F R A C T U R E S B E T W E E N U S

Prologue:

A trip to New York

I first heard about hydraulic fracturing in the United States, while visiting friends at a Buddhist centre in upstate New York. On a wintry afternoon, we took a break from our daily meditation session. There, nestled in the middle of the sixty acres of my friends' beautiful land, and a stone's throw away from clear, running water, we sat down to watch *Gasland*, a documentary that had recently been released by a local filmmaker, Josh Fox.

Down the road, less than an hour away from where we were sitting, Josh had embarked on a journey to document a new gas extraction process called hydraulic fracturing. From his property in upstate New York, south to Pennsylvania, then to Wyoming, Colorado,Texas, and back again, Fox recorded incidents of health and environmental concern that contrasted industry advertisements of a clean-burning fuel and promises of economic prosperity.

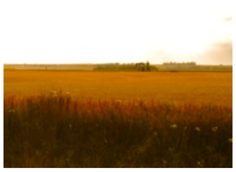
The most iconic section of the film occurred in a family kitchen when, placing a lighter under a running faucet, the water ignited into flames. It was a startling moment. Fox and many of the people interviewed were certain that hydraulic fracturing had transformed the aquifers that stored their drinking water into flammable reservoirs. Perhaps even more troubling was the depiction of companies and lawmakers refusing to take responsibility or acknowledge, what was happening.

Kadampa Meditation Center, Upstate New York

Perhaps fracking is so controversial because the process touches upon deep and primal elements of human experience. The process occurs deep underground. Natural gas is brought out of these depths as a magical, invisible elixir that heats our homes and gives our society energy. Fire and water, two elemental substances upon which humankind's survival has depended since time immemorial, are brought together in a strange alchemical union. All together, the images are more suitable for a tale out of *The Hobbit* than a modern documentary.

It may be no coincidence that a principal developer and champion of hydraulic fracking technology is Haliburton, a company sometimes noted for its checkered past. The "Halliburton loophole," as it is commonly known, opened the door to unchecked fracking production when it was passed into law as part of George Bush's 2005 energy bill. Inserted into the bill by Vice President Dick Cheney, himself a former Halliburton chief executive and significant share-holder, the loophole "stripped the Environmental Protection Agency of its authority to regulate the fracking drilling process" and exempts fracking from the *Clean Water Act*, the *Clean Air Act*, and the *Safe Drinking Water Act* (New York Times, 2009).

Fox's journey across America left me troubled. But I found some solace in the idea that Canadians weren't as beholden to negligence and bias in our lawmaking or industry practices. So I returned home somewhat comforted to be leaving the land of unchecked burning water.



Pictures by Rajan Rathnavalu unless otherwise indicated

Alberta's next bonanza?

Promising Duvernay formation ignites firestorm in oilpatch

DAVE COOPER
Journal Business Writer
EDMONTON

Klondike prospectors panning for gold in Yukon streams a century ago always dreamed of finding the "motherlode."

In Alberta, the source for most of our oil gushers has been known for decades, a very deep formation of shale rock formed 400 million years ago during the Devonian era when the province was an inland sea.

Named the Duvernay by geologists, it was known and ignored — until now.

Thanks to a new technology called multistage hydraulic fracking, this potentially huge deposit has ignited a firestorm throughout the oilpatch, with companies bidding hundreds of millions of dollars each for the right to drill into it.

This land rush has already yielded the province more than $3.2 billion for hundreds of thousands of hectares, and the year isn't over yet. It is likely to set a record, and may even largely erase this year's provincial deficit.

"A lot of very smart industry players have demonstrated a belief in the Duvernay. There are lots of geological signs that is it sizable and will be a major focus for capital spending over the next decade," said Don Rawson, a managing director of equity research at AltaCorp Capital in Calgary.

"But the reality is until you start drilling you aren't going to know

"A lot of very smart industry players have demonstrated a belief in the Duvernay. There are lots of geological signs that is it sizable and will be a major focus for capital spending over the next decade."

Don Rawson, a managing director of equity research at AltaCorp

originally for the oil-bearing zones above the Duvernay.

"Probably the best exposure for Duvernay has been picked over by now, but some of the small companies will be packaging up some of their land rights now and selling them off," said Leach.

Oil and gas giants like Encana, Shell, Talisman and ConocoPhillips were into the Duvernay on the heels of the small firms.

Mike Graham, an Encana vice-president, called the Duvernay "one of the hottest new plays" during a webcast of the firm's third-quarter financial report in late October.

"We plan to spud (begin) three wells during the fourth quarter. We hold about 365,000 net acres in what we believe to be some of the best liquid-rich acreage in the play," he said.

"It is still early days but we are very excited about the potential of the Duvernay shales to add significant liquids volume to the production profile of the Canadian division. And we expect to be more active in this play next year."

As Canada's largest natural gas producer, Encana has been looking for ways to produce more high-value products like liquids and very light oils to balance out its portfolio, which is heavy in lower-value natural gas.

But while the Duvernay may be a rich resource, it is not cheap to produce.

Fracking is very expensive, usually responsible for two-thirds or more of the $10-million to $15-million cost

INTRODUCTION: Return Home

I soon found myself busy with university studies, the images from Fox's documentary ensconced behind the more pleasant memories of my trip. It wasn't until my father brought home a copy of the Edmonton Journal that Fox's film came rushing back to mind. Somehow I found myself leafing through the paper, most likely as a distraction from some pressing assignment. When I opened to the business section I was surprised to be greeted by the main headline, "Alberta's next bonanza?" The article outlined a "firestorm" akin to the Klondike gold rush where companies were spending millions of dollars for the rights to frack vast sections of Alberta. The land rush had already garnered more than $3.2 billion for the provincial government, which owns the mineral rights, something that the writer speculated might erase the 2011 budget deficit. Significantly absent was any mention of potential environmental damage. Amidst the "excitement" and "big potential," there was no concern for water (Cooper 2011, D1).

What struck me the most about this reading was that, in many ways perspectives on this issue were also fractured, divided into various cultures and value-systems. Something I thought was obvious and very important was absent from another's point of view. I don't think I expected an "environmental expose" coming from the business section of one of Alberta's main newspapers, but I certainly thought the controversy warranted at least some mention.

Until then, I had taken only a moderate interest in the source of my province's "wealth". I was a beneficiary of this revenue, but not a very alert or responsible one. Upon reading the article, I determined to do something about the gap I felt between an oil culture that was "excited" and myself, also an Albertan, who was somewhat horrified.

This essay represents some assessment of the journey I have made from reading that article in November 2011 to today, a year later. While here I tackle the scientific and technological basis behind the process and controversy of fracking, of equal interest to me is the human dimension, which I hope to address at another time... How do we know so much about the world around us and yet, at the same time, so little? How we are still so divided in our approach and understanding of the world? And, perhaps more importantly, how we might work together to achieve a more positive future for generations to come?

The writing is divided into six sections:

(1) The Gasland debate
(2) Fossil fuels, environmental challenges, and peak oil
(3) Directional drilling and hydraulic fracturing
(4) Water concerns
(5) Misuse of terms, science, and the law
(6) Conclusion

Picture from the Edmonton Journal, Nov. 5, 2011; photo credit: Dave Olecko.

PART 1: Debating Gasland

Gasland is a film that evokes a great deal of emotion. We follow Josh, a friendly "guy next door" on his journey into the heartland of Gasland USA. On the way we encounter normal folks, going about their lives, who suddenly find their world falling apart. They can't drink their water, their animals are dying, they fear for explosions, they suffer from debilitating headaches and other serious health concerns – their natural world has become a mix of methane and invisible toxic chemicals. At times it feels more a horror movie than a documentary of U.S. industry.

Given its powerful and dramatic narrative, in terms of galvanizing interest and support for the anti-fracking movement, there likely hasn't been a better tool than Fox's film. But it hasn't been without criticism. Truthland was filmed as a documentary in direct response to *Gasland*.[1]

Sponsored by Energy in Depth, a major pro-fracking PR arm of the petroleum industry, Truthland naturally comes out with a pro-fracking message. Set as a rural family's search for the truth, the movie follows the efforts of Pennsylvania dairy farmer and school teacher, Shelley DePue, to find "real honest answers."

In a clear rebuttal to Gasland's iconic central image, Shelley DePue addresses the "burning water business" in the film's opening two minutes. DePue states that "everyone around here knows that it's a natural thing – it's been going on for generations, since long before anyone drilled for natural gas." She travels across the road to a state park and lights methane coming from a spring water source. "Hmm it looks like flaming faucet that Josh showed might be a bit misleading," she says (DePue 2012).

DePue's first interview is with former Secretary of the Pennsylvania Department of Environmental Protection (DEP) John Hanger. During his full interview Hanger says that gas migration is a "real concern," but this is edited out.[2] What is instead included is a narrow rebuttal of *Gasland* and general support for natural gas. DePue concludes, "Boy, that helped clear up a lot... I breathed a little easier about the wells on our farm."

A later interview is with Terry Engelder, a geologist from Penn State University and a well-known advocate for the development of shale gas in the Pennsylvania, Macelus Shale region. Engelder is asked about the chemicals in the frack fluid and responds by saying that it is "basically nothing more than household dish detergent."

After interviewing steel workers (13:18) DePue states, "The bottom line is that responsible gas drilling is good for everybody." This seems to be the film's main message.

Between Gasland and Truthland lies an enormous gulf (fracture?). As one commentator notes:

> The current point-counterpoint debate is endless, and, in many ways, it is less about the science than it is about two incompatible worldviews - the industry's desire to explore for energy vs. activists upset about the introduction of a disruptive industrial process into rural landscapes (Maykuth 2012).

These worldviews, however isolated from one another, do intersect. Since the making of *Truthland,* the drilling operations on DePue's property have been cited for numerous violations, including poor cement casing resulting in methane release from the well and improper waste disposal (Marcellus Shale 2012). Two wells on the DePue property are also part of a lawsuit filed against WPX Energy, the company who drilled and operates the wells, by neighbors whose own well began spewing methane-laden water this past December (Legere 2012). Part of their story is available on Youtube at http://youtu.be/iPM64kseP30?t=5m34s.

The ongoing contention and polarity of views speaks to the need for thoughtful and balanced inquiry. With these aims, I hope the following discussion is of some benefit.

Pictures are from Gasland media kit (Gasland 2012); "Reality Check" image is from Tumblr (Truthland 2012).:

PART 2: Fossil Fuel

A Brief History

The process of fracking arises from the ongoing and intimate relationship our version of civilization has with prehistoric life forms. Since the early 1900s, our society has been powered by carbon based energy forms known as "fossil fuels." Plants, having converted the sun's energy into organic material, decayed over hundreds of millions of years to form underground storage banks of solar energy – principally in the form of coal, oil, and natural gas.

Beginning in the early 1700s, humans were able to draw from this bank in a powerful way, by converting coal into steam energy. The innovation of the steam engine provided an exponential power where there had only been simple tools and animal labour to complement human muscle. With a powerful and concentrated energy source, factories replaced local artisans and the industrial revolution was born.

In the words of economist Jeffry Sachs, this "decisive turning point in human history" ushered us into an age of unprecedented growth and development (in McKibben 2007: 5-6). Humans were suddenly endowed with an unprecedented amounts of energy – "the capacity to do work" (Oxford 2012). Thus, fossil fuels revolutionized human ability for accomplishing daily tasks, making us 100's of times more powerful than our ancestors.

The development of combustion technology in the early 1900s allowed modern society to harness an even more potent energy source, petroleum. This development was foundational to the progress of the 1900s. In the words of ecological observer Bill McKibben, these miracle fuels, "simple, cheap, concentrated power – lie at the heart of our modern economies" (2007). Cheap, easily accessible, and very efficient sources of energy were available in abundance to fuel the industrial revolution, then to power the largest economy in world history and the us along with it.

Early Environmental Challenges

This transformation was not without its costs. The industrial revolution marked the beginning of large-scale environmental problems such as contamination of land, water, and air became commonplace around industrial cities. Acid rain, for example, was first studied around Manchester England during the mid-1800s (EPA 2012). Despite increasing problems, U.K. legislation to curb pollution during this time was often defeated by industry (Weber 2010).

"Smog" (smoke and fog) was coined in London at the turn of the century and was an ongoing problem, culminating in the deaths of more than 4000 people in the "Great Smog of 1952." The disaster prompted England to pass the first modern environmental legislation, the *Clean Air Act* in 1956 [the US EPA notes that air pollution is often hard to recognize and is often ignored "until the problem reaches crisis proportions" (EPA 2010a)].

Much credit for U.S. environmental protection goes to Rachel Carson, whose 1962 book *Silent Spring* sparked debate over pesticides, particularly DDT, and their harmful effects on land, water, and animal (also human) life. While the chemical industry sought to discredit her personally, along with her findings, Carson's observations were, for the most part, taken seriously and were thus able to initiate the modern environmental movement (Lear in Carson 1962). Parallels in Carson's struggles against industry are common today, particularly with respect to hydraulic fracturing.

Less than a decade after Carson's book, in 1970, President Nixon created the Environmental Protection Agency (EPA), while Congress passed the *Clean Air Act Amendments*, "beginning modern efforts to control air pollution" (EPA 2010).

In Canada, the first environmental statue was passed in 1961, the *Ontario Water Resources Act* (Saxe and Campbell 2011). Federally, the *Environmental Contaminants Act* was passed in 1975, followed by the more comprehensive *Canadian Environmental Protection Act* in 1988 (Douglas and Hebert 1999).

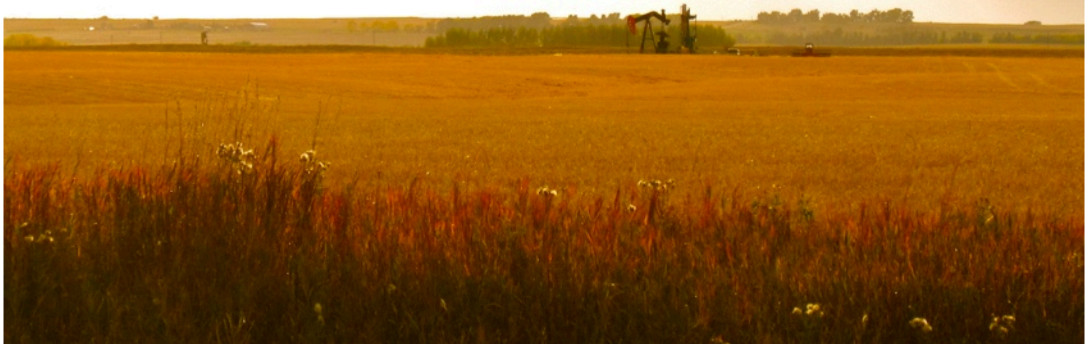
Peak Oil and the "Unconventional" Breakthrough

Only a few decades after humans had begun to tap the earth's oil reserves, scientists began to predict their exhaustion. In 1956, M. King Hubbert, an American geoscientist working for Shell, identified a coming "peak" in U.S. and global petroleum production. With respect to the U.S., Hubbert's prediction was accurate to the year. As he foretold, U.S. petroleum production climaxed in 1970 at 3.44 billion barrels (Demming 2000; US EIA).

Just before the global economic crash of 2008, oil prices reached an all-time high at $145 per barrel . And in 2010, the International Energy Agency (IEA) reported that global production had peaked in 2006 at 70 million barrels per day – a level that the IEA stated would never be regained (2010: 101). Yet two years later, and to many people's surprise, the IEA reported that "profound developments" had "turned the tide" for U.S. energy . The United States was now projected to surpass Saudi Arabia as the world's largest petroleum producer by 2020 and become a net oil exporter. This remarkable assessment was in addition to government reports indicating that U.S. natural gas reserves could meet domestic needs for the next 110 years (U.S. House of Representatives 2011).

As with the combustion and steam engine, this sea change was driven by advancements in technology which enabled the U.S. to harvest previously unreachable deposits (IEA 2012: 1). Following the energy crisis of the 1970s, the U.S. government invested millions of research dollars toward developing unconventional reserves such as coalbed methane (CBM) deposits and shale gas. This research garnered such advancements as the development of directional or horizontal drilling, diamond-studded drill bits, underground imaging and mapping, and innovative seismic tools (Trembath et al 2012). Thus while hydraulic fracturing was first used commercially by Halliburton in 1949, it was only in combination with these other improvements that previously inaccessible "unconventional" deposits were made readily available.

This breakthrough is indeed a mixed blessing. That we are trying at all to access these challenging deposits indicates that the "easy" oil is largely gone. And, while we now have access to these deposits, climate change dictates we should be decreasing our fossil fuel extraction, not increasing it. Sadly, the dimensions of this looming crisis are potentially so vast that, by the time our generation's 'Great Smog' comes, it may very well be too late.



hy·drau·lic
/hīˈdrôlik/

Adjective
1. Denoting, relating to, or operated by a liquid moving in a confined space under pressure: "hydraulic fluid".

frac·ture [1]
/ˈfrakCHər/

Noun
The cracking or breaking of a hard object or material.

PART 3: New Technology

The terminology used to describe the modern processes – "hydraulic fracturing, high volume, slickwater, multi-stage, horizontal drilling" – refers to technical progressions over several decades of research.[1]

1. Horizontal Drilling

Advancements in the 1980s and 1990s allowed for effective drilling at an angle. Thus, after drilling a vertical hole down to the appropriate layer, the drilling can shift horizontally (called the "lateral") along a resource vein. This lateral access can expose up to 3 km more oil or gas for extraction. The production increases are dramatic – between 400 to 700% (Schaeffer 2009).

It is not uncommon for a well to go to depths of between 200 metres (for coalbed methane) and up to 3 km (shale). Lateral wells range from 1 to 3 km (EPA 2010).

2. Hydraulic Fracturing

Conventional oil and gas fields do not require "stimulation" because the porosity of those formations allows the resource to flow freely into the well. "Tight" reservoirs such as tight sand, coalbed methane (CBM), and shale are not as porous. As a result, "fracturing" is required to open conduits in the rock for the gas or oil to escape.

The fracturing process itself is preceded by explosives that perforate holes in the casing that lines the horizontal section of a well. Then a mixture of water, sand, and chemicals is injected into the well under extremely high pressure. The pressurized mixture flows out of the perforated well to "fracture" the oil or gas bearing rock. The sand serves to both break open and maintain the fractures while "slickwater" (water lubricated with chemicals) allows the sand mixture to flow easily down the wellbore and into the rock.

When the pressure is relaxed and the wellbore cleared, the new channels created by the fractured rock allow the gas to flow into and up the wellbore to be captured for market.

"Multi-stage" indicates that the fracturing occurs in stages along the horizontal well, beginning with the "toe" or section furthest from the well head. The cycle of perforation and fracturing can occur up to 18 times, for example, at 100 metre intervals along a 1.8 km horizontal well.

For an excellent visual of the process, see the Oklahoma Energy Resource Board video at: http://www.oerb.com/Default.aspx?tabid=242.[2]

[1] Definitions are from Google search

[2] Also, for interactive maps see: http://exploreshale.org/ or http://www.halliburton.com/public/projects/pubsdata/hydraulic_fracturing/fracturing_101.html#.

PART 4: Water Concerns

Water Use

The EPA states that between 200,000 and 1.3 million litres of waters is used to fracture for coalbed methane (EPA 2010). Other extraction methods require much more. David Pryce, Vice President of the Canadian Association of Petroleum Producers (CAPP), states that a typical B.C. fracture requires between 20 million to 100 million litres of water (Pryce 2012).

To put B.C. usage into perspective, it would take the average Canadian two to ten lifetimes to consume the same amount of water through domestic use (Environment Canada 2004).

The oil and gas industry points out that other sectors like irrigation, power generation, and manufacturing utilize much more water. But, unlike other industries, fracking removes 60 to 90% of the water from the earth's water cycle forever. Most often wastewater is flushed deep underground due to high levels of increased toxicity (Biello 2012). What remains is generally too toxic to be purified through municipal treatment centres.

Chemical additives = "Slickwater"

A comprehensive study by the U.S. House of Representatives revealed more than 750 chemicals and other components have been added to the fracking process, ranging from the benign (e.g. salt and citric acid) to the extremely toxic (e.g. benzene and lead). Among other functions, these substances are used to lubricate the water so it can flow more easily; hence the term "slick" water.

Fracking chemicals additives include 29 that are either known or possible carcinogens, regulated for their risks to human health, or hazardous air pollutants (U.S. House of Representatives [USHR] 2011). Industry (e.g. FracFocus, EnergyinDepth) points to the high volume of water and the low percentage of additives (0.5 to 2%) but this can be misleading.

For example, toxic BTEX compounds (benzene, toluene, xylene, and ethylbenzene) were used in 43 million litres of fracking products between 2005 to 2009 (USHR 2011).Yet benzene is so toxic that more than 0.005 parts per million (about five drops of benzene in 500 barrels of water) is unsafe for drinking; thus the EPA's goal for "an adequate margin of safety" with respect to benzene is a concentration of zero (U.S. Agency for Toxic Substances and Disease Registry 2000, Smith-Heavenrich 2010).

Given its highly toxic nature, it is possible that a single frack could contain enough benzene to contaminate more than 375 billion litres of water – 10 times the water used by New York state in a day (Horwitt 2010).

It should be noted that each frack site will use a different mix of chemical additives, depending on the geology and nature of the operation.

Proprietary secrets

Clear understanding of potential risks is hindered by the secretive nature of the industry. In the above study for example, 356 million litres of fracking fluids contained at least one component that was deemed a trade secret by industry. In requesting this information, the U.S. House of Representatives found that "in most cases companies are injecting fluids containing chemicals that they themselves cannot identify" because they too do not have access to proprietary information from chemical suppliers (USHR 2011).

In addition to public health concerns, the lack of disclosure contributes to ongoing public distrust of industry practices as well as posing significant challenges in testing for water quality and contamination.

Water contamination

Water contamination can and does occur in several ways. Firstly, as noted above, the addition of toxic chemicals render high volumes of water dangerous for human consumption. While industry suggests it may use alternate water supplies (such as brine or salt water), the predictability of clean, potable water makes it easier to manage drilling activities and is therefore more commonly used.

The contamination of water used during the fracking process poses significant concerns for regions prone to drought or water shortages, such as Texas and parts of Alberta. This year in Pennsylvania, generally known for its abundant water resources, fracking was suspended in some areas due to drought (Biello 2012).

Secondly, there are concerns that this contaminated water will migrate during the fracking process into nearby aquifers. In many circles this is considered unlikely to occur during the fracturing of deep shale gas plays where the water is left deep below groundwater levels. This claim has been contested, most recently in an article by Tom Myers in the journal *Groundwater*. Myers suggests that, contrary to popular belief, frack fluids could migrate to groundwater in as little as ten years (Myers 2012).

Nevertheless, fracking fluids have already been found in aquifers and drinking water wells on numerous occasions. Here, the anecdotal evidence is considerable. For example, the Pennsylvania Alliance for Clean Water and Air maintains a "List of the Harmed" which highlights 652 "individuals and families that have been harmed by fracking" (Lisak 2012).[1] Further, an article in Scientific American reports that "more than 1,000 other cases of contamination have been documented by courts and state and local governments in Colorado, New Mexico, Alabama, Ohio and Pennsylvania" (Lustgarten 2008). These incidents are not considered as valid "evidence" by the oil and gas industry – hence the oft-repeated "no documented cases of water contamination."

A survey of the literature reveals very few scientific studies on the subject. As a result, a recent study in Pavillion, Wyoming has garnered a great deal of attention. Beginning in 2009, the U.S. EPA began tests in response to complaints about water quality. The study found contamination in both shallow and deep monitoring wells, and attributed the shallow findings to 33 nearby wastewater storage pits. The storage pits, however could not account for the deeper contamination (EPA 2011).

The EPA's findings were rigorously contested by Encana, the company drilling in the area, as "conjecture". Encana was especially disappointed that the EPA had released its draft report before peer review (Encana 2011). In response to these objections, the EPA commissioned a follow-up study by the U.S. Geological Survey, whose report affirmed the initial findings (Wright et al 2012). These results were again disputed by Encana (Wile 2012). The EPA's final report is expected in 2013.

Thirdly, the fracking process brings up to the surface naturally occurring toxins from deep underground. These include corrosive salts, carcinogens (e.g. benzene) and radioactive elements (e.g. radium). Challenges storing and disposing of the waste-water, called "flowback" or "produced water," pose risks for other water sources. For example, a controversial New York Times article in 2011 reported that Pennsylvania drilling wastewater may contain radioactive elements hundreds or thousands of times above the federal maximum allowed for drinking water (Urbina 2011).

A presentation by EPA officials in Pennsylvania stated that the average horizontal well produced 5,700,000 litres of waste water and posed questions about a "reasonable potential to cause harm" (Bergdale 2009, 552-557). These numbers are of particular concern for a state that has seen the development of 35,000 active wells since 2000. In three years, more than 4.9 billions of litres of waste water was produced in Pennsylvania, much of it treated by municipal plants not designed to remove industry waste (Urbina 2011).

Gas Migration

Another concern is the potential for methane to contaminate ground-water supplies. This problem has occurred in at least eight U.S. states – New York, Colorado, Ohio, Pennsylvania, Wyoming, Texas, and West Virginia – and two Canadian provinces, Alberta and Quebec (see e.g. Urbina 2011, Mall 2011, or Lisak 2012).

In a highly publicized article published by the Proceedings of the National Academy of Sciences , researchers from Duke University also documented "systematic evidence for methane contamination of drinking water associated with shale-gas extraction" in New York and Pennsylvania (Osborne et al 2011). Dr. Karlis Muehlenbachs, a world expert in gas migration, also cites improper well construction as a principal source of methane contamination and states that the problem is going to get worse (Muehlenbachs 2011).

Gas development in Pennsylvania has coincided with a rise in public concern about natural gas extraction. Thus the industry is, arguably, experiencing more scrutiny in Pennsylvania than elsewhere.[1] A search of oil and gas activity from 2009 to 2012 reveals 400 pages of violations. These range from the benign, "failure to report within 30 days" to the disturbing, "Discharge of pollutional [sic] material to waters of the Commonwealth" (Pennsylvania Department of Environmental Protection – Office of Oil and Gas Management 2012). It is therefore no surprise that, with respect to well integrity and gas migration, Pennsylvania has also recorded a number of recent fines. These include $4.6 million against Cabot OIl and Gas and $900,000 against Chesapeake Energy – both for methane contamination of water wells due to defective casing and cementing (R. Myers 2012).

Elsewhere, in 2004, Encana was fined $371,000 by the state of Colorado for water contamination from "inadequate cementing [that] resulted in a loss of well control" (Colorado Oil and Gas Conservation Commission 2004). A recent Quebec study found 50% of new natural gas wells leaked methane (Holzman 2012).

[1] It should be noted, however, that Pennsylvania lawmakers such as Governor Tom Corbett have been widely criticized for industry ties (e.g. McNellis 2011). Further, the PA Department of Environmental Protection was recently criticized in a court filing by its own employees for not including contaminants in water assessment reports, and for using the incomplete findings to dismiss complaints (Hopey 2012).

PART 5: A Study in Misinformation

Misleading Terminology

Fracking is one stage in a complex extraction process. A misrepresentation of this role is often used to deny allegations of environmental contamination. Mark Boling, Executive VP of a U.S. oil and gas company,[1] explains, "What the companies are thinking of when they say hydraulic fracturing hasn't caused anything [environmental damage] – they mean the actual activity of the completion down at 4000 feet." This understanding is contrasted by the use of the term in the public sphere, as Boling explains:

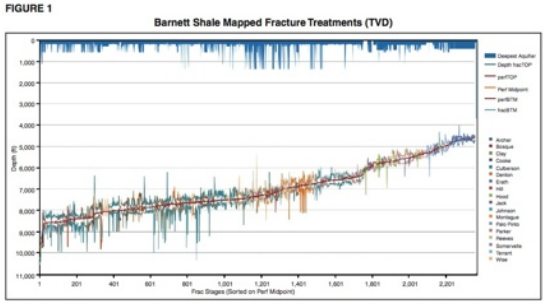
> What a lot of the public is thinking [is that] hydro-fracking is the whole thing: from drilling, to casing the well, to completion. If that's your context, then I can understand when they say, "You're not telling me the truth. Because we do know in Wyoming, Colorado, Ohio, Pennsylvania, and in West Virginia – there has been evidence of gas migration contamination – and it wasn't there before they started drilling. So don't tell me it was a coincidence"
>
> (Boling in Minnaar 2012).

An example comes from the July 2010 edition of the American Oil and Gas Reporter, whose main headline reads, "Data Confirm Safety of Well Fracturing." Kevin Fisher, a manager with Halliburton, reports, "In the more than 60 years following the first treatments [in 1949], more than 2 million frac treatments have been pumped with no documented case of any treatment polluting an aquifer" (Fisher 2010).

The large graphs in Fisher's article support his claim (e.g. Figure 1).[2] The graph demonstrates that, in the region portrayed, fracturing occurs deep underground and far away from groundwater supplies.[3]

This argument is clear. However, the analysis is often misused as a blanket statement to give the impression that the entire fracking process is 100% safe and to dismiss concerns (e.g Inhofe 2011, Fuller in Energy in Depth 2011, Pryce 2012).

FIGURE 1



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The article also alludes to another common industry claim – that fracking is a technology that has proven to be safe for 60 years. In the words of Canadian Association of Petroleum Producers VP David Pryce, "all the approximately 170,000 wells that have been hydraulically fractured in Alberta over the past 60 years have been fracked safely" (Pryce 2012). However, given the recent developments in technology – horizontal drilling, the addition of chemicals, high volumes of water under extremely high pressure, etc. – this is not a 60-year old practice, but a very new one.

Science: Employed to Attack, Ignored as Defense

Society generally relies on science to improve understanding. In this context, however, industry uses science to promote economic interests, often to the detriment of understanding. David Pryce's comment, "safe for 60 years," provides an example of this point. On the one hand, industry rebuttals of peer-reviewed research claim to be holding academics to the highest of scientific standards.
Yet, industry makes claims about its excellent

history based on a lack of scientific study.

The statements “fracked safely” and “no documented cases of contamination” are claims made with little or no supportive evidence. Given the lack of data, such claims suggest that fracking is safe *because* there has been little or no testing. A true scientific claim would indicate the opposite – that there has been rigorous and ongoing testing. A claim relying upon a lack of supportive data is called “argument from ignorance” (argumentum ad ignorantiam) – an argument premised on the absence of analysis.

Pryce claims that all 170,000 Alberta fracked wells have been done safely but there is little baseline data to support this statement. A serious study of the effects of fracking on water supplies would require comprehensive and ongoing baseline samples. If the claim is 170,000 safely fracked wells, then one would require an equal number of baseline samples as supportive data.

Yet CAPP has only recently indicated support for baseline water testing – this past January 2012 (CAPP 2012). Further, such support is merely suggestive. As CAPP states, it is unable to ensure compliance among its members (Canadian Press 2012).

Whereas science finds its foundation from doubt, in this instance, industry has replaced doubt with certainty. What is concerning about this approach is how it functions to discredit the experience of hundreds of people adversely affected by unconventional extraction processes.

Institutions known for their academic and scientific rigor have also come under recent scrutiny. PENN State University’s major funding grants have been criticized as a source of the University’s pro-industry stance on many issues. A controversial 2009 Penn State study that initially failed to disclose its industry funding was used by lawmakers to turn down a state tax on gas drillers (Efstathiou 2012). In November 2012 the State University at Buffalo shut down its “Shale Resources and Society Institute in response to allegations of poor research and industry ties (Philips 2012).

In a recent example that highlights industry influence, this December 2012 the director of the University of Texas’ Energy Institute resigned due to conflict of interest concerns over a recent study. The study, entitled “Fact-Based Regulation for Environmental Protection in the Shale Gas Development” was tainted by its lead author’s concurrent position on the board of a drilling company, for which he received over $1.5 million during the past five years. While the report had been framed as a means to bring “facts” into the debate, it ended up highlighting ubiquitous distortions in the field.

Regulation & the Law: Enforcing Standards or Avoiding Responsibility?

One of the earliest legal battles over hydraulic fracturing began in 1989 in Tuscaloosa County, Alabama, where the McMillan family alleged that a water well on their property had been contaminated by nearby coalbed methane operations. After a lengthy series of legal petitions, in 1997 the EPA was mandated by the U.S. Court of Appeals to regulate fracturing under the *Safe Drinking Water Act*. Three years later, in 2000, the EPA commissioned a study of the effects of fracturing on groundwater supplies.

The positions that framed the debate are not unlike the ones we find today. On the one hand were adversely affected landowners aligned with environmentalists. On the other were political and industry interests focused on moving development ahead, rather than attending to environmental problems (Lathem 2001).

Concerned about the outcome of the legal proceedings, state regulators and industry groups began to lobby Washington to exempt hydraulic fracturing from the *Safe Water Drinking Act*. The lobby found a key ally in former Halliburton CEO Dick Cheney, who became Vice President in 2001. That year Cheney convened a special Energy Task Force that later recommended the exemption to Congress.[1]

To make this recommendation, the task force relied on the EPA study which concluded that CBM fracturing “poses little or no threat to drinking water” (EPA 2004). Called “scientifically unsound” by Weston Wilson, a respected EPA official, the study was heavily criticized for its industry bias. Most importantly the study did not test water samples in contaminated areas. The EPA relied on existing literature, most of which came from industry sources and “pertain[ed] to fracturing fluids’ operational efficiency rather than their potential environmental or human health impacts” (EPA 2004: 4-1). As one observer noted:

> With virtually no scientific research on the migration of fracking fluids into underground sources of drinking water and not knowing completely the ingredients of any fracking fluids, the EPA... concluded fracking does not pose a contamination threat to drinking water (Dolce: 2011).

PART 6: Conclusion

Prospects for the Future

The Halliburton loophole simply marked one more step in an ever-widening regulatory hole. The exemption of hydraulic fracturing from the *Safe Water Drinking Act* was only the latest of many legislative exemptions including the *Clean Water Act*, the *Clean Air Act*, the *Comprehensive Environmental Response, Compensation, and Liability Act*, the *Resource Conservation and Recovery Act*, the *Toxic Release Inventory under the Emergency Planning and Community Right-to-Know Act*, and the *National Environmental Policy Act* (Oil and Gas Accountability Project 2007 cited in Colborn et al 2011).

Given the federal regulatory vacuum, U.S. states have not, for the most part, stepped in. A recent health study observes that state oil and gas commissions assigned to watch over natural gas activity have, as their primary mission "to facilitate gas extraction and increase revenues for the state." When issuing drilling permits, they "have not traditionally required an accounting of how... waste would be handled. In short their focus has not typically been on health and the environment" (Colborn et al 2011).

In 2009, Congress directed the EPA to conduct yet further studies about the effects of hydraulic fracturing on groundwater supplies. A final draft report is expected for public and peer review in 2014 (EPA 2012b). Thus it appears that, more than twenty years after the McMillan family's first complaints of water contamination, there is still much we do not know about hydraulic fracturing. Instead there is, increasingly, less regulation.

Thus, a series of lengthy court battles, successful lobbying, poor research, and the slow wheels of bureaucracy have combined, in many ways, to leave Americans less protected than ever before. There is little hope that the current U.S. administration will change this situation. Despite a contentious and divisive political climate in the United States, support for natural gas development is one policy item that both Democrats and Republicans agree on. In recent major addresses, President Obama has spent considerable time extolling the virtues of natural gas (Obama 2012).

Challenges in Gasland

Despite an abundance of "discourse" on the subject, hydraulic fracturing remains a process shrouded by emotion, self-interest, and controversy. Given this lack of understanding and the serious implications for our water, land, and air, industry and government seem to have done little of substance in responding to concerns.

While the process is complex and multifaceted, industry has employed oversimplified and misleading use of terminology to create a false sense of safety. Further, scientific legalism is regularly used to discredit opposing research findings whereas the absence of scientific study is often misconstrued as evidence supporting fracking safety. Instead working to foster thoughtful and nuanced understanding, combative and simplistic debates have further entrenched polarized positions.

In this context, instruments normally used by society to ensure justice and respectful activity – namely government regulatory bodies and the legal system – have become mechanisms that either delay justice over many years, or function to hide and protect harmful practices. Here, partiality towards commercial interests and bureaucratic inefficiencies have combined to further delay or obstruct effective scientific investigation. Additionally, unknown, "secret" chemicals and the ubiquitous use of non-disclosure agreements with affected parties (something not discussed here) further obscure an already complex subject.

It is unfortunate that important factors that are not in dispute – such as the contamination and loss of massive volumes of potable water during the fracturing process, or the many threats caused by faulty well construction – remain overshadowed by the contentious and obfuscatory nature of the discourse.

This analysis demonstrates how through various means – legal, scientific, political, and media – the natural gas industry has managed to remain aloof from qualified analysis. Through such means industry maintains a pristine 60-year record, despite overwhelming evidence to the contrary.

In conclusion, a combination of various interests interested in profit over clarity make it difficult for society to move forward in a thoughtful and responsible manner. This situation highlights the need for not only for qualified scientific analysis but, in particular, for greater opportunities for meaningful discourse and balanced inquiry.

Epilogue: Alberta

The prospect for Alberta portends for little differences. As University of Alberta political science Professor Laurie Adkin notes, the Alberta government understands the interests of its citizens to be "synonymous" with those of industry (Adkin 2012). As industry's main interest lies in profit over land protection, it is hard to see how our situation will be much different than the U.S. Perhaps a major clue for Alberta's future was already located in my first newspaper reading. In an age of budgetary constraint and fiscal pressures, an extra $3.2 billion from 2011 rents places Albertans on a particular footing with industry.

Already the experiences of Albertans affected by fracking parallel those of landowners in the U.S. in several ways with a regulatory system that favors industry interests, science used to distort intelligent research, and legal dispute as means to delay adequate oversight of industry practices (see: Campbell, Ernst, or Lauridsen 2012). For a discussion of the regulatory process in Alberta, I would direct the reader to fellow student Leah Johnson's essay, "Fracking and Iron Triangles".

Bibliography

Adkin, L. 2012. Government and Oil in Alberta – Presentation for the Students' Oil Sands Delegation. (October). Retrieved from: http://youtu.be/D87iUZjmSac.

Agency for Toxic Substances and Disease Registry. 2000. "Benzene Toxicity Standard and Regulations." (June 1). Retrieved from: http://www.atsdr.cdc.gov/csem/csem.asp?csem=19&po=10.

Alberta Royalty Review Panel. 2007. "Our Fair Share." (September 18). Retrieved: http://www.albertaroyaltyreview.ca/panel/final_report.pdf.

Bergdale, A. 2009. "Marcellus Shale." *New York Times*. From: http://www.nytimes.com/interactive/2011/02/27/us/natural-gas-documents-1.html#document/p533/a9948.

Biello, D. 2012. "How Can We Cope with the Dirty Water from Fracking?" *Scientific American* (May 21). Retrieved from: http://www.scientificamerican.com/article.cfm?id=how-can-we-cope-with-the-dirty-water-from-fracking-for-natural-gas-and-oil.

Campbell, Shawn and Ronalie. 2012. "Fact or Fiction?" Presentation at U of Alberta, Augustana Campus (Nov. 2). Retrieved from: http://frackingab.wordpress.com/campbell/.

Carson, Rachel. 1962. *Silent Spring*. New York: First Mariner Books Ed., 2002.

Colorado Oil and Gas Conservation Commission. 2004. "Notice of Hearing." (June 16). From: http://cogcc.state.co.us/Hearings/Notices/2004/Aug_04/0408OV27.htm.

Cooper, Dave. 2011. "Alberta's next bonanza? Promising Duvernay formation ignites firestorm in oilpatch." *The Edmonton Journal* (November 5). Available at: http://www2.canada.com/edmontonjournal/news/business/story.html?id=be655926-5585-47e7-9d07-a5089dbcae7e&p=3.

Cote, Charles. "De l'eau souterraine contaminee par le gaz de schiste." *La Presse* (December 24). Retrieved from: http://www.lapresse.ca/environnement/dossiers/gaz-de-schiste/201112/23/01-4480758-de-leau-souterraine-contaminee-par-le-gaz-de-schiste.php

Deming, D. 2000. "Oil: Are We Running Out?" *American Association of Petroleum Geologists*. Retrieved from: http://www.energycrisis.info/deming/aapg_oil.pdf.

Deming, D. 2001. Oil: Are We Running Out? in, Downey, M.W., Threet, J.C., and Morgan, W.A., eds *Petroleum Provinces of the 21st Century, AAPG Memoir 74*, 45-55.

Defra - U.K. Department for Environment Food and Rural Affairs. 2011. "Monitoring Networks – Brief History." Retrieved from: http://uk-air.defra.gov.uk/networks/brief-history.

Dolce, C. J. 2011. "Fracking and the Halliburton Loophole." *Huerfano World Journal* (July 14). Retrieved from: http://www.huerfanojournal.com/node/3213.

Efstathiou, J. 2012. "Penn State Faculty Snub of Fracking Study Ends Research." *Bloomberg* (October 2). Retrieved from: http://www.bloomberg.com/news/2012-10-03/penn-state-faculty-snub-of-fracking-study-ends-research.html.

Energy Resources Conservation Board (ERCB). 2012. "News Release: ERCB Releases Investigation Report on Hydraulic Fracturing Incident Near Innisfail." *ERCB* (December 12). Retrieved from: http://www.ercb.ca/news-releases/nr2012-12.pdf

2012. "What are the Impacts on Water?" *ERCB*. (Spring). Retrieved from:http://www.ercb.ca/about-us/what-we-do/current-projects/urf/urf_waterimpacts; PDF at: http://www.ercb.ca/projects/URF/URF_WaterImpacts.pdf.

Encana. 2011. "Why Encana refultes U.S. EPA Pavillion groundwater report." Encana.com (December 2012). Retrieved from: http://www.encana.com/news-stories/news-releases/details.html?release=632327.

Energy in Depth. 2011. "EID Statement on (Latest) Joint Effort by NYT/Environmental Working Group Aimed at Attacking Natural Gas." *Energy in Depth* (August 3). Retrieved from: http://www.energyindepth.org/eid-statement-on-latest-joint-effort-by-nytenvironmental-working-group-aimed-at-attacking-natural-gas/.

Environment Canada. 2004. "Wise Water Use." Retrieved from: http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=F25C70EC-1#cn-tphp.

Environmental Protection Agency (EPA). 2012. "Acid Rain - A Brief History." United States EPA. Retrieved from: http://www.epa.gov/region1/eco/acidrain/history.html.

2012b. EPA's "Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources." Retrieved: http://www.epa.gov/hfstudy/index.html.

2011. "Draft – investigation of Ground Water Contamination near Pavillion, Wyoming." United States EPA (December). Retrieved from: http://www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion_Dec-8-2011.pdf.

2010a. "Origins of Modern Air Pollution Regulations." U.S. EPA (Jan. 29, 2010). Retrieved from: http://www.epa.gov/apti/course422/apc1.html.

2010. "Hydraulic Fracturing Research Study." U.S. EPA (June). Retrieved from: http://www.epa.gov/safewater/uic/pdfs/hfresearchstudyfs.pdf.

2004. "Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study. Retrieved from: http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_coalbedmethanestudy.cfm.

Ernst, J. 2012. "Multi-Million Dollar Landmark North American Lawsuit on Hydraulic Fracturing and Its Impact on Groundwater." *Ernst v. Encana Corporation*. Retrieved from: http://ernstversusencana.com/.

Fisher, K. 2010. "Data Confirm Safety of Well Fracturing." *The American Oil and Gas Reporter* (July). Retrieved from: http://www.halliburton.com/public/pe/contents/Papers_and_Articles/web/A_through_P/AOGR%20Article-%20Data%20Prove%20Safety%20of%20Frac.pdf. Also see: http://www.aogr.com/index.php/magazine/frac-facts.

FracFocus. 2012. "Chemical Use in Hydraulic Fracturing." *FracFocus Chemical Disclosure Registry*. From: http://fracfocus.org/water-protection/drilling-usage.

Gas Drilling Awareness Coalition. 2012. "Marcellus Shale Reality Tour Part 5: Truthland Erupting Water Well." *Youtube* (March 15). Retrieved from: http://youtu.be/iPM64kseP30?t=5m34s.

Gasland. 2012. "Media Kit." Retrieved from: http://www.gaslandthemovie.com/about-the-film/media-kit.

Holzman, D.C. 2011. "Methane Found in Well Water." *Environmental Health Perspectives*, 119 (7): 289. Retrieved from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3222989/.

Hopey, D. 2012. "Lawmaker challenges Pennsylvania DEP's reporting of gas well water safety." *Pittsburgh Post-Gazette* (November 2). Retrieved from: http://www.post-gazette.com/stories/local/state/lawmaker-challenges-pa-deps-reporting-of-gas-well-water-safety-660238/.

Horwitt, D. 2010. "Drilling Around the Law." *Environmental Working Group* (January 20). Retrieved from: http://www.ewg.org/filesEWG-2009drillingaroundthelaw.pdf.

Hubbert, M.K. 1956. "Nuclear Energy and the Fossil Fuels." *Drilling and Production Practice, American Petroleum Institute*, p. 7-25. Retrieved from: http://www.hubbertpeak.com/hubbert/1956/1956.pdf.

Inhofe, J. 2011. "OPINION: Federal interference in energy development regulation a bad idea." *The Hill* (July 19). Retrieved from: http://thehill.com/special-reports/energy-july-2011/172393-federal-interference-in-regulation-of-energy-development-a-bad-idea.

International Energy Agency. 2012. "World Energy Outlook – Executive Summary." Paris: *OECD / IEA*. Retrieved from: http://www.iea.org/publications/freepublications/publication/English.pdf.

International Energy Agency. 2010. "World Energy Outlook" Paris: *OECD / IEA*. Retrieved from: http://www.iea.org/publications/freepublications/publication/weo2010.pdf.

Johnson, Leah. 2012. "Fracking and Iron Triangles: Who Makes it into the Policy Process? Retrieved from: http://frackingab.files.wordpress.com/2012/12/fracking-and-iron-triangles-who-makes-it-into-the-policy-process-leah-johnson.pdf

Kaku, M. 2012. "Solar Revolution." *Big Think* (March 28). Retrieved from: http://bigthink.com/ideas/43384.

Lathem, D. 2001. "LEAF v. EP: A Challenge to Hydraulic Fracturing of Coalbed Methane Wells in Alabama." *Coalbed Methane Association of Alabama* (July 9). Retrieved from: http://www.energyindepth.org/PDF/LEAF_v_EPA.pdf.

Lauridsen, Fiona. 2012. "Burning Water." Presentation at the U of Alberta's Augustana Campus (Nov. 2). Retrieved: http://frackingab.wordpress.com/fiona-lauridsen/.

Legere, L. 2012. "Franklin Forks family sues driller." *The Times Tribune* (April 11). Retrieved from: http://thetimes-tribune.com/news/gas-drilling/franklin-forks-family-sues-driller-1.1298360.

Lisak, J. 2012. "List of the Harmed." *Pennsylvania Alliance for Clean Water and Air* (December 15). Retrieved from: http://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/ .

Marcellus Shale. 2012. "Trouble in Truthland – DEPUE 38H." Retrieved from: http://www.marcellus-shale.us/Depue-Truthland.htm.

McKibben, B. 2007. *Deep Economy: the Wealth of Communities and the Durable Future.* New York: St. Martin's.

McNeill, J.R. 2008. *Global Environmental History in the Age of Fossil Fuels (1800-2007)*. Bolgna: The Bologna International Committee for the Cartography and the Analysis of Contemporary World. Retrieved from: http://www.cartografareilpresente.org/article254.html#nb1.

McNellis, K. 2011. "Names in the News: Pennsylvania's Marcellus Shale Advisory Commission." *National Institute on Money in State Politics* (July 28). Retrieved from: http://www.followthemoney.org/press/PrintReportView.phtml?r=455.

Minnaar, J. 2012. "Un*earthed: The Documentary." *Retrieved from: http://www.youtube.com/watch?v=IPIEzSwPwT0.*

Mordick, B. 2011. "Risks to Drinking Water from Oil and Gas Wellbore Construction and Integrity." *U.S. Environmental Protection Agency.* Retrieved from: http://www.epa.gov/hfstudy/riskstodrinkingwaterfromoilandgaswellboreconstructionandintegrity.pdf.

Muehlenbachs, K. 2011. "Identifying the Sources of Fugitive Methane Associated with Shale Gas Development, updated with new data, Jan 2012. *Resources for the Future* (November 14). Retrieved from: http://www.rff.org/Documents/Events/Seminars/111114_Managing_the_Risks_of_Shale_Gas/Mulenbachs%20Nov%2014FINAL.pdf

Myers, R. 2012. "The Environmental Dangers of Hydro-Fracturing." *Lock haven University.* Retrieved from: http://www.lhup.edu/rmyers3/marcellus.htm.

Myers, T. 2012. "Potentially Contaminant Pathways from Hydraulically Fractured Shale to Aquifers." *Groundwater* (available online April 17). For an online copy see:http://nofracking.com/static/media/PDF/Fracking-Aquifers.pdf .

Nikiforuk, A. 2011. "Fracking Contamination 'Will Get Worse': Alberta Expert." *The Tyee* (December 19). Retrieved from: http://thetyee.ca/News/2011/12/19Fracking-Contamination/.

Ohio Department of Natural Resources, Division of Mineral Resources Management. "Report on the Investigation of the Natural Gas Invasion of Aquifers in Bainbridge Township of Geauga County, Ohio." From: http://s3.amazonaws.com/propublica/assets/natural_gas/ohio_methane_report_080901.pdf.

Pasternak, J. 2001. "Bush's Energy Plan Bares Industry Clout." *Los Angeles Times* (August 26). From: http://articles.latimes.com/2001/aug/26/news/mn-38530.

Phillips, S. 2012. "SUNY Buffalo Shuts Down Shale Institute." *State Impact* (November 19). Retrieved from: http://stateimpact.npr.org/pennsylvania/2012/11/19/suny-buffalo-shuts-down-shale-institute/.

Pryce, David. 2012. "Letter to the Editor Re: Alberta needs a moratorium on fracking." *The Camrose Booster* (May 8).

New York Times Editorial. 2009. "The Halliburton Loophole." *The New York Times* (November 2). Retrieved from: http://www.nytimes.com/2009/11/03/opinion/03tue3.html?_r=0.

Osborn, S.G., Vengosh, A., Warner, N.R., Jackson R.B. 2011. *PNAS* (January 13). Retrieved: http://www.nicholas.duke.edu/hydrofracking/Osborn%20et%20al%20%20Hydrofracking%202011.pdf. Or see: http://www.pnas.org/content/108/20/8172.full.

Shaeffer, K. 2009. "What's a Frac – or WAF?" *Oil and Gas Investments Bulletin.* (May 15) Retrieved from: http://oilandgas-investments.com/2009/natural-gas/whats-a-frac-or-waf/.

Shellenberger, M. and Nordhaus, T. 2012. "The 'Corporate Welfare' Behind the Gas Revolution – The Hamiltonian Promise, from Fracking to Clean Tech." The Breakthrough (October 22). Retrieved: http://thebreakthrough.org/index.php/voices/michael-shellenberger-and-ted-nordhaus/the-corporate-welfare-behind-the-gas-revolution/.

Smith-Heavenrich, S. 2010. "Hydraulic Fracturing Threatens Drinking Water." *Syracuse Peace Council* (June 3). Retrieved from: http://www.peacecouncil.net/pnl/10/795/795water.htm.

Trembath, A., Jenkins, J., Nordhaus, T., Shellenberger, M. 2012. "Where the Shale Gas Revolution Came From – Government's Role in the Development of Hydraulic Fracturing in Shale. *Breakthrough Institute* (May). Retrieved from: http://thebreakthrough.org/blog/Where_the_Shale_Gas_Revolution_Came_From.pdf.

Truthland. 2012. "Fear is Toxic, Truth is the Antidote – Blog." Retrieved from: http://www.gaslandthemovie.com/about-the-film/media-kit.

Urbina, I. 2011. "Regulation Lax as Gas Wells' Tainted Water Hits Rivers." *New York Times* (February 26). Retrieved from: http://www.nytimes.com/2011/02/27/us/27gas.html?pagewanted=all&_r=0.

U.S. Energy Information Administration. "U.S. Field Production of Crude Oil." *EIA.gov.* Retrieved from: http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRFPUS2&f=A.

U.S. House of Representatives. 2011. "Chemicals Used in Hydraulic Fracturing." *Committee on Energy and Commerce – Minority Staff* (April). Retrieved from: http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf.

Weber, R. J. 2010. "Air Pollution: History." *Georgia Tech.* Retrieved from: http://www.aerosols.eas.gatech.edu/EAS%20Air%20Pollution%20Phys%20Chem/Intro1%20AP%20History.pdf.

Wile, R. 2012. "The Entire Oil and Gas Industry is Watching a Tiny Town in Wyoming." *Business Insider* (October 3). Retrieved from: http://www.businessinsider.com/oil-gas-industry-fracking-pavillion-wyoming-2012-10.

Wilson, W. 2004. "Letter to Senators Allard and Campbell and Representative DeGette." (October 8). Retrieved from: http://www.earthworksaction.org/files/publications/Weston.pdf?pubs/Weston.pdf.

Wright, P.R., McMahan, P.B., Mueller, D.K., Clark, M.L. 2012. "Groundwater-Quality and Quality-Control Data for Two Monitoring Wells near Pavillion, Wyoming, April and May 2012. *U.S. Geological Survey.* Data Series 718. Retrieved from: http://pubs.usgs.gov/ds/718/DS718_508.pdf.