Submission to

PARLIAMENT OF SOUTH AUSTRALIA NATURAL RESOURCES COMMITTEE

Inquiry into: Unconventional Gas (Fracking)

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From Heather Gibbons, [redacted])

Contents

Introduction

Water is the most essential resource we have and underpins everything done by the citizens of the Limestone Coast. The precautionary principle needs to be in place to ensure there is NO risk to our magnificent water supply from the use of toxic chemicals used in gas drilling and fracking. The nature of our geology, having invasive gas drilling operations industrialising our beautiful country, and knowing that one mistake that leads to water contamination can put everything as we know it today at risk for tens of thousands of people now, and for generations to come, forever, to me, is illogical. If our aquifer system becomes polluted, it will devastate our region and our state.

The true meaning of democracy, 'government of the people for the people by the people', needs to stand strong. The government represents the ordinary citizens and not big companies, which can bear pressure on people and offer large financial handouts to political parties. I need to see real transparency in every action, at every stage. I want to know this Inquiry is not just another consultation-type process to be gone through the motions but ignored. I want to see DMITRE not being a promoter and regulator of mining and gas drilling operations.

I have many, many questions. I look at what is happening around the world with fracking and I do not want to be part of this experiment on humanity. Human error and mismanagement, human greed and the lack of respect and care for the land and its people seems to be rife. In SA you have the chance to say NO to this right now. The people of the Limestone Coast have demonstrated clearly that they do not want invasive gas drilling. It is essential that this region, 2.2% of the state, remains as a 'clean and green' productive food bowl with its world reknown wine industry. Let's continue to feed our own people and continue valuable export markets.

As a citizen of this area, having been raised on a farm here, I am standing up to have my voice heard to save the land I love from a short term industry that a government, who seems to have lost its real connection with the land, wants to foist upon people like me. We need political leaders with vision for the future for the people they represent. Leave fossil fuels and the power of these companies in the twentieth century and lead us in the twenty-first century to be world leaders in renewable energy where everyone wins and we keep our resources clean and green.

1) The risks of groundwater contamination

WATER AVAILABILITY

1) Water security:

- No one, no group, should be given the authority to put at risk the essential water resources of a region. Water security is the most important issue world- wide. We in the Limestone Coast are extremely fortunate to have a reliable underground water resource.
- Water is the basis of life for all people and animals in the Limestone Coast. Without it, no landholder, business, household or township will function as it does today. Without clean water, schools and hospitals do not function. Without clean water there is no 'clean and green' image for our landholders and there would no longer be an attraction to this area for tourists. Who would want to holiday in a gas field? Water is essential in all our homes and is used for drinking, washing, cleaning and cooking. Would you want to live in or next to a gasfield?
- At present we have learnt we must allocate the underground water, which is carefully monitored for sustainability for all generations. There are groups, who know the value of water, working towards water security eg. SE Water Management Board has worked on the Lower Limestone Coast Water Allocation Plan & recognises that water is the life-blood of our diverse & very productive region. In 2014 SA Water drilled new wells for future water security for local towns eg. Naracoorte & Robe. (Also be aware that in the Upper South East, the cost of mains water from the River Murray has quadrupled for producers who source water from the Tailem Bend to Keith pipeline. (from 'From the Ground Up').
- If the aquifers in the region were contaminated, from where would we get our water? To think of using bottled water or water from the Murray River is totally unsustainable (think of the recent drought). We also do not know the ramifications of invasive gas and mining industries in the headwaters of the Murray-Darling system. Who would pay this cost to reimburse the people if our water was contaminated? It would be cost prohibitive for the state government.
- To risk contaminating the amazing water resource we already have is unthinkable and truly not in the best interests of the people of this region. Using the precautionary principle is essential.

2) Quantity of water

- Fracking requires enormous amounts of water.
- From where does the gas drilling industry get their water? From which aquifer?
- How can the gas drilling industry get an allocation when the water is already fully allocated? Are they allowed a water allocation over other businesses? Do the established businesses thus have water cutbacks? If so, this is very unfair, very wrong.
- Does this industry pay for their water use?

3) Sensitivity of the aquifers:

- Are there any comprehensive 3-D maps of aquifers in the Limestone Coast and the rest of the Otway Basin showing not only their position but links between them? What is the inter-relationship between the aquifers and the surrounding rock strata? Are the intricacies of our underground water system fully understood?
- Where is the independent baseline data about our underground water and how the water flows and interconnects with other systems? What is the real level of scientific understanding of how the aquifers link, the effects of large water-consuming businesses on water tables eg. blue gum forests have caused issues- and so does drought. (In 2006 there was no recharge of any aquifer in the whole of the South East of SA). What are the links between saline bores and bores with good quality water- both inland and nearer the sea?
- If you take too much water out, what is the impact in our limestone region re the Blue Lake, caves, sinkholes, Piccaninnie Ponds, water for stock and other production and town supplies etc? What about the issue of sea water intrusion, which is already being monitored in our region. There is evidence of a direct hydraulic connection of the Dilwyn aquifer to the sea in the form of tidal pressure effects. There has been seawater intrusion in the Donavan's area south of Mount Gambier. Here there was an over allocation of bore water that allowed seawater intrusion to occur. Bores had to be capped to stop this. What might happen with the multiplication effect of hundreds or even thousands of gas wells**?** Who is going to pay the cost for checking thousands of hydrology holes if seawater intrusion is occurring due to fracking activities? Do you get seawater out of an aquifer once it gets in? A document recently released is called 'Preliminary Investigation Of Seawater Intrusion Into A Freshwater Coastal Aquifer: Lower South---East, September 2012. This remains a risk and is of major concern for unconventional gas exploration and drilling.
- Australian geologist Ian Lewis has reported that the dry conditions & a stable water table in & around Mt Gambier are the only things keeping these caves from collapsing (Sunday Night Sink Holes in Australia 27 May 2014). Subsidence already occurs in our region with sinkholes suddenly appearing in football fields, near roads, on farmland and in backyards. We like to

think our country is stable but Mother Nature is very complex and little understood. We do not want to increase this problem by man-made activities. In Victoria, for example, it has been stated that "Potential land subsidence along the Gippsland coast is caused by fluid (oil, gas and water) extraction form the Latrobe Aquifer. Findings of recent studies by CSIRO and the Department of Primary Industries have been summarised as part of this study….." (p4-5 Climate Change, Sea Level Rise and Coastal Subsidence along the Gippsland Coast: Implications for geomorphological features, natural values and physical assets www.gcb.vic.gov.au/staging/wp-content/uploads/2014/04/sealevelrisephase-2-2008t.pdf)

- The sensitivity of the aquifers in this region is of great concern with unconventional gas drilling and fracking. In the 1980s Western Mining Co. explored for a lignite deposit on the Nulty property near Kingston. Pumping tests performed by Western Mining Co. in 1982 significantly interfered with the artesian water in the area, particularly the confined Dilwyn aquifer. Problems included a large drop in pressure heads of bores several kilometres away, which ceased flowing & very slow pressure head recovery & salt was released from the sub-aquifers into the potable confined aquifer. DMITRE filled this collapsing well. (from Deb Nulty's article in the SE Coastal Leader April 2, 2014)
- Another concern is 'artificial leakage' from one aquifer to another. According to the government document 'South Australia – Victoria Border Zone Ground Water Investigation: Results of Pumping Test Program' 2011/23, "Vertical flow between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer is likely to be significant, however this is not well understood." '....the rate of vertical recharge could not be quantified.' Therefore, regardless of where unconventional/or conventional gas projects take place in any part of the Limestone Coast, how can any modelling for water be accurate? Given these facts, it is impossible to clean up an aquifer once it is contaminated, as the contamination may spread quickly through the vertical leakage to the other aquifer, with the potential to affect the water supply for the whole region.
- When we tamper with the complexity of our natural water systems, we cannot know what real consequences there may be. A real understanding of how our water works, is essential, but do we have it? We need the big picture detail, which will be very complex. Zero risk for water security is essential to sustain water availability to all for generations to come.

WELL INTEGRITY

1) Earthquake Region

- The Limestone Coast is an active EARTHQUAKE region in South Australia. There was a large earthquake that hit the region in 1897 (6.5 on the Richter scale) and was felt throughout the

whole region, causing massive damage to Beachport, Robe and Kingston and even caused minor damage in Adelaide. (from http://en.wikipedia.org/wiki/List_of_earthquakes_in_Australia; http://www.pir.sa.gov.au/minerals/earthquakes/major_earthquakes_in_south_australia) There was liquefaction at these three coastal towns, sand volcanoes and water spouts. (http://www.ga.gov.au/scientific-topics/hazards/earthquake/basics/historic#heading-17) There is a probability of future earthquakes. What is the impact of an earthquake and its aftershocks on well casings in a 4km deep drilling well? Will fracking create more earthquakes in our area?

- Have SA earthquake faults been mapped extensively? Are there 2-D and 3-D maps of **all** fault lines across the Limestone Coast?
- Why have the companies been allowed to drill through fault lines near Penola? Is the impact of that fully understood? When the next earthquake occurs will these new man-made pathways be broken and cause leakage and contamination issues? Earthquakes and fault lines are potentially great pathways for contamination. No-one can control what is happening underground.
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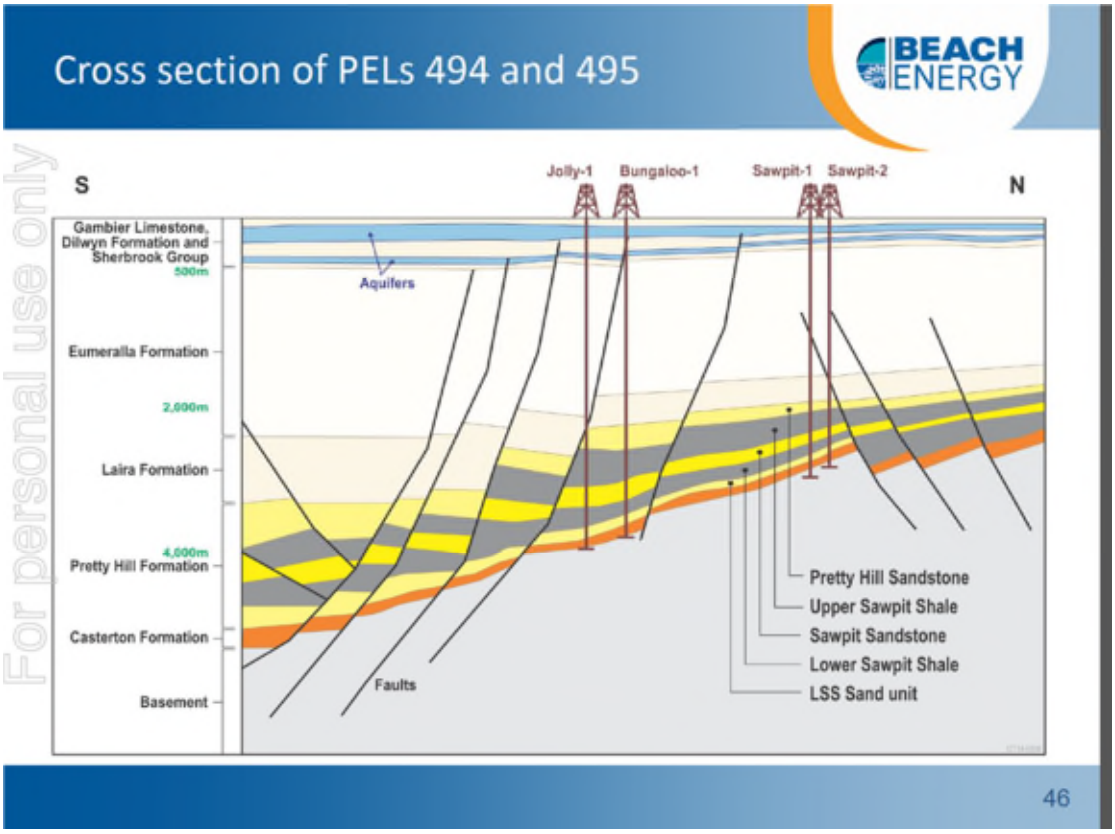

- Was the drilling issue at Jolly 1 because of the fault line?
- Does the Bungaloo 1 drill hole go through a fault line, which goes into the aquifer? If this is so, wouldn't the impact of a future earthquake be devastating to the region's aquifer? Then if you frack the well, will this cause problems such as more earthquakes in an active

earthquake zone?

- According to the Roadmap for Unconventional Gas Projects in South Australia, under the heading of 'Shale Gas Play in the Otway Basin' (p55), it states that '*complex faulting from rift tectonics could be advantageous for unconventional gas through enhancement of natural fracture networks that would improve connection with, and drainage of, the rock matrix'.* I would have thought this faulting would be of major concern in relation to earthquakes, and migration of methane etc. up to the aquifers.
- Methane has migrated up into aquifers, in the Marcellus Shale. "Baldassare says drilling, along with a bad cement job, can cause any gas pocket that has been stable for thousands of years, to start moving. That's because methane, under high pressure, wants to go to an area of lower pressure. " [www.stateimpact.npr.org/Pennsylvania/tag/methane-migration)
- How can anyone be sure that the shale layer has not been fractured by seismic activity at some time in the distant past and thus may pose a risk of leakage of the fracking mix into other rock layers and hence into water bearing or conducting rock. (The shale may be intersected by other porous rock and may be exposed by a fissure produced by the fracking process.)

2) Recent History of Lack of Well Integrity

- The integrity of hydrogeological observation wells associated with drilling can also be an issue. See the hydrology observation drill hole on the Nulty property (unit number 6824-1165 drilled under the permit number 91603) This drill hole was decommissioned in November 2013. (from SE Coastal Leader April 2, 2014) In the 1980s Western Mining Co. explored for a lignite deposit on the Nulty property near Kingston. Thirty years later, there was subsidence alongside of the casing down 20 metres to the unconfined aquifer. Maybe as the water levels dropped in the aquifer, the limestone roof became exposed, leaving a weak spot allowing subsidence to occur. This hydrology drill hole was filled in by DMITRE in 2014. This example shows that even over a few decades well integrity can be an issue. It also shows that abandoned wells are not monitored and showed locals that rehabilitation is legally the responsibility of the present landholder, which is totally unfair. This law needs to be changed.

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Picture of the Nulty's hydrology drill hole.

- SA has only 2 trucks in operation to audit drill holes and wells. How many people are there doing the audits? How are they possibly going to keep track of **all** previous drill holes and wells from the past, let alone new ones? From where does the money come to finance this ongoing and escalating audit system?

3) Steel and Cement

- The Beach Energy Otway Basin South Australia flyer says that their production wells 'are completed with triple steel casing and cement from surface to approximately 500 metres depth. From 500 metres to around 2000 metres, wells are double steel and cement cased. Beyond this, to our target depth, the well is single steel and cement cased. The end result ensures aquifers are isolated by triple steel and cement casing, ensuring no communication between well contents and the aquifers.'
- Ensure means it is certain. That means forever. How long is their 'certain'? Will a triple casing through an aquifer really last longer? We need well integrity forever. Where is the proof that this system is 100% foolproof? If there is any risk at all, gas drilling and fracking should not occur.
- Where is the independent data of well corrosion rates? Salinity is very aggressive to steel and concrete. What about the electrolysis affect, which may make them fail?
- Lifetimes of wells are very short. 6-7% of production wells fail (Fluid Migration Mechanisms due to faulty well design and/or construction: an overview and recent experiences in the Pennsylvannia Marcellus Play by Anthony R Graffea, Ph.D., P.E. October 2012)
- There are issues with the steel. What is the standard of steel and concrete used? Modern steel contains more carbon than steel from the 1950s. It is susceptible to chlorine, carbon dioxide and sulphates. In quality steel the average uniform corrosion rate is one micrometre per year. There is pitting corrosion, which will deteriorate more quickly.

- When fracking occurs, there is huge pressure in the well. What real (not hypothetical) impact does this have if fracked once, or if the well is fracked multiple times?
- Cementing a hole 4 km down is not an ideal environment to do cementing.

CHEMICALS AND WASTE WATER

1) Amount of Chemicals:

- The current method of fracking, which is horizontal, uses water at a high volume and high pressure with chemicals and sand. Many tonnes of chemicals would be used in each well. Have these chemicals been assessed by an independent laboratory for safety with respect to drilling and fracking operations?
- And, how many wells will there be? A document by Frogtech on shale gas commissioned by Vic. and SA government departments, including DEWNR, PIRSA AND SA water, estimated that there will be 3446 shale gas wells in the Otway Basin, most on the South Australian side. I urge you to stop this from happening so this region is not polluted forever more.
- Why is the gas industry able to use tonnes of chemicals, when farmers etc have such strict, (and necessary), controls on chemical use?

2) **Transport Issues:**

- That means there would be many, many truckloads of chemicals and sand coming to a well pad. Accidents can happen on the road. How are these to be dealt with so there is no contamination?
- Who pays for our normal road maintenance when already we have no proper maintenance of country roads? Who pays for the roads the gas companies make?
- Are roads made, owned or controlled totally by the gas drilling company? Does that mean landholders are not able to cross them with stock and machinery at any time they wish? Landholders need to have control of movement on their land.

3) **Spillages and Leaks:**

- Water can easily be contaminated through human error.
- There are chemicals that are used in gas drilling, and also those, which are produced by the gas drilling and fracking process. Spillages at the surface and pollution incidents with waste handling and disposal can occur.
- Will there be gas escaping from pipes, machinery etc into the air?

4) Chemicals and health safety:

- What chemicals would be used in fracking and what are the effects on people's health- as

individual chemicals, and the interaction of a chemical mix? Are the chemicals tested in both contexts? If not, they should be allowed to be used.

- Is BTEX allowed to be used in SA? Is it used in fracking?
- What are health issues for the workers onsite?
- Does our government demand to know all the chemicals used in fracking before companies are allowed to use them in our state? If not, why not? Why are 'proprietary chemicals' which are secret, allowed? No chemicals should be secret as they are going into the environment. The use of all chemicals for drilling and hydraulic fracturing should be prohibited until there is a full independent assessment of the risks they pose to human health and our environment. The lists of chemicals used needs to be totally transparent.

5) Unrecovered toxic chemicals:

- The National Toxics Network website discusses toxic chemicals in the exploration and production of gas and unconventional gas sources (http://www.ntn.org.au/wp/wp-content/uploads/2013/04/UCgas_report-April-2013.pdf). It states the chemical additives in fracking operations amount to large amounts of chemicals being used and up to 40% are not recovered. What happens if an earthquake releases these chemicals upwards to the aquifers and the surface? What unknown, potential pollution is that creating for the future? (remember asbestos and thalidomide!)
- It states that many chemicals have not been assessed for long term impacts, toxicity and how they can change when exposed to natural chemical catalysts eg. radioactive elements. The companies use cancer causing chemicals!
- The drilling muds and flowback, fluid returning to the surface, is also contaminated with heavy metals etc. Methane and air pollution are other issues. Will there be more methane gas escaping into the environment? (methane is a fossil fuel more damaging than coal in terms of total impact.)
- This report shocks me and shows that the health of communities needs to be a high priority. Factoring in the future possible health costs of sick people living near and working in gasfields is essential. Who is liable? - and this may be recognized decades later. The onus of proof that a chemical substance or additive is safe must rest with the proponent to prove. It must not be up to the community to prove that a chemical substance or additive is not safe.

6) Appropriate Assessment:

- Does SA have a detailed Environment (including water) and Health Impact Assessments before a Petroleum Retention Licence (PRL) is issued? Comprehensive baseline data on groundwater, air and soil need to be collected before any gas drilling or hydraulic fracturing

occurs. This should be continued regularly (as recommended by an 'independent scientific committee') and indefinitely. Is this done? If not, why not? Is the gas company responsible for paying for this?

- Known and potential carcinogens, as well as known and potential endocrine disrupting chemicals should not be used. Monitoring must include testing for BTEX, Polyaromatic Hydrocarbons, metals and radionuclides, NORMS and radon gas and other compounds produced by the gas drilling and hydraulic fracturing process. The information needs to be available to the public.
- Who pays for proper, ongoing monitoring costs?

7) Disposal of Contaminated Waste Water:

- Jolly 1 already has shown contaminants from the exploratory well. What are the contaminants in fracking waste water? The water data information for Jolly 1 sump fluid was highly saline (60% as salty as sea water), alkaline pH of 11, and it raised heavy metals such as Barium and Copper, trace amounts of hydrocarbons and phenol. (Some of these are carcinogenic.)
- This contaminated waste water should not be spread on our roads or discharged into streams or the ocean. We do not want it spread on pasture (New Zealand- Taranaki example- http://www.stuff.co.nz/taranaki-daily-news/business/8817459/Fonterra-to-halt-future-landfarm-collections
- We do not want it disposed via underground injection as in Texas and Oklahoma (www.earthworksaction.org; "New Study links Oklahoma earthquakes to fracking': Science Magazine June 2004, www.msnbc.com)
- Salinity of the unconfined aquifer, which underlies much of the Limestone Coast and is the main water supply to most towns in the region, is one of the major factors that already limits water use in the Limestone Coast (www.epa.sa.gov.au) We do not want saline waste water from this industry contaminating our underground water.

8) Holding Ponds:

- Plastic liners on holding ponds deteriorate very quickly . (eg. Salamander-1 well was drilled in the Otway Basin near Nangwarry in the SE of South Australia in 2010 by Panex Geothermal (RAYA Limestone Coast Project). The Stock Journal, a SA statewide paper, published a story on 30th January 2014, with a photo of the muddy tailings and deteriorated plastic lining. This area was cleaned up only after this was published.

The thick layer of drilling mud, which had dried out quickly because of the January heat wave, was taken by an EPA waste transporter, according to the EPA, to an EPA landfill known as Telford's Quarry. There are the risks of accidents whilst transporting contaminated fluids to another site.

- The landfill operator kept the waste separate but has this been disposed of properly yet? Is the EPA landfill giving us 100% security that our aquifers will not be contaminated? Will this have the potential to impact the nearby town water supplies? This shows me that 'best practice' are only words on paper but not actually put into action.
- What happens in the event of flooding? Contaminated water would contaminate the area over which it flowed.
- What **really** happens to the waste water from gas exploration drilling and fracking? Where and how is contaminated water dealt with?

2) The impacts upon landscape

- From where are the huge amounts of water for gas drilling coming? Water in the Limestone Coast is already allocated to agriculture and town supplies. Already towns like Naracoorte and Robe are drilling in 2014 and looking for water for the future. The impact of less water for farming activities would be huge on established businesses that are expecting to last well into the future, not just for a couple of decades.
- If there is no clean water, towns and land production as we see today will no longer exist.
- How will the contaminated water be stored and dealt with? Where will the huge amounts of contaminated water go? How big are proposed holding ponds? Is that big enough when flooding rains occur? What if water overflows from the holding ponds? We do not want massive holding ponds all over the countryside where wildlife can move to and possibly die

from the pollution.

- How is it decontaminated? Is it through evaporation which then leaves behind a toxic sludge? If so what prevents the toxic dust being blown about over surrounding land? What happens with the sludge?
- From where is the sand for fracking being mined? How much impact will that have on roads and land? Who is responsible for maintaining those roads?
- What are all the impacts of many interconnecting roads & pipelines & other infrastructure that will impact on the free movement of the landholder on their land? A landowner needs full control and access of his land so stock and machinery can be moved easily without having to deal with a drilling company.
- Higher truck traffic may cause issues with
    - road safety
    - damage to regional roads and at what cost is the maintenance of road infrastructure to a high standard ? (Already, money is not available for the proper upkeep of regional roads.)
    - spillages of toxic material
    - dust pollution
- Gas drilling is a 24 hour operation that is noisy and is strongly lit up at night. What effect will that have on neighbours?
- The natural landscape will be destroyed where the gas drilling infrastructure will occur. This will not only further impact wildlife but will impact residents, who do not want to live in an industrialised region. Tourists will not want to come either. They come for the natural, peaceful environment, not a smelly, noisy industrialised region.
- Geological impacts are mentioned above and include sinkholes, subsidence and earthquakes.
- What would be the impact on the Blue Lake, and the Piccaninnie Ponds Karst Wetlands (a wetland of international importance) and World Heritage listed Naracoorte Caves?
- The lifetime of wells is short. What happens after the companies leave? eg. rehabilitation of wells, well pads, pipelines and roads? Who pays for these costs?

3) The effectiveness of existing legislation and regulation

- **Examples of failed or unfair legislation**
- "Best Practice' are words written on paper and spoken by department people. I believe it does not exist. Legislation and regulations are not 100% effective within South Australia eg. Plastic liners deteriorate very quickly and that has not been managed well by SA regulators (see above re Salamander-1 well, which was drilled in the Otway Basin near Nangwarry in the SE of South Australia in 2010 by Panex Geothermal (RAYA Limestone Coast Project). (point 8, p11

above)

- Why are companies allocated water for drilling in the Limestone Coast when the water has been fully allocated to agriculture and town supplies?
- How is it that a gas drilling business can come into a region-with exploration and production-and not have to be bound by the rules pertaining to other businesses re water allocation, chemical usage etc?
- All drill holes in the state need to be investigated and audited. The regulator needs to be held accountable for all drill holes and they need to be inspected regularly, aquifer water tested and air quality tested, no matter how long since they were drilled. There are thousands of these drill holes around the state. The Nulty well is an obvious example that this is not being done. A recent audit on Eyre Iron, requested by a group of farmers on Lower Eyre Peninsula has been done revealing that 80% of drill holes inspected by DMITRE are not compliant. But did they inspect **all** the drill holes? Action is required, not words in policies on paper.
- Why are landholders in SA legally responsible for cleaning up a collapsed well on their land?
- There are many other examples within Australia and overseas. It does not lead me to have faith in the 'systems' government departments follow, or pretend to follow. Yes, it makes me very cynical when people are not to be trusted. Eg. AGL recently completed fracking at four CSG test wells just outside Gloucester, but has been vague on the detail of what would happen to the flow-back water from the operation. Hunter Water says in October it refused an application from waste contractor, Transpacific to discharge treated flow-back water from the AGL site. But it says it recently became aware that Transpacific had discharged a prohibited substance into the sewer system from its treatment site on Newcastle's Kooragang Island. The company has since been penalised $30,000 and warned that any further breaches would result in the termination of its commercial agreement with Hunter Water. http://www.abc.net.au/news/2014-12-19/company-fined-for-dumping-csg-fracking-water-from-agl-site-in-n/5978776
- This penalty is a pittance for a large company. I do not want my region to be contaminated at all.

Ideas for the future

1. **Laws:**

- We need to ensure SA laws make fossil fuel companies totally responsible for their actions. That means all baseline data is done. Any risk to water, soil and air contamination means NO to their submission. It means our laws need to stand strong and be enforced to protect the citizens.
- Penalties need to be massive to deter money-hungry companies from damaging the

environment and communities.

- The law needs to be changed so landowners are not responsible for rehabilitating old wells. This is a responsibility of the company involved. What happens when the company no longer exists?
- Currently the government department (DMITRE) approves the licences and is also the regulator and I believe this is a conflict of interest. This needs to change.
- The regulator needs to be able to do its job. That means it needs the finance to have more than 2 trucks to do the work.
- We need a government making laws to encourage sustainable, safe renewable energy sources eg. solar
- Do the different areas of government know what other areas of government are doing? Who is keeping the big picture, the vision for the future?

2. Renewable Energy Focus

- Has the SA Government changed its legislation towards Renewable Energy companies and if so, why?
- How much of government money is put into propping up the fossil fuel industry each year? If this was re-directed to Renewable Energy, it could easily lead Australia in total renewable energy use in the near future. New ideas would be discovered and could be developed in Australia. This would create sustainable and clean energy, and jobs re construction, operation and maintenance of wind and solar 'farms' (and future ideas). Australia could be a world leader.
- SA is already a leader in renewable energy and about 40% of total demand is met through wind and solar. 23% of all SA customers have solar. Victor Harbor does better than the average because their council is progressive. (link http://www.victor.sa.gov.au/solar)
- Gas is a fossil fuel, and any known resource has a short life span with billions of dollars being invested in it. We need to think smart and direct money towards clean, sustainable energy sources for future generations. eg. Circa has received a grant from the SA government to build a pilot plant in this region to produce bio-cellulosic products. A combination of such bio and environmental products in time, plus bio-energy eg using wood residues to co-generate over time will seriously reduce this regions need to rely on the carbon fuel cycle. [http://www.pir.sa.gov.au/pirsa/media_list/forestry/$4.5_million_for_se_forest_industry_projects?SQ_DESIGN_NAME=printer_friendly] Let's think and lead the way with Renewable Energy.
- It is no longer in our best interest to assist a failing fossil fuel industry, which creates so much pollution.

4) The potential net economic outcomes to the region and the rest of the state

What do we value?

- What is the value of our present Limestone Coast productive 'clean and green' agriculture, related businesses, general businesses in towns, which support the local community? Then lets add the value of the people and their homes, holiday homes and the value of tourism to this region. How do you value a whole region of thriving communities?
- What is the projected income from the gas industry? Are they taxed at the same rate as other industries? If not, why not?
- Introduction of wells, pipelines and company road networks will disrupt land usage at what cost to the landholders? Who compensates them?
- Companies often use 'fly in fly out workers, who lose their contact with their families and communities. It also impacts on the infrastructure of the local towns and communities, the businesses and public services. A short term industry with a shifting workforce like this can create new problems eg. mental health issues. What is the cost of social and mental health impacts on the community?
- The gas drilling industry with its high wages can create labour shortages in other existing industries, which may no longer be able to function. What long term impact will that create? How long would the gas industry last- a couple of decades, which is very short term? At the end, where would the unemployed go?

If our water becomes contaminated what is the economic impact? What will be the social and health costs?

- If our water and land become contaminated, the numbers of people in the community will reduce and that flows on and impacts all areas of our communities- local councils, schools, hospitals etc? It could devastate our whole region.
- The impact on invasive gas mining and fracking has the potential to lower property values of landholders involved, their immediate neighbours and the community around them.
- How will this impact local councils and their rate revenue?
- How will this impact landholders re insurance companies and bank loans?
- A National Vendor Declaration is required to be signed when stock are sold so landowners need no contaminants near food production areas otherwise our local and export markets could be lost. The potential impact of gas drilling in a food production area is to lose both local and export markets because of contamination/ fear of contamination.
- How can our SA government, which says it is dedicated to a 'clean and green' image, even think of allowing invasive gas drilling in a food producing region, when producing enough food for the people of the world is a major concern world-wide?

- How much do we value the health of every citizen? If you look world wide, you will see places like New York banning fracking. (New York Public Health Review: http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf)
- What is the cost of contaminating our water and our food chain forever?
- In the future, when the gas companies are all gone and wells are abandoned as is happening already in the USA, who will pay for the monitoring of these wells?

Conclusion

Fracking to produce gas in the Limestone Coast would have major impacts on the Limestone Coast region and its communities. The major issues are the high likelihood of water contamination through well failure, impacts on health through the chemicals used, ineffective regulations and actions to monitor the industry, and the issue of fracking in a seismically active area. Without clean water there could be no society as we know it now- no clean and green agricultural production, which would lead to issues with food security and the breakdown of the sustainable economy of the region and state. No clean town water supplies would impact on every citizen and business and hospitals. Schools would not be able to function without clean water so the whole education system would falter.

Industrialisation of this region could lead to incidents of water contamination through spills and leakages, deterioration of air quality, increased noise, traffic and pollution. It could decrease the value of properties in the industrialised region. If the aquifers became contaminated, this would affect the property values of the whole region. The social impacts could be devastating. There are great risks and short term benefits.

The precautionary principle is essential to make wise decisions for the citizens of this region. Your task is maintain the basic needs of life for the people of this region, not favour big companies, capital gains and political advancement of a few.

Be aware that it is easy to be deceived by so-called scientific evidence. It depends how it is set up, who has done it and for what purpose, and whether all facts have been made evident. Much can be left unsaid and problems may be swept under the carpet rather than acknowledged. What is the real truth? Money is not worth devastating the environment, food and water security, established livelihoods of citizens or the communities of our region or state.

FLUID MIGRATION MECHANISMS DUE TO FAULTY WELL DESIGN AND/OR CONSTRUCTION: AN OVERVIEW AND RECENT EXPERIENCES IN THE PENNSYLVANIA MARCELLUS PLAY

BY

ANTHONY R. INGRAFFEA, PH.D., P.E.

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1.0 INTRODUCTION: LOSS OF WELL STRUCTURAL INTEGRITY

An overall description of mechanisms by which oil and gas wells can develop gas and other fluid leaks can be found in Dusseault *et al.* (2000). These mechanisms can be exacerbated with repeated pressurization of the casing, with open-annulus sections along the casing, and with high gas pressures encountering curing cement or entering such open-hole sections. All of these exacerbating factors lead to more rapid occurrence and upward growth of circumferential fractures, essentially disbonding, in the rock-cement and /or the cement-casing interface.

A schematic depiction of the phenomenon of gas, or additional fluid, migration upwards along a wellbore is presented in Figure 1a, for the simplest case of bypass by disbonding along the surface casing. Figure 2 is a close-up schematic showing other possible fluid pathways. Additional layers of casing and attendant cement interfaces, present in the defective wells in question, do not eliminate these phenomenon; they may, in fact, increase its likelihood. Figure 3 is a snapshot of yet another situation in which an intermediate casing annulus is left un-cemented, but open to a shallow gas source.

These phenomena are not rare in the oil and gas industry. Data on failure rates for cement jobs leading to sustained casing pressure and possible fluid migration into USDW can be found, for example, in Figure 4 from Brufatto *et al.* (2003), who state:

"Since the earliest gas wells, uncontrolled migration of hydrocarbons to the surface has challenged the oil and gas industry…many of today's wells are at risk. Failure to isolate sources of hydrocarbon either early in the well-construction process or long after production begins has resulted in abnormally pressurized casing strings and leaks of gas into zones that would otherwise not be gas bearing".

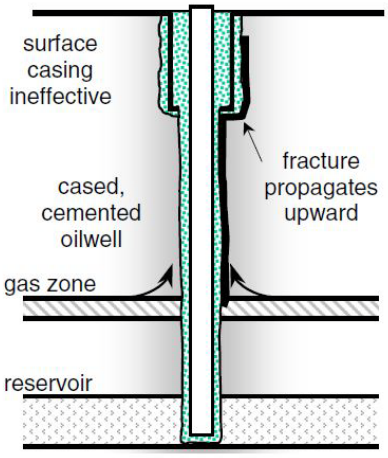


Figure 1. Simplified schematic showing phenomenon of upward gas migration along a casing string. From Dusseault *et al.*, 2000.

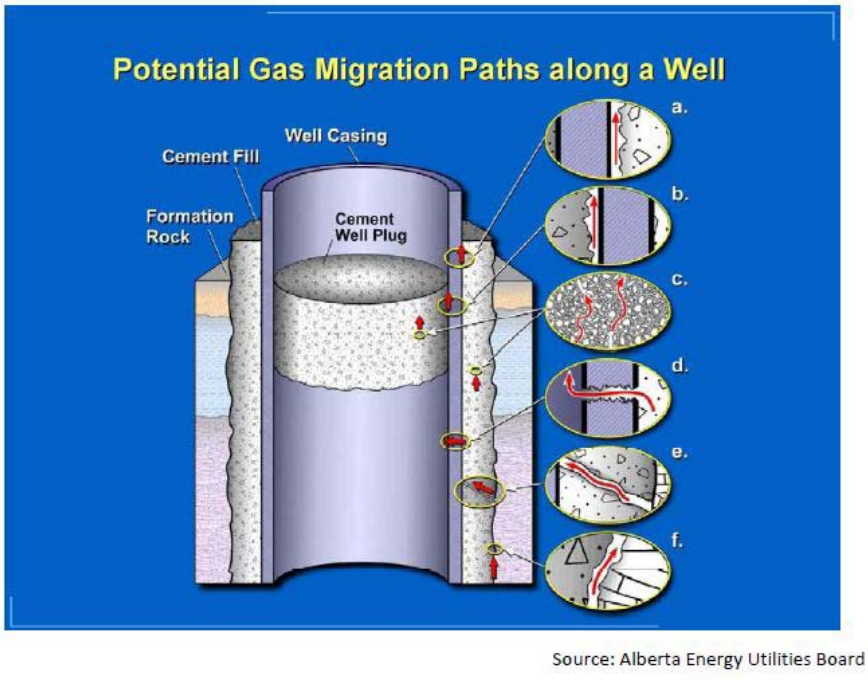


Figure 2. Schematic of details of possible fluid migration paths in and around a cased/cemented well.

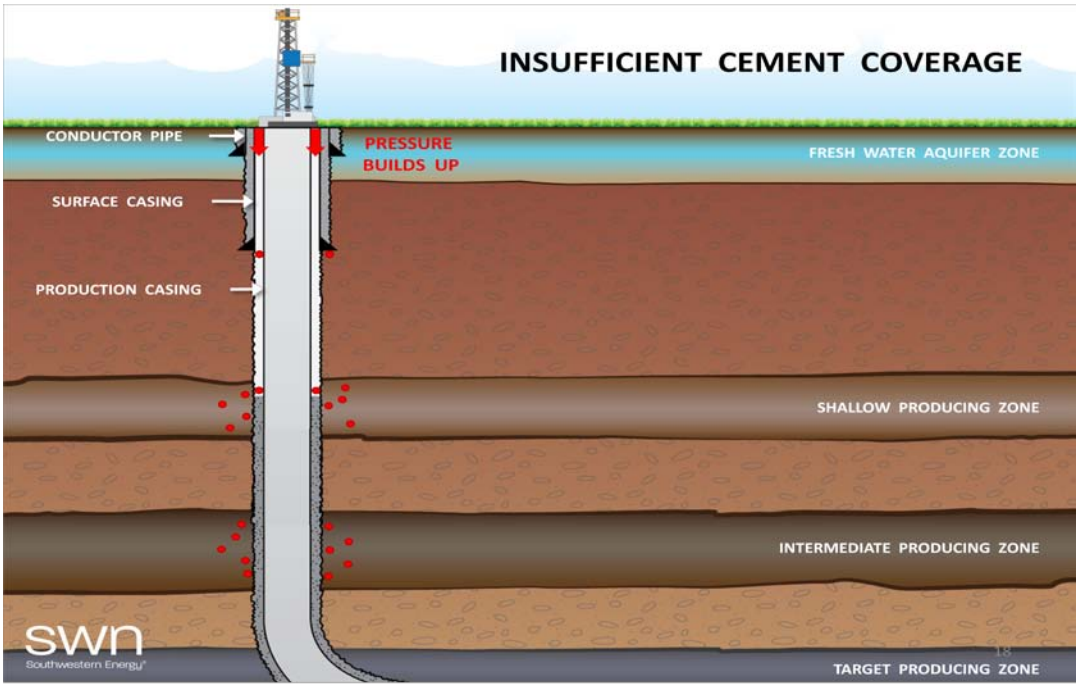
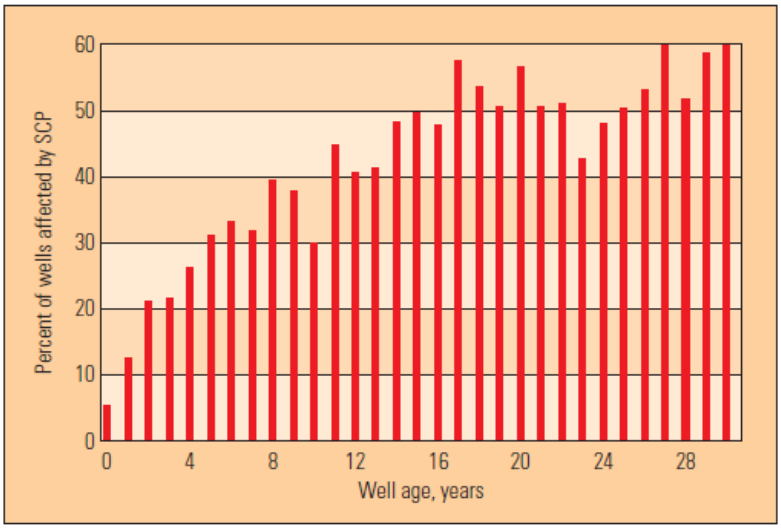


Figure 3. Depiction of entry of gas from a shallow source into an un-cemented annulus, leading to sustained casing pressure and migration of fluids into an USDW. From Boling (2011).



^ Wells with SCP by age. Statistics from the United States Mineral Management Service (MMS) show the percentage of wells with SCP for wells in the outer continental shelf (OCS) area of the Gulf of Mexico, grouped by age of the wells. These data do not include wells in state waters or land locations.

Figure 4. Data on frequency of occurrence of sustained casing pressure (SCP) in offshore wells. From Brufatto *et al.* (2003).

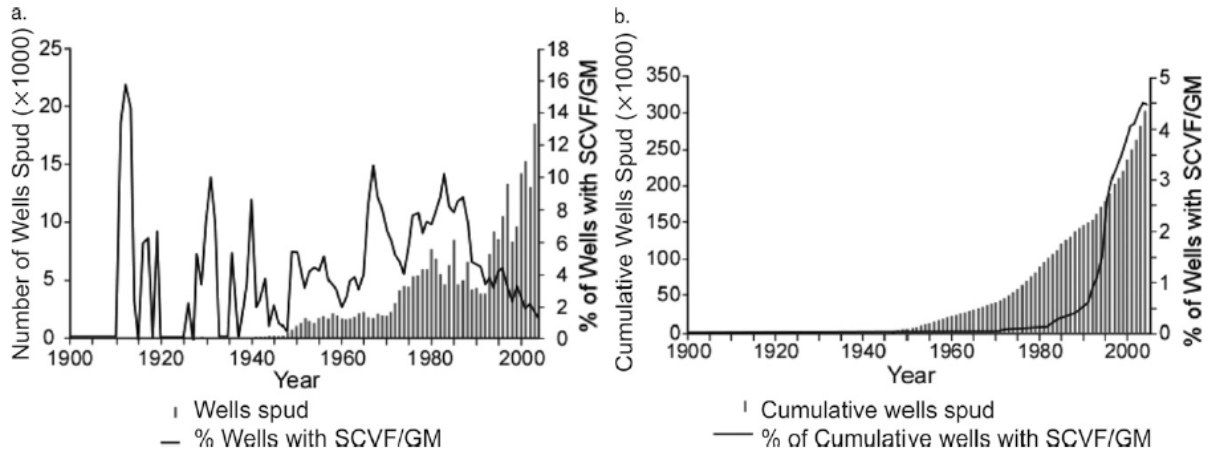


Fig. 8—Historical levels of drilling activity and SCVF/GM occurrence in Alberta: (a) by year of well spud and (b) by cumulative wells drilled.

Figure 5. Data on frequency of occurrence of sustained casing vent flow (SCVF) or gas migration (GM). From Watson *et al*. (2009).

In their statistical analysis of information about nearly 315,000 onshore oil and gas wells, Watson and Bachu (2009) state:

> "Low cement top or exposed casing was found to be the most important indicator for SCVF/GM. The effect of low or poor cement was evaluated on the basis of the location of the SCVF/GM compared to the cement top... the vast majority of SCVF/GM originates from formations not isolated by cement."

Figure 5 shows data gathered by Watson and Bachu that is consistent for young wells with that shown in Figure 4. Note that all these citations are from industry sources. It should be noted that, even with ongoing technological and chemistry improvements in cement and in cementing, loss of wellbore integrity is still common. For example, during 2011, Cabot drilled 68 new Marcellus wells in Pennsylvania, and was cited by PA DEP seven times for "Failure to report defective, insufficient, or improperly cemented casing w/in 24 hrs or submit plan to correct w/in 30 days". Chesapeake Appalachia drilled 279 wells and was cited 24 times for the same violation. A summary of the incidence of well failure in the PA Marcellus since 2010 is presented in Section 3, below.

2.0 PREVALENCE OF FLUID MIGRATION FROM FAULTY WELLS

The science on contamination of drinking water from shale gas drilling, fracing, and production, is recent, ongoing, and incomplete. A peer-reviewed, archival journal study from Duke University (Osborne, *et al*., 2011) found apparent migration of substantial amounts of methane from gas wells to private water wells as far out as 1000m in the Marcellus play in Pennsylvania. A more recent paper from the Duke University team (Warner *et al.*, 2012)

documented geochemical evidence for possible natural migration of Marcellus formation brine to shallow aquifers in Pennsylvania. Also, the U.S. Environmental Protection Agency (EPA, 2011) recently released a preliminary report from an on-going study in Pavilion, WY, that suggests that substances used in fracing might migrate into adjacent water-bearing strata. The study also found clear evidence that there had been migration of methane from gas wells to nearby drinking water wells - likely caused by deficient cement jobs. Inadequate well construction and, of course, spills have been implicated in many states in a large number of cases of migration of drilling related substances into nearby drinking water.

Along with these fairly direct evaluations of the migration of methane and other substances, industry sources have asserted that private water wells are often contaminated by "naturally occurring" methane. This is often presented in an apparently analytical but confusing way, suggesting that the appearance of methane in drinking water wells is sort of "common" and thus unlikely related to any gas well drilling. Such presentation fails nearly entirely to, first, distinguish between dangerous/hazardous levels of methane in water (7 mg/L or more in PA), and much lower levels that are not generally taken to be of concern. Second, it ignores the prevalence or likelihood of having a dangerous "natural" level of methane in drinking water. Third, it ignores any time line: has there been any significant change in the concentration of methane concurrent with the beginning of nearby gas field development?

The New York DEC's data (NYS rdSGEIS, pg. 4-39) make crystal clear that for a 2010 sample of water wells (n=46) in the "Delaware, Genesee, and St. Lawrence River Basins," presumably not near gas wells, just 2% of the wells had a dangerous level over 10 mg/L. One well had a level of 22 mg/L; the remaining wells then had an average level of 0.31 mg/L. This low percentage of "normal" risk has been confirmed repeatedly in studies in PA, Figure 6, in the Southern Tier of NY (1450 water wells, USGS, 2010), in Alberta, Canada (360,000 wells, Griffiths, 2007) and by both independent investigations and by testing by gas drillers (e.g., Boyer, *et al*., 2011). None of these findings suggest, in any way, that dangerous levels of methane are at all common in rural private water wells. Thus, a fairly strong implication is that, if and when methane does occur at high levels in water wells near gas drilling, it is likely due to some aspects of gas drilling, fracing and/or production operations themselves. This is consistent with both the Osborn, *et al.* (2011) study and the EPA Pavilion (2011) preliminary report. Exact migration mechanisms are not yet completely clear in each case, but the potential well failure mechanisms described in the previous section are often implicated.

3.0 RECENT EXPERIENCES IN THE PA MARCELLUS PLAY

A previous review of the PA DEP Marcellus Violations Database at

http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/OG_Compliance

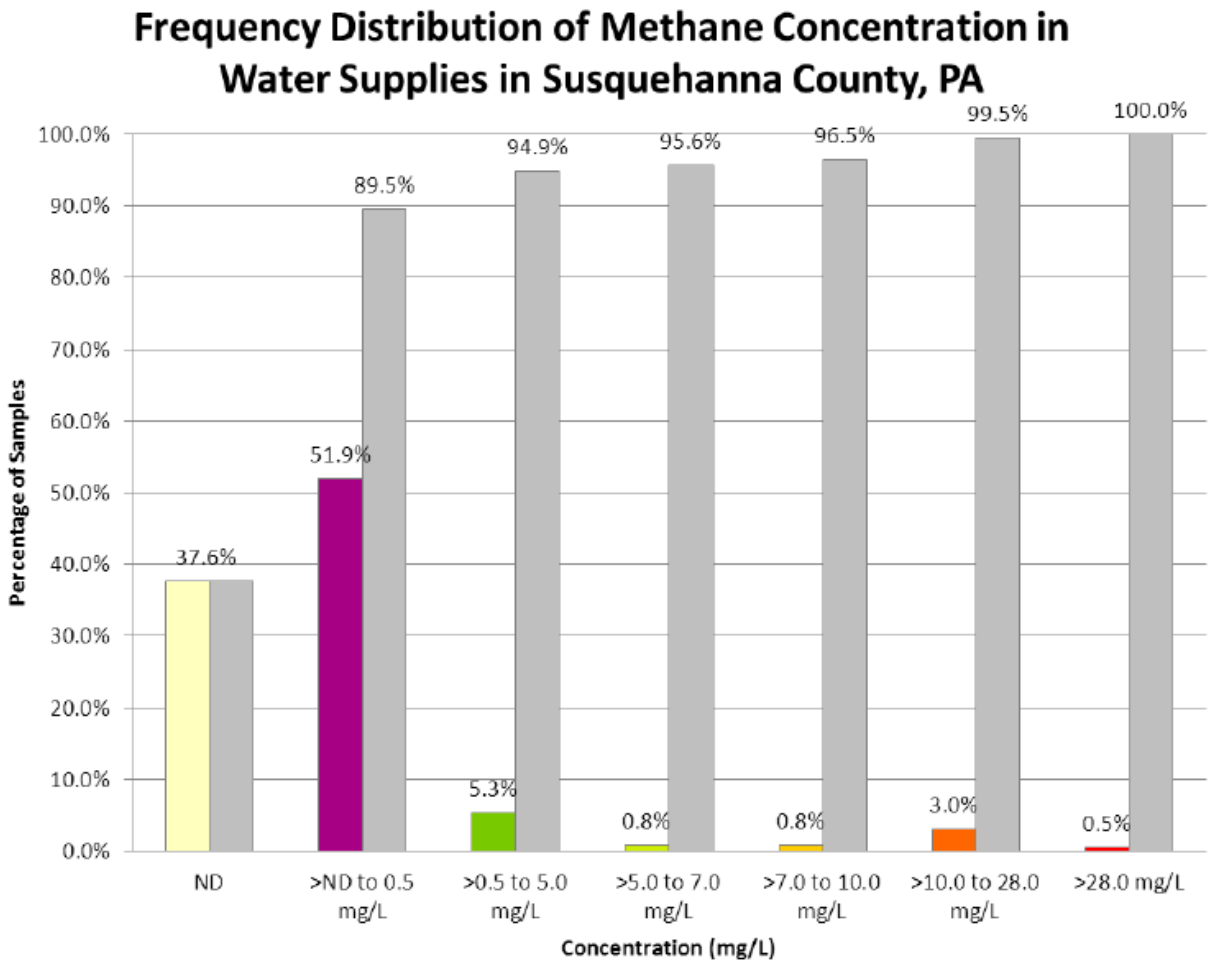


Figure 6. Data collected by PA DEP on methane concentration in private water wells in Susquehanna County, PA. 2433 water supplies were tested: 89.5% had concentrations of methane < 0.5 mg/L, 95.6% had concentrations of methane < 7.0 mg/L. Courtesy of Seth Pelepko, PA DEP.

resulted in the data shown in Figure 7. However, a recent re-review of this database revealed that the data shown in Figure 7 are inaccurate. That data was obtained by searching the violations database for all violations indicating that a well was leaking outside its production casing. Table 1 shows all the violation codes used by PA DEP to indicate that a well is leaking outside its production casing, why it might have occurred, and the consequences of such failure. These were the codes used to filter the entire violations database to identify wells with compromised structural integrity presented in Figure 7.

However, recently it has come to our attention that this filtering process results in a *lower-bound on the number of wells with compromised structural integrity.* That is, more wells have failed cement jobs than have been reported through the violations shown in Figure 7. All inspection

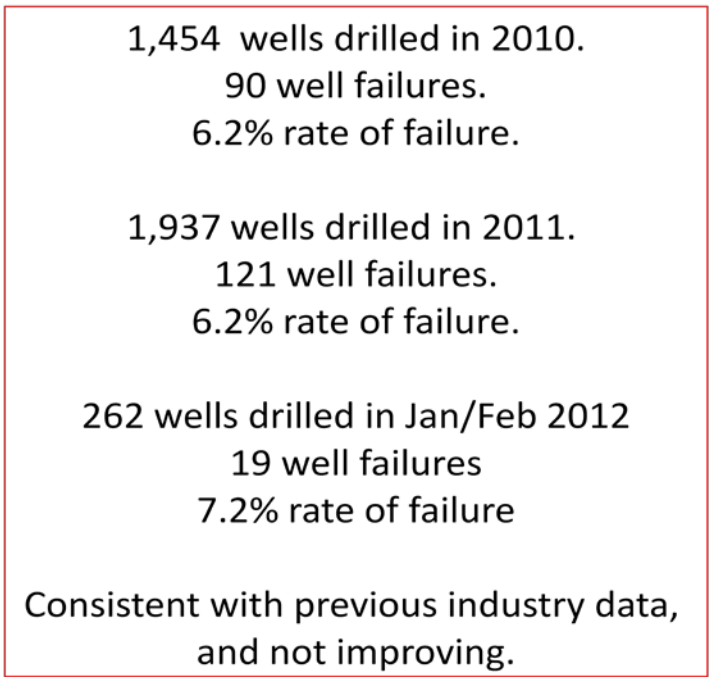


Figure 7. Preliminary results of survey of leaking wells in the Pennsylvania Marcellus play based on violations issued by the DEP. Violations data from http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/OG_Compliance

Table 1. Violation Codes Used to Identify Wells with Violations for Figure 7.

78.73A - Operator shall prevent gas and other fluids from lower formations from entering fresh groundwater.
78.81D2 - Failure to case and cement properly through storage reservoir or storage horizon
78.83A - Diameter of bore hole not 1 inch greater than casing/casing collar diameter
78.73B - Excessive casing seat pressure
78.83GRNDWTR - Improper casing to protect fresh groundwater
78.83COALCSG - Improper coal protective casing and cementing procedures
78.85 - Inadequate, insufficient, and/or improperly installed cement
78.86 - Failure to report defective, insufficient, or improperly cemented casing
207B - Failure to case and cement to prevent migrations into fresh groundwater

reports for the more than 6000 wells drilled to-date in the Marcellus in PA were reviewed; this is a more complete and revealing search than just filtering on certain violations. The inspection reports indicate that many failed wells were not issued violations. Rather, they received "Violation Pending" comments; or comments indicating that "squeezing", a cement repair procedure which would only be done if a well was leaking outside its production casing, had been done or was to be done; or comments that repairs were underway for a perforated casing; or comments that gas was detected at the wellhead at or above the LEL (lower explosive limit).

Table 2 shows the comparison for each of 2010, 2011, and 2012 between the numbers of wells that had actually received violations, and those that were noted in inspection comments to be leaking but had not received violations.

Table 2. Additional Counts of Wells with Loss of Integrity Included in Figure 8.

2010	64 wells with violations, 47 additional wells with loss of integrity noted in Inspection Comments
2011	97 wells with violations, 45 additional wells with loss of integrity noted in Inspection Comments
2012 (Jan-Aug)	31 wells with violations, 36 additional wells with loss of integrity noted in Inspection Comments

Figure 8 contains the revised well failure rates, using both actual violations and inspection comments to identify leaking wells. The complete database supporting the results shown in Figure 8 is available on request to http://www.psehealthyenergy.org/CONTACT.

Finally, it should be noted that a well that appears, at its wellhead, not to be leaking is not necessarily a sound well. It is well known that fluid migration can occur a significant distance away from the wellhead of a well that appears on inspection of only the wellhead to be of sound structural integrity.

4.0 SUMMARY

The most recent experience with shale gas wells in the Pennsylvania Marcellus play reflects long term, world-wide industry data with respect to new wells with compromised structural integrity. Operator-wide statistics in Pennsylvania show that about 6-7% of new wells drilled in each of the past three years have compromised structural integrity. This apparently low failure rate should be seen in the context of a full buildout in the Pennsylvania Marcellus of at least 100,000 wells, and in the entire Marcellus, including New York, of twice that number. Therefore, based on recent statistical evidence, one could expect at least 10,000 new wells with compromised structural integrity. It is too early to discern whether the other industry experience with this technical problem, an increase in loss of integrity with well age, will also be reflected. However,

at play in modern shale gas development are many of the key factors identified by industry researchers as having a negative influence on well structural integrity: the need for deviated wells, rapid development of a field, presence of "shallow" high-pressure gas horizons, and disturbance of young cement due to adjacent drilling activities on the same pad.

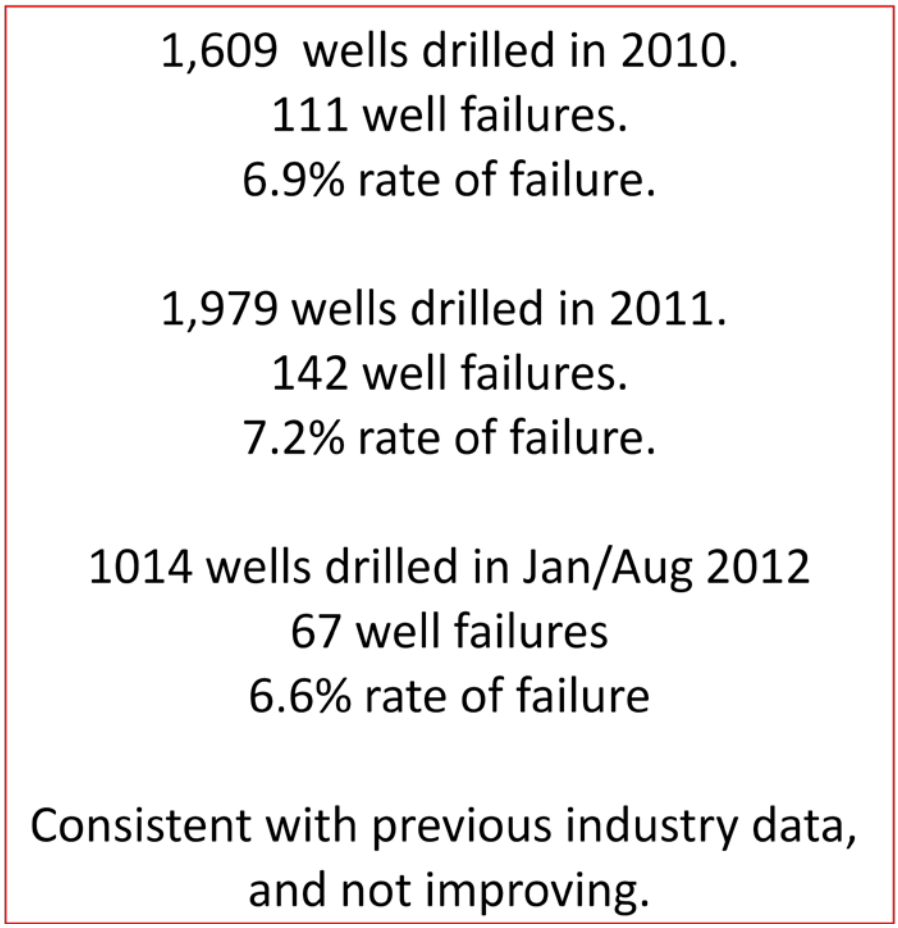


Figure 8. Revised results of survey of leaking wells in the Pennsylvania Marcellus play based on violations issued by the DEP and well inspector comments. Violations and comments data from http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/OG_Compliance

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drilling, which shows an extremely low frequency of water wells with dangerous levels of methane, provided by industry sources, is credible.]

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