the Northern Territory Government immediately declares an indefinite moratorium on the unconventional mining of shale gas.

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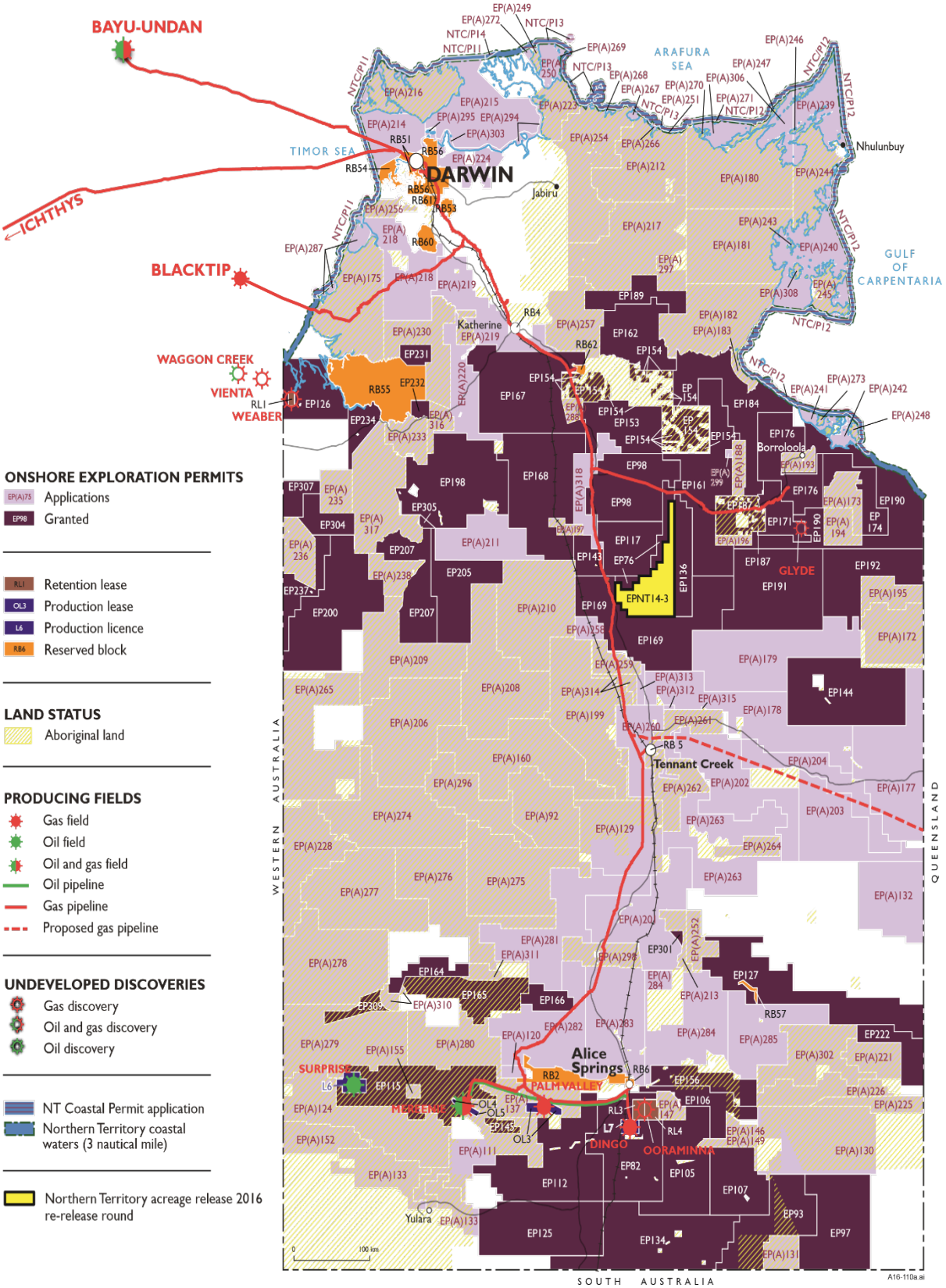
Appendix 1. NT Onshore Petroleum* Titles and Developments Map.



*The term 'Petroleum' on this map also includes Hydrocarbon materials such as shale gas.

Source: CORE (Creating Opportunities for Resource Exploration), Department of Mines and Energy 2016

Appendix 2. Hydraulic Fracturing Chemicals.

Appendix 2 Table. Summary of the fluids and particles used in hydraulic fracturing fluid in Australia.

Injected substance	Purpose	Products used	Notes
Water	Fractures the coal when injected under high pressure	Bore water, farm pond water or groundwater previously extracted from coal seams is often used	Volume of water required is ~0.2 to 1.3 ML per well (USEPA 2011)
Proppant	Keeps the fractures open once the high pressure fluid is removed	Sand Resin-coated sand Ceramics Bauxite (aluminium ore)	The latest technology advances in proppants include high strength ceramics and sintered bauxite
Acid	Dissolves calcite in the coal prior to fracturing	Hydrochloric acid Muriatic acid Acetic acid	Not all wells require this treatment because coal seams do not always contain calcite
Gelling agent or Clay stabilisers	Increases the viscosity of the fluid, to allow more proppant to be carried into fractures	Guar gum Starches Cellulose derivatives Polydimethyldiallylammonium chloride (Claytrol) Tetramethylammonium chloride (Claytreat 3C)	Not all hydraulic fracturing uses a gel; gel-free fracturing is termed ‘slickwater’
Crosslinker	Increase the viscosity of gelling agents	Borate salt Ethyl glycol Isopropanol Disodium octaborate tetrahydrate Boric acid Boric oxide	There are different crosslinkers for different gelling agents

Injected substance	Purpose	Products used	Notes
Biocide	Limits or prevents growth of bacteria that could damage the gelling agent	Glutaraldehyde 2,2-Dibromo-2-cyanoacetamide (DBNPA) Tetrakis(hydroxymethyl)phosphonium sulfate (THPS, Magnacide 575) bronopol (2-bromo-2-nitropropane-1,3-diol) Sodium hypochlorite Sodium thiosulfate Boric acid Caustic soda	The natural polymer gelling agents are good food for bacteria so they encourage bacterial growth - biocides kill these bacteria
pH buffer	Keeps the pH of the fluid in a specified range	Acetic acid Sodium hydroxide Potassium carbonate Sodium carbonate,	Required for the stability of crosslinked polymers
Breaker	Chemically break the bonds of the gel in order to reduce the viscosity back to that of water	Hydrogen peroxides Sodium persulfate Diammonium peroxidisulphate	Only required if a gel is used
Corrosion scale inhibitors		Aloe resin n,n-dimenthyl formamide Methanol Nonyl phenol	
Friction reducers	Reduce fluid surface tension	Oxyalkylated alcohol	
Other additives	Includes foamers, gel stabilisers, clay stabilisers, preservatives, surfactants	Terpenes and terpenoids Sweet orange oil Polyacrylamide Alcohols n,n-dimenthyl formanide Citric acid Ammonium bisulfite Ethylene glycol Potassium chloride	Operators in NSW and Queensland are required to disclose a full list of additives prior to hydraulic fracturing

Source: URS Australia Pty Ltd 2014, p. 26.

Appendix 3. NT Pollution Incidents threatening or causing 'serious environmental harm'.

Section 14 Incident Reports received by the NT EPA since May 2006 are provided below.

NOTE: All notices/licences/reports issued under previous Department/Agency names are valid and are available throughout the NT EPA website. http://www.ntepa.nt.gov.au/waste-pollution/compliance/incidents#reported

Date	Incident	Lot Information	Address
08 April 2016	GEMCO *Stormwater Discharge*		Alyangula Groote Eylandt
16 March 2016	GEMCO *Stormwater Discharge*		Milner Bay, Alyangula Melville Island NT
14 March 2016	Power and Water Corporation - Remote Operations *Diluted Treated Effluent Overflow*	Lot 580 Townsite of Angurugu	Angurugu - Sewer ponds, infiltration basin 1
21 Feb 2016	Cleanaway Darwin *Used Lube Oil spill from Tank*	Lot 5725 Hundred of Bagot	875 Stuart Highway, Holtze
04 Feb 2016	Power and Water Corporation - Remote Operations *Diluted Treated Effluent Overflow*	Lot 580 Townsite of Angurugu	Angurugu - Sewer ponds, infiltration basin 2
20 Jan 2016	Teras Australia *Discharge into Aspley Straight*		Port Melville Project Area, Melville Island NT
20 Jan 2016	GEMCO *Stormwater Discharge*		Milner Bay, Alyangula Groote Eylandt
07 Jan 2016	Power and Water Corporation - Remote Operations *Sewage Overflow* - combination of raw sewage and partially treated sewage	Lot 580 Townsite of Angurugu	Angurugu - Sewer Pump Station 1
27 Dec 2015	Vista Gold *Mt Todd Mine Retention Pond Overflow*		Mt Todd Mine Jatbula Road, Katherine
22 Dec 2015	GEMCO *Stormwater Discharge*		Milner Bay, Alyangula Groote Eylandt
17 Dec 2015	Power and Water Corporation - Remote Operations *Sewage Overflow*	Townsite of Angurugu	Angurugu - Sewer ponds, infiltration basin 1
01 Dec 2015	Power and Water Corporation - Remote Operations *Sewage Overflow*	Lot 580 Townsite of Angurugu	Angurugu - Sewer Pump Station 1

Date	Incident	Lot Information	Address
12 Nov 2015	Northline Pty Ltd *Nitric acid leak*	5963 Hundred of Bagot	14 Dawson Street, East Arm
27 July 2015	Northern Australian Beef Limited *Ground containing listed waste.*	Lot 4 Hundred of Cavenagh Section 5410, Hundred of Strangways	270 Blyth Road Livingstone 2660 Stuart Highway, Livingstone
12 May 2015	Teras Australia *Diesel Spill*	NT Portion 1644	Port Melville Accommodation Village Melville Island. Tiwi Islands
16 March 2015	McArthur River Mine *Air Pollution - unplanned fire*		McArthur River Mine site
16 Feb 2015	BHP Billition Manganese Australia *Stormwater Discharge*		Milner Bay, Alyangula, Groote Eylandt
15 Feb 2015	BHP Billition Manganese Australia *Stormwater Discharge*		Milner Bay, Alyangula, Groote Eylandt
14 Feb 2015	BHP Billiton Manganese Australia *Stormwater Discharge*		Milner Bay, Alyangula, Groote Eylandt
10 Feb 2015	BHP Billiton Manganese Australia *Stormwater Discharge*		Milner Bay, Alyangula, Groote Eylandt
13 Dec 2014	NT Police, Fire and Emergency Services, Berrimah *Oil Spill*	section 6349 Hundred of Bagot	cnr Berrimah road and Export Drive, East Arm
18 Feb 2014	Power and Water Corporation *Discharge of untreated effluent at the Darwin Botanical Gardens*		Gardens Road, The Gardens, Darwin
16 Feb 2014	WDR Iron Ore Pty Ltd *Vehicle in River. Potential for diesel and oil impacts*		Roper Bar Mine Site
13 Feb 2014	WDR Iron Ore Pty Ltd *Uncontrolled Discharge*		Roper Bar Mine Site
12 Feb 2014	WDR Iron Ore Pty Ltd *Uncontrolled Discharge*		Roper Bar Mine Site
24 Jan 2014	John Holland Pty Ltd *Leachate water leak, Shoal Bay Landfill*	Lot 3952 Town of Sanderson	Shoal Bay Waste Depot
9 Aug 2013	McArthur River Mining Pty Ltd *Trailer roll over carrying MRM concrete*		

Date	Incident	Lot Information	Address
24 May 2013	Asphalt Co Australia Pty Ltd *Accidental Fire igniting tyres*	Lot 4490 Hundred of Bagot	66 Syrimi Road Tivendale
22 Feb 2013	Vista Gold Pty Ltd *Uncontrolled discharge*		
18 Oct 2012	Ichthys LNG Pty Ltd *Hydraulic Fluid Leak, Blaydin Point*		
11 Sept 2012	Territory Alliance *Emulsion Spill*		
10 Aug 2012	Department of Defence - Larrakeyah *Ruptured Fuel Tank*		
7 Dec 2011	Power and Water Corporation *Pine Creek Substation*		
23 Mar 2009	Patrick Stevedores Darwin *Acid spill, East Arm Wharf*		
2009	Perkins - Diesel Spill		
2009	Diesel Spill - Black Point		
10 Sept 2008	Peanut Company of Australia *Diesel Spill, Taylors Park, Katherine*		
2 Mar 2008	Darwin RAAF Base *Dispersal of Aqueous Film Forming Foam*		
4 Feb 2008	Parmalat Australia Ltd *Raw milk loss to sewer, Bishop Street, Woolner*		
7 Feb 2007	ORICA Australia Pty Ltd *Cyanide spill near Renner Springs*		
14 Jul 2006	Power and Water Corporation *Fuel spill, Ron Goodin Power Station, Alice Springs*		
27 Jun 2006	BP Australia Pty Ltd *Diesel spill, Roper Hwy, between Mataranka and Ngukurr*		
11 May 2006	BP Australia Pty Ltd *Diesel and Avgas spill, Buchanan Hwy (300km south of Katherine)*		

Source: NT EPA. Accurate at 7 May 2016.

Appendix 4. Accidents Happen: Images.

Pressurized lines being improperly connected or being hammered on while under pressure cause 'production fluid spills' Source: MEF n.d.

Large Fracking Operation Fire in Grady County, Oklahoma. Source: Brown 2016

2011 Gas well blowout. It burned acres of forest in remote Village Creek State Park, Texas.
Source: Nasti 2013

Shale well, West Virginia.
Source: Sierra Club's West Virginia Chapter 2011

A truck hauling fracking lubricant, smashed through guardrails, trees and into a creek, leaking fracking fluid into the creek. West Liberty, West Virginia. Source: Hanson 2012

A fracking tanker accident and spill in the town of Fox Creek, Alberta, Canada.
Source: Bounds 2015

2013, Weld County Colorado. Floods inundated hundreds of fracking wells causing contamination.
Source: The Aspen Times 2013

Scientists inspect a fracking spill in North Dakota.
Source: Vengosh, Lauer, Harkness 2016