Responsible Environmental Management of Oil and Gas Activities in New Brunswick

Case Studies and Lessons Learned

New Brunswick Natural Gas Group

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FORWARD

This document summarizes some of the main environmental issues that have been associated with hydraulic fracturing in other North American jurisdictions and describes how they can be proactively addressed via recommendations contained in Responsible Environmental Management of Oil and Gas Activities in New Brunswick - Recommendations for Public Discussion.

The reader is referred to the above document for a more complete description of recommendations that have been prepared by the New Brunswick Natural Gas Group.

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1.0 COMPONENTS OF HYDRAULIC FRACTURE FLUID FOUND IN PRIVATE WATER WELLS

At the request of residents of Pavillion, Wyoming, the United States Environmental Protection Agency (EPA) began investigating water quality in private drinking water wells in 2008. Monitoring results released on November 9, 2011 and subsequently contained in a draft report released on December 8, 2011 indicate that ground water in the aquifer under investigation contains compounds associated with natural gas production practices, including hydraulic fracturing.

According to the EPA, hydraulic fracturing in gas production wells in the Pavillion area has occurred as little as 372 metres below ground surface and within potable groundwater. The surface casings of some of the gas production wells do not extend through the entire thickness of the shallow groundwater layer. A subsequent review of the EPA study on behalf of the U.S. Congress noted that "The issue at Pavillion, where hydraulic fracturing and gas production are occurring only slightly deeper than the deepest water wells, would likely not be an issue for most shale gas plays."

At least 33 excavated pits previously used for the storage of drill cuttings, produced water and flowback water are present in the study area. According to the authors of the EPA report, detection of high concentrations of benzene, xylenes, gasoline range organics, diesel range organics, and total purgeable hydrocarbons in ground water samples from shallow monitoring wells near the pits indicates that the pits are a source of shallow ground water contamination in the area of investigation.

This case study illustrates the need to:

- Ensure that surface casing extends deep enough to protect potable ground water;
- Avoid hydraulic fracturing within potable groundwater;
- Address the use of pits to store drilling fluids and other liquid wastes including flow-back water and produced water; and
- Establish appropriate set-backs between oil and gas facilities and water wells.

Recommendations for New Brunswick:

- Require that surface casings for oil and gas wells must extend through the entire depth of shallow (non-saline) groundwater aquifers, below the depth of the deepest water wells;
- Prohibit hydraulic fracturing within non-saline groundwater aquifers;
- Require the use of use of "closed loop" (pitless) drill fluid systems;
- Prohibit the use of pits to contain flowback and produced water; and
- Establish appropriate minimum set-back distances between oil and gas facilities and water supplies.

2.0 ELEVATED METHANE CONCENTRATIONS IN PRIVATE WATER WELLS

A study by Duke University's Nicholas School of the Environment, released in May of 2011 showed that in active natural gas-extraction areas (one or more gas wells within a one kilometre distance), average and maximum methane (natural gas) concentrations in drinking-water wells increased with proximity to the nearest gas well. Chemical analysis showed that the methane chemistry was consistent with deeper thermogenic methane sources such as the Marcellus and Utica Shale and matched gas geochemistry from nearby gas wells. Methane is not generally considered to be a health hazard when ingested in drinking water but airborne methane (which can be liberated from the water) can cause asphyxiation in confined spaces and can represent a fire or explosion hazard at high concentrations.

Leaky gas well casings were identified as one potential cause. Another potential cause was increased connectivity between the deep gas-bearing and shallow groundwater after hydraulic fracturing. It was noted that this later occurrence would be more likely if there are abandoned wells located in proximity to the production wells.

Since baseline (pre-fracturing) water well data was not collected, the study was not able to compare pre- and post-fracturing methane concentrations at a given well.

The study found no evidence for contamination of water wells by flowback water or fracturing fluids.

This case study illustrates the need to:

- Assess the potential for hydraulic fracturing to allow methane from deep underground to reach the surface, via pathways outside the well bore;
- Assess the potential for old, abandoned wells to provide a pathway for gas migration;
- Ensure adequate cementing of the oil or gas well casings;
- Ensure that hydraulic fracturing does not take place if there are deficiencies in the well casing cement;
- Avoid "shutting in" the annular space between casings, so that any gas leaks do not result in a build up of pressure that will cause the gas to migrate into shallow groundwater;
- Conduct background (baseline) water well sampling to allow comparison with post fracturing water well data to help determine the cause of elevated methane in water wells; and
- Develop protocols to be followed in the event of a gas leak from a well.

Recommendations for New Brunswick:

- Require an assessment of geological containment prior to hydraulic fracturing;
- Require an analysis of the response of geological formations to hydraulic fracturing including a report that identifies the extent of the fractures that were created;
- Set enhanced standards for oil and gas well bore casing;
- Set enhanced standards for well bore cementing;
- Require cement evaluation logging (testing of the integrity of wellbore cement);
- Require remedial cementing when necessary to ensure the integrity of the well bore;
- Require the use of casing vents to direct stray gas away from aquifers;
- Enhance existing well plugging and abandonment standards;
- Implement mandatory pre-drilling and post-drilling water well testing;Develop stray gas investigation and response guidelines; and
- Establish appropriate minimum set-back distances between oil and gas wells and water supplies.

3.0 ELEVATED BROMIDE CONCENTRATIONS IN SURFACE WATER

Elevated levels of bromide were found in the Monongahela River, Pennsylvania, downstream of the discharge locations of municipal waste water treatment plants that were receiving and treating waste water (flow-back water and produced water) from shale gas wells. The Monongahela River serves as a source of drinking water to over 800,000 people in south-western Pennsylvania. Shale gas operators subsequently stopped sending their waste water to the waste water treatment plants.

Bromide itself is non-toxic and occurs naturally in seawater and underground rock formations, but if water containing bromide is subsequently chlorinated for drinking, the bromide can combine with chlorine to create brominated trihalomethanes, which are probable human carcinogens.

In order to address the above problem, municipal wastewater treatment facilities would have to employ measures to remove total dissolved solids (TDS), because bromide is found in drilling wastewater as a component of TDS. Such measures are expensive and are not typically employed at municipal waste water treatment plants.

This case study illustrates the need to:

- Ensure that wastes generated by hydraulic fracturing are analyzed and that their disposal locations are approved by regulators before the waste leaves the well site; and
- Ensure that waste water treatment facilities that accept waste water from oil and gas activities, are properly designed and monitored.
- Recommendations for New Brunswick:
- Require oil and gas operators to prepare waste management plans that will include the characterization (chemical analysis) of all wastes and approval of disposal locations before wastes leave the well site;
- Establish requirements that must be addressed in relation to the use existing waste water treatment facilities to treat flowback and produced water (i.e. assess the ability of the facility to treat the waste and install all required upgrades); and
- Require water quality monitoring downstream of wastewater treatment facilities that discharge to surface water.

4.0 FRACTURE FLUID ENTERING SURFACE WATER

On April 19, 2011, an equipment failure occurred during hydraulic fracturing, allowing the release of hydraulic fracture fluid from a well. This allowed the fluid to wash onto the well pad. Some of the fluid entered a nearby stream. An environmental analysis released six months later showed no lasting impact on surface water.

This case study illustrates the need to:

- Ensure that the equipment to be used in hydraulic fracturing is tested and shown to be capable of containing the pressures that will be employed;
- Ensure that on-site expertise is available to address an emergency situation; and
- Ensure that emergency containment is available for use in the event of spills.

Recommendations for New Brunswick:

- Require pressure testing of the well bore and surface equipment prior to hydraulic fracturing;
- Set a maximum allowable hydraulic fracturing pressure in relation to the test pressure of the equipment used;
- Require monitoring of well bore pressure during hydraulic fracturing;
- Require that hydraulic fracturing be terminated if pressure is lost;
- Establish requirements for emergency containment of hydraulic fracture fluids;
- Require sealing off and abandonment of defective wells that cannot be properly repaired;
- Require the use of certified well drilling personnel;
- Implement enhanced blow-out protection measures; and
- Establish appropriate minimum set-back distances between oil and gas wells and water bodies.

5.0 COMMUNICATION BETWEEN WELLS DURING HYDRAULIC FRACTURING

In 2010, the British Columbia Oil and Gas Commission issued a safety advisory regarding potential communication of hydraulically fractured wells with adjacent oil and gas wells via the newly created fractures. The Commission noted that such communication has been documented in 18 cases in B.C. and western Alberta. Resultant unintended entry of water, gas, oil, or other formation fluid into an adjacent wellbore could lead to a blow-out if the resultant formation pressure is greater than the pressure exerted on it by the column of drilling mud in the well bore. While each of the above incidents was controlled using standard well safety measures, and no blow-outs occurred, the Commission recommended that well operators consult with and notify the operators of adjacent wells to reduce the possibility of a blow-out

This case study illustrates the need to:

- Ensure that well operators coordinate their activities with other well operators in the vicinity, so that hydraulic fracturing can be carefully monitored to reduce the risk of blow-outs due to subsurface communication between wells

Recommended New Brunswick Response:

- Operators of oil and gas wells should be required to contact any adjacent operators that are drilling, completing or operating an oil or gas well and make arrangements to cooperate through notifications and monitoring of all drilling and completion operations.

6.0 AIR QUALITY IMPAIRMENT AND NOISE

Numerous noise and air quality complaints were received by the Town of Dish, Texas in relation to compressor stations associated with extraction of natural gas from the Barnett Shale. The emission sources included a large group of compression stations under the ownership of five different operators that were constructed in close proximity to houses (in some cases less than 100 metres away).

An environmental consultant was retained by Mayor Calvin Tillman and the people of Dish, Texas to perform an Ambient Air Monitoring Analysis study in the Town of Dish. Results confirmed the presence of multiple recognized and suspected human carcinogens in fugitive air emissions at several locations.

In a subsequent study by the Texas Department of State Health Services, researchers collected blood, urine and water samples from residents of Dish. The study was not able to establish that community-wide exposures to contaminants from gas wells or compressor stations were occurring in the sampled population.

This case study illustrates the need to:

- Set air emission limits;
- Address cumulative air quality impacts;
- Anticipate and mitigate noise impacts; and
- require minimum set-backs between oil and gas facilities and dwellings.

Recommended New Brunswick Response:

- Establish and enforce air emission limits;
- Require air emission monitoring;
- Require ambient air quality monitoring, including cumulative air emissions;
- Require oil and gas operators to prepare and implement emission reduction plans;
- Establish minimum separation distances between oil and gas activities and dwellings, schools, hospitals, etc.;
- Establish enhanced noise level limits; and
- Require noise mitigation and monitoring.

7.0 NATURALLY OCCURRING RADIOACTIVE MATERIALS

Naturally occurring radioactive material (NORM) refers to low level radioactive materials from natural sources that are found in soil and water. In terms of oil and gas development, NORM may be found in drill cuttings, natural gas, and deep groundwater that flows to the surface with the oil or gas. At oil and gas wells, NORM concentrations may be noticeable in areas where sediments tend to accumulate, such as pipes, storage tanks, and other surface equipment or in sediment accumulations inside tanks and process vessels.

This information illustrates the need to:

- Test waste materials from oil and gas activities for NORMs;
- Conduct surveys capable of detecting NORM build-up in the equipment used at a well site; and
- Require prior review by the Province of the proposed method of disposal of NORMs, if any are identified.

Recommendations for New Brunswick:

- Require that wastes generated at a well site must be tested for NORM prior to their removal from the well site;
- Require periodic radiation surveys of well equipment and produced water;
- Require approval by the Province prior to removal of any NORM-affected materials or equipment from a well site.

8.0 GREENHOUSE GAS EMISSIONS

A study released by researchers at Cornell University in March of 2011, suggests that greenhouse gas (methane) emissions from natural gas obtained by high-volume hydraulic fracturing from shale formations are greater than emissions associated with the use of coal. Subsequent studies put forward alternative findings about greenhouse gas emissions from shale gas. The actual amount of greenhouse gas emissions resulting from shale gas production remains the subject of debate.

This information illustrates the need to:

- Require operators of oil and gas wells to address their greenhouse gas emissions.

Recommendations for New Brunswick:

- Require that developers and operators of oil and gas wells must report their greenhouse gas emissions to the Province and prepare and follow a greenhouse gas (GHG) mitigation plan.

Note that the Government of Canada is in the process of developing greenhouse gas regulations for the oil and gas industry. These will be applied to oil and gas activities in New Brunswick and in the rest of Canada, once they have been finalized.

9.0 TRUCK TRAFFIC

Vehicular traffic generated by oil and gas activities can be a safety concern, and can damage roads, particularly in rural areas, where existing traffic volumes are low and roads are not designed for large volumes of heavy trucks. Traffic volumes generated by well drilling can be significant, particularly in the case of wells that are developed using hydraulic fracturing.

This information illustrates the need to:

- Plan trucking routes in advance of hydraulic fracturing to avoid potential environmental and safety issues;
- Document the condition of roads and related infrastructure before the trucking commences; and
- Develop a mechanism that will be used to identify and pay for damage to roads and related infrastructure caused by increased traffic and pay for upgrades to road related infrastructure that may be required before the trucking begins.

Recommendations for New Brunswick:

- Address oversize and overmass loads and weight restrictions through existing permitting processes;
- Require oil and gas operators to prepare truck route plans, to address environmental and safety issues; and
- Require road use agreements and road system integrity studies to identify costs for road repair and upgrades, so they can be assigned to the responsible parties.

10.0 WATER USE

The amount of water needed to drill and hydraulically fracture unconventional oil and gas wells makes water consumption a critical issue in shale gas development. The amount of water required to develop a particular oil or gas well will vary according to the geology. Some of the water used for hydraulic fracturing typically remains in the underground bedrock formations and does not return to the surface.

This information illustrates the need to:

- Reduce water use in oil and gas activities by recycling;
- Direct operators of oil and gas activities to alternative water sources (i.e. besides lakes, rivers and potable groundwater);
- Cumulatively assess the potential impacts of water withdrawals; and
- Require operators of oil and gas wells to report how much water they use.

Recommendations for New Brunswick:

- Identify recycling as the preferred method of managing flowback water and produced water;
- Establish a hierarchy of preferred water sources for hydraulic fracturing (e.g. use of recycled waste water must be considered first);
- Require oil and gas operator to prepare assessments of proposed water sources that consider the needs of other water users, including ecological needs; and
- Require water use planning and reporting by the operators of oil and gas activities.

11.0 WELL CASING CORROSION AND LEAKAGE

Using data from Alberta, the authors of a 2009 study (Watson et. al., 2009) investigated factors that contribute to wellbore leakage in oil and gas wells. The paper focuses on well bores that were drilled for exploration and production of oil and gas and subsequently abandoned.

Exposed (uncemented) casing and subsequent corrosion of the casing where it is contact with the surrounding rock was identified as the main factor in the occurrence of well bore leakage, manifested by surface casing vent flow and gas migration outside the casing. The study demonstrated that enhanced well plugging and abandonment regulations in place in Alberta since 1995 have reduced the likelihood of post-abandonment well bore leakage. Interestingly, it was found that the age of the well bore did not affect the likelihood that an abandoned well bore would develop a leak.

This case study illustrates the need to:

- Require proper cementing of oil and gas well casings;
- Verify that proper cementing has been achieved;
- Monitor well casings for corrosion; and
- Ensure the proper plugging and abandonment of wells that are no longer in production.

Recommendations for New Brunswick:

- Set enhanced standards for well bore casing and cementing;
- Require cement evaluation logging (testing of the integrity of wellbore cement);
- Establish requirements for monitoring of oil and gas wells for leaks, corrosion or deterioration;
- Establish enhanced standards for well plugging and abandonment; and
- Establish an enhanced financial security requirement to ensure that proper well plugging and abandonment takes place.

REFERENCES

B.C. Oil and Gas Commission. Safety Advisory 2010-03 Communication During Fracture Stimulation. May 20, 2010.
http://www.bcogc.ca/document.aspx?documentID=808&type=.pdf

BC Oil and Gas Commission. Oil and Gas Water Use in British Columbia. August 2010
http://www.bcogc.ca/document.aspx?documentID=856

Cathles, Lawrence M. et. al. A Commentary on "The Greenhouse-gas footprint of natural gas in shale formations" by R.W. Howarth, R. Santoro, and Anthony Ingraffea. January 3, 2012.
http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/FINAL%20Short%20Version%20 10-4-11.pdf

Cathles, Lawrence M. et. al.Response to Howarth et al's Reply. February 29, 2012.
http://www.geo.cornell.edu/eas/PeoplePlaces/Faculty/cathles/Natural%20Gas/Response%20to%20 Howarth's%20Reply%20Distributed%20Feb%2030,%202012.pdf

Gilliland, Donald. Spill At Marcellus Shale Drilling Site In Bradford County Prompts Evacuation.. April 20, 2011.
http://www.pennlive.com/midstate/index.ssf/2011/04/fracking_spill_in_bradford_cou.html

Hopey, Don. Bromide Levels in Monongahela River Rose in 2010, Remain High. November 4, 2011.
http://www.post-gazette.com/stories/news/environment/ bromide-levels-in-monongahela-river-rose-in-2010-remain-high-322342/

Howarth, Robert W. et. al. Methane and the Greenhouse-Gas Footprint of Natural Gas From Shale Formations: A Letter. March 13, 2011
http://www.sustainablefuture.cornell.edu/news/attachments/Howarth-EtAl-2011.pdf

Howarth ,Robert W. et. al.Venting and Leaking of Methane from Shale Gas Development: Response to Cathles et al. January, 2012.
http://216.250.243.12/HowarthIngraffeaarticleFINAL1.pdf

Jackson, Robert B., et. al. Responses to Frequently Asked Questions and Comments About the Shale-Gas Paper by Osborn et al. June 13, 2011.
http://www.nicholas.duke.edu/hydrofracking/responses-about-gas-shale

Nissley, Erin L. Review Of Natural Gas Well Failure in Bradford County Shows no Lasting Damage. October 16, 2011.
http://thetimes-tribune.com/news/review-of-natural-gas-well-failure-in-bradford-county-shows-no-lasting-damage-1.1218830#axzz1aweGNxmZ

Osborn, Stephen G. et. al.. Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing. May 9, 2011.
http://www.pnas.org/content/early/2011/05/02/1100682108

Texas Department of State Health Services. Dish, Texas Exposure Investigation Dish, Denton County, Texas - Final Report. May 12, 2010
http://www.dshs.state.tx.us/epitox/consults/dish_ei_2010.pdf

U.S. Environmental Protection Agency. Groundwater Investigation - Pavillion.
http://www.epa.gov/region8/superfund/wy/pavillion/index.html

U.S. Congressional Research Service. The EPA Draft Report of Groundwater Contamination Near Pavillion, Wyoming: Main Findings and Stakeholder Responses. January 25, 2012.
http://wyofile.com/wp-content/uploads/2012/01/R42327-2.pdf

Watson Theresa and Stefan Bachu. Evaluation of the Potential for Gas and CO2 Leakage Along Wellbores. March, 2009.
http://www.spe.org/ejournals/jsp/journalapp.jsp?pageType=Preview&jid=EDC&mid=SPE-106817-PA

Wolf Eagle Environmental.Town of DISH, Texas Ambient Air Monitoring Analysis Final Report. September 15, 2009
http://townofdish.com/objects/DISH_-_final_report_revised.pdf