THE COUNCIL OF CANADIANS LE CONSEIL DES CANADIENS

ACTING FOR SOCIAL JUSTICE AGIR POUR LA JUSTICE SOCIALE

To: hfreview@cbu.ca

Dear Dr. Wheeler and fracking review panelists,

Thank you for the opportunity to provide comments for the hydraulic fracturing review in Nova Scotia.

Who we are

We write to you from the Council of Canadians, Canada's leading progressive advocacy organization with over 100,000 grassroots supporters and local chapters from coast to coast. Through our campaigns, we advocate for clean water, green energy, fair trade, public health care and a vibrant democracy. We educate and empower people to hold our governments and corporations accountable.

We are supported by individual donations from ordinary Canadians and do not accept funding from corporations or government.

We have been very clear in calling for a ban on fracking in Nova Scotia and across Canada, given our many concerns including the massive volumes of water required and the lack of safe methods to dispose of fracking wastewater. It also has huge climate impacts, and there is widespread community opposition to fracking in the province.

Water use

Fracking uses unsustainable amounts of water. A fracking project requires anywhere from 10 million to 200 million litres of water. From 2007-2009, Nova Scotia Environment permitted the withdrawal of up to 1,334,000 litres of fresh water per day from the Kennetcook River for fracking. While the permitted amount was not fully used, the fact that such a high volume was approved is unacceptable.

Half of Nova Scotians rely on groundwater and half on surface water sources for drinking water. In 2012, Nova Scotia communities experienced the worst drought in more than a decade. Water is central to the very existence of people, plants and animals, and all of it must be protected for the common good from generation to generation.

Fracking wastewater

Fracking wastewater is a key threat to drinking water, the environment and public health. Current methods of disposing of fracking wastewater include sending the wastewater to treatment plants before discharging them into waterways or injecting the wastewater back into the ground.

A typical fracked well requires the use of between 55,000 and 220,000 litres of chemicals, but the specific combination and quantities of chemicals used are considered proprietary trade secrets. While some companies are voluntarily reporting some of the chemicals they use, they are not legally required to disclose the full list. The lack of information about fracking chemicals makes it extremely difficult to know what chemicals are in fracking wastewater and what potential health risks they pose.

The National Wildlife Federation points out that there are 13 different types of chemical additives that are needed in the hydraulic fracturing process including acids, clay stabilizers, gelling agents, corrosion inhibitors, biocides, friction reducers, and surfactants. The Endocrine Disruption Exchange has warned that these chemicals have a range of negative health and environmental impacts.

Under the Chemicals Management Plan (CMP), Environment Canada reviewed 265 chemicals used in the fracking process in both Quebec and the U.S. Approximately half of the fracking chemicals did not meet the CMP criteria for further investigation, meaning these chemicals have not been assessed for potential risks to the public. The list of chemicals was obtained through an Access to Information request (http://canadians.org/sites/default/files/ATI-fracking-chemicals-1013.pdf).

Chemicals used in the fracking process pose a threat to our water sources, ecosystems and public health because there are currently no safe methods to dispose of fracking wastewater. Governments continue to approve fracking despite the lack of information on the type and amount of chemicals or an assessment of the impacts of water sources and public health.

Treatment plants

Municipal wastewater plants are not equipped to deal with fracking wastewater. When the wastewater flowback is discharged into waterways, it is a threat to drinking water supplies given that many of the chemicals are undisclosed. While immediate effects may not always be detected, Professor of Engineering Tony Ingraffea from Cornell University notes that the effects of fracking are cumulative. So although communities may not see immediate impacts on their drinking water, communities will see the effects of fracking in 10 or more years.

Seismic activity

The B.C. Oil and Gas Commission (BCOGC) has linked the injection of fracking wastewater into the ground with earthquakes in northeastern B.C. (https://www.bcogc.ca/node/8046/download). The BCOGC's report *Investigation of Observed Seismicity in the Horn River Basin* provides an overview of 38 seismic events recorded by Natural Resources Canada (NRCan) ranging from 2.2 to 3.8 M on the Richter scale from April 2009 to July 2011. There were no seismic events recorded from 1985 to April 2009. The report found that, "The seismicity observed and reported by NRCan in the Horn River Basin between April 2009 and December 2011 was induced by fault movement resulting from injection of fluids during hydraulic fracturing."

The U.S. Geological Survey also warned that in "some locations the increase in seismicity coincides with the injection of wastewater in deep disposal wells. Much of this wastewater is a byproduct of oil and gas production and is routinely disposed of by injection into wells specifically designed for this purpose" (http://www.usgs.gov/blogs/features/usgs_top_story/man-made-earthquakes/). Other places where the injection of wastewater has triggered seismic activity include Youngstown (Ohio), Oklahoma, and Blackpool in the UK.

Kennetcook and Noel test samples

Currently in Nova Scotia, some wastewater (approximately 20 million litres) from the province's sole fracking operation sits in tailings ponds in Kennetcook while more "treated" wastewater is held at the Atlantic Industrial Services (AIS) Debert facility.

In March 2013, Colchester County's Director of Public Works approved AIS's plan to release 4.5 million litres of fracking wastewater into the Chiganois River, potentially impacting communities along the Cobequid Bay and the Bay of Fundy. There was strong public backlash to the proposal with over 40 groups and individuals submitting appeals and over 100 people attending the hearings. Despite AIS claiming to have tested the fracking wastewater, the wastewater was not tested for many chemicals common in the fracking process.

Kennetcook and Noel are rural neighbouring communities in East Hants, Nova Scotia, that have been playing host to fracking wastewater, which has been held in tailings ponds there for the past six years. Some of that fracking wastewater has also been transported to the AIS facility in Debert. Triangle Petroleum's fracking activity in Nova Scotia started in 2007 with exploratory wells in Kennetcook and Noel, but because there is no proven safe method of disposing the waste, and because there was insufficient consideration of the short-term and long-term impacts of fracking wastewater, they remain in tailings ponds to this day.

The Kennetcook ponds garnered media attention when members of East Hants Fracking Opposition Group, who had been monitoring the ponds, spotted a leak in January, which allowed authorities to try to deal with the contamination (http://www.cbc.ca/news/canada/nova-scotia/fracking-waste-water-leak-in-kennetcook-investigated-1.2500500).

We applaud the Nova Scotia government for holding public meetings about the wastewater and for testing it. We also applaud the government's decision to ban the importation of fracking wastewater and for pursuing this review.

However, we are concerned about the pools of fracking wastewater that remain in Nova Scotia. On March 5, 2014, Environment Minister Randy Delorey told community residents that some of the wastewater in Kennetcook leaked into a nearby brook this winter due to overflow. "Treated" wastewater has also been discharged through municipal wastewater systems in Colchester and the Town of Windsor.

While the Nova Scotia government/AIS has conducted tests on this wastewater and released a summary sampling results, testing still is not adequate. While they did test for some chemicals common in the fracking process such as methanol, the BTEX group and phenol, testing was not done for other chemicals common to the fracking process (such as naphthalene, formaldehyde, cumene, and diethanolamine) and listed in the report *Chemicals Used in Hydraulic Fracturing* by the United States House of Representatives Committee on Energy and Commerce (http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic-Fracturing-Chemicals-2011-4-18.pdf).

The handling of wastewater in Nova Scotia highlights a key reason why fracking should be banned in the province: there are currently no methods to safely dispose of fracking wastewater.

Climate impacts

Despite industry representatives and some governments promoting natural gas as a "clean, green fuel," studies show that fracked natural gas can produce as much greenhouse gas emissions as coal. The lifecycle greenhouse gas emissions – that is the combined emissions associated with extraction, combustion, and methane and CO_2 releases – means that fracked gas can be as polluting as coal.

Fracking releases large amounts of natural gas, which consists of both CO_2 and methane, directly into the atmosphere. Fracking wells leak 40 to 60 per cent more methane than conventional natural gas wells. This happens when water is forced down into a fracking well in order to fracture the rock formations. Methane flows up the well and is released into the

atmosphere before it can be captured. The leaked methane is called "fugitive methane" and has been detected using infrared video. It is identified as different from naturally occurring methane. Methane, in particular, is a very powerful greenhouse gas because it can trap 20 to 25 times more heat in the atmosphere than carbon dioxide.

Fracking and other parts of the fossil fuel industry are preventing Canada from reducing its greenhouse gas emissions and doing its fair share to mitigate the global climate crisis.

Fracking would threaten the gains made on the implementation of the *Environmental Goals and Sustainable Prosperity Act* (2007) and put Nova Scotia's goal of being "one of the most environmentally and economically sustainable places in the world by 2020" in jeopardy.

Economic considerations

Many pro-fracking arguments surround the job creation and income potential for the jurisdiction, but the reality is that beyond temporary construction and trucking jobs, few permanent, full-time jobs are created. Those few jobs created typically have poor working conditions and pose risks to workers' health. In a briefing titled *Health Implications of Fracking for Natural Gas in the Great Lakes-St. Lawrence River Basin*, Dr. Theo Colborne noted that some workers were required to sign contracts preventing them from ever revealing their hourly wage or health problems.

Job estimates often do not make clear where the workers will come from and how the local community will actually benefit. Industry fails to consider the negative impacts that fracking would have on existing employment in other industries, such as tourism and agriculture. For example, in Newfoundland the tourism industry raised concerns about the impacts fracking would have on its $1 billion industry. Gros Morne National Park in Newfoundland received international attention when UNESCO raised concerns about how fracking would affect the park, potentially jeopardizing its World Heritage Site status and the local tourism industry.

The Canadian Centre for Policy Alternatives' (CCPA) report *Enbridge Pipedreams and Nightmares* notes that Enbridge boasts that a fossil fuel project like the $5-billion Northern Gateway Pipeline would create 63,000 person-years of employment during its construction phase, and 1,146 full-time jobs once completed. However, CCPA finds these estimates are overblown and that it would only create approximately 1,850 construction jobs per year for three years, and a handful of permanent new jobs once completed. The report points out that between 3 and 34 times the number of direct jobs would be created if the $5 billion were invested in green jobs and industries.

U.S. organization Food & Water Watch (FWW) has also produced reports showing that the estimate of new jobs is overblown and misleading. In their report *Exposing the Oil and Gas Industry's False Jobs Promise for Shale Gas Development: How Methodological Flaws Grossly Exaggerate Jobs Projections*, FWW points out that the Public Policy Institute of New York State (PPINYS) boasted that developing 500 new shale gas wells every year in the five counties of Allegany, Broome, Chemung, Steuben and Tioga would create 62,620 new jobs in New York by 2018. But when FWW analyzed employment data from the Bureau of Labor Statistics in counties with shale gas development in Pennsylvania and compared them to bordering counties in New York without shale gas development, the organization found these claims to be baseless. In fact, FWW found that opening up the five counties in New York to fracking would create no more than two jobs per well in the state compared to PPINYS' claims of 125 jobs per well. Some of the jobs would be in construction, retail or the food industry rather than solely in the drilling industry.

Governments and industry representatives promote fracking as a way to boost job creation. However, these are neither ethical nor sustainable jobs.

Instead of focusing on possible new fracking jobs, our governments could commit to reducing emissions and encourage a whole different set of jobs including weatherproofing, renewable power projects, public transit, sustainable agriculture and much more.

Fracking must be banned

Water is a living commons, to be shared, protected, carefully managed and enjoyed by all. Communities not only have a human right to water, but also a responsibility to protect those waters. The United Nations has recognized water and sanitation as a human right, which means that every government must now come up with a plan of action based on the "obligation to protect, respect, and fulfill" this right. Maude Barlow, National Chairperson of the Council of Canadians, points out that the obligation to protect means that a government is obliged to prevent third parties from interfering with the enjoyment of this human right. This would mean, for instance, protecting local communities from pollution and inequitable extraction of water by corporations or governments.

Policies and decision making on water use should be based on recognizing water as a commons, public trust and human right. Communities all over Nova Scotia and the Atlantic have opposed fracking, and must be part of the decision-making process. I applaud this first step and urge panel members to include the public's comments in the final decision. Please do the right thing and ban fracking in our province.

THE COUNCIL OF CANADIANS LE CONSEIL DES CANADIENS

ACTING FOR SOCIAL JUSTICE / AGIR POUR LA JUSTICE SOCIALE

Sincerely,

Angela Giles
Atlantic regional organizer

Emma Lui
National water campaigner

Please find below supplementary research documents and reports, including peer-reviewed documentation for your review.

GOVERNMENT DOCUMENTS:

BC Oil and Gas Commission *Investigation of Observed Seismicity in the Horn River Basin*
https://www.bcogc.ca/node/8046/download

Environment Canada's list of 265 chemicals reviewed in Quebec and US fracking projects
http://canadians.org/sites/default/files/ATI-fracking-chemicals-1013.pdf

United States House of Representatives Committee on Energy and Commerce
Chemicals Used in Hydraulic Fracturing
http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic-Fracturing-Chemicals-2011-4-18.pdf

USGS *Man-Made Earthquakes Update*
http://www.usgs.gov/blogs/features/usgs_top_story/man-made-earthquakes/

PEER REVIEWED:

1. Abayev, Inessa. *Hydraulic Fracturing Wastewater: Making the Case for Treating the Environmentally Condemned*, Spring, 2013 Fordham Environmental Law Review 24 Fordham Envtl. Law Rev. 275

EXCERPT:
The ever-expanding search for domestic energy supplies in the form of natural gas has fueled a stream of concerns about our greatest natural resource: water. That search has led to the proliferation of "hydraulic fracturing," or "hydrofracking" for short, a rapidly growing method of natural gas extraction in many parts of the country that has garnered a tremendous amount of attention over the past few years. Hydraulic fracturing is a drilling process in which a large-volume mixture of water, sand, and chemical additives are injected (or are pumped) deep underground[1] at high pressure,[2] the ultimate goal of which is to reach trapped pockets of natural gas in porous shale rock formations deep below the ground, and create fractures within the rock to open passages that will allow for gas to flow freely up through the well.[3] While hydrofracking is generally considered to be an economically profitable industry[4] that could lessen our dependence on foreign energy,[5] it has nonetheless been a hot button topic over the past few years as it involves potentially high health-related costs and other well-warranted concerns.

The federal government sets the floor for water standards and allows individual states to exercise primary domain of disposal regulations if they adopt the federal minimums or choose to raise the floor in their respective home states. With many states participating in this primacy program, wastewater disposal is most closely regulated on the state level. 6

2. Bernhard S. Debatin. The Dislocation of Side Effects: Fracking Wastewater Disposal in Appalachian Ohio. Appalachian Studies Association Annual Conference March 29, 2014

ABSTRACT:
The disposal of fracking wastewater—a toxic mix of water, chemicals, sand, and radioactive substances—has increasingly become an issue of environmental concern. Fracking waste fluids represent a serious risk to aquifers and drinking water resources. Injection wells significantly increase the occurrence of earthquakes, which make the already feared migration of injected waste fluids into aquifers even more likely as the geological structure becomes destabilized. Athens County in the Appalachian part of Ohio has currently four active injection wells and two more in the permit process. While the affected communities have little to no benefit from wastewater injection, actual and potential side-effects include community disruption, increased wear and tear of infrastructure, contamination risks, and growing uncertainty among the populace. For instance, in summer 2012, an injection well in Athens County leaked waste fluids from a cracked holding tank. Consequently, the owner of a nearby organic farm sold his operation out of fear he would lose his organic certification because of water contamination. In my paper, I will explore the impact of wastewater injection wells on individuals and communities in Athens County and how the press reports on it. The case of wastewater disposal shows, so my hypothesis, how side effects of the

fracking industry are externalized and dislocated, while there is little public discourse on the actual costs and consequences of this practice.

3. Ellsworth, William L., *Injection-Induced Earthquakes*, Science 12 July 2013: Vol. 341 no. 6142

ABSTRACT:
Earthquakes in unusual locations have become an important topic of discussion in both North America and Europe, owing to the concern that industrial activity could cause damaging earthquakes. It has long been understood that earthquakes can be induced by impoundment of reservoirs, surface and underground mining, withdrawal of fluids and gas from the subsurface, and injection of fluids into underground formations. Injection-induced earthquakes have, in particular, become a focus of discussion as the application of hydraulic fracturing to tight shale formations is enabling the production of oil and gas from previously unproductive formations. Earthquakes can be induced as part of the process to stimulate the production from tight shale formations, or by disposal of wastewater associated with stimulation and production. Here, I review recent seismic activity that may be associated with industrial activity, with a focus on the disposal of wastewater by injection in deep wells; assess the scientific understanding of induced earthquakes; and discuss the key scientific challenges to be met for assessing this hazard.

4. Lara O. Haluszczak, Arthur W. Rose, Lee R. Kump, *Geochemical evaluation of flowback brine from Marcellus gas wells in Pennsylvania, USA*, Applied Geochemistry, 26 Oct 2012.

ABSTRACT:
Large quantities of highly saline brine flow from gas wells in the Marcellus Formation after hydraulic stimulation ("fracking"). This study assesses the composition of these flowback waters from the Marcellus shale in Pennsylvania, USA. Concentrations of most inorganic components of flowback water (Cl, Br, Na, K, Ca, Mg, Sr, Ba, Ra, Fe, Mn, total dissolved solids, and others) increase with time from a well after hydraulic stimulation. Based on results in several datasets reported here, the greatest concentration of Cl^- in flowback water is 151,000 mg/L. For total Ra (combined 226Ra and 228Ra) in flowback, the highest level reported is 6540 pCi/L. Flowback waters from hydraulic fracturing of Marcellus wells resemble brines produced from conventional gas wells that tap into other Paleozoic formations in the region. The Br/Cl ratio and other parameters indicate that both types of brine formed by the evaporation of seawater followed by dolomitization, sulfate reduction and subsurface mixing with seawater and/or freshwater. Trends and relationships in brine composition indicate that (1) increased salt concentration in flowback is not mainly caused by dissolution of salt or other minerals in rock units, (2) the flowback waters represent a mixture of injection waters with highly concentrated in situ brines similar to those in the other formations, and (3) these waters contain concentrations of Ra and Ba that are commonly hundreds of times the US drinking water standards.

5. Nicola Jones Wastewater injection cracks open quake concerns Nature Geoscience 6, 329 29 April 2013

ABSTRACT:
Oklahoma's largest recorded earthquake — magnitude 5.7 — might have been caused by the injection of wastewater from oil drilling in the region. That makes it the largest quake yet linked to the practice of wastewater injection.

Katie Keranan from the University of Oklahoma and colleagues looked at a sequence of quakes.

6. Keranen KM, Savage HM, Abers GA, Cochran ES, *Potentially induced earthquakes in Oklahoma, USA: Links between wastewater injection and the 2011 Mw 5.7 earthquake sequence,* Geology, 26 Mar 2013.

ABSTRACT:
Significant earthquakes are increasingly occurring within the continental interior of the United States, including five of moment magnitude (Mw) 5.0 in 2011 alone. Concurrently, the volume of fluid injected into the subsurface related to the production of unconventional resources continues to rise. Here we identify the largest earthquake potentially related to injection, an Mw 5.7 earthquake in November 2011 in Oklahoma. The earthquake was felt in at least 17 states and caused damage in the epicentral region. It occurred in a sequence, with 2 earthquakes of Mw 5.0 and a prolific sequence of aftershocks. We use the aftershocks to illuminate the faults that ruptured in the sequence and show that the tip of the initial rupture plane is within ~200 m of active injection wells and within ~1 km of the surface; 30% of early aftershocks occur within the sedimentary section. Subsurface data indicate that fluid was injected into effectively sealed compartments, and we interpret that a net fluid volume increase after 18 yr of injection lowered effective stress on reservoir-bounding faults. Significantly, this case indicates that decades-long lags between the commencement of fluid injection and the onset of induced earthquakes are possible, and modifies our common criteria for fluid-induced events. The progressive rupture of three fault planes in this sequence suggests that stress changes from the initial rupture triggered the successive earthquakes, including one larger than the first.

7. Andrew J. Kondash, Nathaniel R. Warner, Ori Lahav, and Avner Vengosh. *Radium and Barium Removal through Blending Hydraulic Fracturing Fluids with Acid Mine Drainage* Environ. Sci. Technol., 2014, 48 (2), pp 1334–1342

ABSTRACT:
Wastewaters generated during hydraulic fracturing of the Marcellus Shale typically contain high concentrations of salts, naturally occurring radioactive material (NORM), and metals, such as barium, that pose environmental and public health risks upon inadequate treatment and disposal. In addition, fresh water scarcity in dry regions or during periods of drought could limit shale gas development. This paper explores the possibility of using alternative water sources and their impact on NORM levels through blending acid mine drainage (AMD) effluent with recycled hydraulic fracturing flowback fluids (HFFFs). We conducted a

series of laboratory experiments in which the chemistry and NORM of different mix proportions of AMD and HFFF were examined after reacting for 48 h. The experimental data combined with geochemical modeling and X-ray diffraction analysis suggest that several ions, including sulfate, iron, barium, strontium, and a large portion of radium (60–100%), precipitated into newly formed solids composed mainly of Sr barite within the first 10 h of mixing. The results imply that blending AMD and HFFF could be an effective management practice for both remediation of the high NORM in the Marcellus HFFF wastewater and beneficial utilization of AMD that is currently contaminating waterways in northeastern U.S.A.

8. Brian D. Lutz, Aurana N. Lewis and Martin W. Doyle, *Generation, transport, and disposal of wastewater associated with Marcellus Shale gas development*, Water Resources Research, Apr 2013.

ABSTRACT:
Hydraulic fracturing has made vast quantities of natural gas from shale available, reshaping the energy landscape of the United States. Extracting shale gas, however, generates large, unavoidable volumes of wastewater, which to date lacks accurate quantification. For the Marcellus shale, by far the largest shale gas resource in the United States, we quantify gas and wastewater production using data from 2189 wells located throughout Pennsylvania. Contrary to current perceptions, Marcellus wells produce significantly less wastewater per unit gas recovered (approximately 35%) compared to conventional natural gas wells. Further, well operators classified only 32.3% of wastewater from Marcellus wells as flowback from hydraulic fracturing; most wastewater was classified as brine, generated over multiple years. Despite producing less wastewater per unit gas, developing the Marcellus shale has increased the total wastewater generated in the region by approximately 570% since 2004, overwhelming current wastewater disposal infrastructure capacity.

9. National Research Council, *Induced Seismicity Potential in Energy Technologies,* National Research Council, 15 Jun 2012.

ABSTRACT:
In the past several years, some energy technologies that inject or extract fluid from the Earth, such as oil and gas development and geothermal energy development, have been found or suspected to cause seismic events, drawing heightened public attention. Although only a very small fraction of injection and extraction activities among the hundreds of thousands of energy development sites in the United States have induced seismicity at levels noticeable to the public, understanding the potential for inducing felt seismic events and for limiting their occurrence and impacts is desirable for state and federal agencies, industry, and the public at large. To better understand, limit, and respond to induced seismic events, work is needed to build robust prediction models, to assess potential hazards, and to help relevant agencies coordinate to address them.

10. Natural Resources Defense Council, *In Fracking's Wake: New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater*
http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf

EXECUTIVE SUMMARY:
This paper analyzes the problem of wastewater generated from the hydraulic fracturing process of producing natural gas, particularly with regard to production in the Marcellus Shale.
It shows that, while hydraulic fracturing (often called “hydrofracking” or “fracking”) generates massive amounts of polluted wastewater that threaten the health of our drinking water supplies, rivers, streams, and groundwater, federal and state regulations have not kept up with the dramatic growth in the practice and must be significantly strengthened to reduce the risks of fracking throughout the Marcellus region and elsewhere.
Hydrofracking and the production of natural gas from fracked wells yield by-products that must be managed carefully to avoid significant harms to human health and the environment. These wastewater by-products are known as “flowback” (fracturing fluid injected into a gas well that returns to the surface when drilling pressure is released) and “produced water” (all wastewater emerging from the well after production begins, much of which is salty water contained within the shale formation).
Both types of wastewater contain potentially harmful pollutants, including salts, organic hydrocarbons (sometimes referred to simply as oil and grease), inorganic and organic additives, and naturally occurring radioactive material (NORM). Thesepollutants can be dangerous if they are released into the environment or if people are exposed to them. They can be toxic to humans and aquatic life, radioactive, or corrosive. They can damage ecosystem health by depleting oxygen or causing algal blooms, or they can interact with disinfectants at drinking water plants to form cancer-causing chemicals.

11. Andrew W. Nelson, Dustin May, Andrew W. Knight, Eric S. Eitrheim, Marinea Mehrho, Robert Shannon, Robert Litman, Michael K. Schultz, *Matrix Complications in the Determination of Radium Levels in Hydraulic Fracturing Flowback Water from Marcellus Shale,* Environmental Technology & Letters Mar 2014

ABSTRACT:

The rapid proliferation of horizontal drilling and hydraulic fracturing for natural gas mining has raised concerns about the potential for adverse environmental impacts. One specific concern is the radioactivity content of associated "flowback" wastewater (FBW), which is enhanced with respect to naturally occurring radium (Ra) isotopes. Thus, development and validation of effective methods for analysis of Ra in FBW are critical to appropriate regulatory and safety decision making. Recent government documents have suggested the use of EPA method 903.0 for isotopic Ra determinations. This method has been used effectively to determine Ra levels in drinking water for decades. However, analysis of FBW by this method is questionable because of the remarkably high ionic strength and dissolved solid content observed, particularly in FBW from the Marcellus Shale region. These observations led us to investigate the utility of several common Ra analysis methods using a representative Marcellus Shale FBW sample. Methods examined included wet chemical approaches, such as EPA method 903.0, manganese dioxide (MnO2) preconcentration, and 3M Empore RAD radium disks, and direct measurement techniques such as radon (Rn) emanation and high-purity germanium (HPGe) gamma spectroscopy. Nondestructive HPGe

and emanation techniques were effective in determining Ra levels, while wet chemical techniques recovered as little as 1% of 226Ra in the FBW sample studied. Our results question the reliability of wet chemical techniques for the determination of Ra content in Marcellus Shale FBW (because of the remarkably high ionic strength) and suggest that nondestructive approaches are most appropriate for these analyses. For FBW samples with a very high Ra content, large dilutions may allow the use of wet chemical techniques, but detection limit objectives must be considered.

12. Diana M. Papoulias and Anthony L. Velasco, *Histopathological Analysis of Fish from Acorn Fork Creek, Kentucky, Exposed to Hydraulic Fracturing Fluid Releases,* Southeastern Naturalist, 28 Aug 2013.

ABSTRACT:

Fracking fluids were released into Acorn Fork, KY, a designated Outstanding State Resource Water, and habitat for the threatened Chrosomus cumberlandensis (Blackside Dace). As a result, stream pH dropped to 5.6 and stream conductivity increased to 35,000 µS/cm, and aquatic invertebrates and fish were killed or distressed. The objective of this study was to describe post-fracking water quality in Acorn Fork and evaluate if the changes in water quality could have extirpated Blackside Dace populations. Semotilus atromaculatus (Creek Chub) and Lepomis cyanellus (Green Sunfish) were collected from Acorn Fork a month after fracking in lieu of unavailable Blackside Dace. Tissues were histologically analyzed for indicators of stress and percent of fish with lesions. Fish exposed to affected Acorn Fork waters showed general signs of stress and had a higher incidence of gill lesions than unexposed reference fish. Gill lesions observed were consistent with exposure to low pH and toxic concentrations of heavy metals. Gill uptake of aluminum and iron was demonstrated at sites with correspondingly high concentrations of these metals. The abrupt and persistent changes in post-fracking water quality resulted in toxic conditions that could have been deleterious to Blackside Dace health and survival.

13. Brian G. Rahma, Josephine T. Batesa, Lara R. Bertoiaa, Amy E. Galforda, David A. Yoxtheimerb and Susan J. Rihaa, *Wastewater management and Marcellus Shale gas development: Trends, drivers, and planning implications*, Journal of Environmental Management Volume 120, 15 May 2013, Pages 105–113

ABSTRACT: Extraction of natural gas from tight shale formations has been made possible by recent technological advances, including hydraulic fracturing with horizontal drilling. Global shale gas development is seen as a potential energy and geopolitical “game-changer.” However, widespread concern exists with respect to possible environmental consequences of this development, particularly impacts on water resources. In the United States, where the most shale gas extraction has occurred, the Marcellus Shale is now the largest natural gas producing play. To date, over 6,000,000 m^3 of wastewater has been generated in the process of extracting natural gas from this shale in the state of Pennsylvania (PA) alone. Here we examine wastewater management practices and trends for this shale play through analysis of industry-reported, publicly available data collected from the Pennsylvania Department of Environmental Protection Oil and Gas Reporting

Website. We also analyze the tracking and transport of shale gas liquid waste streams originating in PA using a combination of web-based and GIS approaches. From 2008 to 2011 wastewater reuse increased, POTW use decreased, and data tracking became more complete, while the average distance traveled by wastewater decreased by over 30%. Likely factors influencing these trends include state regulations and policies, along with low natural gas prices. Regional differences in wastewater management are influenced by industrial treatment capacity, as well as proximity to injection disposal capacity. Using lessons from the Marcellus Shale, we suggest that nations, states, and regulatory agencies facing new unconventional shale development recognize that pace and scale of well drilling leads to commensurate wastewater management challenges. We also suggest they implement wastewater reporting and tracking systems, articulate a policy for adapting management to evolving data and development patterns, assess local and regional wastewater treatment infrastructure in terms of capacity and capability, promote well-regulated on-site treatment technologies, and review and update wastewater management regulations and policies.

14. Charles W. Schmidt, Estimating Wastewater Impacts from Fracking, Environ Health Perspect. Apr 2013; 121(4): a117.

EXCERPT:
Wastewater produced by hydraulic fracturing (“fracking”) for natural gas in the Marcellus Shale is already overwhelming disposal options and will continue to do so as gas development increases, according to newly published research.[1] The investigation did not evaluate environmental consequences of the wastewater. But lead author Brian Lutz, an assistant professor in the Kent State University Department of Biology, says fracking wastewater could have a range of environmental and health impacts if not managed correctly. The analysis was limited to Pennsylvania, which along with West Virginia dominates Marcellus shale gas production today.[2]

15. Colin Schultz Marcellus Shale fracking waste caused earthquakes in Ohio, Eos, Transactions American Geophysical Union Volume 94, Issue 33, page 296, 13 August 2013

ABSTRACT:
Before January 2011, Youngstown, Ohio, had never had an earthquake since observations began in 1776. In December 2010 the Northstar 1 injection well came online; this well was built to pump wastewater produced by hydraulic fracturing projects in Pennsylvania into storage deep underground. In the year that followed, seismometers in and around Youngstown recorded 109 earthquakes—the strongest of the set being a magnitude 3.9 earthquake on 31 December 2011.

16. van der Elst NJ, HM Savage KM Keranen, GA Abers, *Enhanced Remote Earthquake Triggering at Fluid-Injection Sites in the Midwestern United States*, Science, 12 July 2013

ABSTRACT:

A recent dramatic increase in seismicity in the midwestern United States may be related to increases in deep wastewater injection. Here, we demonstrate that areas with suspected anthropogenic earthquakes are also more susceptible to earthquake-triggering from natural transient stresses generated by the seismic waves of large remote earthquakes. Enhanced triggering susceptibility suggests the presence of critically loaded faults and potentially high fluid pressures. Sensitivity to remote triggering is most clearly seen in sites with a long delay between the start of injection and the onset of seismicity and in regions that went on to host moderate magnitude earthquakes within 6 to 20 months. Triggering in induced seismic zones could therefore be an indicator that fluid injection has brought the fault system to a critical state.

17. Warner NR, CA, Christie, RB Jackson, A Vengosh, *Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania*, Environmental Science & Technology, 02 Oct 2013.

ABSTRACT:
The safe disposal of liquid wastes associated with oil and gas production in the United States is a major challenge given their large volumes and typically high levels of contaminants. In Pennsylvania, oil and gas wastewater is sometimes treated at brine treatment facilities and discharged to local streams. This study examined the water quality and isotopic compositions of discharged effluents, surface waters, and stream sediments associated with a treatment facility site in western Pennsylvania. The elevated levels of chloride and bromide, combined with the strontium, radium, oxygen, and hydrogen isotopic compositions of the effluents reflect the composition of Marcellus Shale produced waters. The discharge of the effluent from the treatment facility increased downstream concentrations of chloride and bromide above background levels. Barium and radium were substantially (>90%) reduced in the treated effluents compared to concentrations in Marcellus Shale produced waters. Nonetheless, 226Ra levels in stream sediments (544–8759 Bq/kg) at the point of discharge were 200 times greater than upstream and background sediments (22–44 Bq/kg) and above radioactive waste disposal threshold regulations, posing potential environmental risks of radium bioaccumulation in localized areas of shale gas wastewater disposal.