New Brunswick Shale Gas Air Monitoring Study – Synopsis

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Context of shale gas in Canada and New Brunswick

Shale gas refers to natural gas that is extracted from a type of fine-grained sedimentary rock known as shale. Owing to the characteristics of shale (e.g. silt and clay-sized particles, low porosity), natural gas does not naturally and freely flow through the rock and to a well. As a result, well stimulation methods such as hydraulic fracturing are required to free the gas from the rock formation and increase its mobility. Shale is considered unconventional natural gas, by contrast to conventional natural gas that can be extracted from deposits without relying on well stimulation techniques.

Shale deposits are abundant in Canada. Shale resources are currently in development in the western provinces of Canada (e.g. British Columbia and Alberta). By contrast, shale gas development is currently limited or prohibited by provincial moratoria in the central and eastern provinces (e.g. Ontario, Québec and New Brunswick) (CCA 2014). This geographic discrepancy partly reflects how shale deposits are located nearer to urban areas in the southern part of Canada, whereas they are located in remote regions in the northwest (CCA 2014).

Natural gas production in New Brunswick dates back to 1909, with the drilling of wells in the Stoney Creek Field near Moncton. Estimates indicate that there are 78 trillion cubic feet of gas in place in areas of New Brunswick that have been explored to date.[1] Natural gas development has been gradual in New Brunswick, with about 40 wells having been drilled since 1990.[2] In the summer of 2014, Corridor Resources Inc. completed hydraulic fracturing operations on five well pads in the area around Sussex, New Brunswick. In December 2014, the Government of New Brunswick introduced a moratorium on new hydraulic fracturing development in the province.[3] In 2015, 32 natural gas wells were in production across the McCully gas field, supplying an average of 5.5 million cubic feet per day. A large fraction of the natural gas is collected and treated at the McCully Gas Plant in Penobsquis, New Brunswick.

The suspension of unconventional oil and gas (UOG) development in several provinces across Canada has been spurred by environmental and health concerns in association with potential contamination, depletion, or disturbance of air, land and water resources (e.g. CCA 2014; Ward and Nicol 2016). Several studies, mostly in the United States, have investigated the impact of UOG development on water quality and quantity (e.g. Li and Carlson 2014; Vengosh et al. 2014; Warner et al. 2014). A recurring limitation of water studies has been the lack of baseline data for comparative analyses (i.e. absence of data prior to UOG development activities, such as drilling or well stimulation), or the absence of specific markers to associate environmental contaminants with UOG development activities (e.g. chemicals used explicitly in hydraulic fracturing fluids). Air monitoring studies in active UOG regions are also limited by the absence of baseline and comprehensive air quality data (e.g. Adgate et al. 2014; CCA 2014; US EPA 2013). In addition, as UOG sites can be located within areas where oil and gas production from conventional source rocks is occurring, the allocation of air quality impacts to specific sectors or wells is challenging.

[1] www.capp.ca/canadian-oil-and-natural-gas/industry-across-canada
[2] www2.gnb.ca
[3] www.nrcan.gc.ca/energy/sources/shale-tight-resources/17669

Shale gas extraction and processing activities generate air pollutants that may vary in terms of chemical compounds and quantities released. Compared to conventional gas, shale gas development is expected to increase air pollutant releases due to more extensive well completion activities (e.g. equipment and materials required for hydraulic fracturing) (Ward and Nicol 2016).

Further development of Canadian shale gas resources, or the resumption of gas development, remains a possibility, and will likely depend on economic (e.g. natural gas prices), social (e.g. community acceptability, perceptions, employment) and political factors (e.g. governmental policies and regulations) (CCA 2014). Shale gas development may also become more common near populated areas and communities, increasing the risk of human exposure to air pollutants (Adgate et al. 2014). Thus, the concerns associated with hydraulic fracturing and shale gas need to be addressed so that environmental and health impacts from UOG development may be measured, assessed, avoided or mitigated appropriately across Canada. Reliable environmental monitoring approaches for shale gas development must be defined. In addition, these monitoring approaches need to be flexible, transferable and adaptable to various development scenarios (CCA 2014).

Study background and scope

In 2012, Health Canada and the New Brunswick Department of Environment and Local Government (DELG) began a study to monitor air quality around shale gas activities in the province of New Brunswick.[4] Environment and Climate Change Canada (ECCC) provided equipment and analytical support through the National Air Pollution Surveillance (NAPS) program. Air quality monitoring data near unconventional natural gas activities, which includes shale gas, were not readily available when this study was developed and initiated. The lack of quantitative data limited the ability to fully characterize the population exposure associated with shale gas development in New Brunswick and across Canada. The overall objective of the New Brunswick Shale Gas Air Monitoring Study was to characterize the ambient concentrations of air pollutants near shale gas operations during different stages of development. The results from this study can be used to guide the assessment of human health risks from air pollution associated with shale gas.

The study consisted of four monitoring phases that represented the different stages and activities of shale gas development in New Brunswick:

Phase I – Baseline conditions prior to any development (Baseline);
Phase II – Well development and gas production (Production);
Phase III – Natural gas processing and distribution (Processing); and,
Phase IV – Well closure (Closure).

The monitoring phases reflect a life cycle of shale gas development from an undeveloped site to gas production and well closure, as well as gas transport. However, it was not feasible to monitor air pollutant levels at the same site or over the same time period. All sites were located near Sussex in Kings County, New Brunswick, and within the Kennebecasis River valley. As such, it was expected that

[4] Memorandum of Agreement for Services (MOA no. 4500290325)

the overall air quality monitoring would be representative of the life cycle of shale gas development in this region.

Baseline monitoring was initiated in October 2012 and lasted for twelve months. The baseline site was in Apohaqui, located southwest of Sussex, New Brunswick, within an area of interest where shale gas development may occur in the future. However, the site was not affected by shale gas development or any other significant source of air pollutants when the air monitoring occurred. It was located upwind of the other designated sampling sites and also upwind of Penobsquis, where multiple natural gas wells (both conventional and unconventional) and two gas plants were in operation. This Baseline phase was meant to provide information on regional pollutant levels that can be considered as "normal" for the area in which the study sites were located.

Production monitoring began in June 2014 and ended in March 2015. Monitoring was conducted at well pad F-67 in Penobsquis, New Brunswick, where a hydraulic fracturing event occurred in early September 2014. The well is owned and operated by Corridor Resources Inc. Production monitoring data were collected at eight different sampling locations around the well pad.

Monitoring for the Processing phase was conducted during the summer of 2013, over a 12 week period at eight different sampling locations near a natural gas treatment facility in Penobsquis, New Brunswick. This facility is owned and operated by Corridor Resources Inc.

Monitoring for the Closure phase was conducted during the summer of 2013, over a 6 week period at a well pad located north of Elgin, New Brunswick. The well pad, also owned by Corridor Resources Inc., included two suspended shale gas wells. Closure air monitoring was conducted at five different sampling locations, including a location a few meters away from the well heads.

The selection of the monitoring approach and the pollutants that were targeted during each phase of the study depended on knowledge of potential pollutants of concern, on activities being planned or conducted on-site, as well as on-site conditions, including access to electricity. The data include continuous measurements of carbon monoxide (CO), methane, ozone (O_3), sulphur dioxide (SO_2), total reduced sulphur, fine particulate matter ($PM_{2.5}$), total suspended particulates, nitrogen oxides (NOx) and volatile organic compounds (VOCs), as well as laboratory measurements of integrated samples for VOCs, polycyclic aromatic hydrocarbons (PAHs), elemental carbon and organic carbon, and markers of biomass burning (galactosan, levoglucosan and mannitol).

The project was conducted and completed during a period of significant interest in the economic, health and social impacts of shale gas development in New Brunswick. The air quality monitoring period ended a few months after the Government of New Brunswick implemented a provincial moratorium on hydraulic fracturing, thereby suspending further shale gas development.

Public reporting

Health Canada was responsible for the production and public release of reports associated with the New Brunswick Shale Gas Air Monitoring Study. Collaborators from the DELG and ECCC, as well as

representatives from other government departments and Corridor Resources Inc., were consulted during the development of three reports and given an opportunity to review their content.

A first interim report (Interim Report 01) was released in February 2014. Interim Report 01 outlines the different study phases, the data collection approach, the monitoring and sampling methodologies, and the quality assurance and quality control procedures. It also includes preliminary analyses of the monitoring data collected between October 2012 and April 2013 at the Baseline site.

A second interim report (Interim Report 02) was released in July 2015. Interim Report 02 includes analyses of the data from Baseline, Processing and Closure sites.

Report 03, released in March 2017, is the final report of the New Brunswick shale gas air monitoring study. It presents and analyzes the data collected during Production, and includes comparisons with other phases of the monitoring study.

Results and findings

At the Baseline site, criteria air contaminant (e.g. CO, NOx, O_3, $PM_{2.5}$ and SOx)[5] levels were similar to, or lower than, average pollutant levels reported at air monitoring stations across New Brunswick.[6] Ambient concentrations for non-criteria air contaminants, including air toxics such as metals and PAHs, were also generally lower than levels measured at other provincial sites. Pollutant levels were notably lower than those measured in the larger urban centres of New Brunswick – Fredericton, Moncton and Saint John. Although comparisons were not possible for all pollutants, the absence of significant emission sources of pollutants upwind of the Baseline site suggests that the levels observed were not significantly influenced by local anthropogenic sources. Thus, the site allowed for the collection of regionally representative air pollutant data that could be used to assess the influence of local sources on pollutant levels in the region of Sussex, New Brunswick. As such, the Baseline data provided an appropriate data set against which to compare air quality data collected during the other phases in the study.

Activities conducted on the well pad during Production had a measurable impact on air pollutant levels, especially at downwind locations, but the impact was brief and air pollutant levels remained below current ambient air quality standards. While ambient levels of CO, O_3 and SO_2 did not appear to be substantially influenced by well pad activities, there were measurable, but brief, impacts on $PM_{2.5}$ and NOx, as well as on carbonyl, CH_4, PAH, and some VOC ambient levels. Sizable increases in these air pollutant levels were measured at downwind sampling locations in comparison with upwind sampling locations, highlighting the influence of meteorological conditions. The increases also suggested that activities at the well were the source of air pollution. However, the impacts were brief and air pollutant levels remained below all current ambient air quality standards that have been adopted by the federal

[5] Criteria Air Contaminants and Related Pollutants. Environment and Climate Change Canada. https://ec.gc.ca/air/default.asp?lang=En&n=7C43740B-1

[6] Measurement values are not presented in the Synopsis report. For a detailed description and analysis of air monitoring results from the New Brunswick Shale Gas Air Monitoring Study, the reader may refer to Interim Report 02 (Health Canada 2015) for all sampling locations associated with Phases I, III and IV, and to Report 03 (Health Canada 2017) for all sampling locations associated with Phase II.

or provincial governments in Canada.[7] Moreover, average air pollutant levels during production were similar to those measured at Baseline and to those measured at monitoring sites across New Brunswick (i.e. NAPS monitoring stations). The increases in pollutant levels corresponded to periods of intensive well operations, such as drilling, hydraulic fracturing, snubbing, venting and flow testing. A variety of operations before, during and after a hydraulic fracturing event may have influenced air pollutant levels; in some cases more than the hydraulic fracturing event itself. These included, for example, drilling activities, well snubbing and gas flow testing (refer to Report 03).

At the Processing site, concentrations of criteria air contaminants such as CO, O_3 and $PM_{2.5}$ were comparable to Baseline conditions. However, the data indicated that the natural gas treatment facility had an influence on the ambient level of several VOCs. These included alkane species generally associated with oil and gas operations, such as butane, decane, heptanes, hexane, octane, pentane and propane. Nonetheless, air pollutant concentrations remained below air quality standards that have been adopted by Canadian jurisdictions and were similar to or lower than levels at the Baseline site or at NAPS monitoring sites across New Brunswick. Overall, the results from the Processing site monitoring indicated that emissions from the gas treatment facility had a measurable, but limited influence on air VOC levels.

Ambient concentrations of VOCs and methane were generally low during the monitoring at the Closure site. Criteria air contaminants were not measured during this phase. The measured concentrations for several VOCs associated with the use, manufacture or disposal or petroleum products were higher than those at Baseline, but were all below air quality standards that have been adopted by Canadian jurisdictions. Based on the available information, it was not possible to identify the exact origin(s) of the measured VOCs (e.g., inadvertent spills during previous activities at this site including drilling, hydraulic fracturing or site preparation). Many of these VOCs are not necessarily linked to natural gas production, although they may be indicators of petroleum fuels, such as diesel or kerosene. Hence, the Closure results suggested that fugitive VOC emissions were occurring on or near the well pad, but the results are inconclusive.

Study features and limitations

The New Brunswick Shale Gas Air Monitoring Study is unique in that it includes a representative baseline site for comparison purposes. Baseline or reference air quality conditions are unavailable in most shale gas plays in North America. This is partly because of the rapid pace of shale gas development in areas where monitoring stations were or are not present prior to development. Once an industry is well developed in a given region, it becomes difficult to estimate baseline conditions. Another quality of this study was the monitoring approach. Air pollutant monitors were deployed in very close proximity to the wells, the well pad or the facility, which provided accurate measurements of air pollutant

[7] In the current study, air quality standards, objectives or criteria adopted by the Federal Government, as well as those adopted by the governments of Alberta, British Columbia, New Brunswick and Québec were considered for comparisons with the air monitoring data.

concentrations. In addition, up to eight monitors were setup around the sites, in order to collect multiple samples from different directions and to consider the influence of winds.

The geographic scope of this study is both an interesting feature and a limitation. The study was conducted in a geographic range (i.e. Kings County, New Brunswick) not covered in previous air quality reports associated with shale gas development. The results of this study are considered informative about potential air quality concerns associated with shale gas activities in Kings County, New Brunswick. However, large differences may be observed among natural gas regions and even within a given area due to differences in geographical, meteorological and geological considerations, as well as, the variability in operational conditions and industry practices. Thus, although the study has the potential to highlight possible air quality impacts that could be relevant to other jurisdictions, additional air monitoring and analyses are considered necessary to further characterize impacts in New Brunswick or to characterize air quality impacts in other shale gas producing regions.

The study covered only a few sites and a limited number of activities or events. The Production phase focused on a single well, and on a single hydraulic fracturing event. It is uncertain if the well pad that was monitored (F-67) is representative of other well pads in the McCully Field. Many parameters of well development and hydraulic fracturing operations may influence air pollutant emissions and their impact on ambient air concentrations. The hydraulic fracturing event that was monitored was planned and conducted by the operator based on technological and site-specific constraints and characteristics (e.g., geological features and available equipment). In particular, the hydraulic fracturing relied on liquefied petroleum gas (LPG), which is not the most common fluid used for well completions. In North America, water-based fluids are more frequently employed. In addition, the well did not include a horizontal leg and a relatively small volume of fluid was required for the fracturing stage (600 m^3 of LPG compared to high volume water-based hydraulic fracturing events that can require up to 20 000 m^3 of water; CCA 2014). As unconventional gas exploration is currently limited in New Brunswick, and owing to the current provincial moratorium on hydraulic fracturing, opportunities to conduct further air monitoring of shale gas development are non-existent. Consequently, there is uncertainty regarding the representativeness of this monitored event for New Brunswick and potential extrapolations to other unconventional gas development scenarios across Canada.

In addition, the monitoring for the Processing phase was based around a single gas treatment facility. Further air monitoring is required at multiple gas treatment facilities to more accurately characterize air quality impacts in New Brunswick or in other shale gas producing regions.[8] The same limitation applies to the Closure phase.

More importantly, the study did not evaluate the potential cumulative impacts of multiple wells and gas plants under a scenario of expanding natural gas production in Kings County, New Brunswick. As such, it is not necessarily indicative of the overall air quality impacts of a fully developing or developed unconventional gas play. This would likely involve the concurrent development of several well pads,

[8] To address this limitation, air monitoring may be conducted around facilities that collect and treat natural gas from conventional or unconventional formations. The origin of the gas or the method used to recover the gas is not expected to influence emissions from natural gas treatment facilities.

concurrent well completions, increased road traffic and off-road activity, and increased flaring. The cumulative impacts on local or regional air pollutants could be greater if the unconventional gas play was fully developed.

Conclusions

This study provides an informative snapshot of the impact of shale gas development in New Brunswick, but it is not a definitive representation. Since the onset of this study in 2012, an impressive number of research papers, meta-analyses, risk assessments and environmental or health impacts assessments have been published, as well as policy reports and regulations. These publications, based on analyses across North American gas production regions, show the variability of potential environmental and health concerns and impacts linked to UOG development. They also underline how regulations, industry practices and innovations, geographical and geological features, and meteorological conditions may influence air pollutant emissions and ambient concentrations associated with shale gas development.

Activities from a single well pad increased NOx, $PM_{2.5}$ CH_4, and some PAHs and VOCs, intermittently during specific periods that corresponded to intensive operations, such as drilling, hydraulic fracturing, snubbing, venting and flow testing. These activities did not appear to increase ambient levels of CO, O_3 and SO_2. Emissions linked to natural gas processing also resulted in increased levels of some VOCs. In general, increases were of short duration and ambient pollutant levels quickly returned to baseline values. However, short-term, measurable air quality impacts were observed.

Overall, pollutant levels during Production, as well as other phases, were lower than ambient air quality standards adopted in New Brunswick or in other Canadian jurisdictions. Therefore, the results from the current study suggest that air pollutants did not reach levels that are of concern to environmental and human health, or that would trigger mitigation measures to improve air quality.[9]

Based on the study findings, comprehensive air monitoring is recommended near well pads in order to capture air pollutant releases from unconventional oil and gas development and accurately assess the air quality impacts. Owing to the intermittent and frequent releases of air pollutants during the different stages of well development, the monitoring period should include periods prior to, during and following drilling and well completion stages. Continuous monitors should also be employed, if feasible, along with integrated samples (e.g., 24 h samples, weekly samples), as appropriate for the targeted air pollutants.

The monitoring approach should target NOx and $PM_{2.5}$ along with PAH and VOCs, if possible. Detailed characterization of VOCs also provides considerable value by allowing for the identification of VOC species that are influenced by local oil and gas activities. “Total” VOC values may not correctly reflect

[9] Note that air quality standards were not reviewed or assessed during this study. The rationale or approach used to define air quality standards may vary among pollutants and jurisdictions, depending on the endpoint or the intent of the standard. Thus, some air quality standards may not be the most relevant for an assessment of air pollution health impacts.

the fluctuations of many VOCs by giving too much weight to VOCs that are not associated with oil and gas operations, such as global pollutants (e.g., carbon tetrachloride) or biogenic VOCs (e.g., α–pinene).

In the event of a broader development of unconventional gas plays in New Brunswick, monitoring key regional air pollutants, O_3, $PM_{2.5}$, and NO_2, should also be conducted. These common pollutants are known to be harmful to human health and form the basis of the Air Quality Health Index (AQHI), which is a health protection information tool developed by Health Canada and ECCC.[10] For example, in Fort St. John, British Columbia, a region with considerable UOG development, daily AQHI forecasts are now available to help communities protect their health from air pollution. Samples and measurements should also be collected using validated methods for reliable comparisons with air quality standards and data from regional or national surveillance programs, such as NAPS in Canada.

In light of the increasing knowledge and research on the air quality impacts associated with unconventional gas development and owing to the limitations of the New Brunswick Shale Gas Air Monitoring Study, general statements or extrapolations to other shale plays in New Brunswick or Canada are currently not possible. As a case study, this study contributes to the understanding of the risks and potential air quality impacts of shale gas development in New Brunswick, but it is insufficient to allow for a complete characterisation. The conclusions from this report are considered the most reasonable based on the study findings and provide a reference for discussing air quality impacts associated with UOG development in New Brunswick and Canada. However, limitations and uncertainties remain, and the interpretations are subject to revision if new relevant data become available in the future.

References

Adgate JL; Goldstein BD; McKenzie LM. 2014. Potential public health hazards, exposures and health effects from unconventional natural gas development. Environ Sci Technol 48 (15): 8307–8320.

[CCA] Council of Canadian Academies. 2014. Environmental health impacts of shale gas extraction in Canada. The expert panel on harnessing science and technology to understand the environmental impacts of shale gas. Council of Canadian Academies, Ottawa, ON. 261 pp.

Health Canada. 2014. New Brunswick shale gas air monitoring study – Interim report 01. Catalogue no. H129-38/1-2014 E-PDF. 59 pp. Available at: http://publications.gc.ca/site/eng/search/search.html.

Health Canada. 2015. New Brunswick shale gas air monitoring study – Interim report 02. Catalogue no. H129-38/2-2015 E-PDF. 89 pp. Available at: http://publications.gc.ca/site/eng/search/search.html.

Health Canada. 2017. New Brunswick shale gas air monitoring study – Report 03. Catalogue no. H129-38/3-2017E-PDF. 99 pp. Available at: http://publications.gc.ca/site/eng/search/search.html.

Li H; Carlson KH. 2014. Distribution and origin of groundwater methane in the Wattenberg oil and gas field of Northern Colorado. Environ Sci Technol 48(3): 1484–1491.

[10] www.ec.gc.ca/cas-aqhi/default.asp?Lang=En (accessed April 8, 2016)

[US EPA] United States Environmental Protection Agency. 2013. EPA needs to improve air emissions data for the oil and natural gas production sector. US EPA, Office of Inspector General, Report No. 13-P-0161. 42 pp.

Vengosh A; Jackson RB; Warner N; Darrah TH; Kondash A. 2014. A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States. Environ Sci Technol 48: 8334–8348.

Ward H; Nicol A-M. 2016. Understanding the public health implications concerning shale gas production and hydraulic fracturing. National Collaborating Centre for Environment Health, British Columbia Centre for disease Control. 24 pp.

Warner NR; Christie CA; Jackson RB; Vengosh A. 2013. Impacts of shale gas wastewater disposal on water quality in Western Pennsylvania. Environ Sci Technol 47: 11849–11857.