Submission to
The WA Independent Scientific Inquiry into Hydralic Fracture Simulation in Western Australia 2017 - 2018

March 15, 2018

Submission from:
No Fracking WAy
[redacted]

No Fracking WAy is a Perth-based volunteer community group. Its members have been involved in gathering and sharing information about the unconventional gas industry in Western Australia for the past six years. Our ongoing community liaison has given us a great understanding of the legitimate local, regional, national and global concerns about the unconventional gas industry and its impacts upon human and environmental health. Hence, we are hereby putting forward our submission for your consideration.

a) how hydraulic fracturing may impact on current and future uses o land;

Direct and indirect impacts on current and future uses of land must be assessed.

1. Impacts on land use through contributions to climate change

1.1. Firstly, contributions of greenhouse gases from the unconventional gas industry are a serious threat to current and future land uses. The contributions of greenhouse gas emissions from the unconventional gas industry and its processes to climate change and the impacts of climate change on our state are of great concern, for example to agricultural productivity and the southerly movement of the wheatbelt as the climate warms and dries in the south west of the state, access to safe water supplies as water sources continue to become strained and increasing weather extremes. Of course impacts of climate change are not restricted by borders and global impacts of contributions from hydraulic fracturing in WA must also be taken into account. For the sake of this submission, however, we shall focus on state related impacts.

It has been shown in various studies, including Howarth, Santoro and Ingraffea's study into 'Methane and the greenhouse-gas footprint of natural gas from shale formations', that the equivalent carbon footprint of the unconventional gas industry is on par if not worse than that of coal when considering total emissions from extraction to consumption. This is qualified in Wigley's study, claiming that replacing coal with gas as an energy source actually equates to increased global warming for decades, rather than a decrease (Wigley 2011). This negates shale gas as a viable option as a 'transition fuel' to renewable energy sources and classifies it as a serious threat to our climate.

As a greenhouse gas, methane, which is the major component of natural gas, is 105 times more potent than CO_2 over a 20 year period and 33 times more potent over a 100 year period with an uncertainty of 23%. This 20 year period is vital if we, as a global community and in WA as high emitters of greenhouse gases, are to seriously address climate change. These statistics also highlight the importance of assessing even small leaks of methane.

In a review ớf Australian gas field methane emissions by the Melbourne Energy Institute (25.10.2016), commissioned by the Australia Institute the following findings were made.

- "several major potential sources of methane emissions are assumed to be zero under Australia's accounting and reporting of unconventional gas.

- Methane measurements at US unconventional gas fields have found leakage rates in the order of 10-25 times higher than the Australian Government reports to UNFCCC, and up to 170 times those claimed by the gas industry.

- If leakage rates comparable to those found in the US are at Australian unconventional gas fields it will have serious implications for Australia meeting its emission reduction commitments under the Paris agreement.

  Reference: A review of current and source methane emissions for Australian productions

  Melbourne Energy Institute (25 October 2016)

Additionally, methane has also recently been shown to have an even greater impact on climate change when considering indirect effects with atmospheric aerosols (Howarth et al. 2011, 2).

Greenhouse gas emissions from the unconventional gas industry include "direct emissions of CO2 from end-use consumption, indirect emissions of CO2 from fossil fuels used to extract, develop, and transport the gas, and methane fugitive emissions and venting" (Howarth et al. 2011, 2).

According to studies in the US, fugitive emissions associated with the development of unconventional gas from shale formations, expressed as a percentage of methane produced over the lifecycle of a well, are:

Emissions during well completion (combining losses associated with flow-back fluids and drill out)	1.9%
Routine venting and equipment leaks at well site (not including potential accidents or emergency vents)	0.3 to 1.9%

Emissions during liquid unloading (not all wells require unloading)	0 to 0.26%
Emissions during gas processing (some gas is pipeline ready, while other gas may require processing to remove heavy hydrocarbons and other impurities)	0 to 0.19%
Emissions during transport, storage and distribution	1.4 to 3.6%
Total emissions	**3.6 to 7.9%**

(Howarth et al., 2011)

These figures are conservative and are assuming the use of the best available technology and 'best practice'.

1.2. Another important point in regards to impacts of fugitive emissions is their regulation. At present, concerns exist around how greenhouse gas emissions of the unconventional gas industry are and will be monitored when the industry reaches a production stage in Western Australia.

1.3. Kort et al, used air born carbon data collected over the North Dakota section of the Bakken shale in 2014. They found the equivalent of 1-3% of total global sources of Ethane which. It reduces the atmosphere's oxidative capacity, .and is the second most abundant atmospheric hydrocarbon.

Reference:
Fugitive emissions from the Bakken shale illustrate the role of shale production in the global ethane shift.
Geophysical Research Letters, 43, 4617-4623. doi: 10.1002/2016GL068703
Kort EA. Smith ML. Murray LT. Ghakharia A. Brandt AR .Peischi J. Travis K. (2016)

Franco et al (2016)estimated the annual emissions of methane has risen from 20-35Tg/year over the period 2008-2014, because of the oil and naturlal gas extraction in North America.

Reference: The rising North American methane and ethane emissions from oil and gas activities identified by a-NDACCFTIR and 3-D model analysis
Environmental Research Letters, 11, 044010 doi: 1088/1748-8326/11/4/044010
(April 2016) Franco B. Mahieu E. Simmons L. k. Tzompa-Sosa Z.A . Fischer E.V. Sudo K. Bovy B. Conway S. Grifffin D. Hannigan D.W. and Walker K.A.

Video. Well Failure. *https://www.youtube.com/watch?y=Dxis-vYGM_M*
Ingraffea A.R. (2016)

US methane emissions have risen 30% in the last decade. Using evidence from atmospheric observations, the study traced the largest of these to the central part of the USA, where oil and gas extraction has expanded dramatically over the same time period. Turner et a l(2016)

Reference:
A large increase in U>S> methane emissions over the past decade inferred from satellite data and surface observation Geophysical Research Letters, volume43, Issue 5. **(March 2016)**
Turner A. J. Jacobs .D J. Beumergui J.

2. Surface footprint & infrastructure

2.1. As a typical gas well site has a surface footprint of 3.6 hectares, Western Australian landscapes will be drastically scarred with the expansion of the unconventional gas industry (Broomfield 2012, vii). According to the Department of Mines and Petroleum, Western Australia contains approximately 280 trillion cubic feet of potential shale and tight gas reserves and so to extract such vast reserves, could potentially see the expansion of 25 000 wells across the Mid West and up to 100 000 wells in the Kimberley region (Clean Water Healthy Land, 2013).

This brings into question who will pay for the infrastructure required by the industry such as roads and their upkeep, and any clean up costs once the industry has closed off their wells and left the site. Will these costs fall back on the taxpayer and if so, why should this burden be placed on the state if we are not essentially benefitting financially from this industry?

2.2. Additionally, the loss of carbon sequestering woodland and bushland cleared for the development of the drill sites, pipes, gas field infrastructure and roads must be considered. So too the ecological effects and impacts on biodiversity which have already proven to be of little interest to the industry and associated bodies such as the Department of Mines and Petroleum who are currently the key regulators of the industry. This has been proven in the drilling of a well in Lake Logue Nature Reserve despite the significance of biodiversity in the area and the importance of the region for bird migration (Department of Environment and Conservation 2008, 2). This constant prioritizing of the oil and gas industry over all else is of extreme concern to say the least. For this issue to be addressed, Western Australian law must be changed as it currently allows gas fracking companies to frack in nature reserves and other areas of conservation. Once the industry has developed these areas, they will be permanently altered; no amount of 'rehabilitation' will be able to totally restore ecologically sensitive areas, remove the toxins that can contaminate sites and waterways or restore water sources.

2.3. The unconventional gas industry also threatens water sources through contamination of groundwater aquifers and surface water through the drilling process, through well-casing failure (discussed further in the 'Recommendation' section) as well as via waste water ponds, particularly in flood-prone regions of the state. For example, an unconventional gas well has been drilled in Lake Logue Nature Reserve despite it being a floodplain (Department of Environment and Conservation 2008, 5). This clearly defies logic, bringing high risk to this ecologically significant and delicate region and part of our wildflower country (CCWA 2012). Changing rainfall patterns should then also be taken on board, given that climate change projections indicate increasing rainfall in the north of Western Australia. With increased flooding, how will contamination of land and water be avoided at well sites and via overflowing wastewater ponds?

2.4. Furthermore, social, ethical and visual concerns have not been addressed in the terms of reference and also have impacts on land use. Impacts upon real estate must be considered, given the lack of rights for private land owners. Also, social effects of another short term industry with an increase in FIFO workers disrupting local communities and driving up local rental prices. Such points raise ethical concerns, whereby priorities of a short term destructive industry are put ahead of the longevity, health and sustainability of local industries, communities, environment and the global community.

3. Indigenous land rights

3.1. Many of WA's waterways that are potentially affected by fracking are sacred sites for the indigenous peoples of Western Australia. The Blackwood River (Goode) and the Fitzroy River are major dreaming sites associated with mythical water snakes, or Rainbow Serpents (Toussaint et al. 2001).

No Fracking WAy has also been informed directly by Yinggarda traditional owners that both the Gascoyne River and the Kennedy Range are sacred sites. Placing wants of a temporary industry with permanent detrimental impacts ahead of the culture and rights of indigenous Australians who have inhabited this land for tens of thousands of years is not acceptable.

3.2. The Martu people are also fighting the Toro uranium mine. Imposing the invasion of the fracking industry on their land as well is socially unjust.

3.3. Under Native Title legislation, Aboriginal land owners have the right to negotiate with mining and petroleum companies, but ultimately do not have the legal right to stop them. However, Aboriginal sovereignty has never been ceded, and therefore must be respected, irrespective of what Australian law states.

4. Agriculture

4.1. The impacts of the unconventional gas industry on agriculture in WA must also be considered. With increasing strains on agriculture in the state, competition for land use with a toxic industry is a growing concern farmers, and those of us benefitting from their produce, do not need. Additionally, this competition is unjust as landowners, under Western Australian law, cannot stop the unconventional gas industry from accessing their land irrespective of how long the land has been in their family or how well they have cared for the land. The fracking industry is putting families, communities, land, agricultural produce, livestock and water at great risk of contamination from the chemicals used in the fracking process and potentially exposing them to naturally occurring volatile organic compounds dislodged from within the geological formations in the fracking process as well as risking ill health from localised emissions.

According to the PGER Act, private landowners have no right to object to exploration or development of unconventional gas resources on their private land, hence, the risk this industry places on food security. The PGER Act sets out an entirely separate tenement regime for petroleum exploration and production than that used for coal mining or the mining of other subsurface minerals under the *Mining Act*1978 (WA). This preferential treatment to petroleum companies places their interests ahead of the needs of citizens of the state, ahead of essential industries like agriculture and ahead of more long-term, sustainable industries.

Furthermore, land owners should have their rights clearly spelled out by companies involved, local councils and government, so that any bully tactics from industry or their representatives or threats regarding confidentiality contracts can be put into perspective. Phrases such as ’minimal impact’, or ‘minor adverse effects’ should be clearly defined and associated risks of the industry made clear, without industry or associated government department bias. Moreover, once written approval to an activity is given, currently those persons can be no longer considered as ‘affected persons.’ This undermines the rights, safety and potential compensation for affected parties.

4.2. Access to clean water is essential for a sustainable, productive agricultural industry. The unconventional gas industry clearly threatens this essential state resource. Not only does each well require approximately 30 million litres of water, but this water is sourced from groundwater aquifers, which places further pressure on already strained state water supplies (CCWA 2012a, 2).

4.3. The fracturing of the target formation releases not only the sought after methane gas, but many other organic compounds that have been safely locked in the rocks for aeons. Whilst in WA, the highly toxic and carcinogenic BTEX chemicals have reportedly been banned from the chemical injection fluids, they nevertheless are naturally occurring within the rock. Once fracked, the surface area of the rock is multiplied many times. This means that these chemicals and chemical compounds are much more readily available to contaminate whatever they come in contact with, for example, ground and surface water. Anywhere from 10 to 80% of the injected water and fracking chemicals now mixed with the many other organic compounds returns to the surface, risking contamination at various points throughout the process (DMP 2013a, 3). Hence, WA farms, farmers, local communities and drill site staff are placed at high risk.

5. Tourism

5.1. Given the vast reserves of unconventional gas in Western Australia totalling 280 trillion cubic feet, and exploration tenements for the extraction of this gas covering an extensive area of the state, it is inevitable that the expansion of this industry will negatively impact tourism in WA, noting that tourism is a far more long-term and sustainable industry than the unconventional gas industry. These leases cover the state's iconic Kimberley (Canning Basin), Coral Coast (Carnarvon Basin) and Midwest and South West (Perth Basin). One such example is Empire Oil & Gas' plans to drill within and around the Ningaloo Coast's World Heritage boundaries (MacQuarie Capital 2013). Hence, the unconventional gas industry is a direct threat to tourism in WA.

b) the regulation of chemicals used in the hydraulic fracturing process;

6. Naturally occurring toxic and radioactive substances

6.1. Firstly, this point of reference should not be restricted to chemicals used in the hydraulic fracturing process but also consider naturally occurring substances located within the shale and tight sands which are mobilized during the fracking process, many of which are highly toxic even at very low concentrations (i.e parts per billion). These substances may include lead, arsenic, barium, chromium, benzene, uranium, radium, radon and sodium chloride (Hydrofracking Study Committee 2012, 43).

6.2. Naturally Occurring Radioactive Materials (NORMs) must also be considered along with Technologically Enhanced Naturally Occurring Radioactive Materials (TENORMs) – where NORMs have been concentrated and so their radioactivity increased through industrial processes such as gas production and particularly where drilling fluid is reused (Hydrofracking Study Committee 2012, 44). Hence, the slurry that remains after hydraulic fracturing wastewater has evaporated and the well cuttings can be highly radioactive (Hydrofracking Study Committee 2012, 44-46). The disposal of this waste and its regulation is therefore of great concern and high risk.

6.3. Additionally, the compound 4-nitroquinolone-1-oxide (4-NQO), an extremely potent carcinogen, has been consistently encountered in flowback fluids from the Marcellus shale gas wells, even though it is not known to occur naturally nor is it claimed to be used in hydraulic fracturing fluids. It can be surmised then that reactions occur in the fracking process that are unpredictable and clearly a very high risk (Hydrofracking Study Committee 2012, 43-44). If this industry is to continue in Western Australia, these reactions are obviously difficult to predict or monitor and therefore difficult to regulate and so contribute to the highly hazardous nature of the industry.

6.4 (Busby 2013) reported that among the most concerning of the released materials are part of the uranium chain; Naturally Occurring Radioactive Material (NORMs).

Human activities such as gas exploration can expose people to this ionising radiation. Notably Radium 226 is one of those released. When this reaches air, it becomes radon gas. This has been detected in greater quantities around gas fields and is highly carcinogenic.

Reference :Fracking the Earth: Fracking has grave radiation risksfew talk about
Scientific Secretary of European Commission on Radiation risks **(28 August 2013)**
Busby C

"Once you have a release of fracking fluid into the environment you end up with a radioactive legacy." (Vengosh 2016)

Reference: A critical review of the risk to water resources from unconventional shale gas development and hydraulic fracturing in The United States.
Environmental Science and Technology vol.48 issue 5 pp 36-52
Vengosh H A. Jackson R B. Warner N. Darrah T H. Kondash A. (2014)

7. Who will do the regulating?

7.1. Currently the Department of Mines and Petroleum (DMP) is the key regulator of the unconventional gas industry, as well as the industry itself. Here lies a clear conflict of interest. The DMP has a questionable role in this responsibility firstly in the broader sense, as it is a department which is focused on mining, not on environmental well-being and related social and health issues and so should not be solely responsible for the regulation of the chemicals used in hydraulic fracturing, nor any other aspect of the industry and its processes. An independent body is necessary for providing such functions with the capacity to fulfill all necessary obligations. Furthermore, Mr Bill Tinapple, a former DMP Executive Director, was described by a chairperson of CSIRO at a public lecture as being a fervent advocate of unconventional gas mining in Western Australia. This is in itself a real conflict of interest, leading to poor and biased decision making within a department with a large influence on government policy and a large influence on the outcomes of a hazardous industry. It excludes fair and open public debate on this matter and disregards the many legitimate community concerns.

7.2. Furthermore, the Environmental Protection Authority of Western Australia (EPA), which in theory, is an independent environmental assessment body, is yet to step in to fully assess the risks this industry poses. From the issues raised in this submission, it is clear even one well has the potential to cause serious and irreversible damage, however the EPA has left regulation in the hands of the DMP due to their memorandum of understanding. At what stage is the EPA willing to step in, if at all? Full disclosure of conflicts of interest should be mandatory before appointments are made, and not incidentally discovered later by the investigation from those with counter interests.

7.3. It is therefore required that a truly independent body be involved in the full assessment of the unconventional gas industry and in its regulation. Short and long term risks across all spectrums must be incorporated. This includes local impacts, for example, on site workers, farmers, local communities and also regionally due to potential contamination of land, air, agricultural produce and water. Global impacts must also be fully assessed and regulated as it is clear from this submission that impacts of the industry do not stop at our state or national border.

7.4. Lastly, as stated in many studies into the impacts of hydraulic fracturing for unconventional gas, many of the chemicals used in fracking and associated processes and products are known toxins, allergens, mutagens, and carcinogens and therefore no amount of regulation will be sufficient to eliminate such high risk from the industry, its procedures and follow on effects.

8. Risks of contaminating groundwater and surface water

8.1. As stated by Doctors for the Environment (DEA) member Dr. Marion Carey, "the chemical additives used in fraccing, their degradation products, and compounds mobilised from sediments during the process can pose a risk to animal and human health by contaminating water used for drinking, washing, stock watering and food production. These can include toxic, allergenic, mutagenic and carcinogenic substances as well as methane" (Carey 2012, 28-29). It is evident that the current regulatory framework of chemical use in fracking in WA is insufficient as it is yet to be proven that the chemicals used in the process are safe, that naturally occurring compounds in shale and tight sands mobilized in the fracking process can be controlled or that reactions between the fracking fluids and naturally occurring compounds can be predicted or controlled. Nor can it be guaranteed that these chemicals won't leak, migrate or leach into groundwater and surface water through the many avenues possible, such as well casings, well heads and wastewater ponds. It also cannot be guaranteed that evaporation of waste water, venting or flaring of methane will not have adverse effects. Hence, the precautionary principle must be embraced before we see the potential disasters of this industry eventuating.

8.2. In addition to impacts on human health, "animals have also suffered health effects from fracking chemicals, both from well water contamination and surface spills into ponds and pastures. Veterinarians from Cornell documented cases of contamination and animal owner health impacts in six states where hydraulic fracturing is taking place (Bamberger & Oswald, 2012). They found incidents of a vast range of dermatological, neurological, gastrointestinal, immunological and reproductive problems in both humans and animals, wild and domestic. Several incidents involving livestock are extremely alarming. In one case, the death of 17 cows within one hour occurred when a worker shut down a chemical blender, releasing fracturing fluids into an adjacent pasture. In another case, a defective valve on a fluid tank caused hundreds of barrels of fracking fluid to leak into a pasture exposing goats, which had reproductive problems for the next two years. In a third, a blowout released fluids into a pond and pasture where bred cows were grazing. When the cows gave birth, most had stillborn calves with congenital defects. (p. 59) These incidents beg the question – what will the indirect impact be on unsuspecting people who consume meat, eggs, or milk from animals exposed directly or indirectly to fracking contaminants?" "Without rigorous scientific studies, the gas drilling boom sweeping the world will remain an uncontrolled health experiment on an enormous scale. 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" (Hydrofracking Study Committee 2012, 52).

8.3. See also:

Unconventional gas in Victoria: Potential risks to water and environment. https://www.parliament.vic.gov.au/images/stories/committees/SCEP/GAS/Transcripts/Currell_Pres_22_July.pdf

c) the use of ground water in the hydraulic fracturing process and the potential for recycling of ground water;

9. Quantity of groundwater required and risks

9.1. The quantity of water used in hydraulic fracturing processes for extracting unconventional gas has already been discussed in section A 4.2. Australia is the world's driest populated continent. It is also the fastest drying continent in the world. We derive approximately two thirds of our water for residential and agricultural use from groundwater sources. It is therefore imperative that we protect our groundwater resources to fulfill that most basic human need and right. If we choose to waste millions of litres of fresh water through hydraulic fracturing, we fail to uphold our responsibilities to current and future generations.

9.2. In Western Australia water wastage is particularly serious because areas where fracking companies intend to operate are areas where the water supply is already under stress. The Midwest is so dry that farmers rely completely on groundwater to irrigate their crops, not on rain. When No Fracking WAy members visited Carnarvon earlier this year, we learned that farmers are well aware of water scarcity issues, and carefully manage their own usage through a water co-op. In the Southwest the water levels in underground cave systems are visibly dropping.

9.3. Ground water contaminated through the fracking process, through the addition of chemicals or through the release of compounds from shale or tight sand formations, cannot be safely reintegrated into the water cycle. It is not yet possible to remove all chemicals and toxic or radioactive compounds from water contaminated by fracking. Instead, the industry leaves waste-water to evaporate in containment ponds. This is a waste of water, and leaves behind a toxic residue.

9.4. The fracking process also risks contamination of aquifers, either through well casing failure or through the migration of contaminated water into aquifers through underground fault systems. Geologists still cannot map underground fault systems completely, even “the very best 3D seismic survey data cannot find all faults, in fact, about 20% of all minor fault systems are not detected by seismic survey” (CCWA 2012a, 3). The majority of toxic chemicals used in fracking have not been tested for safety and so pose a direct threat to our ground water resources (CCWA 2012a, 2). As discussed in section 6, fracking also brings up dangerous substances that are naturally occurring in shale and tight sand formations such as NORMS, BTEX chemicals and heavy metals. The risk of these chemicals contaminating our ground water is clearly unacceptable.

10. Recycling ground water

10.1. In some areas of the United States, waste water from the hydraulic fracturing of shale is treated and reused for further fracking. This is publicized as a “sustainable” fracking method because it does not use fresh water. However, it still poses environmental and health risks. The contaminants removed through treatment presumably still have to be disposed of. And while some contaminants are removed, the recycled water is not completely purified. It is still pumped down into the rock formation in a contaminated state. Using contaminated water rather than fresh water for fracking may increase the risk of aquifer contamination and concentration of dangerous substances such as radioactive matter (as discussed in 6.2.).

Recycling frack water cannot be considered as “sustainable fracking” because it leaves so many of the risks associated with the process unresolved, such as well casing failure, migration of contaminated water through underground fault systems, fugitive methane emissions, and so forth.

Further, recycling frack water does not resolve the issue of waste water disposal. Presumably, a fracking company can’t keep recycling frack water indefinitely. Every fracking operation has a limited lifespan. Eventually, contaminated water has to be disposed of.

Recycling ground water for fracking is not a sustainable practice. Rather, it is “greenwashing”; a superficial attempt to make the industry appear environmentally friendly. Instead of devising convoluted methods to greenwash fracking, it would be much more sensible to place a moratorium on fracking until it can be proven safe, or better - ban it completely, investing in renewable energy instead.

d) the reclamation (rehabilitation) of land that has been hydraulically fractured.

11. Defining reclamation

Both the words 'reclamation' and 'rehabilitation' need defining more clearly to ensure that full restoration of original vegetation and wildlife habitat occurs.

12. Choosing the site

Broomfield notes that to facilitate ultimate site reclamation, it is necessary to consider this in the initial site selection which should be optimal "to minimise adverse impacts on sensitive receptors" (Broomfield 2012, 144). This is often overlooked by companies, who seek primarily the sites with best potential for good gas flows with the least amount of expenditure.

13. Reclamation plans

Reclamation plans should be required when companies apply for a licence to drill. This means that regulators must assess and determine baseline information regarding the site contours, vegetation, wildlife habitat, land function and water qualities prior to being given a licence to drill (The Parkland Institute 2013). It should not be left up to industry to supply these details.

See also:
LTG Submission to NT Inquiry April 2017
https://frackinginquiry.nt.gov.au/?a=424035

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

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

14. Developer liability

Developer liability for contamination of local water supplies or soil due to drilling pad operations and reclamation efforts must be clearly spelled out. Where landholders are concerned, they should know this before signing any leases or agreements as to what steps will be taken to return the land to its original state (Skousen and Ziemkiewicz 2011). Neither the landholder nor the government (taxpayers) should be liable at any point in time.

15. Careful topsoil removal and storage

Regulators require that topsoil must be removed and conserved for later land re-use: revegetation or re-forestation. Skousen states that at least 2 feet of topsoil be salvaged and placed in a stockpile as part of site preparation, but 4 feet is preferable (Skousen and Ziemkiewicz 2011, 4). The topsoil should be seeded with a vegetation cover if the stockpile is to remain for more than 6 months (Skousen and Ziemkiewicz 2011, 4). The topsoil should be replaced at a similar thickness to its original state. It must be stored safely and away from potentially contaminating operations and substances. The same procedure should occur for pipeline disturbances (Skousen and Ziemkiewicz 2011).

16. Soil compaction

"Heavy mining equipment can result in soil compaction, reducing porosity, water infiltration, root elongation and crop productivity" (Chong 1997). Chong's study examined depths of tillage treatments at 40, 60 and 80 centimetre depths. The researchers found that though early beneficial infiltration effects occurred best at 80 centimetres, all declined over a three year period. Land that cannot infiltrate water is unlikely to be hospitable for subsequent plant rehabilitation.

17. Removal of mining equipment and well abandonment

Removal of mining equipment is another area of concern. The waste water ponds must be safely emptied without contamination of the site or surrounding land or water. It must be safely removed to hazardous waste facilities. The lining should also accompany this and not be buried on site, or on convenient nearby land. The underground well structures, though they must be adequately plugged according to strict safety guidelines, remain a threat in the long term. Cement deteriorates over time, and the wells which go deep into the ground and through aquifer systems, can and will corrode. This would both connect below levels of strata with the aquifers, and pose serious risks of contamination, both of the aquifers and the surface level soil and structures. These issues pose a serious problem in Western Australia, where the Department of Mines and Petroleum monitors abandoned well integrity for only a period of 2 years. To what extent this monitoring consists of for each well is also not guaranteed nor likely to be sufficient given the long term potential threats that abandoned wells pose. As discussed further in the 'recommendations' section, well integrity after well closure is an important issue as well casings, which consist of cement and steel, can and will corrode over time, leaving an underground time bomb for those not responsible for the mess, to deal with and suffer the consequences from. Thus, when contamination occurs down the track, possibly even away from the original well site, traceability of the source of contamination, and any remediation will be either seriously hampered, too expensive or impossible to carry out.

18. Feasibility of restoration

Broomfield questions whether full restoration of sensitive ecological sites and archaeological sites is possible for hydraulic fracturing unconventional gas well projects (Broomfield 2012). When one looks at the potential extent of shale and tight gas mining activities across the state and the very large surface footprint, covering highly sensitive areas of sensitive ecosystems; unique flora; endangered species; habitat loss (especially mature trees); the arid and drought prone nature of much of Western Australia already threatened with significant effects of climate change; the huge amount of water used for the process; the well documented and serious contamination risks to diminishing water supplies; the complex, expensive, and in some cases impossible task of achieving appropriate restoration; serious doubt about the viability of hydraulic fracturing for unconventional gas in this state is posited.

It t appears that roads, houses schools and shopping centres etc. are built on or near abandoned gas wells.
Joyce (June 2016) for Wyoming Public Media reported that an abandoned gas well leaked methane into a school in Wyoming, shutting the school down for months. On closer analysis CO2 and volatile organic compounds were also found to be present.. A second abandoned well was found just behind the playground though not yet leaking.
Reference: <u>Mysterious Gas Leaks In A Town Surrounded by Wells.</u>
Retrieved from: Wyomingpublicmedia.org/post/mysterious-gas-leak-surrounded-wells#strea/O
Joyce. S. Wirfs-Brock J. (14/6/16)

In Investigating oil and gas challenges in Colorado, Finley (2015) found that companies could shut down active wells in response to decreasing prices or oil and gas, which complicated their oversight. In the case of abandoned wells, restoration fell on the state where owners could not be located. This was the case with most of the 83 sites known to the regulator. It was also known that companies do not fully restore the land for years after the cessation of production. Advance planning was seen as crucial requiring management and stewardship of landscapes.
"The state requires oil and gas companies to restore all sites completely-to reduce erosion, loosen compacted soil, prevent dust storms and control invasions of noxious weeds." He reported. However the state didn't set a timetable or time period for companies to complete the required work.

Reference: Colorado land impact of oil and gas boom. Scars spread and stay.
The Denver Post
Finley B. (28.2.15)

Joyce, (Feb.2016) reported that Colorado had more than 35,000 abandoned wells, and Wyoming
had more than 50,000. Once plugged with cement, there was no systematic monitoring for leaks. Some of the plugged wells were 'super emitters' of methane. After the wells were cut off below the ground and plugged, there was often no surface indicator as to the well locations. They could be under roads, driveways and even houses. A slow leak into a building could be an explosion hazard.
Reference: Living on top of forgotten oil and gas well
Inside Energy
Joyce S .(9.2.16)
On National Public Radio US`, 5Joyce S. (19.10.15) reports that in Wyoming, and many other US states, a bond is paid by the companies before drilling starts, in case of bankruptcy or abandonment. In Wyoming it cost the state US$11 million to plug orphaned wells between1997 and 2014 but only 3 million US was covered by bonds.
Reference: Abandoned wells The Rising Cost Of Cleaning Up After Oil And Gas.
Inside Energy **Joyce. S. Wirfs-Brock J. (1 Oct.15)**
retrieved from: insideenergy.org/2015/10/01/the-rising-cost-of-cleaning-up-after-oil-and-gas/

Recommendations

19. Terms of reference

Importantly, the terms of reference for this inquiry are far too restrictive. Broader terms of reference are necessary in order to fully assess the implications for Western Australia of hydraulic fracturing for unconventional gas. Additionally, impacts of this industry and its processes that occur outside of the state of Western Australia must also be addressed (for example global impacts from contributions of unconventional gas extraction to climate change).

20. Precautionary principle and cumulative risk

The precautionary principle and prevention principle must be engaged, particularly due to the high risk nature of this industry, as stated in the European Commission report into the potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing (Broomfield 2012). In this sense, cumulative risks and impacts must also be assessed especially due the intended expansion of the industry. Obviously with increasing expansion of hydraulic fracturing comes increased chance if accidents, connection of underground fractures and so also increasing rates of migration of fluids and gases thus increasing risks and detrimental impacts.

21. Well casings

Another point which must be considered is in regard to well casings. As the well casings used in unconventional gas extraction consist of steel and cement, both being materials that can and will corrode, even industry claims of 'best practice' do not guarantee well casing security. In fact, operator-wide statistics in Pennsylvania have shown that 6-7% of new wells drilled in the last 3 years have already compromised structural integrity (Clean Water Healthy Land 2013a). Obviously, over time this figure increases as wells corrode and the cement cracks and degrades, thereby allowing the remaining waste water, naturally occurring volatile organic compounds and methane to migrate; the more this industry expands, the more migration will occur (Clean Water Healthy Land 2013a). As stated by Clean Water Healthy Land, in WA we are likely to see tens of thousands of gas wells across one landscape. Only one well of these tens of thousands need critically fail to render an aquifer undrinkable. Once an aquifer is contaminated, it cannot be restored. Well failures with conventional gas wells are common so unconventional gas extraction is even higher risk. Risks can be reduced by using 'best practice' technology, but they can never be eliminated.

In 2016, an inter-disciplinary team led by University of Colorado researchers found methane in 42 water wells in the intensely drilled Denver/Julesberg Basin where high volume horizontal fracking which began in 2010, found that 11 if the 42 wells had already been identified by the State Regulator to suffer from barrier factors
Reference: Denver-Julesberg Basin of Colorado.*proceedings of the National Academy of Sciences 113(30). Doi:10.1073/pnas.1523267113 (2016)*

The international Association of Hydrogeologists in 2015 noted in its submission to the Hawke Inquiry noted the following.

- Annular pathways will form over time as chemical, mechanical and thermal stresses cause deterioration of well structures and component parts
- Stray gas migrating upwards can lead to explosions if not vented properly away from buildings and drinking water wells
- Improperly abandoned wells include the formation of cracks in cement casings of packers, corrosion of steel production casings, faulty valves and leaking temporary plugs or surface caps.
- Improper cement isolation can lead to aquifer contamination

  Reference: Internatioal.Association of Hydrogeologists submission to the Hawke inquiry2015 https://frackinginquiry.nt.gov.au/other-australian-inquiries/2014-northern-territory-inquiry-terms-of-reference?a=389286

Nikiforuk (2014) reported on a University of Waterloo study which claimed Canada had 50,.000 leaky wells. Massive amounts of leakage of methane in the atmosphere like these could impacts on climate change the study reported.

Reference:

- Canada's 500,000"leaky energy wells: Threat to Public
  The Tyee retrieved from
  http://www.thetyee.ca/News/2014/06/05//Canada-Leaky-Energy-Wells
  Nikolforuk A .(June 2014)
  In an informative video, Ingraffea (2016) identifies the extent of well failure which is present even in many new wells, but increases dramatically over time.
  Reference:
- Video. Well Failure. *https://www.youtube.com/watch?y=Dxis-vYGM_M*
  Ingraffea A.R.(2016)

22. Economics

22.1. The economic impacts of the unconventional gas industry must also be assessed. As stated by The Australia Institute, "majority of the economic benefits from these activities [coal and gas mining] are shipped offshore, with 84% of the mining industry foreign-owned. Australia's key non-mining export oriented industries - including manufacturing, tourism and agriculture - are being damaged as a result of the high dollar and skills shortage related to the mining expansion. There are currently no adequate controls to protect Australia and its landscapes from these impacts" (The Australia Institute 2013, 15). Additionally, as discussed earlier in this submission, costs of infrastructure, rehabilitation (if it's at all possible) and so forth will be born of the state, not those responsible.
22.2. Furthermore, at least 80% of the coal and gas reserves owned by fossil fuel companies will be 'unburnable' if the global goal of keeping global warming to below 2 degree Celsius is to be met. And this is a generous figure. Given that a global rise of 0.8 degrees has already created detrimental impacts across the world, obviously even a 2 degree rise is too much. Fossil fuel companies are budgeting on these reserves which are still in the ground, but will not be able to be extracted if addressing climate change is to be taken seriously. Investments in these industries rest upon a "speculative bubble that ignores their impact on global carbon budgets and their exposure to rapid devaluation" (The Climate Institute 2013).

23. Insufficient regulation and misleading information

23.1. As taken from the Clean Water Healthy Land website, "As stated by the previous Minister for the Environment, Hon. Bill Marmion it remains the State Government's preference that the environmental impacts of shale gas fracking are regulated by the Department of Mines and Petroleum (DMP)".

"In 2011, the DMP commissioned an independent expert (Dr. Tina Hunter) to review its regulatory arrangements for gas fracking in WA, which falls under the Petroleum and Geothermal Resources Act. In her report, Dr. Hunter concluded that "there are no legal provisions in the [petroleum] Act that specifically pertains to the management of the environment in onshore petroleum activities."

"Dr. Hunter identified DMP's requirement for proponents to develop 'Environmental Management Plans' (EMP) as a measure to manage environmental impact, however she also noted that "under the current legislative framework the EMP is legally unenforceable."

"While some improvements have been made since this report, the fundamental failures noted by Dr. Tina Hunter have not been rectified. As a consequence the WA community cannot have confidence in the regulatory regime currently in place for shale gas fracking in WA".

23.2. The flow of misleading information released by the industry and associated bodies such as the Australian Petroleum Production and Exploration Association (APPEA) must also be considered and of course rectified. Startlingly, much of this messaging is also repeated by the DMP, a governmental body that theoretically is meant to be acting in the state's best interest (that is, the citizens of the state). However, individuals and communities are being led to believe this industry is safe, such as in publications by APPEA stating that most chemicals used in fracking and associated processes can be found in common household products and therefore are no threat. As stated by the DEA, while we may have antifreeze in our cupboards, or household cleaners, it doesn't mean they are safe to drink and many of the chemicals used in fracking fluids or mobilized in the fracking process are highly toxic at even minute quantities (Doctors for the Environment 2012, 5). Organisations (such as APPEA) and particularly government departments and representatives must be held to account for providing misleading information, implying that the processes involved in hydraulic fracturing for unconventional gas and its direct and indirect impacts are benign, when they are clearly anything but.

24. Renewable energy

Lastly, Western Australia does not need unconventional gas for domestic use. The majority of the unconventional gas intended for extraction in WA is for export to Asia - its more favourable market. Our state energy demands can be easily met with renewable energy sources as extensively researched by organisations such Sustainable Energy Now (study into the South West Interconnected System) and Beyond Zero Emissions (see reference list for reports on both). We currently have sufficient resources to enable the state to comfortably transition to 100% renewable sources for stationary energy including wind power and concentrated solar thermal. Additionally, renewable energy provides the added benefit of safer jobs for Western Australians.

For all of the reasons discussed in this submission, individually and cumulatively, No Fracking WAy demands a ban on unconventional gas mining (including, but not limited to, extraction methods such as hydraulic fracturing) in Western Australia, and worldwide. There is sufficient evidence worldwide to prove why this industry is too high a risk and the changing climate doesn't allow us the time to continue taking such risks and sourcing ever more energy intensive, high risk energy sources when renewable sources are abundant and the technology readily available.

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