Abstract

This paper takes a participatory risk assessment approach to understanding the environmental impacts associated with hydraulic fracturing in Nova Scotia. Analyzing 238 unique public submissions to the Expert Panel, it was found that a significant majority of these stakeholders oppose hydraulic fracturing and want to see a continued moratorium or ban in the province. The main perceived risks by those submitting comments on hydraulic fracturing in order of significance were related to: water, community and infrastructure, economy, waste and clean-up, human health, climate change and other environmental issues like increased potential for earthquakes and habitat fragmentation. These citizens’ perspectives were compared to and supported by available scientific literature suggesting that hydraulic fracturing poses credible threats to human and environmental systems. Uncertainty exists regarding the manageability of environmental risks and externalities and a precautionary approach to developing hydraulic fracturing in Nova Scotia is recommended. Given the multi-faceted nature of this type of development, hydraulic fracturing may be considered a complex or ‘wicked problem’ that is difficult to resolve in purely scientific terms. Ongoing public consultation, interdisciplinary research and careful consideration of policies and regulations moving forward is required to ensure the balance between sustainability and economic renewal in Nova Scotia.

How to Read this Paper
This discussion paper will in due course form the basis of a chapter in the full report produced for the Hydraulic Fracturing Independent Review and Public Engagement Process in Nova Scotia.¹ The paper should be read in conjunction with the Primer on Hydraulic Fracturing² which we released on March 10th 2014. This paper explores the potential environmental impacts of hydraulic fracturing in Nova Scotia from the perspective of Nova Scotians and others who have submitted contributions to our Review and cross-relates these perspectives to the available scientific literature on environmental risks associated with the technology. This paper does not specifically address Aboriginal perspectives or legal/treaty issues affecting Aboriginal communities which will be the subject of other papers. To see a full list of other topics being considered in other chapters of the final report, and to view the tentative release schedule for discussion papers, please visit the project documents page on our website.

How to Provide Feedback on this Paper
We now invite feedback on this discussion paper – for example if there are any aspects that are not clear or which require further explanation. Please email your feedback to hfreview@cbu.ca with ‘Environment’ in the subject line using the feedback form available on the website³. We request that you do not make comments directly in the PDF document and prefer to receive feedback using the form provided, in an email or word attachment, or alternatively please write to HF Review, Verschuren Centre for Sustainability in Energy and the Environment, Cape Breton University, P.O. Box 5300, 1250 Grand Lake Road, Sydney, Nova Scotia, B1P 6L2. The deadline to submit feedback on this discussion paper is July 20th, 2014. All feedback received will be taken into account in the final version of the document.

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¹ See the Verschuren Centre (Cape Breton University) website http://www.cbu.ca/hfstudy for full details of the study and all project documentation.
² Available from http://www.cbu.ca/hfstudy
³ The discussion paper feedback form is available here: http://www.cbu.ca/hfstudy/resources/project-documents
Thank you

Dr David Wheeler
President of Cape Breton University, on Behalf of the Expert Panel, July 2nd 2014
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1.0 An Introduction to Complex or ‘Wicked’ Problems

Many leading scientists have warned in recent years that human activity is quickly and perhaps irrevocably undermining biodiversity and climate stability, and suggest that rapid and robust changes in society are required to avert threats to the long-term sustainability and resiliency of human and ecological systems (MEA, 2005; IPCC, 2014). Given the challenging, complex and interrelated nature of the multiple global crises, some suggest we have entered the Anthropocene, a new geological epoch dominated by humans and fossil fuel use (Steffen et al., 2007), characterized by complex or ‘wicked’ problems 4 that are increasingly difficult to solve using traditional approaches to science, technology and governance (Levine et al., 2012). While energy is a necessity, the resolution of energy use with associated environmental, social and economic impacts is one of the most significant wicked problems facing all societies. (Coyle and Simmons, 2014). In this context, it is very challenging to assess the potential benefits and costs hydraulic fracturing – or “fracking” - for shale gas and its environmental impacts (North et al., 2014). A holistic and inter-disciplinary approach exploring potential benefits and risks within the geography, ecology, culture, policy frameworks and public perspectives in Nova Scotia is therefore required.

4 "Wicked problems" are part of the social planning literature, first mentioned in the late 1960s, and used to characterize multidimensional issues where there is incomplete or contradictory knowledge, a diversity of opinions involved, interconnections with other complex problems, and significant economic considerations at stake. This makes wicked problems difficult to resolve and requires interdisciplinary approaches, respect for differing perspectives, active inclusion of stakeholders that are directly affected, and recognition that while it may be possible to improve a situation it is rare to find a true solution. Energy is seen as a wicked problem with complex interrelationships with social, economic and environmental factors and “no easy answers” for its intersection with sustainability (Coye and Simmons, 2014). Indeed, “super wicked problems” have been used to characterize climate change because of the urgency of the issue, existence of irrational policies that discount the future, lack of effective and adequate decision-making, and irony that people causing the problem must also find the solution (Levin et al., 2012). Scientists and decision-makers are increasingly using the wicked problems framework to better assess the integrated and multidimensional nature of environmental risks, including the US Environmental Protection Agency regarding the challenges associated with air quality management (Stahl and Cimorelli, 2012).
2.0 Nova Scotia’s Natural Resources, Energy and Environmental Goals

2.1 Ecozone and Natural Resources

Nova Scotia is part of the Atlantic Maritime Ecozone and is characterized by: a cool, moist climate heavily influenced by the Atlantic Ocean; mixed forests with red spruce, balsam fir, yellow birch, sugar maple and some boreal species; representative wildlife such as white-tailed deer, moose, black bear, racoon, blue jay, eastern bluebird; and major land use devoted to forestry, agriculture and mining (Webb and Marshall, 1999). Given the natural resource-base, much of the economic activity within the region is based on primary industries, such as forestry, fisheries, agriculture and coal mining (Beck, 2009). Given the biophysical environment of the region, it is promoted as “Canada’s Ocean Playground”, and the tourism industry also benefits significantly from the natural resource base and scenery (Photo 1).

2.2 Regional Energy

Nova Scotia’s electricity comes from a variety of sources (Figure 1). Principally coal and petcoke (55.8%), followed by natural gas (19.8%) and renewables like wind, tidal and hydro (17%), with some imported power and oil (1.9%), and energy efficiency programs helping offset 5.5% of the annual demand (Efficiency Nova Scotia, 2013). Since 2006, coal consumption declined from its high at 80%, with an anticipated reduction to 40% or lower by 2020 (Government of Nova Scotia, 2012a).
2.3 Environmental Goals and Planning

In 2007, Nova Scotia positioned itself as a national and international leader regarding environment and sustainability initiatives, by bringing into force the Environmental Goals and Sustainable Prosperity Act (EGSPA), also known as the Green Economy Act. This legislation created an ambitious plan to achieve environmental and economic prosperity - to have “one of the cleanest and most sustainable environments in the world” and improve “the Province’s economic performance to a level that is equal to or above the Canadian average” by the year 2020 - and is making significant progress in this regard (Government of Nova Scotia, 2012b).

The EGSPA states 21 short and medium term goals, binding the government to follow through on policy commitments focused on five broad categories (Lahey and Doelle, 2012): 1) energy use and sources; 2) greenhouse gas (GHG) emissions and air pollutants; 3) resource conservation and protected areas; 4) water treatment and management; and 5) government initiatives to realize goals on a set timeline. Nova Scotia’s regulations and associated activities to shift away from coal to cleaner energy sources received recognition and awards (Government of Nova Scotia, 2012b), yet beyond the legislated requirement for 40% renewable electricity generation commitment by 2020, the question of what mix of energy sources will replace it remains. The Government of Nova Scotia (2012a) views expansion of natural gas as an important way to diversify energy production thereby reducing coal use and associated environmental and human health effects; however, there are distinct differences between “conventional” (e.g. Sable Island) and “unconventional” (e.g. hydraulic fracturing) natural gas production. EGSPA provisions have implications for whether hydraulic fracturing is an appropriate technology given the potential environmental impacts – positive or negative – this technology may have on GHG emissions and air quality (Table 1).

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<th>GOAL</th>
<th>Progress</th>
<th>Potential Implications</th>
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<td>Greenhouse gas emissions will be at least 10% below the levels that were emitted in the year 1990 by the year 2020</td>
<td>While NS has a declining GHG profile, the province is still at 5.2% above 1990 levels</td>
<td>What are the implications of hydraulic fracturing on provincial GHG emissions? Will hydraulic fracturing contribute or detract from this goal?</td>
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<td>Emission of nitrogen oxides to be reduced by 28% by 2015 and 44% by 2020, relative to emissions in 2000.</td>
<td>NOx emission were 32.6% below 2000 levels in 2011</td>
<td>What are the implications for hydraulic fracturing on air quality, specifically NOx, will hydraulic fracturing enhance or detract from emission targets?</td>
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<td>By 2015, 25% of Province’s electricity will be supplied by renewable energy sources, and this will increase to 40% by 2020</td>
<td>Renewable are up, from 13.5% in 2010, to 17% in 2013, goal achievement still in progress.</td>
<td>What are the implications of hydraulic fracturing on overall energy production? Will hydraulic fracturing and associated natural gas undercut renewable energy development and associated opportunities?</td>
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Sources: Government of Nova Scotia 2012a+b; EGSPA

Table 1: Example Provisions within Nova Scotia's Environmental Goals and Sustainable Prosperity Act that have Implications for Hydraulic Fracturing
Given the importance of public participation in policy issues regarding shale gas, this report responds to the expressed views of 238 Nova Scotians and others, and combines this with scientific scholarship, a process advocated in the literature on participatory environmental risk assessment (Mauro et al., 2009; NRC 2008; NRC 1996). This “analytic-deliberative approach” is effective for emerging technologies, for example shale gas, as it helps identify potential problems at the onset, generating “collaborative science” that increases the quality and legitimacy of results (North et al., 2014).

3.0 Environmental Perspectives of Nova Scotians

3.1 Public Input and Approach

The Expert Panel engaged in public meetings to seek public feedback, and encouraged submissions from citizens and stakeholders. Between October 30/2013 and April 30/2014, the Panel received 745 submissions, comprising 507 form letters sent in response to a call from the Council of Canadians and 238 unique comments from citizens, professional organizations, environmental organizations, industry, municipalities and community groups (Table 2). Although not everyone indicated their locations, it was clear from the content that nearly all unique submissions were from Nova Scotia, with a handful from outside the province but with an expressed interest in the region (e.g. owned property in Nova Scotia or were considering moving to the region). Some citizens stated their profession, demonstrating a diversity of stakeholder input with submissions from academics, farmers, laborers entrepreneurs, medical doctors and veterinarians, chemists, engineers, faith workers, retirees and others. If the same individual or group made multiple contributions, all this content was counted as a single “unique comment”, with submissions ranging from short emails to multi-page letters, some containing references to scientific studies, popular articles and other media. Individuals and groups submitting provide tremendous insight into various topics related to hydraulic fracturing. It is important to note that the results may not be representative of the perspectives of all Nova Scotians given that data were not generated from a randomly selected sample of the population, rather it was a self-selecting group of interested citizens and organizations. To better appreciate the diversity and depth of unique submissions (n=238), social science research techniques were used to code, tabulate and categorize content from submissions into themes (Maxwell, 2013). This facilitates a quantitative assessment of topics presented to the

| Table 2: Type of Unique Submissions to the Expert Panel on Hydraulic Fracturing (n=238) |
|-----------------|-----------------|
| **Group Type**   | **Number**      |
| Citizen          | 215             |
| Professional Organization | 10              |
| Environmental organization | 6              |
| Industry         | 3               |
| Municipal        | 2               |
| Community Group  | 2               |
| **Total**        | 238             |
Expert Panel, creating a ranking of the 10 most commented upon hydraulic fracturing-related issues within the submissions, and presentation of associated qualitative comments.

3.2 Findings from Public Submissions

Nova Scotians that made submissions to the Expert Panel were largely concerned about risks associated with hydraulic fracturing. Individuals submitting form letters (n=507) suggested that hydraulic fracturing presents serious risks, and asserted that gains made through the Environmental Goals and Sustainable Prosperity Act would be threatened. They called for an outright ban on the industry. This is perhaps not surprising, given that form letters were coordinated by the Council of Canadians, which is a social action organization focused on water, energy, health and democracy and is known for its active opposition to hydraulic fracturing. Of the 238 unique submissions, 183 individuals also mentioned a moratorium on shale gas development, with 179 of these supporting a moratorium and 4 against having one in place. Overall, 92.1% of submissions call for either a moratorium or ban on hydraulic fracturing in Nova Scotia, with only 0.5% against this type of initiative (Table 3).

If one chooses to exclude form letters – say over concerns of bias or because the volume of responses skews the data - 75% (179/238) of unique submissions mentioned support for a moratorium, 1.7% (4/238) did not want a moratorium, and the remainder did not comment on this issue. Since the form letters were very similar, it was easy to document concerns being repeatedly expressed by these individuals. However, the emails and letters from Nova Scotians were highly personalized, with individuals and stakeholders from across the province offering a diversity of views on hydraulic fracturing that were quantified through the coding analysis (Table 4).

Concerns regarding water resources, specifically its contamination from hydraulic fracturing, were the highest ranked (158 comments), followed by risks associated with industrial activities on community and infrastructure (126 comments) such as damage to roads, increased traffic, noise pollution and other issues. Citizens worried about adverse impacts on the economy (100 comments) - especially for land-based industries such as farming, forestry, fishing and tourism – and also had concerns
that potential job creation was inflated and that home values would decrease in areas with active hydraulic fracturing. **Waste and clean up** was also of high concern (89 comments), with a number of people expressing their dissatisfaction with the Kennetcook situation where exploratory hydraulic fracturing waste water containment ponds had leaked, and waste byproduct remains on site and continues to be of concern. **Human health** (88 comments) was presented as a significant concern, given potential for poor air quality for those in close proximity to hydraulic fracturing sites, and larger questions about the effects on mental health and marginalized peoples. Many were worried that hydraulic fracturing will exacerbate **climate change** (84 comments),

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<th>Table 4: Ranking of Public Issues and Concerns Mentioned in Unique Submissions (n=238) to the Expert Panel on Hydraulic Fracturing</th>
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Notes: For each submission, discrete topics were coded, and totals for the themes and sub-themes represent the number of times unique issues were raised within all 238 public comments. Numbers in brackets indicate how many times sub-themes were mentioned and add up to the total for that theme.
through fugitive methane emissions nullifying natural gas as a “bridge fuel”, although 2/18 reporting on this sub-theme thought that natural gas would help in the transition to a more sustainable energy system. Many were concerned hydraulic fracturing reinforces societal dependence on hydrocarbon-based energy. The cost and complexities of creating effective policy and regulation (75 comments) were also expressed, specifically regarding enforcement and monitoring, and a desire to see a precautionary approach to developing the shale gas industry. Other environmental issues (71 comments) expressed more general concerns as well as the potential for seismic events, habitat fragmentation, soil contamination and associated effects on animal health and regional geology, with much of the commentary focusing on cumulative and long-term impacts. Industry deception (62 comments), in the form of dishonesty and non-disclosure of impacts in order to maximize profit was mentioned, and the effect this might have on worker and community safety was presented as an issue. Finally, some believed that an inadequacy of science (46 comments) on this issue (e.g. new industry, few studies, etc) made it difficult to gain credible knowledge on the issue of hydraulic fracturing and its long-term consequences. However, a minority of contrasting submissions (6/46) argued that an absence of evidence regarding negative impacts is proof that the industry is safe. Overall, the vast majority of submissions expressed concerns over negative impacts with only a few speaking to positive aspects of hydraulic fracturing, largely those stakeholders linked to industry associations.

This paper explores the science of hydraulic fracturing, specifically looking at environmental impacts and their relationship to other intersecting issues, in order to determine if expressed public concerns regarding shale gas development are justified based on the literature. Seven of the ten themes from submissions are explored in detail, and the issues of regulation, scientific uncertainty and concerns about industry deception are woven throughout the text and addressed specifically in the summary remarks. Given the interdisciplinary nature of environmental issues, forthcoming and already released papers by other expert panelists further elaborate on the topics presented.

4.0 Environmental Impacts of Hydraulic fracturing

Until recently, few systematic studies on the environmental impacts of shale gas development existed in the Canadian context. However, in the spring of 2014, the Council of Canadian Academies (CCA), an independent, non-profit organization designed to offer expert-based assessments of pressing public issues released a report entitled Environmental Impact of Shale Gas Extraction in Canada. While the report acknowledges that shale gas is a “game changer”, it states that hydraulic fracturing in Canada over the past decade has not been accompanied with appropriate investments in research and monitoring to better understanding the environmental, community and health effects of the industry, and outlines key knowledge gaps regarding impacts on water, climate, air contaminants, landscape and earthquakes (CCA, 2014). The CCA report provides an important in-depth analysis of many of the concerns presented by
those Nova Scotians who have participated in this process to-date, and thus is a foundational document for this paper. Where available, newer studies on hydraulic fracturing are included, and to the best degree possible relevant issues for Nova Scotia are taken into account.

4.1 Impacts on Water

According to the literature, there are legitimate concerns regarding potential impacts hydraulic fracturing may have on groundwater consumption and possible subsurface and surface contamination (Figure 2), although these vary by region and situation (CCA, 2014). While hydraulic fracturing is generally water intensive, overall volumes are not expected to put a burden on water resources in most Canadian jurisdictions, including Nova Scotia (Gagnon, 2014), yet there is cause for concern at seasonally specific peak demand times, or in the case of droughts (CCA, 2014). Groundwater contamination is a legitimate risk, from gas leaking alongside or through damaged or incorrectly sealed well casings, and via upward long-term migration of gas within natural fractures in the earth into the water table (CCA, 2014). At the surface, contaminant concerns relate mostly to spills associated with 1) industrial activities and chemical storage at hydraulic fracturing well pads and; 2) concerns over the storage and handling of “flowback water” that returns to the surface – after initially being injected under high pressure into the well in order to “hydraulically fracture” shale deposits that contains hydraulic fracturing fluids as well as salts, naturally occurring radioactive materials (NORMS), and trace metals like arsenic and barium (CCA, 2014). Given that this Expert Panel process has other reports focused on water and well integrity, these issues are discussed in greater detail elsewhere (Gagnon, 2014; Dusseault, 2014).

According to Nova Scotia Environment (2014), approximately half of the Province uses groundwater for water supply, and many correspondents felt water should not be put at risk. They questioned whether or not the short-term economic benefit is worth the long-term environmental risk of contaminating water supplies, including this quote from a local engineer who advocated a precautionary approach regarding groundwater:

“Do you discount future costs (the potential contamination of a aquifer in 50 years’ time as contaminants work their way to the surface through failed casings and cement) to a possible short economic boom over 10 years?”
(Submission 206)

It’s important to note that the rural geography of eastern Canada plays an important role in framing citizen risk perceptions regarding water issues and associated risk profiles for communities. As noted by the CCA (2014):
Figure 2: Conceptual Water Contamination Pathways

There are several pathways by which potable groundwater could become contaminated by shale gas development, as shown in the schematic above. Sources of surface water contamination include spills at the shale gas well site of toxic chemicals and challenges with “flowback water” storage and handling that may contain radioactive materials, trace metals, salt and other substances.
“In the eastern provinces of Canada, where there are substantial shale gas resources, shale gas development would make unavoidable the drilling of gas wells relatively close to water wells relied on for drinking by rural residents” (Council of Canadian Academies, 2014)

Thus, rural communities, with well-based water systems, are likely at greater risk, especially if living near areas with substantial shale gas resources. Submissions to the Expert Panel note the adverse impacts of hydraulic fracturing on rural communities and water, including this from a family physician:

“I am concerned about potential contamination and overuse of public water supplies, both drinking water and agricultural irrigation water, with many Nova Scotia communities already painfully aware of their lack of sustainable potable water supplies...” (Submission 211)

The science regarding contamination of well water from hydraulic fracturing is controversial and inconclusive. Some US studies indicate homes within 1 km of shale gas production are 6 times more likely – than homes further away – to be contaminated with stray gases such as methane, ethane and propane (Jackson et al., 2013; Vengosh et al., 2013). Contrasting studies suggest stray gases are naturally occurring in aquifers and cannot be definitively linked with shale gas activities (Baldassare et al., 2014; Molofsky et al., 2013). Concerns regarding water, communities and wellbeing, especially those within rural and remote regions, were voiced clearly in submissions received by our Panel. Following water as the primary concern within the submissions were community and infrastructure impacts.

4.2 Community and Infrastructure

Since shale gas development often takes place in rural towns and communities, these smaller populations are often more susceptible to adverse impacts, given the limited resources of these areas combined with the potential for rapid industrialization that may require specialized equipment, workforces and infrastructure (Jacquet, 2014). A major concern of residents near active hydraulic fracturing sites is truck traffic and damage to roads – usually not designed for industrial activities – as a single hydraulically fractured well requires nearly 2000 one-way truck trips to supply construction materials, equipment, chemicals, workers, but mostly water (CCA, 2014). This issue was germane to Nova Scotians corresponding with our Panel, many whom saw a conflict between the current built environment and what would be required to support the hydraulic fracturing industry in the future:

“...we can be certain that the documented wear and tear on existing roads will be severe beyond the current budget allocations of the country/municipality. Are we expecting such a landfall from the increased
taxes on the oil drilling that these expenses will be covered? What is the plan here? The roads are already falling apart (Submission 74)

In rural areas of the US, communities have often been underprepared for rapid growth (Shafit et al., 2013), and it is acknowledged that “…implementing a large-scale new industry such as oil and gas in eastern Canada would have required much more preparation and prior public consultation” (Rivard et al., 2014). Submissions indicated that the push to industrial-scale hydraulic fracturing of the province is too rapid and they wanted more input, as noted by this comment:

“Nova Scotians deserve, at the very least, a referendum on this most serious of environmental issues” (Submission 27)

Thematic analyses on stakeholder perceptions of socio-environmental impacts of shale gas in the US, document similar patterns of negative concerns have been documented, yet there has also been a positive association between perceptions of risks and opportunity, suggesting hydraulic fracturing may be a “double edged sword” for communities (Schaft et al., 2013; Ladd, 2013; Wynveen, 2011; Braiser et al., 2011; Dalton, 2014). Uneven distribution of benefits and risks, combined with environmental attitudes, can create polarizing views regarding energy development and lead to “corrosive communities” (Jacquet, 2014). Concern over this type of scenario was present in the public submissions:

“[Hydraulic fracturing] has the potential to divide communities between those who support and those who oppose its use. In rural areas here we rely on relationships to live together this can be poisonous” (Submission 36)

Given the complex terrain regarding the social dimensions of emerging technologies, specifically in the energy sector, an entire report is devoted to these issues where they are discussed in greater detail. Similarly, economic issues have been considered elsewhere in the Expert Panel process, and will only be dealt with briefly in this paper.

4.3 Economy

Since the 1970s, the sociological literature on oil and gas development indicates that industry may increase job prospects and cash flow, while simultaneously creating adverse impacts on community-level institutions and municipal services, increasing risks of pollution and contamination events, which can result in out-migration and loss of other types of development and investments (Jacquet, 2014). The hydraulic fracturing industry in the US is following a similar pattern, creating concerns over the possibility of a boombtown scenario (Jacquet, 2014; Weber at al., 2014; Christopherson and Rightor, 2012), and submissions to our Panel indicated concerns about this:
“I am convinced that the long term risks and costs of this industry will outweigh the short term economic benefits... It seems economic benefits are the sole reason our government is considering allowing this industry into our province... I worry that hydraulic fracturing would cause a boom bust industry cycle” (Submission 182)

US studies on community perspectives of hydraulic fracturing often provided more balance on the issue, noting both the pros and cons, whereas submissions to the Expert Panel were largely negative. A lack of positive attitudes might relate to differences in socio-economic opportunity, as studies have found US citizens who hold land leases and collected royalty payments view local shale energy development positively, while those who do not receive income perceive the industry negatively (Jacquet, 2014; Kriesky et al., 2013). Submissions often weighed the benefits and risks in their submissions and largely identified with the latter:

“...Nova Scotians are speaking out and saying that economic benefits are not enough to outweigh the costs of creating a shale gas industry...”
(Submission 143)

As Nova Scotia’s provincial government claims hydrocarbons within the ground, royalty payments would not flow directly to individuals as they do in the US (Cherry, 2014; Jacquet, 2014), and this difference combined with concern regarding overhyped job creation and economic underperformance of the industry (Mauro et al., 2013; Kinnaman, 2011) may contribute to a lack of perceived local opportunities and hence greater perception of risk amongst the public. A paper on environmental concerns regarding hydraulic fracturing in Canada (Rivard

Photo 4: A shale gas well pad near rural homes in the Marcellus Shale in Pennsylvania, increasing risk to local groundwater, decreasing property valuation, and in likely conflict with other land-based industries such as farming, forestry and tourism. Photo courtesy of the Council of Canadian Academies.
et al., 2014) notes this tension between citizens and governments: “economic benefits for provincial jurisdictions no longer sway public opinion if there is a perception of environmental degradation should the industry be allowed to proceed”.

The major economic concern in submissions was that hydraulic fracturing would adversely affect environmentally based industries - such as agriculture, tourism, forestry and fishing – a possibility also discussed by the CCA (2014) who speculated that these conflicts would be particularly pronounced in Nova Scotia given a rural population higher than the national average (Photo 4). Summing up the conflict between shale gas and these land-based industries, one submission said:

“Fishing, forestry, agriculture, and tourism are the mainstays of the local community economy and none of those industries are compatible with developing a shale gas industry over the same landscape”
(Submission 1)

Numerous citizens corresponding with our Panel worried that hydraulic fracturing’s environmental impacts would threaten property values, especially in areas where industry was active. A representative from a regional economic development association captured this point:

“If poor air quality and a lack of potable water quality drives away people and residents one can only imagine what that will do to property values and resales. The municipalities will experience reduced valuations and property values” (Submission 68)

Hydraulic fracturing may indeed adversely affect property valuation and salability, given it makes land more difficult to plan, subdivide and use, and can create (actual or perceived) concerns over water quality that is “a key driver of property value”, especially in rural areas (Lipscomb et al., 2012). In a US study, many prospective buyers would not purchase homes close to hydraulic fracturing operations, and those that might would likely reduce their bids by 5-15% in a robust real estate market, with losses increasing by another 10% in weaker markets (Thourpe et al., 2013). Although no Canadian studies were found in the literature reviewed, the Canadian Association of Energy and Pipeline Landowner Associations has published a warning for property owners about prematurely entering contracts with industry over concerns with oil and gas development and associated home devaluation and waste and clean up costs (CAEPLA, 2010).
4.4 Waste and Clean up

Approximately one quarter to half of the water injected into a fracked well returns to the surface, known as “flowback”, and it contains potentially hazardous materials from hydrocarbons (such as benzene and other aromatics), hydraulic fracturing fluids that may include toxics, and substances dissolved from the shale including salts, trace metals (e.g. arsenic and barium) and naturally occurring radioactive materials, or NORMs (CCA, 2014). Given the complexity of dealing with these waste streams, industry found ways to recycle the flowback waters to refrack wells, yet a fraction of this remains at the surface and is sometimes stored in containment ponds or treated if the proper facilities exist regionally. In Nova Scotia, the issue of waste and clean up of flowback waters have been particularly sensitive topics, as outlined by the CCA (2014):

“In Nova Scotia, managing the flowback water from the two hydraulically fractured wells near Kennetcook has emerged as a major issue. The flowback volume was unexpectedly high... and the province did not have regulations in place concerning options for its disposal or treatment. About 14 million litres of flowback water was produced, most of which was saline water from an intersected permeable fault zone; NORM were also detected in the open, lined storage pits. (Council of Canadian Academies, 2014).

Nova Scotians’ submissions to the Expert Panel referred to the issues taking place at Kennetcook. From concerned citizens across the province, to locals directly witnessing the impacts of this exploratory hydraulic fracturing, many expressed frustration and dismay:

“I also live 5 km from one of the waste ponds, left behind by a fracked test well. After 6 years that pond is still there, waiting for remediation. During this winter that waste pond overflowed into a local stream, and that made its way into the Minas Basin. Our communities have watched as our regulators have failed to act on our behalf. They are scrambling to find a solution for millions of liters of waste water left behind from 2 fracked test wells. If hydraulic fracturing is allowed in Nova Scotia, the same company who has not found an acceptable solution for water from 2 fracks, would seek to develop hundreds of well sites. How? And if the province can not deal with 2 test wells, how can it ever regulate an entire industry?”
(Submission 70)

Flowback waters are often stored in lined containment ponds, but even when double lined, they are known to leak over time, or can overflow due to precipitation events such as intense rainfall (CCA 2014). Based on access to information requests, No Frac (2013) prepared the Out of Control report about the situation in Kennetcook, which indicates that the containment ponds were originally designed to hold fresh water for hydraulic
fracturing, and Nova Scotia Environment (NSE) granted permission for storage of flowback waters after the fact. These containment ponds were first known to leak in 2011 (No Frac, 2013) and then again in early 2014, after heavy rain and snow weighed down containment pond covers, causing the wastewater to spill out from underneath (CBC, 2014a+b). A US study suggests application of these flowback waters to the land may adversely affect soil chemistry by increasing sodium, chloride and acidity, causing damage and/or mortality to ground vegetation, although more research is required on this issue (Adams, 2011).

Prior to the containment pond leaks, NSE was trying to determine how to best deal with the flowback waters, and some of this effluent was ultimately shipped to the Town of Windsor to be processed by the local water treatment plant. In a submission from The Town of Windsor there were concerns expressed regarding how and why this happened:

“Between March 2010 and August 2011, the Town of Windsor processed approximately 7 million liters of fracking wastewater through the Windsor Sewage Treatment Plant. At no time had the Town been advised of NORMs or any concerns with fracking water until the news broke in late 2011 that indeed radioactivity or other unmentioned chemicals may be prevalent in the water...All along, we were under the impression that Nova Scotia Environment were monitoring the fracking waters and entire process...[The Nova Scotia] Government needs to address how this byproduct should be disposed of safely through sewage-treatment plants before one can even address the issue of fracking itself!” (Submission 7)

Municipal treatment plants cannot usually process flowback waters, as the salinity adversely affects microbial activity that breakdown normal waste, and because NORMs often flow right through the treatment plant into the municipal water system and/or the environment (CCA, 2014). Desalination processes and other advanced methods are being developed to treat flowback waters (Shaffer et al., 2013), and are now being considered by the Nova Scotia Government to deal with the approximate 25 million litres of remaining hydraulic fracturing waste water in the province (CBC, 2014c). The high costs and uncertain efficacy of these approaches make them less desirable to industry than deep-well disposal where the waste is permanently injected into the ground, a process that also carries risks for contamination of groundwater and potential seismicity (CCA, 2014). However, NSE has repeatedly refused to allow deep well injection of these flowback waters, arguing that they need to be processed at an approved facility, which is a decision lauded by environmental groups. The CCA (2014) corroborates the significant challenges and costs associated with handling, treating and cleaning up of hydraulic fracturing flowback waters, which can also lead to conflict and confusion as the Nova Scotia example indicates:
“The operator and the [Nova Scotia] government have been unable to agree on how to dispose of the flowback water...this stalemate has become a symbol of the difficulties of wastewater disposal associated with shale gas development in eastern Canada” (Council of Canadian Academies, 2014).

According to one of the few papers in the literature on well site reclamation, “improperly abandoned gas wells threaten human health and safety as well as pollute the air and water”, and more advanced regulatory options (e.g. cash bond, predrilling fee, severance tax) are advocated to ensure industry adequately pays for the proper closure and cleanup (Mitchell and Casman, 2011).

### 4.5 Human Health

Nova Scotians interacting with the Expert Panel were most concerned about air quality, given the contaminants generated by hydraulic fracturing, increased truck traffic, creation of ground level ozone, and the impacts this would have on human health, both physical and mental. Comments were often very holistic in nature, as outlined by this medical doctor:

“The health impact of increased air pollution, noise pollution, increased road traffic, loss of peaceful country vistas can not easily be measured. That does not mean it is not important and does not exist. Impact on the mental health of residents affected by fracking must also be considered. Fracking disproportionately affects rural residents, who in general have lower incomes and less mobility, and less of a voice. For these reasons I cannot support hydraulic fracturing in Nova Scotia.” (Submission 78)

Although air emissions from hydraulic fracturing are derived from similar sources as conventional gas, shale development requires additional effort and emissions are more intensely produced, given longer drilling times, more truck traffic, stronger pumps, and larger holding ponds (CCA, 2014). Nitrogen oxides (NOx), Sulphur Oxides (SOx), Volatile organic compounds (VOC), particular matter (PM) and air toxics will enter the air during well development and gas production, although it’s difficult to calculate exact emissions due to poor data quality (Figure 3). When combined, NOx, VOCs and carbon monoxide can contribute to ground-level ozone that can cause respiratory health issues, and certain VOCs have been found in much higher concentrations than Health Canada recommendations during the completion phase of hydraulic fracturing (CCA, 2014). Citing studies conducted in Texas, the CCA (2014) notes that the most commonly cited health issues associated with shale gas included “sinus problems; throat irritation; allergies; fatigue; eye and nasal irritation; joint pain; muscle aches and pains; difficulty breathing; and vision impairment”. Air pollutants associated with shale gas can also contribute to small increases in the risk of cancer and other diseases for those living in...
close proximity to wells, largely due to cumulative and long-term ambient exposure to chemicals like benzene (CCA, 2014). The potentially cumulative and long-term impacts of hydraulic fracturing were a consistent theme across many submissions, with health concerns particularly expressed from those living in regions with prospective hydraulic fracturing development:

As a community member, home-owner, and parent living on the North Shore of Nova Scotia, I see hydraulic fracturing as a direct threat to public health and the future well-being of my family and my community. Health concerns go beyond dangerous toxins in our water and air to the unknown compounded health effects of this unprecedented combination and magnitude of extraction technologies. (Submission 164)

The externalities associated with air emissions are not well known, however, data are becoming available, and one study from Pennsylvania estimates that environmental and health damages for a single year of hydraulic fracturing across the region range from $7.2 to $32 million dollars (USD). While a significant impact – financially and biophysically – this is less than similar estimates for coal in the same area (Litovitz et al., 2013). Although localized emissions from natural gas increase near production areas,
ambient ozone and particulate matter are reduced for communities upwind of electric power generation because overall emissions decrease (Allen, 2014). Understanding emissions from hydraulic fracturing is a key issue, especially as it relates to climate change and its long-term consequences.

4.6 Climate

Production and consumption of shale gas increase carbon dioxide and methane that contribute to climate change. After a well has been initially fractured, the “flowback” stage occurs with residual water and natural gas and carbon dioxide coming back to the surface, and how these emissions are handled is central to the greenhouse gas (GHG) emissions debate. Natural gas produces less CO₂ than coal per unit of energy produced, given the efficiencies of single and combined cycle gas turbine power and, compared to coal fired power plants on an energy equivalency basis, can reduce emissions by 48% to 70% depending on technologies used (CCA, 2014). However, methane leakage across the entire supply chain (e.g. production, transport and storage) of natural gas – known as “fugitive emissions” – can reduce the greenhouse gas benefits of lower emissions at the consumption stage (Allen, 2014). This is of particular concern, because methane is a more potent greenhouse gas (GHG) than CO₂, especially over shortly time frames: approximately 84 times more potent at the 20 year timescale compared to 28 times over a 100 year period (CCA, 2014). The heat-trapping potential of methane was raised in submissions to the panel:

“...methane which is released in the process of fracking, is a much more potent greenhouse gas, in the short-term, than is carbon dioxide. It will accelerate, not reduce, the effects of climate change we are beginning to see in our world” (Submission 94)

There is no debate that methane is a powerful GHG and given the urgency to address climate change some scientists model its impact using the more aggressive 84 times scenario (CCA, 2014). The most high profile – and controversial – research using these modeling assumptions is by Howarth et al (2011) and Howarth (2014) and states the GHG footprint of both unconventional and conventional natural gas are higher than coal and oil. Fugitive emissions and their impact on GHG continues to be debated – with studies advocating both for and against natural gas from a climate perspective (CCA, 2014) – and there is an increasing acknowledgement that methane leakage is poorly understood and largely underestimated in both the US and Canada (Brandt et al., 2014). The international scientific community studying climate change now questions the benefit of switching fully to natural gas, but acknowledges it may play a role in transitioning away from coal when fugitive emissions can be kept low and when combined with renewables (IPCC, 2014). Despite this, many submissions indicated that the overall risks outweighed benefits and many people wanted to see the government pursue an energy plan based more on renewables:
“If we take strong and proactive steps now, by rejecting [fracking], we can look forward to a new energy future based on renewable hydro, wind, and even tidal power, while avoiding the crushing defeat of communities...”
(Submission 17)

A recent study suggests that shale gas development leads to lower energy prices, higher overall consumption of energy, and may displace the use and investment in renewables citing US examples where wind projects had trouble competing against natural gas plants despite incentives for the wind turbine industry (Newell and Raimi, 2014). Given these factors, the researchers found that the net climate impacts of shale gas could be either positive or negative depending on the situation, and that strict climate policy and regulations on fugitive emissions are critical if benefits are to be realized (Newell and Raimi, 2014). To achieve a net benefit, natural gas would have to displace more coal and petroleum than nuclear, hydro and renewables known for their low GHG emissions (Newell and Raimi, 2014). In the US, wells were initially vented, sending methane and other air emissions directly into the atmosphere, but flaring has become a transition practice to burn off pollutants at source, with regulations taking effect in 2015 so that wells have “green completions” in place that will capture gas and other chemicals before commercial production begins (O’Sullivan and Palsev, 2012). In the Canadian context, Alberta and British Columbia largely prohibit venting and also have flaring reduction targets (CCA, 2014), although the quality of reporting and regulation of these processes has been questioned, with suggestion that the “transition fuel” description used in BC is a ruse for carbon-intensive natural gas development (Stephenson et al., 2012). Many submissions simply did not accept that shale gas was part of the solution to climate change:

“Climate change is the greatest threat to our generation and future generations. Every country in the world has agreed to a 2 degree limit of warming. In order to meet this target, we need to leave 80% of the proven fossil fuel reserves in the ground. Allowing fracking in the province of Nova Scotia will accelerate us towards climate chaos” (Submission 82)
According to the *Copenhagen Accord*, global temperatures must not surpass 2 degrees Celsius in order to avert climate destabilization; thus society has 5 times more oil, coal and gas than can be used if we are to meet this target (Berners-Lee and Clark, 2013). Rapid efforts to decarbonize human society are required to avoid serious impacts on human and natural systems, with low-carbon energy needing to nearly quadruple by 2050 relative to 2010 in order to stabilize the global climate (IPCC, 2014).

### 4.7 Environment

Many submissions comment on environmental issues associated with hydraulic fracturing, as well as concerns of the potential for earthquakes (or seismicity), habitat fragmentation and impacts on agricultural lands and livestock. According to the CCA (2014), hydraulic fracturing can cause earthquakes by injecting or extracting liquids from wells under pressure, possibly triggering a seismic event related to preexisting geological conditions, or inducing a new fracture that destabilizes a formation. While earthquakes as a result of hydraulic fracturing have been documented in the US, UK and Canada, they are usually too small to cause property damage, although some have been felt at the surface and this has heightened public concern (CCA, 2014; Sumy et al., 2014). In some jurisdictions, industry has settled with homeowners claiming that hydraulic fracturing induced earthquakes damaging their properties (Trotman, 2013), and some are concerned “man made” earthquakes caused by hydraulic fracturing would not be covered by conventional insurance (Roach, 2014). Citizens and environmental groups commented on earthquake potential, citing the possibility of deep wastewater disposal from the Kennetcook site, one submission stated:

“Our group commended the previous Minister of Environment for his strong stance on not allowing wastewater to be injected into wells. The association of disposal wells with earthquakes has been recognized and has recently been expanded to include concern about the process of fracking actually triggering earthquakes” (Submission 194)

While the overall earthquake potential from hydraulic fracturing is considered to be small - especially in areas considered tectonically stable like the east coast (Rast, 1979) – the long term consequences of multiple deep waste water disposal wells in a region is not well understood and there may be a delayed reaction associated with these activities (CCA, 2014; Ellsworth, 2013). Research demonstrates that of all activities related to hydraulic fracturing wastewater disposal via well fluid injection has the greatest risk for seismicity “with maximum magnitudes sometimes exceeding 5” (McGarr, 2014). Since little is known about why earthquakes occur in eastern Canada (NRCan, 2013), questions remain about the safety of wastewater disposal, and quoting the CCA (2014) at length here is useful:
“...whether wastewater injection can be safely carried out in all regions of Canada – specifically, Quebec, New Brunswick, and Nova Scotia – is unknown. More information on the potential for geological formations in these provinces to receive large volumes of injected fluids without over-pressurizing reservoirs is needed to determine whether this waste disposal option is possible” (Council of Canadian Academies 2014).

Given that hydraulic fracturing infrastructure takes up considerable physical space (3 ha/well pad), combined with the fact that wells are productive for a relatively short time and new ones are often added to keep production stable (Hughes, 2013), industry can have significant impacts on land and associated habitat fragmentation (CCA, 2014). While technology is allowing for more wells per wellpad – decreasing the footprint of industrial activities - satellite imagery from established shale gas plays in the US demonstrate how lands have significantly changed over time (Figure 4). Further surface disturbances are caused by road and pipelines linked to wellpads that extend into the surrounding landscape (Mitchell and Casman, 2011). These impacts to the landscape were of concern to some people making submission to the expert panel:

“Seeing the fracturing process underway from an aerial view shows the devastation to the landscape. Wildlife are already being pushed farther away due to habitat destruction caused by human encroachment. This is producing pockets of wilderness areas which separates groups of animals from each other and thereby weakens the species. The fracturing equipment dots the landscape like a cancer and spreads it’s deadly pollution into the waterways and air” (Submission 10)

Research from the eastern US demonstrates that intensive hydraulic fracturing poses “many threats to biodiversity” – including extirpation or extinction - especially for species with restricted geographic ranges that overlap with industrial activities largely due to degradation of water quality and fragmentation of forests (Gillen and Kiviat, 2012). Top soil and proper re-vegetation is required to reclaim old well sites, otherwise forest fragmentation and loss of biodiversity will be exacerbated, specifically for migratory birds and other animals species requiring canopy protection (e.g. shade and humidity) within a deep forest environment (Mitchell and Casman, 2011). In Nova Scotia, habitat fragmentation has led to the mainland moose, American marten and the Canada lynx being listed as endangered, and concern exists that these along with other endangered species might further be pressured by hydraulic fracturing (EAC, 2014). Mitigating energy development impacts on wildlife requires species-specific studies, with a focus on reducing human activity, creating and maintaining refuge habitat, and modifying the timing of industrial activities to account for ecologically sensitive periods (Northrup and Wittemyer, 2013). In Nova Scotia, biodiversity considerations have been mapped across the province, indicating that approximately 60% of the region should be actively managed to conserve “genes, species and ecosystems over time” (Beazley et al.,
More recent spatial analysis, adapted for both Canada and the US, can quickly and effectively map how hydraulic fracturing activities fragment both forested and agricultural lands (Raciot et al., 2014). These considerations are particularly important given some regions of Nova Scotia contain old growth Acadian forest (Stewart et al., 2003) and significant changes are expected to the forestry sector due to climate change that require adaptive management (Steenberg et al., 2013; Steenberg et al., 2011; Bourque and Hassan, 2008). Citing similar issues presented in this report, a woodlot association made a submission to the panel:

“Members of our Association have expressed significant concerns with the development of hydraulic fracturing in Nova Scotia and its potential for negative impact to their homes and forest land...The risks of hydraulic fracturing highlighted above lead our Association to recommend that this practice not take place in Nova Scotia” (Submission 218).

Submissions also expressed concern over the impact that hydraulic fracturing may have on agricultural lands, like this one from a veterinarian and farmer:

“Because there are so many important reasons to preserve agricultural land, we feel that it is vital at this time to make a case for farmland...all the negative impacts that hydraulic fracturing can have on rural communities
and how it could create excessive fragmentation of our agricultural land base” (Submission 23).

In areas with hydraulic fracturing, farmers are often concerned about pollution and its impacts on humans, animals and soil, and in some regions agriculturalists compete with industry for land and water resources (Russell, 2013). Researchers have documented mortalities and reproductive difficulties (e.g. irregular cycles, stillbirths, failure to breed) in a variety of livestock and companion animals in close proximity to hydraulic fracturing across six US states, usually linked to surface spillage of flowback waters and other chemicals. One situation caused the death of 17 cows in a single hour from accidental but direct exposure to hydraulic hydraulic fracturing fluids (Bamberger and Oswald, 2012). As noted by the CCA (2014), veterinary literature can “serve as a sentinel for human health”, given similar exposure pathways. Citing concerns, one regional agricultural association made a submission indicating they had passed a motion calling for a 10-year moratorium on hydraulic fracturing because of potential for adverse impacts on water quality and supplies; safe disposal of waste waters; concern over devaluation of rural property; destruction of habitat; and in order for a full review on hydraulic fracturing to be completed. Indeed, farmers in Nova Scotia corresponding with our Panel viewed hydraulic fracturing and farming as incompatible, and one who had recently moved to the province indicated that her family would have no choice but to leave if shale gas were developed:

“My husband and I moved to Upper Stewiacke area in Nova Scotia...We left our well established professional careers to come to this area to pursue our dream of farming...If [fracking] happens, sadly I will have to shut my farm operations down, sell my home and land, and leave. I will not stay around to witness the imminent destruction. I refuse to stay and be poisoned.”

(Submission 93)

While some farmers may never accept hydraulic fracturing and decide to leave the region, research suggests that those remaining normalize adverse impacts given their economic vulnerability and limited ability to influence industrial activities near their farms (Malin, 2014). This documented lack of ability to shape how hydraulic fracturing unfolds in communities speaks to the need to consider social justice and its linkages with environmental degradation for indigenous and non-indigenous peoples alike (Willow, 2014). The land-based, inter-generational and often sacred connections that many indigenous peoples have with their environment has led some communities to assert their indigenous rights and resist hydraulic fracturing claiming lack of proper consultation (Ornelas, 2014). Indeed, it is important for the public to have effective input in decision-making regarding emerging technologies and development within their region. This is the rationale for taking a participatory risk assessment approach to this report.
5.0 Risk, Responsibility and Renewal

Shale gas development is controversial - given significant regulatory and scientific uncertainty – yet available research indicates that hydraulic fracturing presents credible threats to human and environmental systems with real and immediate impacts for local communities and longer-term consequences for climate stability and future generations. Indeed, shale gas development within this context presents a complex or ‘wicked’ problem for citizens and decision-makers, which is difficult to solve using traditional approaches to science and governance. Indeed, technological innovation can produce environmental risks that are difficult to predict, regulate and manage, and a broader and more democratic and citizen-based approach to risk decision-making is required (Beck, 1992; Beck, 1995). Combining the “two cultures” of risk analysis – linking science-based assessments with broader psychological, sociological, cultural and economic factors (Jasonoff, 1993) – this interdisciplinary paper integrates submissions to the Expert Panel with research studies in order to create dialogue between citizens, science and the larger issue of the environmental impacts of hydraulic fracturing in Nova Scotia.

A critical finding is that 238 citizens interacting with the panel were well informed and much of their socio-environmental concerns are substantiated by the available literature. Research on “perceptions of risk” – across a diversity emerging technologies that are similar to shale gas (Pidgeon et al., 2006) - demonstrate that the public is rational and influenced by a diversity of factors including emotion, worldviews and trust (Slovic, 1999). While early risk research assumed scientific knowledge was superior to that of the public (Zinn and Taylor-Gooby, 2006), it is increasingly clear that citizens are highly capable of estimating hazard potential and the assumption that experts have superior risk judgment is now questioned (Wright et al., 2002). Dismissal of the public, assuming they are “uneducated” and need to “get the facts” regarding hydraulic fracturing, has been documented as a form of stakeholder silencing used by industry advocates to generate a pro-development discourse (Hudgins and Poole, 2014). As noted by the CCA (2014), holistic approaches to risk assessment are needed, as the history of science and technology regarding major energy developments demonstrates that environmental impacts were largely not anticipated, especially by those expecting benefits:

“What is perhaps more alarming is that where substantial adverse impacts were anticipated, these concerns were dismissed or ignored by those who embraced the expected positive benefits of the economic activities that produced those impacts”. (Council of Canadian Academies 2014)

While the 238 submissions are not necessarily representative of Nova Scotians generally, they provided detailed accounts of the types of concerns that exist amongst the public, and demonstrate that many citizens are engaged in this issue and want to play an active
role in decision-making. Increasing public and stakeholder participation regarding shale gas development is advocated as a way to manage and reduce risks (North et al., 2014), and is an approach that will benefit Nova Scotia in its ongoing deliberations on this issue.

That 75-90% of submissions support maintaining a moratorium or ban on shale gas - largely due to concerns over environmental impacts and their broader implications – speaks to the need for government to further consult with the public. A 2013 poll of 1300 Nova Scotians – that was statistically significant and representative of the population as a whole - found 69% support for a moratorium or ban until risks can be mitigated (Colley, 2013). Even with stringent government regulations, a slight majority (53%) of Nova Scotians still oppose the development of hydraulic fracturing in the province, with 39% supportive, and another 8% largely undecided (Corporate Research Associates, 2013). These data, combined with submissions to the Expert Panel, indicate that many Nova Scotians are not currently persuaded by potential economic opportunities from shale gas in the face of perceived and documented environmental risks. This finding is consistent with the recently released Now or Never report – based on various public outreach and data collection approaches – regarding the Nova Scotia economy that states:

“There is general consensus of the importance of using Nova Scotia’s natural resources to generate wealth in the province, although the protection of the environment trumps job creation in the development of such resources. It is also clear that there is a significant segment of the population that believes some natural resources, such as shale gas, cannot be developed in an environmentally safe manner regardless of how strict the regulations” (Ivany et al., 2014)

Many submissions to the Expert Panel expressed concern about the lack of scientific evidence to prove the safety of hydraulic fracturing and advocated a “precautionary approach”. Given a lack of peer-reviewed data on both social and environmental issues – combined with an absence of baseline information to assess and monitor if hydraulic fracturing is having negative, long-term and cumulative effects – the recently released Council of Canadian Academies expert panel report on hydraulic fracturing also highlighted the advantages of a “go slow” approach to ensure a holistic and rigorous evaluation of shale gas development (CCA, 2014). In other jurisdictions, shale gas controversies were exacerbated because the speed and scale of development did not provide enough time for a thorough consideration of unforeseen impacts (North et al., 2014). Cumulative impacts – across human and ecological systems – are often difficult to assess and perhaps even harder to regulate, increasing complexity and unpredictability in ways that undermine communities, environments and associated governance (Jacquet, 2014; Malin, 2014). Given the known and potential environmental impacts associated with hydraulic fracturing across different time scales - as outlined by both citizens and the literature – a precautionary approach in Nova Scotia is prudent. This will not only
increase public trust in the process, it will ensure that much needed time to better assess environmental risks, their interconnections with society, and an appropriate response moving forward.

More regionally specific data are required to better assess the long-term environmental consequences of hydraulic fracturing. Groundwater contamination from hydraulic fracturing is a major concern amongst the public and risks through upward migration of natural gas, leaky well casings and abandoned wells are possibilities associated with this industry, and additional information on this as well as the impacts of flowback waters on human health and the environment is required (CCA, 2014). Given that shale gas development in Nova Scotia would largely take place in populated rural and semi-rural areas (CCA, 2014), a better appreciation of the potential impacts and monitoring of private wells and potable water are needed to mitigate adverse effects. Given concerns that hydraulic fracturing may compete with water use at seasonally specific peak demand times, consideration must be given to how regulations would be designed to account for this, and the potential for drought conditions that are anticipated with climate change (IPCC, 2014) and already beginning to affect Nova Scotia with water shortages and adverse impacts on farming (e.g. Delany, 2012).

If it was ever pursued in Nova Scotia, the shale gas industry would likely have a significant impact on community and infrastructure, as hydraulic fracturing produces contaminants, excessive noise, heavy truck traffic, and the potential for a “boom-bust” economic scenario. With many costs often externalized – e.g. road maintenance, environmental cleanup, groundwater contamination, human health – uncertainties regarding net benefits for local and regional economies remain and “far more research is required” to determine the balance of risks and benefits (Barth, 2013). This research must consider the unique nature of externalities associated with unconventional natural gas, which are often ‘non-point source’ in nature, and hence difficult to identify, predict, control and account for within the economic system. This makes it difficult to establish cause-and-effect linkages, undermining the ability to establish responsibility and potential liability for adverse environmental impacts caused by industry. Therefore the unique nature of externalities associated with hydraulic fracturing need to be considered in regulatory frameworks that are responsive and precautionary (Holahan and Arnold, 2013). Determining what impact hydraulic fracturing might have on other competing land-based industries - such as forestry, agriculture and tourism - must be considered in advance to ensure sustainable development across the entire natural resource-based economy. Studies on the potential habitat fragmentation caused by hydraulic fracturing in Nova Scotia must be coordinated and carried out, to determine the net impact of this industry on biodiversity in both natural and managed ecosystem. Examples of these approaches and their importance are becoming available (e.g. Raciot et al., 2014).

While transitioning from coal to natural gas may have benefits from a climate change perspective, available literature suggests this is highly dependent on the efficacy
of regulations and monitoring, given possible fugitive methane emissions and increased use of abundant natural gas supplies. Furthermore, since cheaper natural gas is known to displace investment in and use of renewable energy, without a strict regulatory framework in place hydraulic fracturing may undermine the Province’s ambitions in wind and tidal energy that are crucial to the emerging green economy. Carefully traversing this natural gas “bridge” - with high quality data and carefully designed regulations - is an absolute must and the Environmental Goals and Sustainable Prosperity Act (EGSPA) is an important tool in this regard. Speaking about climate change to the media (CBC, 2014), Christine Lagarde, the Managing Director of the International Monetary Fund, advocated a full cost accounting of energy projects:

“…externalities such as wastage of water, congestions on the roads, additional risks to mortality and so on, need to be included in the thinking process that applies to policies encouraging the use of one or another form of energy” (Christine Lagarde, Managing Director, IMF)

Climate change is a real and present danger for Atlantic Canadians already affecting their culture, livelihoods, community infrastructure and economies (Mauro, 2013). A new study suggests research and policy are massively underestimating the financial costs to society of inaction on mitigation of greenhouse gases (Dietz and Stern, 2014). Indeed, continued public commitments to the fossil fuel industry may be a “failing strategy”, given that climate change will force society to curtail GHG emissions, and some academics are now encouraging citizens and their governments to begin shifting investments away from fossil fuel industries in order to protect the environment and long-term civic well-being (Arbuthnott and Dolter, 2013).

Prior to any potential commercial development of hydraulic fracturing, pathways and technologies for wastewater treatment and well pad clean up must be determined in consultation with all relevant stakeholders, and research is increasingly available on these topics (e.g. Shaffer et al., 2013, Mitchell and Casman, 2011). The experience at Kennetcook demonstrates the political and ecological consequences of not having a well-developed plan in place and these issues must be promptly resolved given that leaking and improperly disposed of hydraulic fracturing sites are known to adversely affect human and environmental health (Mitchell and Casman, 2011). Furthermore, negative experiences with resource development amplify public risk perception of shale gas (Braiser et al., 2011) and increase awareness of negative environmental impacts (Willits et al. 2013) that will make it difficult to pursue commercial-scale hydraulic fracturing in Nova Scotia without first dealing with the issues created by exploratory drilling at Kennetcook. Efforts to increase public confidence in governance and industry specifically as it relates to waste water treatment and site clean up are crucial. Many submissions were generally critical of industry and their track record, a point also made in Now or Never:
“The reputation of most companies in Nova Scotia in terms of operating in an environmentally responsible manner is perhaps underwhelming, demonstrating an area of opportunity. If the general public had a more positive opinion of the environmental practices of private business, there would be less resistance to the development of natural resources” (Ivany et al., 2014).

Trust in industry, combined with increasing local benefit, are key variables influencing overall environmental risk perception of shale gas. In many submissions, people believed that potential opportunities were simply overstated, and that costs for communities were substantial, specifically impacts on human health and infrastructure like roads and bridges, and other municipal services. Having a clear plan in place for distribution of financial benefits, ensuring that both individuals and municipalities receive much-needed funds from development of their natural resources is essential. As Jacquet (2014) points out, some communities may benefit from shale gas, while others may not, and determining the factors that create successful development of natural resources while ameliorating risks is needed. That some US communities have experienced both benefits and risks from shale gas development – seeing it as a “double edged sword” - speaks to the possibility of harnessing opportunities especially if externalities can be properly accounted for and risks effectively mitigated. At present, there is an open debate in the scientific literature about the manageability of environmental risks and externalities associated with shale gas, and that is the knowledge gap Nova Scotians need to be aware of and their governments need to work on prior to commercial development of this industry. While tens of thousands of hydraulic fracturing well exist in North America, very little data exist on their environmental impacts due to a lack of testing and monitoring as noted discussed by the CCA (2014):

“Despite a number of accidents and incidents, the extent and significance of environmental damage is difficult to evaluate because the necessary research and monitoring have not been done. Data are lacking for characterizing and assessing the environmental impacts of shale gas development adequately, particularly in relation to groundwater contamination and fugitive methane emissions. There are no vulnerability identification and management systems in place to identify those areas in Canada where hydraulic fracturing will be so risky that it should not be undertaken.” (Council of Canadian Academies, 2014)

As this report demonstrates, having citizens and communities involved in the risk assessment and decision-making process regarding shale gas is an important first step co-generating interdisciplinary knowledge that may help to unpack and mitigate potential problems before they occur, while increasing trust amongst stakeholders. New approaches in the social sciences may help create awareness and understanding of
hydraulic fracturing and its impacts on socio-ecological and should be utilized (Willow and Wylie, 2014). As noted in *Now or Never*, reducing conflicts over extractive industries will only be achieved through public input, enhanced regulations, and when necessary the courage of citizens and their governments to decide against certain natural resource development opportunities if the balance between benefits and risks cannot be achieved:

"The opposition to uranium mining and fracking as extractive resources comes from a genuine concern for the environmental impacts of such industries, as well as a desire to explore alternatives to such extraction for our energy needs. Yet, we see other jurisdictions financially benefiting from such industries and governments are receiving much needed revenues to contribute to public infrastructure, health care, transportation and education. Nova Scotia must find a way forward in these conflicts. There are a variety of mechanisms to decrease conflict and ensure community benefit. In some cases, it may mean that we do not develop some resources where in other cases it may mean that we have enhanced regulatory frameworks that ensure community input and environmental protection"

(Ivany et al., 2014)
References


Lead Author Biography

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