

## **A Brief Issue Paper on Hydraulic Fracturing and Unconventional Gas Practices**

It is encouraging that Nova Scotia agreed to implement a review process of hydraulic fracturing for shale gas and other hydrocarbons.

It is also positive that the government has agreed not to issue any further licenses for hydraulic fracturing until the review is complete.

### **Why are we still so concerned?**

The objective of the review, as presently stated, leads to only one outcome – the development of shale gas including hydraulic fracturing, or fracking, regulated “based on best practices.”

**The review of hydraulic fracturing has not been defined to allow for all options to be examined -- including the options of a ban or moratorium.**

The “Final Scope” document released by the Departments of Energy and Environment states, “the team will make recommendations to the Ministers to ensure industry and regulatory best practice is being employed in the province.”<sup>1</sup>

We are aware that shale gas cannot be profitably extracted without fracking. **It appears that as things are proceeding, after a short break for this review, the shale gas industrial process, including hydraulic fracturing, regulated in some way, will become a reality in Nova Scotia.**

Recent scientific studies and evidence from gas developing areas where fracking for shale gas is taking place, document a range of serious problems. There is no valid, unbiased evidence that the development of shale gas including hydraulic fracturing can be done in a way that can protect environment, health and climate at this time.

This is why MLAs around the province continue to hear from their constituents on this issue.

Recently, Minister Parker stated publicly that the issue is turning out to be more complex than expected. He also stated that the review process will take longer than initially expected.

We are glad to hear this. We agree completely that the issue is complex.

- We believe that before decisions are made about whether to allow shale gas industrial development including hydraulic fracturing, many issues and options, including the options of a moratorium or ban, need to be evaluated, ranging far beyond a technical review of regulations.
- We hope the government will recognize the need, and value, of slowing down. Evaluating the full range of impacts based on valid evidence and recognizing cumulative impacts, would be a wise step to take before deciding whether to allow unconventional gas development including fracking in Nova Scotia.

### **The Hydraulic Fracturing Review Too Narrow in Scope**

The government has made it clear this is a technical and policy review, with a fairly limited scope. The stated objectives are to identify potential environmental issues, determine how they are managed elsewhere, and make recommendations to the Ministers of Energy and Environment to “ensure industry and regulatory best practice.”<sup>2</sup>

The Review’s information gathering is focused on how best to regulate on a limited range of issues. Important questions are not being asked. The review does not appear to be assessing health risks, the full range of environmental impacts, impacts on existing industries including tourism and agriculture, climate impacts, and the actual economic bottom line, including costs downloaded to the province and to individual taxpayers. The result of these omissions could mean that the committee will not identify the potential for significant harm that could result from pursuing a purely regulatory approach, especially given the limited number and scope of scientific studies available at this point in time.

### **Best practices are not necessarily safe practices**

We cannot assume that best practices are based on valid research evaluating risks and potential harm. Two examples illustrate this point. Immense amounts of toxic wastewater are generated, contaminated with fracking chemicals as well as toxins released from the shale, often including radioactive elements. No disposal method has yet been evaluated for safety to this time.<sup>3</sup> Human and animal health risks have not been evaluated, although significant health problems are emerging in gas intensive areas.<sup>4</sup> Safe levels of short and long-term exposure for many chemicals emitted from gas fields to the air and potentially into drinking water are not yet established, especially for children and other vulnerable populations.<sup>5</sup>

### **Too narrow in allowable outcomes**

Overwhelmingly, public submissions addressing the scope of the Provincial review asked the government to consider a moratorium or ban. Many scientists and health professionals recommend a moratorium. In spite of this, a decision was made in Nova Scotia to focus narrowly on determining regulations based on best practices. Since this scope was finalized, additional evidence supports the conclusion that a province-wide moratorium or ban makes good sense, given the significant risks being documented in areas where shale gas is well established.

### **Too narrow in participation and transparency**

The Review Committee is composed solely of staff of the Departments of Energy and Environment. There are no representatives from key stakeholders from other sectors: no independent civil society representatives, environment, health or aboriginal groups, or independent academics. There are no representatives from the Departments of Health, Agriculture, or Rural Development. Further, the workings of the committee are not transparent, despite making updates available online.

The decisions being made will have significant impacts on many aspects of life in Nova Scotia for decades or longer. Broad representation, public participation and transparency are needed.

### **“ Unconventional” gas - New technologies, new industry, new risks**

Hydraulic fracturing *per se* is not a new technique. Conventional fracturing methods (of vertical wells) have been used since the 1950s. However, shale gas extracted using high-volume slickwater fracturing techniques in combination with horizontal drilling and multi-well platforms, is a very different process. It is called “unconventional gas” by the industry, and it is unconventional in many ways. In this document, when we use the term hydraulic fracturing or fracking, we refer to this unconventional and relatively new process. Shale gas (and some other hydrocarbons) can only be profitably extracted using these new technologies.

Kerry Guy, Natural Gas Advocacy representative for the Canadian Association of Petroleum Producers (CAPP) admitted that this was a “ ... **fairly new technology of horizontal multi-stage fractured wells**”<sup>6</sup> in an email to a North Shore resident. Guy clarified that only 1200 of 170,000 (less than 1%) of wells in western Canada have been fractured using these new techniques.

The use of a high-volume slickwater fracturing technique in combination with horizontal drilling and multi-well platforms (in some areas) has been widely used **for only 4-5 years**, according to Dr. Anthony R. Ingraffea, a Cornell University professor of civil and environmental engineering who specializes in rock fracture mechanics and spent 25 years working for the oil and gas industry

### **What is different about “unconventional” gas**

The “unconventional” shale gas industrial process is different from conventional oil and gas in many of its impacts above and below ground -- impacts on water, on air quality, and on land.

Shale gas development involves thousands of wells, well pads, wastewater pits, gas flare offs, compressors, truck traffic (estimated at 1,000 heavy trucks per well per frack), roads and pipelines. These are often located

close to homes, schools, farms, and communities, and close to streams and watercourses. Every step of the shale gas process impacts air quality during normal operations. Each step of the operation also provides opportunity for accidents, leaks, and spills. The **cumulative impacts of shale gas development on water, air, land, and communities** are very different from conventional oil and gas development. These cumulative risks and impacts need to be evaluated.

**Example:** Industry statistics reveal that 5% of wells leak in the first year. [See Appendix A] In a project of one well, that's a one in 20 chance of leakage -- not too bad. In a project of 200 wells, such as the proposed development in Hants County by Triangle Petroleum [Appendix B], **5% leakage means 10 leaking wells – in the first year alone.** Statistics also indicate that the number of leaking wells increases over time. <sup>7</sup>

Experts in the field of geology, engineering, public health, veterinary medicine and seismology (earthquakes) tell us that much is still unknown about the potential long- term impacts of shale gas development. They also tell us that there are troubling indications of problems.

“Because shale-gas development is so new, scientific information on the environmental costs is scarce. Only this year have studies begun to appear in peer-reviewed journals, and these give reason for pause. We call for a moratorium on shale-gas development to allow for **better study of the cumulative risks to water quality, air quality and global climate. Only with such comprehensive knowledge can appropriate regulatory frameworks be developed.**” (Ingraffea, *Nature*, vol.477, no.7364, pp. 271-275 September 15, 2011)

- We believe that it is important to recognize that shale gas development involving hydraulic fracturing is an **essentially new industry, using essentially new techniques, and giving rise to new issues and risks which have not yet been studied for their full impacts.**
- We believe that the scale and nature of hydraulic fracturing for shale gas requires an evaluation of cumulative impacts and risks, not covered by a piece-by-piece permitting approach. Given the scale of the shale gas industry, **the potential for harm and the difficulty in preventing harm is much greater than for an industry contained within walls in one location.**

### **New industries with potential for significant harm need to be fully evaluated**

The existing review process appears to approach “unconventional” shale gas as if it is an industry whose impacts are well understood, and that all that remains is to decide how it should be regulated.

- We believe that the “unconventional gas” industry should be treated as a new industry, which has a potential for serious, irreversible damage to the environment, including human health. In the case of a new industry with potential for harm, an open and public full assessment and evaluation based on a well established and validated body of knowledge is needed before a decision is made to proceed. This approach has been used in the past with other industries.

### **Health Aspects**

Medical professionals are voicing concerns about the potential health impacts of the unconventional gas industry and are urging caution.

The Medical Society of the State of New York **passed a resolution supporting "a moratorium on natural gas development in the state until valid information is available to evaluate the process for its potential effects on human health and the environment."** (December 10, 2010)

A sub-committee of the American Pediatric Society, the Pediatric Environmental Health Specialty Unit, recommends: "... **health professionals should advocate for human health effects to be a part of the discussion regarding NGE/HF [natural gas extraction/hydraulic fracturing.]**" <sup>8</sup>(August 2011)

The Nova Scotia Environment Act states:

“The purpose of this Act is to support and promote the protection, enhancement and prudent use of the environment while recognizing the following goals:

**(a) maintaining environmental protection as essential to the integrity of ecosystems, human health and the socio-economic well-being of society...”**

Yet, to date, Nova Scotia’s review process has not agreed to include a Public Health perspective .

There is increasing evidence that shale gas development including hydraulic fracturing is leading to serious health concerns. Water contamination is only one of the problems. Air pollution has become a major area of concern.

- Water samples from wells in Pavillion, Wyoming contained 10 compounds used in fracking, including **benzene, a known carcinogen, at 50 times the safe level** for human consumption. A three-year Environmental Protection Agency (EPA) study concluded that fracking compounds were the likely source of contamination. <sup>9</sup>
- Air quality samples in Dish, Texas found high levels of 15 chemicals, including benzene, xylene, naphthalene and carbon disulfide. These chemicals can cause respiratory damage, reproductive damage, central nervous system damage and cancer. **Some levels were 10 times the recommended level for short-term exposure.** <sup>10</sup>
- Air samples from a Colorado drilling area found benzene at **48.5 to 800 times higher than the EPA level for increased cancer risk from long-term exposure.**<sup>11</sup>
- The same samples found acrylonitrile, a respiratory toxin and carcinogen, at **790-3000 times above safe levels.**<sup>12</sup>
- In 2009, Wyoming failed to meet federal air standards for the first time. Gas wells, 27,000 of them, most drilled within the previous five years, were emitting toluene, a central nervous system toxin, and benzene, a carcinogen. <sup>13</sup>
- In 2011, rural Wyoming experienced ozone levels higher than the worst days in Los Angeles.<sup>14</sup>
- Gas field ozone can spread up to 200 miles beyond the gas production region, damaging human lungs as well as trees and forage crops. <sup>15</sup>

### **Increased illness in gas producing areas**

Health statistics in gas producing districts show preliminary evidence of health impacts in intensively drilled areas in Texas.

- **Breast cancer rates rose significantly** among women living in the six Texas counties with the most intensive gas drilling (Heinkel-Wolfe, 2011).<sup>16</sup> By contrast, over the same time period, breast cancer rates declined within the rest of Texas.
- A Texas hospital serving six counties near drilling sites reported **asthma rates three times higher** than the state average.<sup>17</sup>

One of the US government’s top scientists, Dr. Christopher Portier, Director of the US Agency for Toxic Substances and Disease Registry and National Center for Environmental Health, notes “... anecdotal evidence of environmental illness [in areas of shale gas development] is sufficient to warrant a more serious and systematic approach to studying it... **In some communities it has been a disaster... More research is needed for us to understand public health impacts from natural gas drilling and new gas drilling technologies.**” <sup>18</sup>

Many medical professionals and organizations urge that we take a precautionary approach, including a moratorium on fracking for shale gas, until there is sufficient evidence to make informed decisions.

- We believe that it is not possible to design regulations which would protect “the integrity of human health” without a full evaluation of public health impacts as part of the process.
- We believe that public health issues should be thoroughly evaluated as part of any decision making process relating to shale gas development and hydraulic fracturing.

- We believe that Nova Scotia would be wise to refrain from issuing hydraulic fracturing licenses until potential consequences for Nova Scotians' health (and implications for our health care system) are thoroughly investigated, based on valid scientific evidence. This evidence does not yet exist, as noted above. The Nova Scotia Environment Act states, "the lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation."

### Economic Aspects

The main argument for allowing hydraulic fracturing for shale gas is, of course, the potential economic benefit. Royalties are expected to boost provincial finances, and hopes are that extensive job creation could draw Nova Scotians home from the oilfields of the West.

If the major rationale for allowing hydraulic fracturing of shale gas is presumed economic benefit, it would seem appropriate to conduct a detailed Economic Cost/Benefit Analysis as part of any decision making process, including the costs of potential negative effects on human health and the environment.

Analyses from other jurisdictions indicate that:

- **Royalty payments may be minimal, given that shale gas wells produce 75 -80% of their life production within the first 24 months. [see Appendix C ] Two years appears to be the present period of royalty holiday in Nova Scotia, during which no royalties are collected,** as noted in company information to investors.<sup>19</sup>
- Gas prices are at a 10 year low right now, also affecting predicted royalty income.
- Actual jobs created are likely to be a fraction of what is promised.<sup>20</sup> A study by Keystone Institute found that rather than a claimed job gain of 48,000 jobs in 18 months in Pennsylvania, actual job gains were only 20% of that number. <sup>21</sup> An analysis of job projections in New York found that rather than creating 125 jobs per well, as an industry funded study by the PPINY claimed, job gains were likely to be only 2 jobs per well. <sup>22</sup>
- Most high paying jobs will not go to local residents. According to a study by Food and Water Watch, in NY, an estimated 70% of jobs would go to workers from outside the state. <sup>23</sup> Wages and taxes on income would also go out of state.
- Gas supply estimates for many parts of the US have been substantially downgraded in the past year, with **supply estimates reduced by 66% or more.**<sup>24</sup> <sup>25</sup>Estimates of recoverable supplies are even lower.<sup>26</sup> This calls into question many of the economic and energy claims for shale gas, including estimates of a 30 year production phase.
- The boom-bust cycle of shale gas development must be considered in any economic evaluation. It is also necessary to distinguish between drilling phase jobs, which are short term and account for up to 98% of jobs and production phase jobs, which are longer term and account for less than 5% of jobs.<sup>27</sup> A Penn College of Technology report estimated production phase jobs at just 0.18 jobs per well. <sup>28</sup>

There are also significant offsetting costs downloaded to the province, municipalities and individual tax payers including:

- Tremendous damage and wear on local roads and bridges<sup>29</sup>, not designed for continuous stresses from heavy water bearing tanker trucks and other equipment. Trucks carrying water, sand, chemicals equipment and waste water generated by the fracking process are estimated to average 1,000 truck trips per well per frack (each well being fracked up to 18 times.)
- Risks to existing industries including agriculture (conventional and organic, dairy and meat), wineries, fisheries and aquaculture, forestry, tourism, golf and resorts. These industries could be severely impacted by fracking, with resulting loss of employment, income and tax revenues.
- Devaluation of real estate. Properties close to gas wells and well pads are at risk of drastically decreased value, and significant difficulty in selling or refinancing. <sup>30</sup> Property devaluation has a downward impact on provincial and municipal tax bases.
- Significant costs of effective monitoring and enforcement of regulations. Estimated costs must consider costs of investigating and documenting damage (similar to the EPA 3-year in depth study in

- Wyoming), up to and including defending against legal challenges. Gas companies (with very deep pockets) are well able to challenge findings against them through lengthy court action.
- Cost of long-term monitoring and remediation of wells and well sites after they are handed back to the province. Research indicates<sup>31</sup> that many wells will leak as years go by, creating environmental hazards which will be the responsibility of the province. Evaporation pits may also pose long term hazards. Dr. Theo Colborn predicts fracking waste evaporation pits have the potential to become future hazardous waste sites requiring costly cleanup. <sup>32</sup>In the US these are called Superfund sites, and there is a federal fund which covers investigation and clean up costs. <sup>33 34</sup>
  - Health costs associated with increased illness. Economic impacts of lost work days and productivity.
  - Costs of frequent water testing for residents of drilling areas, as recommended by the Pediatric Environmental Health Specialty Unit.<sup>35</sup> Baseline water testing is not sufficient for protection. Costs of potentially permanent replacement water supplies, or water purification and maintenance, in cases of water contamination where filtration can correct problems (not always possible.)

Dr. Susan Christopherson and colleagues at Cornell University in the Finger Lakes region of New York have prepared a series of working papers that address key economic issues related to shale gas drilling and production. <sup>36</sup>

In the US, vastly inflated figures about the number of jobs that would be created, inflated figures about actual gas reserves, as well as the life of gas wells, have not been demonstrated on the ground.

- We believe that a full Economic Impact Analysis of shale gas including an evidence-based evaluation of both benefits and costs relating to shale gas development should be conducted and open to public input and analysis before any decision is made to proceed. We believe that this is consistent with the mandate of environmental protection in the Environment Act, which recognizes “**maintaining environmental protection as essential to the integrity of ecosystems, human health and the socio-economic well-being of society.**”

## Climate

### Reconsider shale gas development in light of new climate evidence

When the government decided to incorporate unconventional onshore gas as part of its energy plan, this appeared to be a positive decision from a climate perspective. Since that time, strong scientific evidence has emerged indicating that shale gas is not going to advance climate goals.<sup>37</sup> Nova Scotia would not be the first to reconsider its support of shale gas in the light of changing evidence. Robert F. Kennedy, an early supporter of shale gas who sits on New York State Governor Andrew Cuomo's High Volume Hydraulic Fracturing Advisory Panel, has changed his views, based on emerging scientific evidence. <sup>38</sup>

### Is fracking for shale gas a “clean” energy from a climate perspective?

It appears not, and increasingly so. A recent study by the National Oceanic and Atmospheric Administration (NOAA) and the University of Colorado<sup>39</sup> shows that wells leak and release significant amounts of methane, an extremely powerful greenhouse gas, into the atmosphere, which may make it no “cleaner” than dirty coal. Two earlier studies came to the same conclusions.<sup>40</sup>

**Do we need to develop shale gas for energy?** According to the Pembina Institute and the David Suzuki Foundation, <sup>41</sup>“Economic modeling studies show unequivocally that economically efficient policies to cut GHG emissions will lead to a lower level of natural gas production and use than the “business-as-usual” level. In this sense, natural gas is not a bridging fuel in the fight to curb climate.” (The groups also note, “New production facilities for natural gas — and particularly shale gas — are likely to cause substantial environmental impacts aside from climate change.”)

According to Nobel Prize winning economist, Paul Krugman, solar is very close to becoming a viable alternative to both coal and unconventional gas. Krugman contrasts the real costs of fracked gas, including the externalized costs of environmental, health and infrastructural damage (which he labels a hidden subsidy), with the rapidly dropping cost of solar energy which he argues has none of these down sides. “**Fracking is**

**not a dream come true;**” writes Krugman, **“solar is now cost-effective.”**<sup>42</sup>

- We believe that given the immense scale of this industry, shale gas development is likely to derail climate objectives in Nova Scotia.
- We believe that full-cost accounting of the climate impacts of shale gas development should be added to other environmental considerations in any decision making process.

### **Much is still unknown**

**“All these states are flying blind. A long list of technical questions remain unanswered..”** *Scientific American’s* Board of Editors, November 2011.

At this time, there is insufficient reliable information to determine whether hydraulic fracturing for shale gas can be developed without widespread harm.

The US Congress has directed the US Environmental Protection Agency to conduct a nationwide study to examine whether fracking presents a risk to water resources. The final report will be released in 2014. <sup>43</sup>

In September 2011, Canadian Environment Minister Peter Kent asked Environment Canada and a panel of independent scientists with the Council of Canadian Academies to conduct two parallel studies of the environmental impacts of hydraulic fracturing. The Council of Canadian Academies notes that their study will likely take 18-24 months.<sup>44</sup> It is important to note that this review is **limited to a literature review. It will not be able to address key issues which have not yet been studied and published.**

Medical experts, including top US government scientist, Dr. Christopher Portier, Director of the National Centre for Environmental Health of the Centers for Disease Control and Prevention, are calling for detailed health studies, which have not yet been done. <sup>45</sup>

- It appears that the present review, expected in April or May of 2012, will be concluded while there are still gaping voids in the evidence required to make a reasoned decision on this industry. Given the absence of substantive studies of risk, it is hard to see how Nova Scotia’s present review can determine whether identified “best practices” are safe, or determine whether regulatory measures can effectively protect the public from immediate or long-term harm.

### **No rush to develop**

Finally, one might ask why there is such a drive, such pressure to take up this controversial technology quickly. Gas reserves embedded in shale are not going away. Given today’s low price for natural gas, it is likely to increase in value over time.

Nova Scotia, in particular, should be in no rush to exploit this resource. With the announcement of the multi-billion dollar contract at Irving Shipbuilding, with Encana’s Deep Panuke well expected to commence production this summer, and Shell’s new offshore exploration proposing nearly 1 billion dollars of investment over six years, Nova Scotia is looking at unprecedented sources of revenue and employment in the petroleum and military support industries.

### **Precautionary principle**

The Nova Scotia Environment Act states in section 2(a) (ii),

**“... the precautionary principle will be used in decision-making so that where there are threats of serious or irreversible damage, the lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation.”**

The precautionary principle exists **precisely to give guidance** in situations where there is strong indication of the possibility of harm, but all the details are not yet known. We believe that hydraulic fracturing for unconventional gas is exactly the type of situation where the precautionary principle should be applied.

Nova Scotia is not in the same situation as areas where shale gas development is in full swing. In those areas, improving regulations to provide improved protection needs to be an immediate concern.

**However, in Nova Scotia, where shale gas industrial development including fracking has barely begun, the immediate concern, given evidence of potential serious and irreversible harm, should be to investigate all the facts and make a fully informed decision before deciding whether to proceed.**

- We urge the government to follow the precautionary principle enshrined in the Environment Act and **adopt a 10 year moratorium or ban on shale gas development including hydraulic fracturing, until valid information, including a body of peer-reviewed independent research, exists about the risks and to what extent harm can be avoided. In the interim, harm will be avoided, not compounded.**

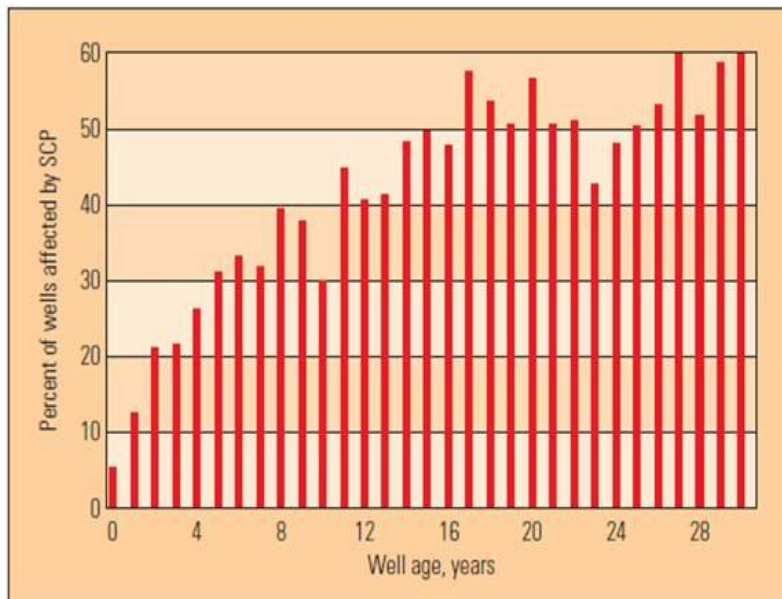
This briefing document was drafted by the Nova Scotia Fracking Resource and Action Coalition (NOFRAC.) NOFRAC is a group comprising more than 100 members, representing more than 15 environmental and community organizations. NOFRAC has members residing in all seven of the on-shore petroleum lease agreement blocks and in other parts of the province. The coalition was formed in December 2010.





Appendix A

“Since the earliest gas wells, uncontrolled migration of hydrocarbons to the surface has challenged the oil and gas industry”



SCP=Sustained Casing Pressure. Also called sustained annular pressure in one or more of the casing annuli.

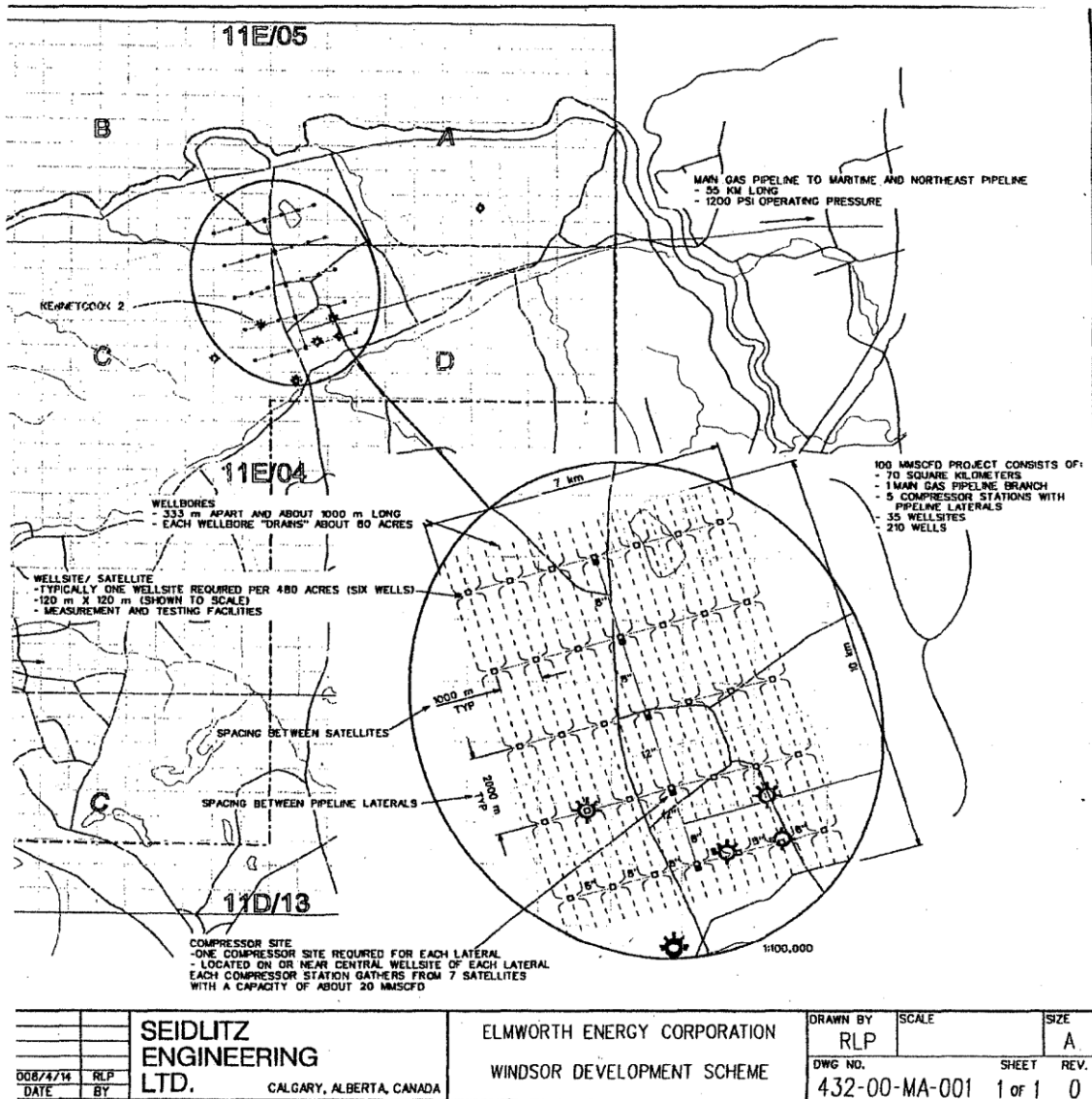
^ Wells with SCP by age. Statistics from the United States Mineral Management Service (MMS) show the percentage of wells with SCP for wells in the outer continental shelf (OCS) area of the Gulf of Mexico, grouped by age of the wells. These data do not include wells in state waters or land locations.

Brufatto *et al.*, *Oilfield Review*, Schlumberger, Autumn, 2003

Appendix B

Development Application Plan, Triangle Petroleum Corporation (Elmworth Energy), Windsor Block, near Kennetcook, Nova Scotia, June 2008.

Plan for 210 wells, 35 well pads, 5 compressor stations on 70 square kilometers. Triangle has lease rights to 747,625 gross acres, or 1920.7 square kilometers.

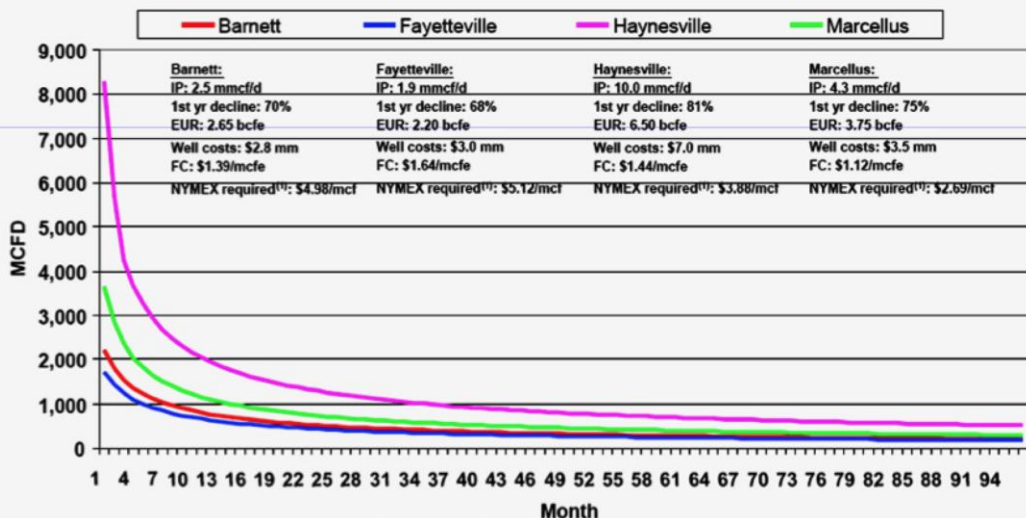


Elmworth Energy Corporation engages in the oil and gas exploration and development activities for Triangle Petroleum Corp. Elmworth Energy Corporation is a subsidiary of Triangle Petroleum Corp.

Appendix C

2008 Investor and Analyst Meeting

# Major Shale Type Curves



21



Pre-leasehold pro forma finding costs range from \$1.12-\$1.64/mcfe

(1) NYMEX natural gas price required to generate a pre-tax 10% rate of return  
 • Risk disclosure regarding unproved reserve estimates appears on page ii of the meeting presentation package

<sup>1</sup> <http://www.gov.ns.ca/nse/pollutionprevention/docs/Consultation.Fracturing.Scope.pdf>

<sup>2</sup> Ibid

<sup>3</sup> *Research and Policy Recommendations for Hydraulic Fracturing and Shale Gas Extraction*, Robert B. Jackson, Brooks Rainey Pearson, Stephen G. Gas Extraction R. Warner, Avner Vengosh, Duke University, Durham, N.C., May, 2011, <http://www.nicholas.duke.edu/cgc/HydraulicFracturingWhitepaper2011.pdf>

<sup>4</sup> Abraham Lustgarten, Nicholas Kusnetz and ProPublica. *Science lags as health problems emerge near natural gas wells*, 19 September 2011. Scientific American. <http://www.scientificamerican.com/article.cfm?id=science-lags-as-health-problems>

<sup>5</sup> *Health Impact Assessment for Battlement Mesa, Garfield County Colorado*, Witter et al, Colorado School of Public Health, September 2010, <http://www.garfield-county.com/public-health/documents/1%20%20%20Complete%20HIA%20without%20Appendix%20D.pdf>

<sup>6</sup> Private email to Graham Hutchinson, January 31, 2010 "To date, some 600 deep horizontal shale gas wells have been drilled in British Columbia with a similar number of wells having been drilled in Alberta. As you can see this represents less than 1% of all the wells that have been fracked in Alberta and British Columbia. This reflects the fairly new technology of horizontal multi-stage fractured wells, while the 170,000 wells reflects the last 60 years of industry activity."

<sup>7</sup> Appendix A

<sup>8</sup> Pediatric Environmental Specialty Units, *PEHSU Fact Sheet on Natural Gas Extraction and Hydraulic Fracturing for Health Professionals*, August 2011 [http://aoec.org/pehsu/documents/hydraulic\\_fracturing\\_and\\_children\\_2011\\_health\\_prof.pdf](http://aoec.org/pehsu/documents/hydraulic_fracturing_and_children_2011_health_prof.pdf)

<sup>9</sup> *Feds Link Water Contamination to Fracking for the First Time, EPA releases report linking water contamination in Pavillion, Wyoming to fracking after 3-year investigation* (This study is presently in peer review process), <http://www.propublica.org/article/feds-link-water-contamination-to-fracking-for-first-time/single>, see also *Draft report Pavillion Groundwater Investigation*, January 2010 sampling and update <http://www.epa.gov/region8/superfund/wy/pavillion/PavillionWyomingFactSheet.pdf>

<sup>10</sup> *Town of DISH, Texas, Ambient Air Monitoring Analysis Final Report*, Wolf Eagle Environmental, September 15, 2009, [http://townofdish.com/objects/DISH - final\\_report\\_revised.pdf](http://townofdish.com/objects/DISH - final_report_revised.pdf)

<sup>11</sup> *Gassed! Citizen Investigation of Toxic Air Pollution from Natural Gas Development* <http://www.gcmonitor.org/downloads/gassedreport.pdf>

<sup>12</sup> Ibid

<sup>13</sup> *Regulation Lax as Gas Wells' Water Hits Rivers*, Ian Urbina, February 26, 2011, New York Times, *Drilling Down* series, (Summary of key facts at *New York Times' Findings in a Nutshell* March 15, 2011, <http://protectingourwaters.wordpress.com/2011/03/15/new-york-times-findings-in-a-nutshell/> )

<sup>14</sup> [http://www.huffingtonpost.com/2011/03/08/wyoming-ait-pollution-gas-drilling\\_n\\_833027.html](http://www.huffingtonpost.com/2011/03/08/wyoming-ait-pollution-gas-drilling_n_833027.html)

<sup>15</sup> *Natural Gas Operations from a Public Health Perspective*, Dr. Theo Colborn, *Human and Ecological Risk Assessment: An International Journal*, Taylor & Francis Online, Volume 17, Issue 5, Sept 20, 2011 <http://www.endocrinedisruption.com/chemicals.journalarticle.php>

<sup>16</sup> <http://www.dentonrc.com/local-news/special-projects/gas-well-drilling-headlines/20110831-breast-cancer-rate-climbs-up.ece>

<sup>17</sup> Urbina, ibid

<sup>18</sup> Lustgarten et al, Scientific American, ibid

<sup>19</sup> Triangle Petroleum Corporation. Overview: Shale Gas Summary, Appendix B.

<http://www.trianglepetroleum.com/index.php?page=overview>

<sup>20</sup> *Economists Concerned About Economic Impact on NYS of Shale Gas Exploration, Drilling, Production and Transmission*, Dr. Jannette M. Barth, Ph.D., Dr. Edward C. Kokkelenberg, Ph.D., Dr. Timothy Mount, Ph.D. letter to Gov Cuomo dated 12/14/2011, <http://catskillcitizens.org/learnmore/EconomistsLetterDec142011.pdf>

<sup>21</sup> [http://keystoneresearch.org/media-center/media-coverage/report-marcellus-shale-boom-adds-almost-10000-jobs-3-yearshttp://catskillcitizens.org/learn\\_one.cfm?t=2&c=22](http://keystoneresearch.org/media-center/media-coverage/report-marcellus-shale-boom-adds-almost-10000-jobs-3-yearshttp://catskillcitizens.org/learn_one.cfm?t=2&c=22)

<sup>22</sup> *Exposing the Oil and Gas Industry's False Jobs Promise for Shale Gas Development: How methodological flaws grossly exaggerate job projections*, <http://www.foodandwaterwatch.org/tools-and-resources/exposing-the-oil-and-gas-industrys-false-jobs-promise/>

<sup>23</sup> Ibid

<sup>24</sup> <http://www.nytimes.com/2012/01/29/us/new-data-not-so-sunny-on-us-natural-gas-supply.html?pagewanted=all>

<sup>25</sup> <http://energybulletin.net/stories/2012-02-05/falling-feeling-shale-gas-estimates-continue-downward>

<sup>26</sup> Ibid

<sup>27</sup> *Workforce Development Challenges in the Natural Gas Industry*, Jeffrey Jacquet, February 2011, [http://www.greenchoices.cornell.edu/downloads/development/marcellus/Marcellus\\_Jacquet.pdf](http://www.greenchoices.cornell.edu/downloads/development/marcellus/Marcellus_Jacquet.pdf)

<sup>28</sup> Ibid

<sup>29</sup> [http://www.huffingtonpost.com/robert-f-kennedy-jr/fracking-natural-gas-new-york-times-\\_b\\_1022337.html](http://www.huffingtonpost.com/robert-f-kennedy-jr/fracking-natural-gas-new-york-times-_b_1022337.html)

<sup>30</sup> <http://www.nytimes.com/2011/10/20/us/rush-to-drill-for-gas-creates-mortgage-conflicts.html?pagewanted=all> , <http://www.savecoloradofromfracking.org/harm/propertyvalues.html>

<sup>31</sup> see Appendix A

<sup>32</sup> Colborn, ibid

<sup>33</sup> Colborn, ibid

<sup>34</sup> <http://www.epa.gov/superfund/sites/>

<sup>35</sup> PEHSU ibid

<sup>36</sup> <http://www.greenchoices.cornell.edu/development/marcellus/policy.cfm>

<sup>37</sup> R. W. Howarth et al. *Clim. Change Lett.* 106, 679–690; 2011, <http://www.eeb.cornell.edu/howarth/Howarth%20et%20al%20%202011.pdf>, R. W. Howarth et al. *Clim. Change* in the press), Petron et al, National Oceanic and Atmospheric Administration (NOAA) and University of Colorado, <http://www.nature.com/news/air-sampling-reveals-high-emissions-from-gas-field-1.9982>,

---

<sup>38</sup> Kennedy, Robert, *The Fracking Industry's War on the New York Times – And The Truth*,  
[http://www.huffingtonpost.com/robert-f-kennedy-jr/fracking-natural-gas-new-york-times-\\_b\\_1022337.html](http://www.huffingtonpost.com/robert-f-kennedy-jr/fracking-natural-gas-new-york-times-_b_1022337.html)

<sup>39</sup> <http://www.nature.com/news/air-sampling-reveals-high-emissions-from-gas-field-1.9982>

<sup>40</sup> Howarth, *ibid*

<sup>41</sup> *Is Natural Gas a Climate Change Solution for Canada*, David Suzuki Foundation and Pembina Institute, May 2011,  
<http://www.davidsuzuki.org/publications/reports/2011/is-natural-gas-a-climate-change-solution-for-canada/>

<sup>42</sup> [http://www.nytimes.com/2011/11/07/opinion/krugman-here-comes-solar-energy.html?\\_r=1](http://www.nytimes.com/2011/11/07/opinion/krugman-here-comes-solar-energy.html?_r=1)

<sup>43</sup> <http://www.epa.gov/hfstudy/>

<sup>44</sup> <http://www.scienceadvice.ca/en/assessments/in-progress /shale-gas.aspx>

<sup>45</sup> [http://www.huffingtonpost.com/2012/01/04/christopher-portier-gas-drilling\\_n\\_1184776.html](http://www.huffingtonpost.com/2012/01/04/christopher-portier-gas-drilling_n_1184776.html)