

The Regulation of Shale Gas Development: State of Play

Lisa Sumi, MSc

June 28, 2013

Prepared for Council of Canadians

Re: Ontario Energy Board Proceedings:

EB-2012-0451: Enbridge Gas Distribution Inc.; and

EB-2012-0333 and EB-2013-0074: Union Gas Limited

Introduction	2
Section 1. Environmental Issues Facing the Shale Gas Industry	3
Water use in the Marcellus shale	4
Water contamination related to Marcellus and Utica shale development	5
Air pollution related to Marcellus shale development	6
Potential health impacts related to Marcellus shale	7
Waste management in the Marcellus and Utica shales	8
Wastewater.....	9
Solid wastes	10
Section 2. Regulatory Initiatives	11
Federal hydraulic fracturing initiatives and regulations	12
EPA hydraulic fracturing study	12
Proposed Frac Act.....	12
Potential changes to the Toxic Substances Control Act	13
Federal air regulations	13
2012 EPA regulations on air emissions from natural gas operations	13
Potential tightening of ground-level ozone standard	14
Potential to control greenhouse gases from oil and gas operations	15
Federal water regulations	16
Limits on chloride	16
Wastewater discharge standards	16
Federal (and state) hazardous waste regulations	16
Pennsylvania-specific regulations and initiatives	17
New air permit system	17
Municipal authority.....	18
Chloride water quality criterion	18
Severance tax	19
Ohio-specific regulations	19
Radiation.....	20
Injection wells and seismicity.....	20

Severance tax	21
West-Virginia-specific regulations	21
Moratoria and bans related to shale development.....	21
Local government initiatives.....	22
Statewide bans and moratoria related to shale gas.....	22
Conclusions.....	23
Endnotes.....	24

Introduction

I have prepared this report at the request of the Council of Canadians. I am an environmental consultant with specialization in extractive industries and energy research. A copy of my Curriculum Vitae is attached as Schedule “A” to this report.

The purpose of this report is to provide an overview of the potential environmental and regulatory issues that may affect gas production from shale basins in the United States, and in particular, supply from those basins presented as significant future sources of natural gas for the residents of the Ontario and the Greater Toronto Area (the “GTA”).

Environmental impacts and regulatory safeguards are viewed as major challenges with respect to shale gas development. For example, in a 2011 KPMG poll, oil and gas industry executives perceived environmental and sustainability concerns as the biggest challenge facing shale gas development (41 percent), with regulatory concerns voted as the second (27 percent).¹

The present applications before the Ontario Energy Board (the “Board”) promise to realize certain benefits such as access to relatively abundant shale gas reserves from the United States, in particular from the Marcellus and Utica shales.

I have not reviewed the complete record of these proceedings, but have reviewed the evidence and interrogatory responses of Union Gas and Enbridge regarding the potential for regulatory or legislative initiatives related to shale gas development in the United States, and how these may influence the supply of natural gas to Ontario and the Greater Toronto Area.

While both applicants have acknowledged the relevance of this issue, neither has carried out an analysis to address it. For example, Union Gas stated that, “The new Contracts will obtain supply from the Dawn Hub. Changes in legislation or regulation might limit the available supply from shale basins. This risk is mitigated by the fact that the Dawn Hub is connected to many diverse supply basins.”² The company does not however, elaborate on the nature of prospective regulations or on the extent of their affect on shale gas supplies.

In a similar vein, Enbridge’s application cites U.S. Energy Information Administration (EIA) projections for future shale gas production and supply without providing an analysis of the assumptions made by EIA, such as the failure of EIA to analyse potential regulatory initiatives in its projections of shale gas supply.³

Similarly, in the Union Gas and Enbridge responses to the Council of Canadians' interrogatories, neither company provides further insight into the costs of mitigating or remediating the environmental and public health impacts of shale gas production or of compliance with federal, state and local regulations.⁴

For example, in its response to the Council of Canadian's Interrogatory, Union Gas responded that:

While it is not possible to anticipate specific legislative or regulatory measures that may affect Shale Basin gas supply in the United States and/or Canada, we note that there have been a variety of proposals regarding the environmental impacts of shale development and the appropriate response to protect the environment. . . Additional regulation has the potential to add some additional costs to the development of shale gas wherever it is located. This would include shale from the Marcellus and Utica formations in proximity to Ontario, but also the shale formations in western Canada.⁵

The following report is divided into two sections. The first describes the major environmental challenges facing the shale gas industry today – the seriousness of these impacts underscores the need for determined action by governments to address them. The second describes the extent to which governments have responded to these challenges, and the potential impact of emergent regulatory and economic measures on the pace and extent of shale gas development in the Marcellus and Utica basins.

The focus here is primarily on Marcellus and Utica shales, as these formations are the major sources of potential natural gas supply identified by the applicants. Much of the environmental analysis refers to the Marcellus shale, which is farther along in its development than the Utica shale.⁶ Given that Marcellus and Utica shale gas reserves are located primarily in Pennsylvania, West Virginia, Ohio and New York, most of the regulatory issues discussed below pertain to development in those states.

The key conclusions of this paper are:

1. Information about the environmental and public health impacts of shale gas development continues to grow, revealing a diverse array of very serious affects, including:
 - regional water shortages, which may impact the ability of Marcellus operators to obtain the large volume of water needed to drill and fracture wells;
 - contamination of drinking water from shale development,
 - air pollution, which has affected local and regional air quality and threatens public health;
 - the large volume of wastewater generated from shale gas wells, which is already overwhelming existing disposal options;

- earthquakes, which have been linked to shale gas wastewater disposal via underground injection; and
 - toxic and radioactive chemicals in wastes, which are posing disposal challenges and concerns.
2. State regulatory agencies in Pennsylvania, West Virginia and Ohio were ill-prepared for the pace of drilling, and the environmental impacts that accompanied the shale gas boom. Not only were regulations inadequate to protect the environment and public health from shale gas development, but state agencies tasked with overseeing drilling, production and waste disposal were and in many cases remain underfunded and understaffed. Consequently, these states are still in “catch-up” mode, and tightening of regulations can be expected.
 3. Both state and federal government continue to develop and strengthen regulations to address some of the impacts, but the large gap between known impacts and existing regulations means more safeguards are needed.
 4. Voluntary and regulatory mechanisms to mitigate environmental impacts can impose significant costs on shale gas development. With almost every new regulatory initiative proposed, the shale gas industry has expressed concerns related to the costs of compliance, and has argued that some proposed regulations will result in decreases in drilling. One potential federal regulation related to ozone is said to be the most costly regulation ever proposed for the industry.
 5. If governments respond with effective regulatory and economic measures to the environmental challenges facing the shale gas industry, the cost of shale development will certainly rise, and in some cases is likely to become uneconomic. In other cases, the risks associated with shale gas development may be considered too great to allow for any development of this energy resource, and moratoriums now in place in the Marcellus shale may become permanent and spread to other jurisdictions.

Section 1. Environmental Issues Facing the Shale Gas Industry

In 2010, during the Board’s Natural Gas Markets Review the Council of Canadians submitted a report entitled Environmental Concerns and Regulatory Initiatives Related to Hydraulic Fracturing in Shale Gas Formations: Potential Implications for North American Gas Supply.⁷ Since that time, a body of information regarding environmental impacts related to shale gas development has been generated, and policies and regulations have been established to address some of the impacts. However, substantial information and policy gaps remain.

In 2013, Resources for the Future (RFF), a non-profit organization funded by a mix of donors including shale gas companies,⁸ surveyed U.S. experts from government agencies, industry, academia, and environmental organizations for their insights into the potential environmental risks associated with shale gas development. Experts were asked to identify priority environmental risks for which government regulation and/or voluntary industry practices were currently inadequate to protect the public or the environment. There was consensus on 12

environmental risk pathways among all four groups of experts: seven involved potential risks to surface water quality (including water use), two involved potential risks to air quality, two involved potential risks to groundwater quality, and one related to habitat disruption.⁹

Freshwater withdrawal for hydraulic fracturing was one of the top priorities most often selected by experts in all four groups. Air emissions (primarily methane), the escape of methane due to poor casing and cementing, and wastewater treatment and disposal were also among the top priorities for further action. Although contamination from solid wastes was not a consensus issue, 44 percent of the experts identified it as a priority issue.¹⁰ These issues are discussed below.

The RFF report did not attempt to address what the authors called “final” impacts of shale development such as health, climate change or energy markets.¹¹ In the past couple of years scientific research has begun to emerge on the links between shale gas development and health, and so this issue is also addressed below.

Water use in the Marcellus shale

Shale gas development is contingent upon an ample supply of water. Hydraulic fracturing, which is required to stimulate gas production in shale formations, typically use millions of gallons of water per shale gas well.¹² The median estimate of water usage per well is around five million gallons for the Marcellus shale.¹³

According to ALL Consulting, in the Marcellus shale region, “Although many streams, rivers, and lakes may be theoretically viable as water sources based on available volume alone, a much smaller subset of water bodies may have practical potential for use by the natural gas industry, based on the distance to a given well. The costs of transporting water from the source to the well site can quickly and dramatically exceed the simple cost of obtaining the water.”¹⁴

As water supplies tighten due to drought conditions and competition for limited resources Marcellus operators are likely going to have to travel farther afield to obtain fresh water, thus increasing the cost of doing business.

Despite the perception of northeastern U.S. states as water rich, water resources in many of the Marcellus shale states are under water stress.¹⁵ For example, in 2013, the non-profit organization Ceres analysed industry data and found that nearly half (47 percent) of U.S. shale gas and oil wells developed between January 2011 and September 2012 took place in water basins with high or extremely high water stress.¹⁶ In Pennsylvania, often considered a relatively wet state, 72 percent of the wells drilled were located in areas of medium to high water stress.¹⁷ As the Marcellus shale gas industry continues to grow, it will place increasing pressures on regional water resources.

A 2011 article in the *Temple Law Review* found that, “Dry streams and reduced stream flow will likely be a recurring problem for Pennsylvania, given that currently the Commonwealth has only around 1,100 gas wells but may have up to 50,000 wells by the year 2030. . . [this] presents a host of wide-ranging environmental problems and has potential to disrupt Pennsylvania’s water system because of the huge volumes of water necessary to fracture a single well. Pennsylvania’s existing water law is not well-equipped to handle the increased use of water precipitated by the dramatic increase of natural gas extraction.”¹⁸

The potential for water restrictions and competition between Marcellus shale gas operators and other water users is gaining widespread recognition. A December 2012 report by the consulting firm Accenture found that “access to water sources is likely to become more of a constraint for operators in arid regions facing growing depletion of water resources, and in areas where water flows and availability follow seasonal variations. In Pennsylvania, for instance, access to permits for water can be more of a challenge in the summer when minimum flow rates need to be maintained.”¹⁹

Such water constraints have already been playing out for Marcellus operators. In August 2011, 13 water withdrawal permits (11 related to natural gas projects) in Pennsylvania’s Susquehanna River Basin were temporarily suspended due to low stream levels.²⁰ In July 2012, amidst record heat and drought conditions, the Susquehanna River Basin suspended 64 water withdrawal permits, the majority of which belonged to Marcellus shale operators.²¹

Operators in the Marcellus shale and elsewhere are attempting to reduce use of fresh water by recycling hydraulic fracturing wastewater, but much of the water injected during hydraulic fracturing cannot be recycled because it remains trapped in the formation.²² Marcellus operators that are recycling wastewater still rely on large quantities of fresh water, which they mix with recycled water.²³ (See “Waste management in the Marcellus and Utica shales” below)

Water contamination related to Marcellus and Utica shale development

There is increasing scientific evidence that the development of horizontal gas wells in the Marcellus shale has impacted groundwater. A 2011 study published in the National Academies of Science (NAS) documented systematic evidence for methane contamination of drinking water associated with shale-gas extraction. Testing took place in aquifers overlying the Marcellus and Utica shale formations in northeastern Pennsylvania and upstate New York.²⁴ In 2013, a second study published in the NAS documented higher concentrations of methane, ethane and propane in Pennsylvania drinking water wells that were within one kilometer of Marcellus shale wells than in those further afield. The authors suggested that faulty well construction or imperfections in cement meant to prevent migration of gas or fluids on the outside of the wellbore were the most likely routes of contamination.²⁵

The number of cases of contamination of water supplies from gas drilling has increased since Marcellus shale development began in Pennsylvania. According to the Pennsylvania Department of Environmental Protection (DEP), the agency counted 83 cases of drilling-related impacts on water supplies between 2008 and 2012.²⁶ Examples of impacts include contamination from drilling and hydraulic fracturing operations, contamination from leaky wastewater impoundments, methane contamination from faulty wellbores and casing, and construction-related contamination.

In May 2013, the *Scranton Times-Tribune* reviewed DEP data and found that the rate of drilling-related water contamination incidents increased with the start of the Marcellus boom. During the 20 years prior to the start of Marcellus shale development there were only a few cases of drilling-damaged water supplies per year. Since Marcellus shale drilling started there have been more than 16 cases per year.²⁷

Water contamination comes with high costs – both in terms of regulatory fines and requirements to replace tainted water. Several companies have been fined by the Pennsylvania DEP for faulty casing resulting in contamination of water supplies. For example, in 2009, high methane levels in water wells led to an explosion, and methane remained at explosive levels in at least four homes in Dimock, Pennsylvania.²⁸ DEP inspectors discovered that the well casings on gas Marcellus shale wells drilled by Cabot Oil & Gas were cemented improperly or insufficiently, allowing natural gas to migrate into groundwater and contaminate 13 water supplies. The company was fined \$120,000.²⁹ The DEP initially ordered Cabot to build an \$11 million water pipeline to supply affected homes, but that order was replaced in 2010 when Cabot offered a \$4.1 million settlement to purchase the affected homes or install water treatment systems.³⁰ Most families rejected Cabot's offer, and in 2012, Cabot reported that it had reached terms for a settlement with 32 of 36 Dimock families that were suing the company for water pollution. Terms of the deal were not disclosed.³¹

In 2011 the DEP determined that Chesapeake Energy had improperly cased and cemented two Marcellus shale wells allowing natural gas to migrate into the groundwater and contaminate 16 families' drinking water supplies. The company received a \$900,000 fine from DEP, the largest the agency had ever levied. Chesapeake was also ordered to restore or replace the affected water supplies.³² In June 2012, Chesapeake agreed to pay \$1.6 million to buy three of the families out of their homes in Bradford County, Pennsylvania.³³ There are at least 30 other families in the area with similar lawsuits against Chesapeake.³⁴

There have undoubtedly been many other cases of companies paying to replace water, but almost all of the disputes involving water contamination are settled through litigation, and involve confidentiality clauses. Media outlets have recently reported on a few other Marcellus shale cases where some information is known: The details of one settlement in Pennsylvania were recently ordered unsealed by a judge. The family said their water and health was impacted by Range Resources' wells and other Marcellus shale activities, and documents revealed a \$750,000 settlement. In another case, Marcellus operator Royal Dutch Shell provided bottled water and paid for hotel rooms so that residents with methane in their water could have access to clean water for showers.³⁵

Air pollution related to Marcellus shale development

The extraction and production of shale gas, as with any oil and gas development, emits a variety of air pollutants including methane, carbon dioxide, particulate matter, carbon monoxide, a variety of hazardous air pollutants (HAP), and volatile organic compounds (VOC) and nitrogen oxides, which combine to form the pollutant ozone.³⁶ The increasing density of wells and ancillary facilities such as compressor stations in shale gas development regions has led to growing scrutiny of air impacts from government agencies, researchers and public health professionals.

In a January 2013 paper published in *Environmental Research Letters*, RAND estimated damages from shale-gas-related air emissions in Pennsylvania ranged between \$7.2 and \$32 million dollars. The authors found that damages from nitrogen oxides may be of particular concern in counties and regions where shale gas extraction is concentrated. In those locations,

the total emissions from shale gas operations may be equivalent to adding a major new source of pollution even though individual sources of emissions, such as gas wells, are likely to be regulated as minor sources.³⁷

Ozone, which is linked to wide range of health effects including aggravated asthma, increased emergency room visits and hospital admissions, and premature death, is a pollutant of concern for many regions facing increases in natural gas development.³⁸ In 2008, the National Park Service cautioned that, “with expanded Marcellus Shale development, this activity may push several new counties (and parks) into nonattainment, particularly since [the U.S. Environmental Protection Agency (EPA)] has recently tightened the ozone standard.”³⁹

In 2012, ozone levels exceeded the federal 1- and 8-hour ozone standards in a number of Pennsylvania counties, including some rural counties with considerable Marcellus shale development.⁴⁰ A June 2013 commentary published by the Institute of Medicine notes that if more exceedances of the ozone standard are measured—a likely occurrence if EPA tightens its ozone standard (discussed in Section 2 of this report)—the state may be required to limit industrial development in Pennsylvania, which is “the opposite of the state’s goal in supporting Marcellus Shale activities.”⁴¹

Air pollution as it links to public health is on the radar of federal government agencies. In 2013, the National Energy Technology Laboratory and the National Institute for Occupational Safety and Health agreed to perform collaborative research with three other federal agencies related to airborne emissions and air quality from shale gas operations. The collaboration hopes to improve scientific understanding of the rate of generation and fate of air pollutants that contribute to regional air quality hazards, and to evaluate the potential cumulative impacts of exposure on human health.⁴² Given the emerging science related to air emissions from natural gas development, the outcome of the collaborative effort could be a strengthening of federal air regulations related to oil and gas.

Potential health impacts related to Marcellus shale

According to the Institute of Medicine at the National Academies of Science, “Public health was not brought into discussions about shale gas extraction at earlier stages; in consequence, the health system finds itself lacking critical information about environmental and public health impacts of the technologies and unable to address concerns by regulators at the federal and state levels, communities, and workers.”⁴³

Another issue limiting the advancement of knowledge regarding shale gas health impacts is that when impacts occur, especially water contamination, citizens often agree to cash settlements or property buyouts from the shale gas operator. A recent review by *Bloomberg News* of hundreds of regulatory and legal filings, found that most settlements include a gag order on the affected citizens - a strategy that keeps data from regulators, policymakers, health researchers and the news media. Aaron Bernstein of the Harvard School of Public Health told *Bloomberg News* that non-disclosure agreements “have interfered with the ability of scientists and public health experts to understand what is at stake here.”⁴⁴

Academic institutions and public health professionals in Colorado, which experienced unconventional natural gas drilling booms earlier than the Marcellus boom, have led the field in investigating potential linkages between natural gas pollution and public health. In 2010, the Colorado School of Public Health published a study indicating higher risks for cancer and other health problems because of air quality near gas wells that were hydraulically fractured. Within about a mile of these sites, researchers found elevated levels of benzene and as well as chemicals that can irritate eyes and cause headaches, sore throats, or breathing difficulties.⁴⁵ A 2012 study in Colorado based on air sampling data showed that due to the toxicity of air emissions near natural gas sites, residents living closer to the sites had a greater risk of health-related impacts than those living further away.⁴⁶ A third Colorado study to be published in the journal *Human and Ecological Risk Assessment*, found dozens of non-methane hydrocarbons in the air near drilling sites, including some chemicals known to harm the brain and nervous system.⁴⁷

Up until recently, there has been a void in public health research related to potential impacts from Marcellus shale development.⁴⁸ In the past couple of years, however, some information has begun to emerge regarding potential health impacts related to Marcellus shale development.

In 2012, a peer-reviewed journal article examined animal and human health impacts caused by gas drilling in six states, including incidents in Pennsylvania's Marcellus shale. The authors, Bamberger and Oswald, found that reproductive problems were most common, but other symptoms in both animals and humans included upper respiratory issues, burning of the eyes, nosebleeds, diarrhea, vomiting, rashes, headaches and neurological problems, and sudden death in animals that had contact with drilling and hydraulic fracturing fluids and wastes.⁴⁹

Recent health surveys conducted in the Marcellus shale have provided information on health symptoms that have appeared post shale-gas development, as reported by residents.⁵⁰ The symptoms reported in these surveys were very similar to the health symptoms identified in the Colorado studies and the Bamberger-Oswald study.⁵¹

Increasingly, health professionals in the Marcellus shale region are undertaking major research projects to investigate the potential connection between shale development and health. For example, in 2013, Geisinger Health System received funding to conduct a multi-year research project into potential health impacts of Marcellus shale gas drilling.⁵² According to the initiative's lead researcher, the examination of possible health effects will require decades of research, but there are critical issues to address immediately, such as the collection of baseline data.⁵³ The University of Pennsylvania Perelman School of Medicine Center for Excellence in Environmental Toxicology is also working on several studies to assess the potential health impacts from Marcellus shale operations on Pennsylvanians.⁵⁴

In the coming years, there will be increased pressure on state regulators to carry out baseline health, air and water assessments prior to drilling new areas.⁵⁵ It is also likely that regulations related to emissions of chemicals released throughout the shale development process will be strengthened to protect public health.

Waste management in the Marcellus and Utica shales

Wastewater

Marcellus shale gas wells produce large volumes of wastewater over the life of the well. Initially, a portion of the chemical-waste mixture injected to hydraulically fracture the well returns to the surface (i.e., flowback). Over time, more of the injected fluids, as well as the brines or “produced water” from the formation itself must be removed from the well.⁵⁶

These brines are far saltier than seawater and often contain elements such as strontium and radium,⁵⁷ as well as high total dissolved solids, and other metals.⁵⁸ In the Resources for the Future survey of U.S. shale gas experts, radium and other radioactive materials found in flowback, produced water and drilling fluids and cuttings were frequently identified as a priority for government or industry action.⁵⁹ There is a valid basis for concern. A 2011 USGS study found a median concentration of 1,727 picocuries per litre (pCi/L) of radium in wastewater from Marcellus shale wells in Pennsylvania.⁶⁰ This is close to 350 times the drinking water standard set by EPA.⁶¹

Wastewater volumes have increased significantly over the past few years. According to a February 2013 study carried out by Kent State and Duke universities, wastewater from natural gas production in the Pennsylvania portion of the Marcellus shale has increased by about 570 percent since 2004 as a result of increased shale gas production.⁶² The researchers also found that the wastewater produced by Pennsylvania Marcellus shale operators is already overwhelming current wastewater disposal infrastructure capacity.⁶³ It is highly probable that wastewater disposal is going to remain a long-term and costly challenge for both Marcellus and Utica shale gas operators.⁶⁴

Many operators in the Marcellus shale are trying to decrease the volume of wastewater by reusing flowback water, and to a lesser extent the saltier produced water. During the first half of 2012, Pennsylvania Marcellus shale operators were able to re-use 89 and 76 percent of flowback and produced water, respectively.⁶⁵ (During the second half of the year, re-use dropped to 80 and 58 percent, respectively.⁶⁶)

Although high volumes of wastewater are currently re-used, it is unlikely that re-use will solve the wastewater disposal capacity issue. A 2012 report prepared for the U.S. Department of Energy stated that “. . . eventually the supply of flowback and produced water is expected to exceed the reuse capacity. At this point, a growing volume of high-TDS produced water must either be deep-well injected, or water and salt recovery is required.”⁶⁷

Currently, the preferred option for disposal of wastewater from Pennsylvania’s Marcellus shale operations has been to truck these wastes to Ohio, where they are injected into saltwater disposal wells (also known as Class II Underground Injection Control wells). In the second half of 2012, 87 percent of the wastewater that was disposed (i.e., not recycled/reused) by Marcellus shale operators went to injection wells in Ohio.⁶⁸

If the Utica shale begins to see considerable development, Utica operators will be competing with Marcellus operators for injection well disposal capacity.⁶⁹ It has been postulated that if this occurs, Ohio regulators might decide to limit the number of operators who can use the underground injection wells to operators based in Ohio, for instance, by imposing extra costs or restrictions on operators in Pennsylvania.⁷⁰

Concerns have been raised about the safety of deep-well injection of such large volumes of shale gas wastewater. Since oil and gas waste is exempt from federal hazardous waste rules (despite the presence of radioactive minerals), it can be injected into Class II injection wells rather than Class I hazardous waste wells. According to report by researchers from the Natural Resources Defense Council and Carnegie Mellon University, “Shale gas wastewater should be disposed of in Class I hazardous waste disposal wells, which are subject to regulations that are more protective of health and the environment than the regulations for the Class II wells currently used for oil and gas waste disposal. Injecting wastewater into Class II wells instead of Class I hazardous waste wells may increase the risk of injection fluids’ migrating into sources of drinking water. It may also increase the risk of earthquakes.”⁷¹

A leading geoscientist and injection expert who works with the U.S. Department of Energy’s Lawrence Berkeley National Laboratory has stated that the risk to water from injection wells used for oil and gas wastes is high, “partially because of the enormous number of these wells and the fact that they are not regulated with the same degree of conscientiousness.”⁷²

In the past several years, earthquakes have been associated with the injection of wastewater from shale operations.⁷³ In 2011, the Youngstown area of Ohio experienced a dozen seismic events. An Ohio Department of Natural Resources investigation found “compelling” evidence that it said strongly indicated that the Youngstown earthquakes were induced by injection of oil and gas wastewater.⁷⁴ The push to impose more stringent injection well regulations related to seismicity is discussed in Section 2 of this report.

A small portion of Marcellus wastewater goes to municipal treatment plants in Pennsylvania and other nearby states.⁷⁵ Recent research shows that the treatment and release of wastewater from shale gas wells by permitted water treatment facilities increases the concentration of chlorides in surface water.⁷⁶ As mentioned later in this report, Pennsylvania and EPA are considering tighter chloride standards to protect aquatic life from shale-gas-related wastewater discharges.

Solid wastes

Solid wastes are produced during shale gas drilling (e.g., rock cuttings are removed as the well is drilled), as well as later in the development process. For example, one of the consequences of recycling Marcellus shale wastewater is that it produces high volumes of sludge that contains hydrocarbons, metals and radioactive substances.⁷⁷

The radioactive materials in solid wastes from shale gas drilling have garnered increased attention in the past couple of years. In April 2013, a truckload of drill cuttings from a Marcellus shale gas well in Greene County, Pennsylvania triggered radioactivity alarms at a landfill in a nearby county. The waste was later hauled out of state, because it was too radioactive for landfills in Pennsylvania.⁷⁸ In May 2013, two trucks with drilling waste from Pennsylvania were turned away from Ohio landfills because radiation was 36 times the limit allowable under Ohio laws.⁷⁹

According to the *Pittsburgh Tribune-Review*, these are not isolated incidents. In 2012, radiation alarms went off 1,325 times at Pennsylvania landfills, and more than 1,000 of those alarms were

from trucks carrying oil and gas waste. The paper reports that the spike in radiation alarms roughly corresponds to the increase in shale drilling activity.⁸⁰

The Pennsylvania DEP is in the middle of a review of radioactivity in drilling waste, flowback water, and on the equipment that handles these wastes.⁸¹ It's not clear if any regulatory changes will result from the study.

One possible outcome would be the banning of on-site burial of drill cuttings, which is currently allowed by the Pennsylvania DEP.⁸² The practice has raised concerns among nearby residents and environmental advocates.⁸³ At least one Marcellus operator, Anadarko, has voluntarily stopped using the practice due to the potential for long-term pollution liability.⁸⁴ And in 2011, the Delaware River Basin Commission drafted regulations that require off-site disposal of Marcellus shale drill cuttings.⁸⁵

In Ohio, there are similar concerns related to radioactive solid wastes from shale drilling, including the potential for Ohio to become a repository for Marcellus shale wastes from states like Pennsylvania, and the potential that landfill leachate from radioactive cuttings might be treated at municipal wastewater plants incapable of removing radiation, thus resulting in the release of radioactive chemicals into Ohio waterways.⁸⁶ Ohio may soon take some regulatory action related to disposal of radioactive materials at landfills. This is addressed in Section 2.

Section 2. Regulatory Initiatives

The regulatory landscape related to shale gas drilling is multi-layered. State agencies regulate most aspects of shale gas development, but operators must also abide by federal environmental laws such as those governing water quality and air emissions. Local governments tend to have very limited regulatory powers, but in some states they have the ability to control where drilling occurs through zoning laws.

Federal and state-specific regulatory initiatives related to shale gas development are discussed in more detail below.

It has become increasingly clear that state regulatory agencies in Pennsylvania, West Virginia and Ohio were ill-prepared for a shale gas boom. Not only were regulations inadequate to protect the environment and public health from shale gas development,⁸⁷ but state agencies tasked with overseeing drilling, production and waste disposal were and in many cases remain underfunded and understaffed.⁸⁸

At the federal level, natural gas production companies have major exemptions from parts of at least seven federal environmental laws that were written to protect air and drinking water from hazardous and radioactive chemicals released by heavy industries.⁸⁹ There are efforts to remove many of these exemptions (discussed more below). At the present time, due to gridlock in the U.S. Congress, it is unlikely that such efforts will be successful. The potential for changes to federal laws will become more politically feasible if the composition of the U.S. Congress

changes. It is likely, however, that public pressure to remove these exemptions will continue to intensify as shale gas (and oil) development impacts the lives of more communities and citizens.

According to a 2013 report from the World Resources Institute, “Public debates over the rapid development of unconventional natural gas. . . are leading to a growing trend toward more environmental regulation of oil and gas development.⁹⁰ Others have referred to a shifting regulatory landscape, particularly related to water issues in the Marcellus shale.⁹¹

The continued development of regulatory and legislative proposals at state and federal levels reflects the concern that more regulatory safeguards are needed to ensure that shale gas development can be done safely, and with minimal impact to the environment and those living with the development.

Some states and communities are considering or have enacted moratoria on the process until the risks and impacts associated with hydraulic fracturing and shale gas development are better understood. Others have banned drilling or hydraulic fracturing outright. Section 2 ends with information on local and statewide moratoria and bans related to the Marcellus and Utica shales.

Federal hydraulic fracturing initiatives and regulations

EPA hydraulic fracturing study

In 2010, the U.S. Congress directed the U.S. Environmental Protection Agency (EPA) to investigate the relationship between hydraulic fracturing and drinking water.⁹²

EPA currently has 18 research projects underway in its investigation of whether and how hydraulic fracturing might impact drinking water resources. The research is designed around five stages of the hydraulic fracturing water cycle: water acquisition, chemical mixing, well injection, flowback and produced water, and wastewater treatment and disposal. The study focuses primarily on the hydraulic fracturing of shale formations to extract natural gas.⁹³

A preliminary report is expected in late 2014, with the final peer-reviewed study to be released in 2016.⁹⁴ The study is expected to provide decision-makers with high-quality scientific information on which to base future regulatory actions related to hydraulic fracturing.

Proposed Frac Act

Requirements for chemical disclosure of hydraulic fracturing fluids are widely viewed as beneficial.⁹⁵ One of the primary reasons that citizens and advocacy organizations have pushed for disclosure is to know what chemicals to test for in drinking water prior to the fracturing of oil and gas wells.⁹⁶ Such baseline information is valuable to water well owners, as well as regulatory agencies carrying out investigations of alleged contamination events, as it provides an empirical means to determine if fracturing fluid chemicals have contaminated water supplies.

In May 2013 the *Fracturing Responsibility and Awareness of Chemicals (FRAC) Act*, sponsored by U.S. Rep. Diana DeGette (Dem-Colorado) and cosponsored by U.S. Rep. Chris Gibson (Repub-New York), was introduced in the U.S. House of Representatives. The FRAC Act would require disclosure of the chemicals used in hydraulic fracturing fluids and would remove the oil

and gas industry's exemption from the *Safe Drinking Water Act*. The FRAC Act was first introduced in 2008 by DeGette. The 2013 FRAC Act is the first bi-partisan version of the bill.⁹⁷

At the present time, more than half of the 29 states where hydraulic fracturing is used to stimulate oil and gas production have regulations requiring some level of disclosure of hydraulic fracturing fluids.⁹⁸ But there is a wide variation in the requirements. For example, only five states provide some kind of pre-fracturing chemical disclosure (Arkansas, Indiana, Montana, West Virginia and Wyoming).⁹⁹

The Frac Act would provide minimum reporting requirements for states,¹⁰⁰ including a requirement for operators to disclose anticipated hydraulic fracturing chemicals to state regulatory agencies and the public prior to drilling, and actual chemicals used within 30 days after drilling is completed. It also requires the disclosure of trade-secret-protected chemicals to state or federal agencies or a treating physician in the case of medical emergencies, and it would repeal a provision exempting hydraulic fracturing from the SDWA.¹⁰¹

The oil and gas industry has stated that passage of the FRAC Act would “cripple the U.S. economy.”¹⁰²

Previous versions of the FRAC Act have failed to make it to the floor of the Republican-controlled House of Representatives, and it is likely that this will be the case in 2013. It could, however, be passed into law if the composition of Congress changes with mid-term elections in 2014, or the presidential election in 2016. According to some commentators, the proposed bill itself serves a purpose— “its very existence has been an effective political tool to raise awareness and. . . stimulate a very public debate about the pros and cons of the issue.”¹⁰³

Potential changes to the Toxic Substances Control Act

In 2012, the EPA announced advance notice of a proposed rulemaking and stakeholder process that could require manufacturers and processors of chemicals used in hydraulic fracturing to disclose information under the Toxic Substances Control Act (TSCA).¹⁰⁴ According to one legal analysis, the rules are likely to require manufacturers and processors to maintain and submit reports to EPA detailing the composition of the chemical substances and mixtures used in hydraulic fracturing, any existing health and environmental effects data, as well as exposure and disposal information.¹⁰⁵ EPA has not yet moved forward with this process.

The Washington Legal Foundation has said that “The TSCA rulemaking may provide ammunition for environmental groups to continue to pressure EPA to pull back parts or all of the RCRA [oil and gas exploration and production waste] exemption.”¹⁰⁶ (The Resource Conservation and Recovery Act (RCRA) is discussed below)

Federal air regulations

According to a 2013 report from World Resources Institute, while state policy leadership has been critical for reducing pollution from oil and gas operations, the authors argue that a strong case remains for federal rules to overcome barriers and to more effectively improve air quality.¹⁰⁷

2012 EPA regulations on air emissions from natural gas operations

On April 17, 2012, EPA issued regulations to reduce harmful air pollution (e.g., volatile organic compounds and air toxics) from the oil and natural gas industry. The final rules included the first federal air standards for natural gas wells that are hydraulically fractured, along with requirements for several other sources of pollution in the oil and gas industry that were not being regulated at the federal level.¹⁰⁸

In its comments to EPA regarding the proposed rule, the Marcellus Shale Coalition (MSC) of shale gas operators made numerous statements regarding the high costs associated with the proposed regulations. While EPA addressed some of the coalition's concerns in the final rule, there were many "costly" items that were retained. (See examples in endnote.¹⁰⁹)

One of the requirements of the new regulations is that new hydraulically fractured gas wells and re-fractured gas wells undergo reduced emissions completions (REC), which requires specialized equipment to capture gas that would otherwise be vented. In its November 2011 comments on EPA's proposed regulations, the American Petroleum Institute (API) stated that: "The equipment prescribed to conduct Reduced Emission Completions will simply not be available in time to comply with the current final rule schedule We believe it will take years to manufacture sufficient specialized equipment and adequately train operators how to safely conduct these operations."¹¹⁰

In February 2012, a report was produced for API that modeled two scenarios: one with a high rate of REC equipment manufacturing and one with a lower rate of equipment production. The analysis demonstrated that it could be 2015 (under the high-rate estimate) or 2017 (low-rate) before there would be enough equipment to perform RECs on the same number of wells that would have been drilled in the absence of the new regulation. EPA revised its final rule and gave industry a cushion of three years before the requirement for RECs takes effect (i.e., RECs are required starting January 1, 2015).¹¹¹ If API's lower estimate of REC equipment availability turns out to be accurate, approximately 3,000 fewer wells will be drilled in 2015 and 2016 because of the EPA REC requirement.¹¹²

Potential tightening of ground-level ozone standard

The *Clean Air Act* directs EPA to set National Ambient Air Quality Standards (NAAQS) at levels that will protect public health and welfare, and requires the agency to review the standards every five years. In March 2008, EPA set the NAAQS for ground-level ozone (8-hour average) at 75 parts per billion (ppb).¹¹³ This new ozone standard was immediately challenged in the D.C. Circuit Court of Appeals. The American Lung Association, several environmental groups, and some states argued for a more stringent standard based on the recommendations of EPA's scientific advisory committee, which had suggested a standard between 60 and 70 ppb. Business and industry groups argued that the costs of meeting the new standard far outweighed any potential benefits, and argued that the standard remain at 75 ppb.¹¹⁴

In July 2011, EPA proposed tightening the ozone standard from 75 ppb to 70 ppb.¹¹⁵ Later that year, President Obama announced that an ozone standard would not be proposed until after a review of the most up-to-date science was completed in 2013. EPA is expected to propose a new standard by the end of 2013.¹¹⁶

In October 2012, the 22-member Clean Air Scientific Advisory Committee (CASAC) Ozone Review Panel, charged with providing independent advice to EPA on the scientific and technical aspects of the ozone NAAQS, found that EPA's first draft policy assessment (August 2012) "provides a strong rationale for consideration of ozone standards (8 hour averages) of between 60 ppb and 70 ppb. If the EPA considers levels below 60 ppb, adequate justification should be provided."¹¹⁷

A more stringent NAAQS for ozone would bring more areas of the country into nonattainment, forcing states like Pennsylvania, which have counties out of compliance with the current ozone standard, to take action to reduce pollution from sources like oil and gas operations that significantly contribute to ozone (smog) formation.¹¹⁸

In 2011, Dana Wood from the company BP said that at a 60 ppb ozone standard "Oil and gas development will be slowed, limited, or precluded by the lower ozone NAAQS through the air permitting and [environmental impact statement] processes."¹¹⁹ In May 2013, the American Petroleum Institute's director of regulatory and scientific affairs told reporters that a tightening of the ozone standard "could be the costliest EPA regulations ever."¹²⁰

Potential to control greenhouse gases from oil and gas operations

As mentioned in the report by Anthony Ingraffea submitted by the Council of Canadians as part of the Board's Proceedings EB-2012-0451, EB-2012-0333 and EB-2013-0074, there are large volumes of methane emitted over the life-cycle of a shale gas well.

Methane is a potent greenhouse gas, and the natural gas industry is the single largest contributor to anthropogenic methane emissions in the U.S.¹²¹

In 2009, EPA found that greenhouse gas pollution endangers public health and welfare by leading to long lasting changes in the climate that can have a range of negative effects on human health and the environment.¹²² In March 2012 the EPA used section 111(b) of the *Clean Air Act* as the basis for a proposed air quality standard for greenhouse gas emissions from new power plants.¹²³ In December 2012, attorneys general from seven Northeast states—New York, Connecticut, Delaware, Maryland, Massachusetts, Rhode Island, and Vermont—announced their plans to sue EPA for its failure to use section 111(b) of the *Clean Air Act* to directly regulate methane emissions from the oil and gas industry.¹²⁴ As of June 26, 2013, no suit has been filed.

The oil-and-gas-related air regulations passed by EPA in April 2012 were designed to limit harmful air pollutants from oil and gas operations. EPA estimated that a side-benefit of reducing these harmful pollutants would be a reduction of methane on the order of approximately 19 million metric tons of carbon dioxide equivalent (CO₂e).¹²⁵ This is a fraction of the 145 million metric tons of CO₂e (released as methane) that EPA estimates were emitted from the natural gas sector in 2011.¹²⁶

In 2013, the Congressional Budget Office released a report showing that lawmakers could increase federal revenues and help mitigate climate change by establishing a carbon tax.¹²⁷ In February 2013, U.S. Senators Bernie Sanders and Barbara Boxer introduced comprehensive climate legislation that proposes to put a \$20/metric ton price on carbon pollution.¹²⁸ According

to the Congressional Research Service, a tax of \$20/metric ton of carbon dioxide could increase the price of natural gas by approximately \$1.00 per thousand cubic feet of gas.¹²⁹ The proposed tax could cost the natural gas industry at least \$3.16 billion dollars per year.¹³⁰

The success of a tax on carbon currently hinges on support from a substantial portion of Republican congressional members. The Republican Party has long been against a carbon tax to address climate change, but some members of the party have begun to speak out in support of a carbon tax on industry. Some analysts have said that it's possible a carbon tax could be part of broader negotiations around federal taxes in the coming years.¹³¹

Future regulation of greenhouse gases such as carbon and methane have the potential to influence the pace and extent of shale gas development in the U.S. In a 2011 report on shale gas, KPMG wrote that in order to meet carbon reduction targets, there is a risk that governments could compel the industry to make these investments through regulation. "Such moves could dramatically increase costs across the entire oil and gas industry, with particularly impact on highly cost-sensitive shale gas development operations."¹³²

Federal water regulations

Limits on chloride

According to EPA, flowback (i.e., wastewater from the hydraulic fracturing process) and produced water from fracturing operations have very high levels of total dissolved solids (TDS), and chlorides are the major component of flowback TDS. EPA is in the process of updating its chloride water quality criteria for the protection of aquatic life under *Clean Water Act*. EPA's criteria are used by states when considering updates to applicable state water quality standards. A draft criteria document is expected in summer 2014.¹³³ As discussed below, the natural gas industry has expressed opposition to new chloride standards in Pennsylvania, citing financial burdens on the industry.

Wastewater discharge standards

In 2011, EPA published a plan to develop standards for wastewater discharges from shale and coalbed methane gas development. In its announcement, EPA acknowledged that, "some shale gas wastewater is transported to treatment plants, many of which are not properly equipped to treat this type of wastewater." A proposed rule for shale gas wastewater is expected in 2014.¹³⁴

The American Petroleum Institute, and shale gas developers Chesapeake and Range Resources, the industry-group Marcellus Shale Coalition and other industry representatives have opposed the development of federal wastewater standards for shale gas, citing, among other things, "the cost and burdens on the industry."¹³⁵

Federal (and state) hazardous waste regulations

Oil and gas producers are currently exempted from federal hazardous waste rules such as the Resource Conservation and Recovery Act (RCRA), which applies to disposal of wastes such as drilling cuttings, sludge produced water from oil and gas development.¹³⁶

As more information has come to light on the toxic components such as radioactive materials, metals and hydrocarbons present in oil and gas wastes, more pressure has been exerted at the state and federal levels to regulate these wastes as hazardous.

- At an April 17, 2013 House Natural Resources Committee hearing on state and federal oil and gas rules U.S. Representative Matthew Cartwright said he plans to introduce legislation "in the coming months" to ensure that RCRA applies to the oil and gas sector.¹³⁷
- A 2013 bill in California seeks to regulate wastewater from oil and gas hydraulic fracturing operations as a hazardous waste. California often plays a leading role in setting environmental standards across the country.¹³⁸ There could be moves in other states if California passes such a law.
- In 2011 and 2012, New York's Assembly voted to regulate the wastewater and solid wastes like other hazardous wastes.¹³⁹ These bills were not passed by the Senate. Such legislation has been viewed by industry as being "well intentioned, but is an attempt to make [hydraulic fracturing] cost prohibitive."¹⁴⁰ Similar legislative attempts are likely to come to the fore again if New York begins to permit shale gas development in the state.
- In 2011, Kansas oil and gas regulators stated that the RCRA exemption for oil and gas waste needs to be reviewed to address the challenges faced by state regulators when dealing with the massive amount of this waste.¹⁴¹
- In 2010, the Natural Resources Defense Council petitioned EPA to reconsider the RCRA exemption of oil and gas wastes from hazardous waste regulations.¹⁴²

There could be significant costs if industry has to treat drill cuttings, sludge and produced water as hazardous waste. If shale gas developers were to lose the RCRA exemption they would probably be forced, at great expense, to start more rigorously testing the waste for toxicity. They might also have to do what most other industries do: ship any sludge or salts that are high in radioactivity to Idaho, Washington State or the few other jurisdictions in the U.S. with landfills that are permitted to accept such waste.¹⁴³

In 1991, the U.S. oil industry warned Congress that a strict approach in reauthorizing the Resource Conservation and Recovery Act (RCRA) could shut down 80 percent of the country's oil wells and 75 percent of its gas wells.¹⁴⁴ No recent analysis of the impact on industry was found.

Pennsylvania-specific regulations and initiatives

Pennsylvania is responsible for approximately 90 percent of gas produced from the Marcellus shale.¹⁴⁵ Therefore, any major changes to Pennsylvania natural gas regulations have the potential to influence Marcellus shale gas supply.

New air permit system

In early 2013, the state's Department of Environmental Protection (DEP) finalized new air emissions standards for a general permit, called a GP-5, for engines and other equipment at natural gas compressor stations. The new permit imposes emissions limits that are 75 to 90 percent stricter than the existing limits on emissions from compressor station engines. The new standards were developed specifically to address the emerging shale-gas extraction industry in the state.¹⁴⁶

The new permit standards include requirements deemed by the natural gas industry as being “costly” and “aggressive”, such as leak detection using far-infrared devices, reporting a wide range of hazardous air pollutants, and an emissions limit for non-methane, non-ethane hydrocarbons of 10 parts per million.¹⁴⁷

Municipal authority

Zoning authority and preemption of municipal authority by the state is an issue that may affect future drilling in some areas of Pennsylvania.

In 2009, the Pennsylvania Supreme Court issued two decisions that gave local municipalities control, via zoning ordinances, over the location of drilling activity, but not the activity itself. In other words, a municipality could prohibit drilling in certain zones such as residential areas, but could not regulate aspects such as the time or noise levels of drilling activity. As a result of these two rulings, several municipalities found they could control drilling either under existing zoning ordinances or by amending their zoning ordinances, and proceeded to do so.¹⁴⁸

In 2012, Pennsylvania included provisions in its *Oil and Gas Act* (Act 13) that restricted the ability of local municipalities to regulate oil and gas operations. In the wake of Act 13’s passage, seven Pennsylvania towns and an environmental organization sued Pennsylvania alleging that provisions of Act 13 violated the state’s constitution. In July 2012, Pennsylvania’s Commonwealth Court found that Act 13’s restrictions on local government zoning unconstitutionally barred local governments from their right to separate industrial activity from residential neighborhoods.¹⁴⁹

In response to the court ruling, a spokesperson for the Marcellus natural gas industry stated that, “The premise for the General Assembly’s action earlier this year was to provide certainty and predictability that encourages investment and job creation across the Commonwealth. Lack of uniformity has long been an Achilles’ heel for Pennsylvania and must be resolved if the Commonwealth is to remain a leader in responsible American natural gas development and reap the associated economic, environmental and national security benefits.”¹⁵⁰

The state appealed the ruling, and the Pennsylvania Supreme Court heard arguments in October 2012.¹⁵¹ No decision has yet been made by the court.¹⁵²

Chloride water quality criterion

In 2010, Pennsylvania DEP drafted a proposed “Ambient Water Quality Criterion” for chloride, which essentially adopted EPA’s 1988 chloride standard. The new criterion was recommended by DEP “for protection of aquatic life due to increasing concerns about the Statewide impact of natural gas extraction from the Marcellus Shale formation.”¹⁵³ In 2012, after a re-evaluation of the science, the Pennsylvania Environmental Quality Board proposed that the DEP adopt Iowa’s equation-based aquatic life criteria for chloride, which was developed collaboratively with the EPA.¹⁵⁴ DEP agreed with this recommendation.¹⁵⁵

As part of Pennsylvania’s 2013 Triennial Review of Water Quality Standards, DEP withdrew its proposal for an equation-based aquatic life criteria for chlorides. As part of its rationale, DEP stated “The Stroud Water Research Center prepared an expert report on ambient water quality

criteria for chlorides . . . The report concluded that the criteria proposed by DEP may not be protective of sensitive species and, as a result, they recommended other more protective criteria.¹⁵⁶ DEP also admitted that existing tools to protect aquatic life were not sufficient,¹⁵⁷ and recognized the need to develop a new chloride standard before the next triennial review (2016).¹⁵⁸

According to Consol Energy, the proposed standard could have cost industry billions of dollars.¹⁵⁹ As a new chloride criterion has not yet been proposed, the economic impacts on the industry are not yet known. But as mentioned above, DEP has indicated that a more protective chloride standard is necessary.

Severance tax

Pennsylvania is the only state with substantial oil and gas reserves that does not have a severance tax. Instead, the state has imposed an impact fee on Marcellus shale gas developers.¹⁶⁰ In Pennsylvania, the fee is not imposed on the amount of gas the industry produces, but is a flat rate per well, regardless of how much those wells produce.¹⁶¹ According to the Pennsylvania Budget and Policy Center, a 4 percent natural gas severance tax could generate between \$434 million and \$490 million for Pennsylvania in 2013-14, about twice as much as the \$229 million the impact fee is expected to generate.¹⁶²

When the severance tax debate was occurring in 2011, the natural gas industry said that any significant severance tax on Marcellus gas could induce a redirection of investment flows to other shale plays or other profitable investments.¹⁶³ In 2013, Kathryn Klaber, the president of the Marcellus Shale Coalition, an industry group said that increasing tax rates on drilling would slow investments, thus leading to lower production.¹⁶⁴

According to Kenneth Medlock III, a director at the Center for Energy Studies at Rice University, as shale gas production increases the state will be stressed to provide more resources for inspections, environmental and health monitoring, and other costs. The impact fee is “going to get reviewed at some point. It's going to have to.”¹⁶⁵

There was no proposal for a severance tax in 2013 legislative session in Pennsylvania. It is possible, however, that a Marcellus shale gas severance tax may become an issue pending the outcome of the 2014 Pennsylvania governor's race.¹⁶⁶

Ohio-specific regulations

The Utica shale, located primarily in Ohio, has not been developed as quickly as the Marcellus shale. According the Ohio government, 87 of the 215 shale natural gas wells in the Utica shale play produced natural gas or oil in 2012.¹⁶⁷

Ohio, however, has been the recipient of large volumes of wastes from Marcellus operations in Pennsylvania. There have been problems with waste disposal ranging from earthquakes to radioactivity to illegal disposal. Consequently, legislation has emerged to address some of these issues. These laws may or may not pass this year, but they point to an increasing awareness of the environmental issues related to wastes generated by the oil and gas industry. The problems posed by disposing of Marcellus wastes are only going to be compounded if and when the Utica shale is targeted more seriously by shale gas developers.

Radiation

There have been several proposals during the 2013 Ohio legislative session related to the regulation and disposal of radioactive shale gas wastes.

In February 2013, the Ohio Departments of Natural Resources, Environmental Protection and Health submitted a joint proposal to legislators that they said would tighten regulations dealing with low-level radioactive wastes from drilling in the Utica shale. The proposal would allow drill cuttings to be disposed at well sites unless cuttings are contaminated with oil-based materials such as some drilling muds. In that case, it must shipped to one of Ohio's 39 licensed municipal solid waste landfills. Drilling muds and some types of equipment would have to be tested, and could only be disposed of in a solid waste landfills if they contains less than 5 picocuries per gram (pCi/g) of radioactive content.¹⁶⁸

According to the Ohio health department, wastes with higher-than-allowed radiation levels could be shipped to one of several low-level radiation landfills in the West, to a Michigan landfill that allows radiation levels up to 50 pCi/g, or blended with clean dirt to dilute and reduce radiation levels and sent to an Ohio municipal landfill. The latter option would require approval from the state EPA and health department.¹⁶⁹

State officials said they are unable to estimate the volume of drilling wastes that would be affected by the new rules. There could be significant costs to industry if large volumes of wastes are prohibited from entering Ohio solid waste landfills. Radioactive Waste Management Associates has estimated that disposing of solids wastes containing radium in an Ohio municipal landfill would cost a fraction of the cost of sending the waste to a low-level radiation landfill (approximately \$1.60 per cubic foot versus \$114 – \$350 per cubic foot, respectively).¹⁷⁰

The proposed regulations governing the disposal of radioactive oil and gas waste were included in the Governor's budget proposal, removed with bipartisan support in the House budget bill, and then added back into the Senate's version of the budget bill.¹⁷¹ The Ohio budget bill went into conference committee on June 18 and must be signed by governor Kasich by June 30, 2013.¹⁷²

If a provision related to radioactive shale wastes is not included in the budget signed by the governor, it is possible the issue could be addressed by the House Agriculture and Resources Committee after the 2013 summer recess.¹⁷³ Due to the technical nature of the issue, several legislators have expressed the opinion that it would be more appropriate for radioactivity issue to be separated from the budget bill and addressed during a comprehensive revision of the state's landfill laws due this fall.¹⁷⁴

Injection wells and seismicity

In June, 2012, a U.S. Geological Survey official provided testimony at a U.S. Senate hearing saying better permitting information is needed to give useful information to local regulators about the earthquake risks of particular injection well operations. Federal regulations currently require seismic assessments for some sorts of wastewater injection, such as hazardous waste from manufacturing, but not for oil and gas wastes. The oil and gas industry says it would be cost-prohibitive to apply the same rules.¹⁷⁵

In 2012, in response to a series of earthquakes thought to be related to oil and gas waste injection,

the Ohio Department of Natural Resources developed more stringent rules to govern injection wells.¹⁷⁶ Ohio's new injection well rules include the ability for the ODNR to require seismic tests or evaluations.¹⁷⁷ It is not clear, however, how often ODNR will require seismic assessment prior to permitting new injection wells. Therefore, it remains to be seen whether or not Ohio's new injection rules will be cost-prohibitive to some injection well developers in the state.¹⁷⁸

Severance tax

On June 20, 2013, Ohio House Representative Robert Fagan introduced a bill to enact a 7.5 percent severance tax on oil, gas and condensate extracted from horizontal drilling.¹⁷⁹ This bill follows on the heels of a June 5, 2013 proposal by Governor John Kasich for a 4.5 percent severance tax that would be turned into an income tax refund for Ohioans and revenue stream for the 33 counties affected by shale oil and gas exploration. If a severance tax is not passed during the legislative session it could go to statewide ballot.¹⁸⁰

Tom Stewart, vice president of the Ohio Oil and Gas Association has said that a severance tax is "a huge concern and will have a big impact on our industry."¹⁸¹ In April 2013, he wrote that, "Though the Utica holds great potential, we may not know its real value or viability for months or even years to come. If the severance-tax increase is enacted and the Utica fails to live up to expectations, the math may not make sense for some companies and they might choose to invest in one of the other promising shale plays in the U.S. or abroad."¹⁸²

West-Virginia-specific regulations

West Virginia is the only state other than Pennsylvania with significant gas production from the Marcellus shale.¹⁸³ Therefore, future regulatory changes in West Virginia could have an impact on Marcellus shale gas production.

In December 2011, the West Virginia legislature passed the *Natural Gas Horizontal Well Control Act* to regulate the production of natural gas from horizontally drilled wells including Marcellus shale wells. At the time, lawmakers required the state's Department of Environmental Protection to carry out three studies to determine if further regulations were warranted.

The studies included: an investigation waste pits and impoundments and evaluate whether a special regulatory provision is needed for radioactivity or other toxins; a determination of whether the Act's requirement that wells be 625 feet from an occupied dwelling was sufficient given the noise, light, dust and volatile organic compounds generated by the drilling of horizontal wells; and an air quality study measuring contaminants at various stages of the process: wellpad construction, vertical drilling, horizontal drilling, hydraulic fracturing and well completion.

As of March 2013 the studies, which were supposed to be completed by the end of 2012, had not yet been released.¹⁸⁴ Based on the outcome of the studies, it is possible that new regulations could be developed related to pits/impoundments, setback between wells and homes, and air emissions from Marcellus shale development.

Moratoria and bans related to shale development

There are some U.S. citizens who believe that no amount of regulation can protect communities from the impacts of shale development. In places where this is the prevalent view, citizens and local governments have banned or are trying to ban shale gas development. In other places, citizens and governments have opted for moratoria, in order to take the time needed to put regulations in place that better protect the environment and public health from impacts related to shale gas development.

Local government initiatives

In 2010, citizens in a few localities were mounting local campaigns to pass ordinances or resolutions to ban or stall the development of shale gas development in their communities. This trend has grown considerably in the past few years.¹⁸⁵

Recent court rulings have increased the ability of local governments to influence shale gas development. As mentioned above, in 2009, the Pennsylvania Supreme Court issued two decisions that gave local municipalities control, via zoning ordinances, over the location of drilling activity. As a result, communities in the state have used their ordinances to ban drilling in residentially zoned areas. In May 2013, a New York state appeals court ruled that townships in New York may ban hydraulic fracturing and shale gas drilling within municipal borders.¹⁸⁶ In June 2013, the Ohio Supreme Court agreed to hear a case regarding whether oil and gas drillers must follow city ordinances or whether state regulations take precedence.¹⁸⁷

There is no single source of information for all of the bans and moratoria that have been passed with respect to Marcellus shale development. Data collected from various sources suggests:

- As of June 2013, there were approximately 60 hydraulic fracturing/drilling bans, 112 moratoria, and 85 movements to obtain bans or moratoria in New York state.¹⁸⁸
- In Ohio, several municipalities have already banned hydraulic fracturing (e.g., Plains Township, Broadview Heights, Mansfield, Athens, and others).¹⁸⁹ Numerous other municipalities have rejected drilling proposals, and passed resolutions seeking a statewide moratorium on hydraulic fracturing as well as greater local control over oil and gas regulation.¹⁹⁰ In January 2012, a ban was placed on injection wells in the vicinity of the Youngstown earthquakes.¹⁹¹ The temporary ban was lifted in November 2012. In August 2012, Cincinnati became the first Ohio city to ban injection wells.¹⁹²
- Municipalities in Pennsylvania have passed ordinances banning the extraction of gas within city limits. These include Pittsburgh, West Homestead, Baldwin, Wilkinsburg, Forest Hill Borough, State College Borough, Ferguson Township, and Highland Township.¹⁹³
- In West Virginia, hydraulic fracturing is banned in and within one mile of Morgantown.¹⁹⁴

Statewide bans and moratoria related to shale gas

Statewide polls show growing support for drilling moratoria. A poll conducted in October-November 2012 by the University of Michigan's Center for Local, State and Urban Policy and Pennsylvania's Muhlenberg Institute of Public Opinion found that 52 percent of Michiganders and 58 percent of supported a moratorium on hydraulic fracturing until there is a more full understanding of the possible risks with the process.¹⁹⁵

Moratoria and bans enacted at the state level have temporarily or permanently stopped development of portions of the Marcellus and Utica shales.

- A de facto moratorium on hydraulic fracturing has been in place in New York State since 2010 due to concerns over health effects and environmental impacts of high volume hydraulic fracturing.¹⁹⁶ Drilling will not be permitted until New York's Department of Environmental Conservation completes a health impact analysis related to hydraulic fracturing and makes a determination that shale gas development will not harm public health.¹⁹⁷ It's unclear when this will happen.¹⁹⁸
- In 2011, Governor Martin O'Malley signed an executive order for a three-year moratorium on drilling in Maryland while state agencies conducted a study into the impacts of hydraulic fracturing. No drilling permits may be issued in the state until August 2014.¹⁹⁹
- In 2012, Vermont banned importation and storage of fracturing wastewater in the state, as well as the hydraulic fracturing process itself.²⁰⁰
- In 2012, the State of Ohio banned drilling under Lake Erie.²⁰¹

In 2013, more ban and moratorium proposals have been put forth at the state level. Although at least two have failed to become law these proposals demonstrate that there continues to be momentum and support for taking extra precautions related to shale gas development.

- In 2013 the New York Assembly passed a bill supporting a 2-year hydraulic fracturing moratorium.²⁰² The Senate did not vote on a moratorium bill during the 2013 legislative session.
- In May 2013 Senator Cecelia Tkaczyk introduced a bill in the New York Senate that prohibits the import of waste byproduct from other states, including Pennsylvania and Virginia that allow hydraulic fracturing.²⁰³ The bill did not go to a vote in the 2013 session.
- In 2012, the New Jersey legislature passed a bill to ban the import of wastewater from Pennsylvania, but Governor Christie vetoed the bill.²⁰⁴ A vote to override the veto may yet occur in the 2013 legislative session.²⁰⁵
- In April 2013, a statewide ban on injection wells (until proven safe) was proposed in Ohio. This bill is in the Agriculture and Natural Resources Committee.²⁰⁶
- In April 2013, the Board of State Canvassers approved petition language proposing a ban on hydraulic fracturing in Michigan, *where there is a potential for Utica shale development*. If ban supporters garner 258,088 signatures a proposed ban can be put on the 2014 statewide ballot.²⁰⁷
- On April 30, 2013, the same day 100,000 petitions supporting a gas drilling moratorium were handed to governor Tom Corbett, Senator Jim Ferlo announced his intention to introduce legislation to enact a statewide moratorium on shale gas drilling in Pennsylvania and was looking for more co-sponsors.²⁰⁸ As of June 27, 2013 a drilling moratorium bill had not yet been introduced in the Pennsylvania legislature.²⁰⁹

Conclusions

As these have been summarized in the introduction to this report, they aren't repeated here save to say that in my opinion, the applications before the Board in these proceedings overestimate the available and reliable supply of natural gas from US shale gas reserves because they fail to properly assess the potential impact of measures required to mitigate and remediate the environmental and public health impacts of shale gas development.

Endnotes

¹ KPMG International. 2011. *Shale Gas - A Global Perspective*. p. 19. <http://www.gses.com/images/documents/shale-gas-global-perspective.pdf>

² *Union Gas Application EB-2013-0074. Section 11, p. 35.*

³ Enbridge Gas Distribution Inc. EB-2012-0451. Exhibit A, Tab 3, Schedule 5 - "Natural Gas Demand, Supply & Expected Gas Supply Benefits," p. 14.) For example, Enbridge did not mention that EIA stated: "The potential impacts of pending or proposed legislation, regulations, and standards (and sections of existing legislation that require implementing regulations or funds that have not been appropriated) are not reflected in the projections." (U.S. Energy Information Administration. 2012. *Annual Energy Outlook 2012 with Projections to 2035*. DOE/EIA-0383. p. ii. [http://www.eia.gov/forecasts/aeo/pdf/0383\(2012\).pdf](http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf))

⁴ Enbridge Gas Distribution Inc. Response to Council of Canadians Interrogatory #1. June 7, 2013. EB-2012-0451/EB-2012-0433/EB-2013-0074. Exhibit I.A1.EGD.COC.1 and 2.

⁵ Union Gas Limited. June 7, 2013. Answer to Interrogatory from Council of Canadians. EB-2012-0451/EB-2012-0433/EB-2013-0074, Exhibit I.A1.UGL.COC.3.

⁶ For example, as of June 21, 2013, 6,830 Marcellus shale wells had been drilled in Pennsylvania, while as of June 1, 2013 only 228 Utica shale wells had been drilled in Ohio, the main state with Utica shale development. (Pennsylvania Department of Environmental Protection.. Weekly Workload Report. Week of 6/15/2013 to 6/21/2013.

<http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/2012/WEBSITE%20Weekly%20Report%20for%20Last%20Week.pdf> Accessed June 26, 2013. Ohio Division of Oil and Gas Resources Management. June 1, 2013. Map of Horizontal Utica-Pt.Pleasant Well Activity in Ohio.

http://www.dnr.state.oh.us/portals/10/Energy/Utica/UticaWellsActivity_06012013.pdf Accessed June 26, 2013)

⁷ Sumi, L. Sept. 21, 2010. *Environmental Concerns and Regulatory Initiatives Related to Hydraulic Fracturing in Shale Gas Formations: Potential Implications for North American Gas Supply*. Submission by the Council of Canadians to the Ontario Energy Board 2010 Natural Gas Market Review. http://www.ontarioenergyboard.ca/OEB/_Documents/EB-2010-0199/Report_Sumi_CoC.pdf

⁸ Chesapeake Energy Corporation and Shell Oil Company are funders of Resources for the Future. Both companies are involved in the Marcellus Shale. (Resources for the Future web site: "About Us."

http://www.rff.org/centers/energy_economics_and_policy/Pages/About.aspx; Shell web site: "Appalachia."

<http://www.shell.us/aboutshell/projects-locations/appalachia.html>; Chesapeake web site: "Marcellus Shale."

<http://www.askchesapeake.com/Marcellus-Shale/Pages/Information.aspx>)

⁹ Krupnick, A., Gordon, H. and Olmstead, S. Feb. 2013. *Pathways to Dialogue: What the Experts Say about the Environmental Risks of Shale Gas Development*. p. 52. http://www.rff.org/Documents/RFF-Rpt-PathwaystoDialogue_FullReport.pdf

¹⁰ *Ibid.* p. 72.

¹¹ "Each burden may have final impacts on human health, markets, ecosystems, climate change, and/or quality of life. The survey does not incorporate the links between burdens and final impacts because the expertise needed to identify priority cells is different from that needed to assess final impacts." (*Ibid.* p. 3.)

¹² Hydraulic fracturing is required for tight formations such as shale, because they do not have the necessary natural permeability to allow a sufficient quantity of natural gas to flow freely to the wellbore. (Arthur, D., Uretsky, M., and Wilson, P. 2010. *Water Resources and Use for Hydraulic Fracturing in the Marcellus Shale Region*. ALL Consulting. p. 19.

http://fracfocus.org/sites/default/files/publications/water_resources_and_use_for_hydraulic_fracturing_in_the_marcellus_shale_region.pdf)

¹³ Logan, J., Heath, G., Macknick, J., Paranhos, E., Boyd, W. and Carlson, K. 2012. *Natural Gas and the Transformation of the U.S. Energy Sector: Electricity*. U.S. Department of Energy, National Renewable Energy Laboratory, Tech. Report-6A50-55538. p. 73. <http://www.nrel.gov/docs/fy13osti/55538.pdf>

¹⁴ Arthur, D., Uretsky, M., and Wilson, P. 2010. *Water Resources and Use for Hydraulic Fracturing in the Marcellus Shale Region*. ALL Consulting. p. 19.

http://fracfocus.org/sites/default/files/publications/water_resources_and_use_for_hydraulic_fracturing_in_the_marcellus_shale_region.pdf

¹⁵ Dillon, M. 2011. "Water Scarcity And Hydraulic Fracturing In Pennsylvania," Temple Law Review. Vol. 84, pp. 209, 210. http://sites.temple.edu/lawreview/files/2012/02/84.1_Dillon.pdf

¹⁶ Extremely high water stress was defined as over 80 percent of available water is already being withdrawn for municipal, industrial and agricultural uses. (Freyman, M. and Salmon, R. May 2013. Hydraulic Fracturing & Water Stress: Growing competitive pressures for water. CERES. p. 3. http://www.ceres.org/resources/reports/hydraulic-fracturing-water-stress-growing-competitive-pressures-for-water/at_download/file)

¹⁷ *Ibid.* p. 8.

¹⁸ Dillon, M. 2011. "Water Scarcity And Hydraulic Fracturing In Pennsylvania," Temple Law Review. Vol. 84, pp. 202, 245. http://sites.temple.edu/lawreview/files/2012/02/84.1_Dillon.pdf

¹⁹ Accenture. Dec. 10, 2012. *Water and Shale Gas Development: Leveraging the US experience in new shale developments*. pp. 27, 28. <http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Water-And-Shale-Gas-Development.pdf>

²⁰ Susquehanna River Basin Commission web site: "13 water withdrawals remain on hold to protect streams in the Susquehanna Basin," August 30, 2011. http://www.srbc.net/whatsnew/Newsletters/article_58.asp

- ²¹ Magyar, R. July 19, 2012. "Near drought conditions impacting Marcellus shale gas drilling," *Examiner.com*. <http://www.examiner.com/article/near-drought-conditions-impacting-marcellus-shale-gas-drilling>
- ²² It has been estimated that 30% to 70% of the total water injected into the well returns to the surface as flowback and produced waters. (Dae Sung, I., Herman, J., Elsworth, D., Tae Kim, H., and Suk Lee, H. April 2011. "A Critical Evaluation of Unconventional Gas Recovery from the Marcellus Shale, Northeastern United States." *KSCE Journal of Civil Engineering*. Vol. 14, No. 4. p. 685. http://www.ems.psu.edu/~elsworth/publications/journals/2011_j_ksce_marcellus_issues_thumb.pdf) Others estimate that only 10 to 30% of the water used to fracture a well returns to the surface. (Rassenfoss, S. July 2011. "From Flowback to Fracturing: Water recycling grows in the Marcellus Shale." *Journal of Petroleum Technology*. p. 49. <http://www.spe.org/jpt/print/archives/2011/07/12Marcellus.pdf>).
- ²³ For example, Range Resources is fracturing wells in southwest Pennsylvania with fluids containing flowback water run through a 25 micron filter. It also adds anti-scaling chemicals and biocides, and mixes it with 80% or more fresh water. (Rassenfoss, S. July 2011. "From Flowback to Fracturing: Water recycling grows in the Marcellus Shale." *Journal of Petroleum Technology*. p. 50. <http://www.spe.org/jpt/print/archives/2011/07/12Marcellus.pdf>)
- ²⁴ They found that methane levels in drinking water wells in active gas production areas (less than 1 km from wells) were 17 times higher than outside of active gas production areas. An isotopic analysis of the methane suggests that the methane in the active gas production areas originated from deep underground – i.e., it was consistent with deeper thermogenic methane sources such as the Marcellus and Utica shales and matched gas geochemistry from gas wells nearby. In contrast, lower-concentration samples from shallow groundwater at nonactive sites had isotopic signatures reflecting a more biogenic or mixed biogenic/thermogenic methane source. (Osborn, S., Vengosh, A., Warner, N. and Jackson, R. May, 2011. "Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing," *Proceedings of the National Academy of Sciences of the United States of America*. 108(20): 8172–8176. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3100993/>)
- ²⁵ Jackson, R., Vengosh, A., Darrah, T., Warner, N., Down, A., Poreda, R., Osborn, S., Zhao, K. and Karr, J. June 2013. "Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction," *Proceedings of the National Academy of Sciences of the United States of America*. Web version published ahead of print June 24, 2013. <http://www.pnas.org/content/early/2013/06/19/1221635110.full.pdf+html>
- ²⁶ Legere, L. May 19, 2013. "Sunday Times review of DEP drilling records reveals water damage, murky testing methods," *Scranton Times-Tribune*. <http://m.thetimes-tribune.com/news/sunday-times-review-of-dep-drilling-records-reveals-water-damage-murky-testing-methods-1.1491547>
- ²⁷ Ibid.
- ²⁸ Legere, L. Oct. 26, 2009. "Nearly a year after a water well explosion, Dimock Twp. Residents thirst for gas-well fix," *Scranton Times-Tribune*. <http://thetimes-tribune.com/news/nearly-a-year-after-a-water-well-explosion-dimock-twp-residents-thirst-for-gas-well-fix-1.365743>
- ²⁹ Pennsylvania Department of Environmental Protection. Nov. 4, 2009. "DEP reaches agreement with Cabot to prevent gas migration, restore water supplies in Dimock Township," Press Release. <http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2418&typeid=1>
- ³⁰ Legere, L. Dec. 17, 2010. "Settlement between Cabot and DEP draws criticism, praise," *Scranton Times-Tribune*. <http://thetimes-tribune.com/news/settlement-between-cabot-and-dep-draws-criticism-praise-1.1078753>
- ³¹ Legere, L. August 15, 2012. "Cabot, Dimock families near settlement on gas drilling contamination," *Scranton Times-Tribune*. <http://thetimes-tribune.com/news/gas-drilling/cabot-dimock-families-near-settlement-on-gas-drilling-contamination-1.1359097>
- ³² Pennsylvania Department of Environmental Protection. May 17, 2011. "DEP fines Chesapeake Energy more than \$1 million," Press Release. <http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=17405&typeid=1>
- ³³ Phillips, S. June 21, 2012. "Chesapeake to pay \$1.6 million for contaminating water wells in Bradford County," *State Impact (a project of National Public Radio)*. <http://stateimpact.npr.org/pennsylvania/2012/06/21/chesapeake-to-pay-1-6-million-for-contaminating-water-wells-in-bradford-county/>
- ³⁴ Begos, K. June 12, 2012. "\$1.6M settlement in Pa. gas drilling lawsuit," *Associated Press*. Available at: <http://www.businessweek.com/ap/2012-06-22/1-dot-6m-settlement-in-pa-dot-gas-drilling-lawsuit>
- ³⁵ Efstathiou, J. and Drajem, M. June 5, 2013. "Drillers silence fracking claims with sealed settlements," *Bloomberg*. <http://www.bloomberg.com/news/2013-06-06/drillers-silence-fracking-claims-with-sealed-settlements.html>
- ³⁶ EPA web site: "Basic Information – Emissions from the oil and natural gas industry." <http://www.epa.gov/airquality/oilandgas/basic.html>
- ³⁷ Litovitz, A., Curtright, A., Abramson, S., Burger, N. and Samaras, C. Feb. 2013. "Estimation of regional air-quality damages from Marcellus Shale natural gas extraction in Pennsylvania," *Environmental Research Letters*. 8:1. p. 6. http://iopscience.iop.org/1748-9326/8/1/014017/pdf/1748-9326_8_1_014017.pdf
- ³⁸ For example, "Concentrated natural gas development has led to elevated ozone levels in rural parts of Wyoming and Utah where little other industrial activity occurs . . . and has also contributed to ozone pollution in more urban and industrial areas such as the Dallas Fort-Worth metropolitan area." (Logan, J., Heath, G., Macknick, J., Paranhos, E., Boyd, W. and Carlson, K. 2012. *Natural Gas and the Transformation of the U.S. Energy Sector: Electricity*. U.S. Department of Energy, National Renewable Energy Laboratory, Tech. Report-6A50-55538. p. 50. <http://www.nrel.gov/docs/fy13osti/55538.pdf>)
- ³⁹ National Parks Service. 2008. *Potential Development of the Natural Gas Resources in the Marcellus Shale*. p. 8. http://www.nps.gov/frhi/parkmgmt/upload/GRD-M-Shale_12-11-2008_high_res.pdf

- ⁴⁰ EPA non-attainment designations for 2012 (U.S. Environmental Protection Agency web site: “Nonattainment designations for the 2008 ozone standards – counties by state, April 30, 2012 and May 31, 2013.” <http://www.epa.gov/ozonedesignations/2008standards/final/finaldes.htm>) included the Marcellus shale counties in the southwest quadrant of the state. The counties of Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, and Westmoreland have seen a total of 1,712 Marcellus shale wells drilled between 2004 and June 21, 2013. This is 27% quarter of all Marcellus wells drilled in the state during that time period. (Pennsylvania Department of Environmental Protection web site: Wells drilled by County. Searched all counties between Jan. 1, 2004 and June 21, 2013. Counted unconventional wells only. http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/Wells_Drilled_By_County)
- ⁴¹ Goldstein, B.D. June 11, 2013. “Engaging health in decision making: The Marcellus Shale and sustainability.” Commentary. *Institute of Medicine*. Washington, DC. <http://www.iom.edu/Global/Perspectives/2013/EngagingHealthinDecisionMaking>
- ⁴² U.S. Department of Energy web site: “Interagency Collaboration to Address Environmental Impacts of Shale Gas Drilling.” April 23, 2013. <http://energy.gov/fe/articles/interagency-collaboration-address-environmental-impacts-shale>
- ⁴³ “The Health Impact Assessment of New Energy Sources: Shale Gas Extraction.” Announcement and summary of meeting at the Institute of Medicine, April 30-May 1, 2012. <http://www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30.aspx>
- ⁴⁴ Efstathiou, J. and Drajem, M. June 5, 2013. “Drillers silence fracking claims with sealed settlements,” *Bloomberg*. <http://www.bloomberg.com/news/2013-06-06/drillers-silence-fracking-claims-with-sealed-settlements.html>
- ⁴⁵ Witter R, McKenzie, L., Towle, M., Stinson, K. Scott, K., Newman, L. and Adgate, J. September 2010. *Health Impact Assessment for Battlement Mesa, Garfield County Colorado*. Colorado School of Public Health, University of Colorado Denver. Available: <http://tinyurl.com/6hcwrpz> Accessed June 26, 2013.
- ⁴⁶ McKenzie, L.M., Witter, R.Z., Newman L.S., Adgate J.L. May 2012. “Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources.” *Science of the Total Environment*. 1;424:79-87. Available at: <http://cogcc.state.co.us/library/setbackstakeholdergroup/Presentations/Health%20Risk%20Assessment%20of%20Air%20Emissions%20From%20Unconventional%20Natural%20Gas%20-%20HMcKenzie2012.pdf>
- ⁴⁷ In an air quality study conducted in 2010, and accepted for publication by *Human and Ecological Risk Assessment: An International Journal*, Theo Colborn and her colleagues sampled air quality in rural western Colorado before, during and after drilling and hydraulic fracturing of a new natural gas well pad. (Source: Colborn, T., Schultz, K., Herrick, L. and Kwiatkowski, C. (In Press) “An exploratory study of air quality near natural gas operations,” *Human and Ecological Risk Assessment: An International Journal*. Available at: <http://www.endocrinedisruption.com/chemicals.air.php>
- ⁴⁸ Schmidt, C. August 2011. “Blind Rush: Shale gas boom proceeds amid human health questions,” *Environmental Health Perspectives*. 119(8):a348-a353. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3237379/#r23>
- and Hobson, K. April 1, 2013. “Health questions key to New York fracking decision, but answers scarce,” *National Geographic News*. <http://news.nationalgeographic.com/news/energy/2013/04/130401-new-york-fracking-health-questions>
- ⁴⁹ Bamberger, M. and Oswald, R.E. January 2012. “Impacts of gas drilling on human and animal health,” *New Solutions*. 22(1):51-77. http://www.psehealthyenergy.org/data/Bamberger_Oswald_NS22_in_press.pdf
- ⁵⁰ Steinzor, N., Subra, W. and Sumi, L. 2013. “Investigating Links between Shale Gas Development and Health Impacts Through a Community Survey Project in Pennsylvania.” *New Solutions*. 23:1:55-83. Available at: <http://www.newsolutionsjournal.com/index.php/newsolutionsjournal/issue/view/19> and Ferrar, K., Kriesky, J., Christen, C., Marshall, L., Malone, S., Sharma, R., Michanowicz, D., and Goldstein, B.. June 2013. “Assessment and longitudinal analysis of health impacts and stressors perceived to result from unconventional shale gas development in the Marcellus Shale region,” *International Journal of Occupational and Environmental Health*. 19:2:104-112. Available at: <http://www.ingentaconnect.com/content/maney/oeh/2013/00000019/00000002/art00005;jsessionid=945kde08p4m45.alice> See summary at: <http://www.fractracker.org/2013/04/healthresearch/>
- ⁵¹ Colorado research by Witter et al. (see footnote 46) indicated that air emissions from natural gas projects could contribute to health effects such as headaches, upper respiratory illness, nausea and nosebleeds and a possible small increase in lifetime cancer risks. (April 2013. “Health impact assessments prove critical public health tool: best way to gauge impact of gas drilling on communities,” *Science Daily*. <http://www.sciencedaily.com/releases/2013/04/130422175712.htm>). In Pennsylvania’s Marcellus shale, Steinzor et al. found that a large percentage of surveyed residents living in close proximity to Marcellus shale facilities reported health impacts such as headaches, breathing difficulties, nosebleeds and nausea, among other symptoms. (Steinzor, N., Subra, W. and Sumi, L. 2013. “Investigating Links between Shale Gas Development and Health Impacts Through a Community Survey Project in Pennsylvania.” *New Solutions*. 23:1:55-83 Available at: <http://www.newsolutionsjournal.com/index.php/newsolutionsjournal/issue/view/19>)
- ⁵² Osborne, C. Feb. 19, 2013. “Health firm secures \$1m grant to study the impacts of fracking, natural gas drilling,” *CBS SmartPlanet*. <http://www.smartplanet.com/blog/bulletin/health-firm-secures-1m-grant-to-study-the-impacts-of-fracking-natural-gas-drilling/13071>
- ⁵³ “Geisinger leads Marcellus Shale Initiative.” *Geisinger Research Connections*. Winter 2013. p. 3. <http://www.geisinger.org/research/cx/73809-1-ResearchCnxWinter2013WEB.pdf>
- ⁵⁴ “Field Survey of Health Perception and Complaints of Pennsylvania Residents in the Marcellus Shale,” is an assessment of the health complaints of residents who live near Pennsylvania gas wells and who visited a medical professional about their physical symptoms. “Groundwater Quality and Health Outcomes in Adjacent Areas With and Without Hydrofracturing Activities,” a partnership with Columbia University, and will study water quality and a set of data obtained from medical insurance companies

on what are called “billable health outcomes,” or visits to a doctor. They'll compare these data in areas that do and don't have shale development, and will focus on the Pennsylvania and New York border. The “Harvard World Map: Fracking Research Repository for All Concerned,” will use the Harvard World Maps tool to create proximity maps of drilling sites, air quality, water quality and health effects to see if there is any association. (Sirk, K. March 21, 2013. “Doctors assess fracking impact,” *Shale Reporter*. http://www.shalereporter.com/blog/kimberley_sirk/article_8f1a9b70-924c-11e2-a1b0-001a4bcf6878.html)

⁵⁵ For example, in 2012 Nirav R. Shah, Public Health Commissioner for the State of New York, was selected to review New York Department of Environmental Conservation's health impact analysis to determine if it adequately addressed and mitigated public health concerns related to shale gas development (referred to as high volume hydraulic fracturing – HVHF). In 2013, Shah failed to deliver his assessment on schedule, in part due to the complexities of the issues. He wrote that “The decision to permit HVHF is important, and involves complex questions about the impact of the process on public health. The time to ensure the impacts on public health are properly considered is before a state permits drilling. Other states began serious health reviews only after proceeding with widespread HVHF. In my view, that is not the right approach for New York to take if we are serious that public health is the paramount question in making the HVHF decision. And as Health Commissioner, protecting the public health is my primary job.” (Letter available at: <http://ecowatch.com/2013/fracking-decision-delayed>)

McKenzie et al., suggest: “Risk assessment can be used in health impact assessments to direct health risk prevention strategies. Risk management approaches should focus on reducing exposures to emissions during well completions. These preliminary results indicate that health effects resulting from air emissions during unconventional natural gas development warrant further study. Prospective studies should focus on health effects associated with air pollution.” (See footnote 46.)

In 2011, a group of doctors, nurses and environmentalists called on New York officials to carry out a health impact assessment prior to allowing drilling in that state. They group asked state officials to assess disease rates in potential drilling areas to establish a baseline, identify specific risks from drilling and propose steps to mitigate those risks. (Kusnetz, N. Oct. 6, 2011.

“Doctors ask New York to study health impacts before allowing fracking,” *ProPublica*.

<http://www.propublica.org/article/doctors-ask-new-york-to-study-health-impacts-before-allowing-fracking>)

⁵⁶ Produced water is water found in the same formations as oil and gas. When the oil and gas are produced to the surface, the produced water is brought to the surface, too. It is also referred to as “brine,” “saltwater,” or “formation water.” Produced water contains some of the chemical characteristics of the formation from which it was produced and associated hydrocarbons. (Clark, C.E. and Veil, J.A. September 2009. *Produced Water Volumes and Management Practices in the United States*. p. 13. <http://www.netl.doe.gov/technologies/coalpower/ewr/water/pdfs/anl%20produced%20water%20volumes%20sep09.pdf>)

⁵⁷ Rassenfoss, S. July 2011. “From Flowback to Fracturing: Water recycling grows in the Marcellus Shale.” *Journal of Petroleum Technology*. p. 50. <http://www.spe.org/jpt/print/archives/2011/07/12Marcellus.pdf>

⁵⁸ “In addition to high salinity and hardness levels (Mg, Ca, Sr, Ba), much Marcellus produced water also contains significant levels of naturally occurring radioactive materials (NORM), particularly radium. (Silva, J., Matis, H., Kostedt, W. and Watkins, V. January 2012. *Produced Water Pretreatment for Water Recovery and Salt Production*. Final Report, Research Partnership to Secure Energy for America, submitted to the U.S. Department of Energy. p.iii.)

http://www.rpsea.org/attachments/contentmanagers/5665/08122-36-FR-Pretreatment_Water_Mgt_Frac_Water_Reuse_Salt-01-26-12.pdf)

⁵⁹ Krupnick, A., Gordon, H. and Olmstead, S. Feb. 2013. *Pathways to Dialogue: What the Experts Say about the Environmental Risks of Shale Gas Development*. p. 53. http://www.rff.org/Documents/RFF-Rpt-PathwaystoDialogue_FullReport.pdf

⁶⁰ Rowan, E.L., Engle, M.A., Kirby, C.S., and Kraemer, T.F. 2011. *Radium content of oil- and gas-field produced waters in the northern Appalachian Basin (USA)—Summary and discussion of data*. U.S. Geological Survey Scientific Investigations Report 2011–5135. p. 15. <http://pubs.usgs.gov/sir/2011/5135/>

⁶¹ U.S. EPA web site: “Radionuclides in drinking water rule.”

<http://water.epa.gov/lawsregs/rulesregs/sdwa/radionuclides/regulation.cfm>

⁶² Lutz B.D., Lewis, A. and Doyle, W. Feb. 8, 2013. “Generation, transport, and disposal of wastewater associated with Marcellus Shale gas development.” *Water Resources Research*. 49:2, pp. 647-656. <http://dx.doi.org/10.1002/wrcr.20096>

⁶³ Ibid.

⁶⁴ “Hydrofracturing typically requires 2MM – 6.5MM gallons of water per shale gas well. About 15-25% of this water returns to the surface as “flowback” within 30 days after hydrofracturing. “Produced water” continues to flow at a much reduced rate, e.g. 2-10 bbl/day, for the life of the well.” (Silva, J., Matis, H., Kostedt, W. and Watkins, V. January 2012. *Produced Water Pretreatment for Water Recovery and Salt Production*. Final Report, Research Partnership to Secure Energy for America, submitted to the U.S. Department of Energy. p.iii.) http://www.rpsea.org/attachments/contentmanagers/5665/08122-36-FR-Pretreatment_Water_Mgt_Frac_Water_Reuse_Salt-01-26-12.pdf

⁶⁵ Clark, C.E. and Veil, J.A. September 2009. *Produced Water Volumes and Management Practices in the United States*. p. 20. <http://www.netl.doe.gov/technologies/coalpower/ewr/water/pdfs/anl%20produced%20water%20volumes%20sep09.pdf>

⁶⁶ Data from Pennsylvania Department of Environmental Protection. Statewide Data Downloads. 2012. July-Dec 2012 (Unconventional wells).

https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/ExportWasteData.aspx?PERIOD_ID=2012-2

⁶⁷ “. . . eventually the supply of flowback and produced water is expected to exceed the reuse capacity. At this point, a growing volume of high-TDS produced water must either be deep-well injected, or water and salt recovery is required.” (Silva, J., Matis, H., Kostedt, W. and Watkins, V. January 2012. *Produced Water Pretreatment for Water Recovery and Salt Production*. Final Report, Research Partnership to Secure Energy for America, submitted to the U.S. Department of Energy. p.iii.)

http://www.rpsea.org/attachments/contentmanagers/5665/08122-36-FR-Pretreatment_Water_Mgt_Frac_Water_Reuse_Salt-01-26-12.pdf

⁶⁸ Total flowback and produced water = 16.7 million barrels (bbl). Recycled/reused water = 13.3 bbl. Of the remainder (2.8 million bbl) 2.45 million bbls went to Ohio injection wells. (Data from Pennsylvania Department of Environmental Protection. Statewide Data Downloads. 2012. July-Dec 2012 (Unconventional wells).

https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/ExportWasteData.aspx?PERIOD_ID=2012-2

⁶⁹ “The ability for injection wells to accept waste both in Pennsylvania and surrounding states is constrained, with a limited number of injection-well formations available and growing concerns about the safety of these wells. Potential growth in oil and gas production in Ohio and West Virginia may lead to higher demand for injection wells in those states. With high transport costs to injection wells and potentially rising costs for disposal, injection wells may soon be pricier and less available for waste acceptance.” (Lewis, A. May 2012. *Wastewater Generation and Disposal from Natural Gas Wells in Pennsylvania*. Duke University Master’s research. p. 27. http://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/5320/Lewis_MP2.pdf)

⁷⁰ Catalyst Connection. Marcellus-Regional Innovation Cluster and Pittsburgh Gateways Corporation. March 2012. *Marcellus Shale Water Management Study*. p. 53.

http://catalystconnection.org/Docs/pdf/Catalyst_Marcellus_Shale_Water_Management_Study_June_2012.pdf

⁷¹ Hammer, R., VanBriesen, J. In *Fracking’s Wake: New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater*. Natural Resources Defense Council. p. 89. <http://www.nrdc.org/energy/files/Fracking-Wastewater-FullReport.pdf>

⁷² Lustgarten, A. Sept. 20, 2012. “The trillion-gallon loophole: Lax rules for drillers that inject pollutants into the earth,” ProPublica. <http://www.propublica.org/article/trillion-gallon-loophole-lax-rules-for-drillers-that-inject-pollutants>

⁷³ See, for example: Keranen, K., H.M. Savage, G.A. Abers, E.S. Cochran. 2013. “Potentially induced earthquakes in Oklahoma, USA: Links between wastewater injection and the 2011 Mw 5.7 earthquake sequence,” *Geology*. 10.1130/G34045.1.

http://profile.usgs.gov/myscience/upload_folder/ci2013May3015351271984Keranen%20etal%20Geology%202013.pdf and Soraghan, M. March 29, 2012. “Remarkable spate of man-made quakes linked to drilling, USGS team says,” *EnergyWire*. <http://www.eenews.net/stories/1059962190>

⁷⁴ Ohio Department of Natural Resources. (ODNR). March 2012. *Preliminary Report on the Northstar I Class II Injection Well and the Seismic Events in the Youngstown, Ohio, Area*. p. 4. <http://ohiodnr.com/downloads/northstar/UICreport.pdf> and ODNR Press Release. “ODNR releases preliminary report on Youngstown area seismic activity.” Mar. 9, 2012. Available at: http://www.ohiodnr.com/home_page/NewsReleases/tabid/18276/EntryId/2711/Ohios-New-Rules-for-Brine-Disposal-Among-Nations-Toughest.aspx

⁷⁵ Feb. 20, 2012. “Marcellus shale gas drillers recycling more waste,” *Associated Press*. Available at:

<http://fuelfix.com/blog/2012/02/20/marcellus-shale-gas-drillers-recycling-more-waste/>

⁷⁶ “. . . an additional 1.5 facilities treating waste upstream in a watershed. . . results in a 10–11% increase in Cl– downstream.” (Olmstead, S., Muehlenbachs, L., Shih, J., Chu, Z. and Krupnick, A. March 11, 2013. “Shale gas development impacts on surface water quality in Pennsylvania,” *Proceedings of National Academy of Sciences*. p. 5 of 6.

<http://www.pnas.org/content/early/2013/03/06/1213871110.full.pdf+html>

⁷⁷ “There is a downside to producing drinking water quality from what flows out of the Marcellus Shale. It is far saltier than sea water and laden with elements such as strontium and radium. A 1-million-gallon-a-day plant distilling water from the Marcellus generates about 400 tons of waste, according to an SPE paper by Blauch.” (Rassenfoss, S. July 2011. “From Flowback to Fracturing: Water recycling grows in the Marcellus Shale.” *Journal of Petroleum Technology*. p. 50.

<http://www.spe.org/jpt/print/archives/2011/07/12Marcellus.pdf>) Promtech has estimated that a plant treating 100,000 gallons per day of flowback for re-use would produce between 9,200 and 45,700 lbs/day of sludge, depending on the initial concentration of contaminants. (Keister, T. ProChemTech International, Inc. Jan. 29, 2010. “Marcellus Hydrofracture Flowback and Production Wastewater Treatment, Recycle, and Disposal Technologies.” *Presentation at The Science of Marcellus Shale Conference, Lycoming College, Williamsport*. http://energy.wilkes.edu/PDFFiles/Library/The_Science_of_Marcellus_Shale_Wastewater.pdf)

⁷⁸ Peirce, P. April 23, 2013. “Shale truck sets off alarm in South Huntingdon,” *Tribune-Review*.

<http://triblive.com/news/westmoreland/3888698-74/radiation-max-poister#axzz2Wt7SNqWz>

⁷⁹ Costarella, M. June 1, 2013. “Will radioactive waste be the next challenge or opportunity?” *Youngstown Vindicator*.

<http://www.vindy.com/weblogs/shale-sheet-fracking/2013/jun/01/will-radioactive-waste-be-next-challenge-or-opport/>

⁸⁰ Puko, T. May 11, 2013. “Radioactive fracking debris triggers worries at dump sites,” *Pittsburgh Tribune-Review*.

<http://triblive.com/business/headlines/3945499-74/gas-radiation-radioactivity#ixzz2Wt98QfNR>

⁸¹ Phillips, S. January 24, 2013. “PA DEP to study radiation related to Marcellus Shale,” *State Impact Project (National Public Radio)*. <http://stateimpact.npr.org/pennsylvania/2013/01/24/pa-dep-to-study-radiation-related-to-marcellus-shale/>

⁸² Pennsylvania Code. §78.61. Disposal of drill cuttings. <http://www.pacode.com/secure/data/025/chapter78/s78.61.html>

⁸³ PennFuture. Jan. 31, 2013. “Danger in plain site.” *PennFuture Facts*. Vol. 15, No. 2.

http://www.pennfuture.org/media_pff_detail.aspx?MediaID=1527

⁸⁴ For example, Anadarko not only carts its drill cuttings offsite, it also received permission from the state to dig up previously buried cuttings from wells that it had already drilled. According to Anadarko, it did this because “We want to say we haven’t buried anything here. . . It always could be a risk. It could come back to you.” (Maykuth, A. Feb. 13, 2011. “Closed-loop systems: Innovative way to dispose of Marcellus drilling debris,” *Philadelphia Inquirer*. http://articles.philly.com/2011-02-13/business/28532329_1_marcellus-shale-drilling-high-pressure-injection)

- ⁸⁵ Delaware River Basin Council. November 8, 2011. Draft Natural Gas Development Regulations. Section (xiv) reads: “Cuttings and fluids from the target formation must be transported offsite within 45 days after completion of well drilling. . .” <http://www.nj.gov/drbc/library/documents/naturalgas-REVISEDdraftregs110811.pdf>
- ⁸⁶ Ohio Environmental Council. Monday May 13, 2013. “Environmentalists to Ohio Senate: Junk the ‘dump & glow amendment.’” <http://www.theoec.org/press-releases/environmentalists-ohio-senate-junk-dump-glow-amendment>
- ⁸⁷ See, for example: Wheeler, T. March 9, 2013. “Fracking brings prosperity, problems to Pennsylvania,” *The Baltimore Sun*. http://articles.baltimoresun.com/2013-03-09/news/bs-md-fracking-20130309_1_marcellus-shale-gas-boom-natural-gas/2 and Adams, S. Dec. 14, 2011. Marcellus Shale bill passes West Virginia Legislature,” *West Virginia Watchdog*. <http://westvirginia.watchdog.org/3846/marcellus-shale-bill-passes-west-virginia-legislature-video/>
- ⁸⁸ Wiseman, H. 2012. “Fracturing Regulation Applied,” *Duke Environmental Law and Policy Forum*. Vol. 22. <http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1235&context=delpf>; Earthworks. 2012. *Breaking All the Rules: The Crisis in Oil & Gas Regulatory Enforcement*. http://www.earthworksaction.org/issues/detail/oil_gas_enforcement#UcfCNOuGFFQa; and Lustgarten, A. Dec. 30, 2009. “State Oil and Gas Regulators Are Spread Too Thin to Do Their Jobs,” *ProPublica*. <http://www.propublica.org/article/state-oil-and-gas-regulators-are-spread-too-thin-to-do-their-jobs-1230>
- ⁸⁹ Urbina, I. March 3, 2011. “Pressure limits efforts to police drilling for gas,” *New York Times*. http://www.nytimes.com/2011/03/04/us/04gas.html?pagewanted=all&_r=0
- ⁹⁰ Bradbury, J., Obeiter, M., Draucker, L., Wang, W. and Stevens, A. April 2013. *Clearing the Air: Reducing Upstream Greenhouse Gas Emissions from U.S. Natural Gas Systems*. World Resources Institute Working Paper. P. 30. http://pdf.wri.org/clearing_the_air_full.pdf
- ⁹¹ Brannon, T., Shepherd, W. 2012. *Marcellus Shale Drilling Comparative White Paper – the regulatory approaches of New York, Ohio, Pennsylvania and West Virginia*. Center for Energy and Sustainable Development, West Virginia University College of Law. <http://energy.law.wvu.edu/r/download/130703>
- ⁹² U.S. Environmental Protection Agency web site: “EPA’s Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources.” <http://www2.epa.gov/hfstudy>
- ⁹³ U.S. Environmental Protection Agency. December 2012. *Study on the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report*. Executive Summary. p. 1. <http://www2.epa.gov/hfstudy/study-potential-impacts-hydraulic-fracturing-drinking-water-resources-progress-report>
- ⁹⁴ Downing, B. June 18, 2013. “EPA study on fracking threat to water will take years,” *Akron Beacon Journal*. <http://www.ohio.com/news/epa-study-on-fracking-threat-to-water-will-take-years-1.407046>
- ⁹⁵ Tiemann, M., Vann, A. January 10, 2013. *Hydraulic Fracturing and Safe Drinking Water Act Regulatory Issues*. Congressional Research Service Report for Congress. R41760. p. 25. <http://www.fas.org/sgp/crs/misc/R41760.pdf>
- ⁹⁶ Natural Resources Defense Council. 2012. *State hydraulic Fracturing Disclosure rules and Enforcement: A Comparison*. p. 4. <http://www.nrdc.org/energy/files/Fracking-Disclosure-IB.pdf>
- ⁹⁷ Diana DeGette web site: May 9, 2013. “DeGette and Gibson introduce bipartisan FRAC Act.” http://degette.house.gov/index.php?option=com_content&view=article&id=1272:degette-and-gibson-introduce-bipartisan-frac-act&catid=76:press-releases-&Itemid=227
- ⁹⁸ As of June 2013, there are 18 states with varying levels of requirements for oil and gas operators to disclose fracturing fluids, and others such as California, Alaska were considering such regulations. State with regulations include: (AR, CO, ID, IN, IL, LA, MI, MO, MS, NM, ND, OH, OK, PA, TX, UT, WV, WY. (Source: Hall, K. 2013. “Mandatory disclosure of hydraulic fracturing fluid composition,” *Idaho Law Review*. pp. 11, 12. <http://www.uidaho.edu/~media/Files/orgs/Law/law-review/2013-symposium/Hall.ashx> and June 18, 2013. “Illinois governor signs hydraulic fracturing regulation,” *Oil and Gas Journal*. <http://www.ogj.com/articles/2013/06/illinois-governor-signs-hydraulic-fracturing-regulation.html>). In 2012, there was confirmed fracking activity in at least twenty-nine states. (Natural Resources Defense Council. 2012. *State hydraulic Fracturing Disclosure rules and Enforcement: A Comparison*. p. 7. <http://www.nrdc.org/energy/files/Fracking-Disclosure-IB.pdf>)
- ⁹⁹ Natural Resources Defense Council. 2012. *State hydraulic Fracturing Disclosure rules and Enforcement: A Comparison*. p. 8. <http://www.nrdc.org/energy/files/Fracking-Disclosure-IB.pdf>
- ¹⁰⁰ “. . . the SDWA does not prohibit states from establishing requirements that are stricter than federal requirements.” Tiemann, M., Vann, A. January 10, 2013. *Hydraulic Fracturing and Safe Drinking Water Act Regulatory Issues*. Congressional Research Service Report for Congress. R41760. p. 10. <http://www.fas.org/sgp/crs/misc/R41760.pdf>
- ¹⁰¹ H.R. 1921: Fracturing Responsibility and Awareness of Chemicals Act. 113th Congress, 2013-2015. Available at: <http://www.govtrack.us/congress/bills/113/hr1921/text>
- ¹⁰² Energy In Depth web site: Bell, J. Feb. 18, 2013. “Subtraction through addition via the FRAC Act.” <http://energyindepth.org/national/subtraction-through-addition-via-the-frac-act/> Note: Energy In Depth is a campaign of the Independent Petroleum Association of America.
- ¹⁰³ Wilber, T. January 5, 2012. “Status of the FRAC Act: Gone today, here tomorrow?” *Shale Gas Review*. <http://tomwilber.blogspot.com/2012/01/status-of-frac-act-gone-today-here.html>
- ¹⁰⁴ U.S. Environmental Protection Agency web site: “Hydraulic fracturing chemicals; Chemical information reporting under TSCA section 8(a) and health and safety data reporting under TSCA section 8(d).” <http://yosemite.epa.gov/oepi/rulegate.nsf/byRIN/2070-AJ93>

¹⁰⁵ Culleen, L. and Sahay, S. Oct. 9, 2012. "Additional fracking chemical substance reporting requirements under TSCA may further complicate landscape," Advisories. Arnold & Porter LLP.

http://www.arnoldporter.com/public_document.cfm?id=19067&key=26H3

¹⁰⁶ Waeckerlin, E. and Green, J. Feb. 24, 2012. "Hydraulic fracturing & TSCA: EPA's surprising move and its sweeping implications," Washington Legal Foundation, Legal Backgrounder . Vol. 27, No. 2.

http://www.wlf.org/upload/legalstudies/legalbackgrounder/2-17-12Waeckerlin_LegalBackgrounder.pdf

¹⁰⁷ Bradbury, J., Obeiter, M., Draucker, L., Wang, W. and Stevens, A. April 2013. *Clearing the Air: Reducing Upstream Greenhouse Gas Emissions from U.S. Natural Gas Systems*. World Resources Institute Working Paper.

http://pdf.wri.org/clearing_the_air_full.pdf

¹⁰⁸ U.S. Environmental Protection Agency web site: "EPA issues final air rules for the oil and natural gas industry,"

<http://www.epa.gov/airquality/oilandgas/actions.html>

¹⁰⁹ MSC comment: "MSC believes that the average cost per ton of VOCs reduction without sales may be twenty times greater than that estimated by EPA. The overall cost to the industry to implement [reduced emissions completions] REC's would be substantially higher than the \$20.2 million estimate used by EPA." (p. 32) EPA action: Reduced emissions completions were still required in the final EPA rule. (p. 49497)

MSC comment: "NSPS Subpart OOOO should offer an exemption for all affected facilities handling gas with less than 10% VOC content by weight . . . Controlling VOC emissions from [this] equipment . . . would raise the cost per ton of VOC reduced by a factor of 2 to 5 times." (p. 34) EPA action: No exemption was granted in the final EPA rule. (pp. 49521, 49523).

MSC Comment: ". . . requests that the final regulation include an exemption for wells <5% VOC by weight. . . As the Tons of VOCs per flowback drops towards zero, the cost for doing REC's compared to VOC per ton reductions increases exponentially." (p. 32) EPA action: EPA determined "that providing a low-VOC concentration exclusion would be inappropriate". (p. 49516)

MSC comment: "We believe that the leak threshold for natural gas processing plants should be 10,000 ppm rather than 500 ppm. The compliance burden and cost to maintain leaks below 500 ppm is unreasonably high compared to that for 10,000 ppm. . . could cause a financial impact almost twice that associated with [existing requirements]." (pp. 44, 45) EPA Action: EPA retained the proposed level of 500 ppm. (p. 49492)

(Sources of information MSC Comments: Kathryn Z. Klaber, Marcellus Shale Coalition (MSC). Nov. 30, 2011. *Comments on the Proposed Rule, Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews*, 76 Fed. Reg. 52,738 (Aug. 23, 2011). <http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2010-0505-4246> EPA actions: Federal Register. August 16, 2012. □ Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews; Final Rule. (Environmental Protection Agency). EPA-HQ-OAR-2010-0505. <http://www.gpo.gov/fdsys/pkg/FR-2012-08-16/pdf/2012-16806.pdf>)

¹¹⁰ Cited in: Advanced Resources International Inc. Feb. 2012. *Estimate of Impacts of EPA Proposals to Reduce Air Emissions from Hydraulic Fracturing Operations. Final Report for the American Petroleum Institute*. p. 12.

http://www.api.org/~media/Files/Policy/Hydraulic_Fracturing/NSPS-OG-ARI-Impacts-of-EPA-Air-Rules-Final-Report.pdf

¹¹¹ U.S. Environmental Protection Agency. (No date). *EPA's Air Rules for the Oil and Natural Gas Industry. Summary of Key Changes to the New Source Performance Standard*. p. 1. <http://www.epa.gov/airquality/oilandgas/pdfs/20120417changes.pdf>

¹¹² Table 3 shows that in the Low-REC scenario 8,329 wells are drilled in 2015 (10,974 would have been drilled in the absence of regulation) and in 2016 10,876 wells are drilled (11,507 would have been drilled). By 2017, there is enough equipment to perform RECs on all of the wells that would have otherwise been drilled. (Advanced Resources International Inc. Feb. 2012. *Estimate of Impacts of EPA Proposals to Reduce Air Emissions from Hydraulic Fracturing Operations*. Final Report for the American Petroleum Institute. p. 12. http://www.api.org/~media/Files/Policy/Hydraulic_Fracturing/NSPS-OG-ARI-Impacts-of-EPA-Air-Rules-Final-Report.pdf)

¹¹³ U.S. Environmental Protection Agency. 2008. *Final Revisions to the National Ambient Air Quality Standards for Ozone*. Fact Sheet. http://www.epa.gov/glo/pdfs/2008_03_factsheet.pdf

¹¹⁴ Analysis from: Brandt-Erichsen, S. Sept. 6, 2011. "Obama Administration withdraws proposed ozone standard; fight over air toxics and other EPA rules expected this fall," Marten Law. http://www.martenlaw.com/newsletter/20110906-ozone-standard-proposal#_ednref24

¹¹⁵ U.S. Environmental Protection Agency. July 2011. *Regulatory Impact Analysis – Final National Ambient Air Quality Standard for Ozone*. p. 3. http://www.epa.gov/air/ozonepollution/pdfs/201107_OMBdraft-OzoneRIA.pdf

¹¹⁶ March 20, 2013. "States challenge EPA action on ozone standard," *Argus Media*.

<http://www.argusmedia.com/News/Article?id=839587>

¹¹⁷ Clean Air Scientific Advisory Committee Ozone Review Panel. November 26, 2012. *CASAC Review of the EPA's Policy Assessment for the Review of the Ozone National Ambient Air Quality Standards (First External Review Draft – August 2012)*. EPA-CASAC-13-003. p. 2. [http://yosemite.epa.gov/sab/sabproduct.nsf/0/E67094C7FBBECD8685257AC200727082/\\$File/EPA-CASAC-13-003+unsigned.pdf](http://yosemite.epa.gov/sab/sabproduct.nsf/0/E67094C7FBBECD8685257AC200727082/$File/EPA-CASAC-13-003+unsigned.pdf)

¹¹⁸ Bradbury, J., Obeiter, M., Draucker, L., Wang, W. and Stevens, A. April 2013. *Clearing the Air: Reducing Upstream Greenhouse Gas Emissions from U.S. Natural Gas Systems*. World Resources Institute Working Paper. p. 31.

http://pdf.wri.org/clearing_the_air_full.pdf

¹¹⁹ Wood, D. (BP). 2011. *As An Oil and Gas Director, Why Does Ozone Matter to Me???* Presentation at the Interstate Oil and Gas Compact Commission 2011 Midyear Meeting.

<http://www.ioGCC.state.ok.us/Websites/ioGCC/Images/2011%20Midyear%20Meeting%20Presentations/IOGCC%20Ozone.pdf>

¹²⁰ Hattem, J. May 30, 2013. "Oil industry frets over new smog standard," *The Hill*.

[http://thehill.com/blogs/regwatch/energyenvironment/302573-oil-industry-frets-new-smog-standard-](http://thehill.com/blogs/regwatch/energyenvironment/302573-oil-industry-frets-new-smog-standard)

¹²¹ Federal Register. August 16, 2012. □ *Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews; Final Rule*. (Environmental Protection Agency). EPA-HQ-OAR-2010-0505. p. 49536. <http://www.gpo.gov/fdsys/pkg/FR-2012-08-16/pdf/2012-16806.pdf> Also see: April 28, 2013. "EPA lowered estimates of methane leaks during natural gas production," *Associated Press*. Available at: <http://fuelfix.com/blog/2013/04/28/epa-lowered-estimates-of-methane-leaks-during-natural-gas-production/>

¹²² U.S. Environmental Protection Agency web site: Carbon Pollution Standard for New Power Plants. Basic Information. <http://epa.gov/carbonpollutionstandard/basic.html>

¹²³ Bradbury, J., Obeiter, M., Draucker, L., Wang, W. and Stevens, A. April 2013. *Clearing the Air: Reducing Upstream Greenhouse Gas Emissions from U.S. Natural Gas Systems*. World Resources Institute Working Paper. p. 32. http://pdf.wri.org/clearing_the_air_full.pdf

¹²⁴ Letter from New York Attorney General Eric T. Schneiderman, Connecticut Attorney General George Jepsen, Delaware Attorney General Joseph R. Biden, II, Maryland Attorney General Douglas F. Gansler, Massachusetts Attorney General Martha Coakley, Rhode Island Attorney General Peter Kilmartin and Vermont Attorney General William H. Sorrel to EPA Administrator, Lisa Jackson. Dec. 11, 2012. Clean Air Act Notice of Intent to Sue for Failure to Determine Whether Standards of Performance Are Appropriate for Methane Emissions from Oil and Gas Operations, and to Establish Such Standards and Related Guidelines for New and Existing Sources. http://www.ag.ny.gov/pdfs/ltr_NSPS_Methane_Notice.pdf

¹²⁵ U.S. Environmental Protection Agency. 2012. "Overview of final amendments to air regulations for the oil and natural gas industry." Fact Sheet. <http://www.epa.gov/airquality/oilandgas/pdfs/20120417fs.pdf>

¹²⁶ U.S. Environmental Protection Agency. April 2013. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011*. Chapter 3, p. 3-3. <http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Chapter-3-Energy.pdf>

¹²⁷ Congressional Budget Office. May 2013. *Effects of a Carbon Tax on the Economy and the Environment*. <http://www.cbo.gov/publication/44223>

¹²⁸ Bernie Sanders, U.S. Senator for Vermont web site: Feb. 14, 2013. "Sanders, Boxer Propose Climate Change Bills." <http://www.sanders.senate.gov/newsroom/news/?id=2a869a44-1597-42a8-b625-1a88db3febbc>

¹²⁹ Ramseur, J., Leggett, J., and Sherlock, M. Sept. 17, 2012. *Carbon Tax: Deficit Reduction and Other Considerations*. p. 11. Congressional Research Service Report for Congress. R42731 <http://www.fas.org/sgp/crs/misc/R42731.pdf>

¹³⁰ This is based on 2011 carbon dioxide and methane emissions from natural gas systems in the U.S. (Data are from the most recent greenhouse gas inventory from the U.S. EPA. The agency did not separate out shale gas emissions, so it was not possible to determine the cost to Marcellus and/or Utica shale producers). In EPA's inventory, natural gas systems released 145 million metric tons (145 Teragrams) of carbon dioxide as methane, and 32 million metric tons as carbon dioxide. If we subtract the 19 million metric tons expected to be captured or reduced by the 2012 EPA oil and gas air regulations promulgated in 2012, that leaves 159 million metric tons of carbon dioxide equivalent. At \$20/metric ton, the carbon tax would equal \$3.16 billion for the natural gas industry. (EPA. April 2013. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011*. Chapter 3, p. 3-3. <http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Chapter-3-Energy.pdf>)

¹³¹ Hargreaves, S. August 2, 2012. "Carbon tax gets unusual support," *CNN.Money*. <http://money.cnn.com/2012/07/30/news/economy/carbon-tax/index.htm>

¹³² KPMG International. 2011. *Shale Gas - A Global Perspective*. p. 19. <http://www.gses.com/images/documents/shale-gas-global-perspective.pdf>

¹³³ U.S. Environmental Protection Agency web site: "Natural Gas Extraction – Hydraulic Fracturing." <http://www2.epa.gov/hydraulicfracturing>

¹³⁴ U.S. Environmental Protection Agency web site: Oct. 20, 2011. "EPA Announces Schedule to Develop Natural Gas Wastewater Standards/Announcement is part of administration's priority to ensure natural gas development continues safely and responsibly," Press Release. <http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/91e7fad4b114c4a8525792f00542001!OpenDocument>

¹³⁵ Comments on the Environmental Protection Agency (EPA) Notice: Notice of Final 2010 Effluent Guidelines Program Plan. Docket ID: EPA-HQ-OW-2008-0517. <http://www.regulations.gov/#!docketDetail;D=EPA-HQ-OW-2008-0517>

American Petroleum Institute: "...they would impose arbitrary limits on the oil and gas industry that would hinder domestic production of oil and natural gas."

<http://www.regulations.gov/contentStreamer?objectId=0900006480d000b9&disposition=attachment&contentType=pdf> Chesapeake Energy: "...could result in the imposition of substantial, unwarranted burdens on producers."

<http://www.regulations.gov/contentStreamer?objectId=0900006480ca6dbf&disposition=attachment&contentType=pdf> Range Resources: "...we do not believe that the development of a Shale Gas Extraction pretreatment standard on indirect discharges of produced water is an appropriate or necessary path for EPA to follow at this time. The costs and burdens on the industry are simply not supported by existing facts and information."

<http://www.regulations.gov/contentStreamer?objectId=0900006480f744ec&disposition=attachment&contentType=pdf>

Marcellus Shale Coalition: “MSC does not believe that the development of a Shale Gas Extraction pretreatment standard on indirect discharges of produced water is an appropriate or necessary path for EPA to follow at this time. The costs and burdens on the industry, in addition to the taxpayer, are simply not supported by existing facts and information.”

<http://www.regulations.gov/contentStreamer?objectId=0900006480f733eb&disposition=attachment&contentType=pdf>

¹³⁶ U.S. Environmental Protection Agency. 2002. *Exemption of Oil and Gas Exploration and Production Wastes from Federal Hazardous Waste Regulations*. <http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf>

¹³⁷ Obey, D. April 25, 2013. “Awaiting EPA, Democrat Plans Bill To End RCRA Waiver For Oil, Gas Wastes.” InsideEPA.

¹³⁸ March 1, 2013. “California introduces bill to regulate fracking waste as hazardous waste,” *Waste Business Journal*.

<http://www.wastebusinessjournal.com/news/wbj20130305F.htm>

¹³⁹ Ewart, S. Feb. 27, 2012. “Assembly approves bill to regulate drilling wastewater,” *Legislative Gazette*.

<http://www.legislativegazette.com/Articles-Top-Stories-c-2012-02-27-81381.113122-Assembly-approves-bill-to-regulate-drilling-wastewater.html> and New York Water Rangers web site: June 16, 2011. “New York Water Rangers Applaud Assembly for Acting to Protect State Waters from Hazardous Waste,” Press Release. <http://readme.readmedia.com/New-York-Water-Rangers-Applaud-Assembly-for-Acting-to-Protect-State-Waters-from-Hazardous-Waste/2584049/print>

¹⁴⁰ Ewart, S. Feb. 27, 2012. “Assembly approves bill to regulate drilling wastewater,” *Legislative Gazette*.

<http://www.legislativegazette.com/Articles-Top-Stories-c-2012-02-27-81381.113122-Assembly-approves-bill-to-regulate-drilling-wastewater.html>

¹⁴¹ November 16, 2011. “Kansas supports EPA repeal of oil and gas waste exemption,” *Waste Business Journal*.

<http://www.wastebusinessjournal.com/news/wbj20111122J.htm>

¹⁴² Natural Resources Defense Council. Sept. 8, 2010. “Letter to Lisa Jackson, EPA Administrator Petition for Rulemaking Pursuant to Section 6974(a) of the Resource Conservation and Recovery Act Concerning the Regulation of Wastes Associated with the Exploration, Development, or Production of Crude Oil or Natural Gas or Geothermal Energy.”

http://docs.nrdc.org/energy/files/ene_10091301a.pdf

¹⁴³ Urbina, I. March 1, 2011. “Wastewater recycling no cure-all in gas process,” *New York Times*.

http://www.nytimes.com/2011/03/02/us/02gas.html?pagewanted=all&_r=0

¹⁴⁴ September 16, 1991. “Industry opposes tightening RCRA rules,” *Oil and Gas Journal*.

<http://www.ogj.com/articles/print/volume-89/issue-37/in-this-issue/drilling/industry-opposes-tightening-rcra-rules.html>

¹⁴⁵ See Hughes evidence submitted to the Board on behalf of Council of Canadians.

¹⁴⁶ Pennsylvania Department of Environmental Protection. Jan. 31, 2013. “DEP announces final air quality permit for natural gas operations, proposes new environmental controls,” Press Release.

<http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=19840&typeid=1>

¹⁴⁷ For example, during the draft review period Chesapeake, Range Resources, Anadarko and the Marcellus Shale coalition commented that “FLIR testing on a quarterly basis will not be practical for many operators due to the costs associated with equipment and training.” The response from DEP was that, “The Department believes that quarterly monitoring for leaks using a FLIR camera or other leak detection monitoring device is necessary.” (p. 109) Markwest Liberty commented that, “Requiring reporting on the speciation numerous HAPs would be extremely time-consuming and costly. . . and would greatly increase the resources required to comply with and oversee the program.” DEP responded, “The Department believes that HAPs need to be speciated to accurately assess the impact of these HAPs on the environment. Speciated HAPs were reported in the calendar year 2011 emission inventory from oil and gas industry sources. Consequently, these requirements remain in the final GP-5.” (p. 40) And the Gas Processors Association commented that, “Conditions C.1.(b)(ii) and C.1.(b)(iii) impose CO and NMHC standards of 5 ppm and 10 ppm, respectively. An oxidation catalyst would be required to meet these aggressive emission standards.” DEP Response: “The Department has determined 9 ppmvd @ 15% O₂ (as propane) as [best available technology] for NMNEHC for turbines rated equal to or greater than 1000 bhp and less than 15,000 bhp. . . the Department has determined an NMNEHC emission limit of 5 ppmvd @ 15% O₂ (as propane) . . . for simple cycle turbines rated at equal to or greater than 15,000 BHP.” (pp. 86-88) (Pennsylvania DEP. January 31, 2013. *Comment and Response Document, General Permit GP-5*.

http://www.dep.state.pa.us/dep/deputate/airwaste/aq/permits/gp/January_31_2013-GP5_Comments_and_Response_Document.pdf

¹⁴⁸ Kristi, K. July 30, 2012. “Pennsylvania Commonwealth Court’s decision in Robinson Township v. Commonwealth: Like oil and water, fracking and zoning don’t easily mix (Part II).” Widener Environmental Law Center.

<http://blogs.law.widener.edu/envirolawblog/2012/07/30/pennsylvania-commonwealth-courts-decision-in-robinson-township-v-commonwealth-like-oil-and-water-fracking-and-zoning-dont-easily-mix-part-ii/>

¹⁴⁹ Detrow, S. July 26, 2012. “Commonwealth Court: Act 13’s zoning restrictions are unconstitutional,” *State Impact (a project of National Public Radio)*. <http://stateimpact.npr.org/pennsylvania/2012/07/26/commonwealth-court-rules-on-act-13/>

¹⁵⁰ Marcellus Shale Coalition web site: June 2012. “MSC statement on Pa. Commonwealth Court ruling.”

<http://marcelluscoalition.org/2012/07/msc-statement-on-pennsylvania-commonwealth-court-ruling/>

¹⁵¹ Olson, L. Oct. 17, 2012. “Pennsylvania Supreme Court hears arguments over Marcellus Shale law,” *Pittsburgh Post-Gazette*.

<http://www.post-gazette.com/stories/local/marcellushale/state-supreme-court-hears-arguments-over-marcellus-shale-law-657906/>

¹⁵² March 2013. “Pa court resignation affects Act 13 zoning decision,” *Marcellus Drilling News*.

<http://marcellusdrilling.com/2013/03/pa-supreme-court-resignation-affects-act-13-zoning-decision/>

- ¹⁵³ May 1, 2010. "Proposed Rulemaking. Environmental Quality Board [25 PA. Code Ch. 93] Ambient Water Quality Criterion; Chloride (Ch)." *Pennsylvania Bulletin*. Vol. 40. <http://www.pabulletin.com/secure/data/vol40/40-18/771.html>
- ¹⁵⁴ July 7, 2012. "Proposed Rulemaking. [25 PA. Code Ch. 93] Triennial Review of Water Quality Standards." *Pennsylvania Bulletin*. Vol. 42. <http://www.pabulletin.com/secure/data/vol42/42-27/1292.html>
- ¹⁵⁵ Pennsylvania Department of Environmental Protection. No date. *Rationale for the Development of Ambient Water Quality Criteria for Chloride – Protection of Aquatic Life Use*. http://files.dep.state.pa.us/PublicParticipation/Public%20Participation%20Center/PubPartCenterPortalFiles/Environmental%20Quality%20Board/2012/EQB%20-%20April%2017,%202012/Triennial%20Review/07%20TR13_Rationale-Chloride_Criteria.pdf
- ¹⁵⁶ Pennsylvania Department of Environmental Protection. April 2013. *Comment and Response Document. Triennial Review of Water Quality Standards. Report to Environmental Quality Board*. p. 18. <http://files.dep.state.pa.us/PublicParticipation/Public%20Participation%20Center/PubPartCenterPortalFiles/Environmental%20Quality%20Board/2013/April%2016%20EQB/TRIENNIAL/Comment%20Response%20Document.pdf>
- ¹⁵⁷ *Ibid.* p. 20. See Comment 30: "DEP already has the tools to protect aquatic life in receiving waters from excess salinity associated with chlorides" and DEP's response.
- ¹⁵⁸ *Ibid.* p. 18.
- ¹⁵⁹ *Ibid.* See comment 31, commenter (17) is Consol Energy according to "Commentator List." *Triennial Review of Water Quality Standards – TR13*. <http://files.dep.state.pa.us/PublicParticipation/Public%20Participation%20Center/PubPartCenterPortalFiles/Environmental%20Quality%20Board/2013/April%2016%20EQB/TRIENNIAL/Commentator%20List.pdf>
- ¹⁶⁰ State Impact (a project of National Public Radio) web site: "What The New Impact Fee Law, Act 13, Means For Pennsylvania," <http://stateimpact.npr.org/pennsylvania/tag/impact-fee/>
- ¹⁶¹ May 14, 2013. "Impose real tax on gas," Editorial. *Times-Tribune*. <http://thetimes-tribune.com/opinion/impose-real-tax-on-gas-1.1488625>
- ¹⁶² Pennsylvania Budget and Policy Center. June 18, 2013. "Pennsylvanians shortchanged by drilling fee that fails to keep pace with gas production," Press Release. <http://pennbpc.org/pennsylvanians-shortchanged-drilling-fee-fails-keep-pace-gas-production>
- ¹⁶³ For example, see: Considine, T.J. July 14, 2010. *The Economic Impacts of the Marcellus Shale: Implications for New York, Pennsylvania, and West Virginia*. Prepared for the American Petroleum Institute. p. iv. <http://www.api.org/policy/exploration/hydraulicfracturing/upload/API%20Economic%20Impacts%20Marcellus%20Shale.pdf>
- and Levy, M. September 12, 2010. "Marcellus Shale tax front and center in Capitol," *Times Herald*. <http://www.timesherald.com/articles/2010/09/12/news/doc4c8d7ced6e626784380824.txt>
- ¹⁶⁴ May 11, 2013. "Marcellus shale gas production boom stirs debate over taxes," *Associated Press*. Available at: <http://triblive.com/news/editorspicks/4003784-74/gas-production-fee#axzz2Wt7SNqWz>
- ¹⁶⁵ May 23, 2013. "Marcellus shale gas production boom stirs debate over taxes," *Associated Press*. Available at <http://triblive.com/news/editorspicks/4003784-74/gas-production-fee#axzz2XLTHq5Wn>
- ¹⁶⁶ Nov. 29, 2012. "Democrat John Hanger opens gubernatorial bid," *Central Penn Business Journal*. <http://www.centralpennbusiness.com/article/20121129/CPBJ01/121129839/Democrat-John-Hanger-opens-gubernatorial-bid>
- ¹⁶⁷ May 17, 2013. "Slow start to Utica shale boom," *UPI*. http://www.upi.com/Business_News/Energy-Resources/2013/05/17/Slow-start-to-Utica-shale-boom/UPI-99831368810307/#ixzz2X4Ubh9uy
- ¹⁶⁸ Downing, B. Feb. 11, 2013. "Ohio agencies introduce legislation to strengthen rules on low-level radioactive wastes from drilling," *Akron Beacon Journal*. <http://www.ohio.com/news/ohio-agencies-introduce-legislation-to-strengthen-rules-on-low-level-radioactive-wastes-from-drilling-1.372545>
- ¹⁶⁹ *Ibid.*
- ¹⁷⁰ Belcher, M. and Resnikoff, M. (Radioactive Waste Management Associates). June 13, 2013. *Hydraulic Fracturing Radiological Concerns for Ohio*. Fact sheet prepared for FreshWater Accountability Project Ohio. p. 6. http://rwma.com/OHIO_FACT_SHEET_6-10-13.pdf
- ¹⁷¹ Downing, B. June 18, 2013. "Activists troubled by radiation issue in pending Ohio budget Bill," *Akron Beacon Journal*. <http://www.ohio.com/blogs/drilling/ohio-utica-shale-1.291290/activists-troubled-by-radiation-issues-in-pending-ohio-budget-bill-1.406808>
- ¹⁷² Kasey, P. June 14, 2013. "Ohio budget bill may regulate radioactive oil and gas waste," *Grounded – State Journal Energy Blog*. <http://www.wboy.com/story/22595711/ohio-budget-bill-may-regulate-radioactive-oil-and-gas-waste>
- ¹⁷³ Downing, B. March 30, 2013. "Radiation from drilling may be handled by new Ohio landfill laws," *Akron Beacon Journal*. <http://www.ohio.com/blogs/drilling/ohio-utica-shale-1.291290/radiation-from-drilling-may-be-handled-by-new-ohio-landfill-laws-1.385620>
- ¹⁷⁴ Guernsey Soil & Water Conservation District. March 29, 2013. "Radioactive Drilling Waste Proposal In Budget Could Be Dumped Into Broader Landfill Overhaul." <http://guernseysoil.blogspot.com/2013/03/radioactive-drilling-waste-proposal-in.html>
- ¹⁷⁵ Soraghan, M. June 20, 2012. "More information needed for injection permits, USGS official says." *EnergyWire*. Available at: http://www.eenews.net/special_reports/deep_underground
- ¹⁷⁶ Guth, D. April 29, 2013. "Ohio tries to avoid repeat of 2011 injection well quakes," *West Energy News*. <http://www.midwestenergynews.com/2013/04/29/ohio-tries-to-avoid-repeat-of-2011-fracking-wastewater-injection-well-earthquakes/>

¹⁷⁷ The Oil and Gas chapter of the Ohio Administrative Code says: “The chief may require the following tests or evaluations of a proposed brine injection well. . . Geological investigation of potential faulting within the immediate vicinity of the proposed injection well location, which may include seismic surveys or other methods determined by the chief to assist in identifying potential faulting within the immediate vicinity of the proposed injection well. “ (Ohio Administrative Code. 1501:9-3-06 (C)(2). <http://codes.ohio.gov/oac/1501%3A9-3-06>)

¹⁷⁸ Guth, D. April 29, 2013. “Ohio tries to avoid repeat of 2011 injection well quakes,” *West Energy News*. <http://www.midwestenergynews.com/2013/04/29/ohio-tries-to-avoid-repeat-of-2011-fracking-wastewater-injection-well-earthquakes/>

¹⁷⁹ Downing, B. June 20, 2013. “Hagan pushing higher Ohio severance tax,” *Akron Beacon Journal*. <http://www.ohio.com/blogs/drilling/ohio-utica-shale-1.291290/hagan-pushing-higher-ohio-severance-tax-l-1.407421>

¹⁸⁰ Varden, J. June 7, 2013. “New severance-tax plan offers aid to 33 counties,” *Columbus Dispatch*. <http://www.dispatch.com/content/stories/local/2013/06/06/Kasich-reviving-frack-tax-plan.html>

¹⁸¹ Downing, B. Jan. 2, 2013. “Utica shale development continues slow, steady progress in Ohio,” *Akron Beacon Journal*. <http://www.ohio.com/news/local/utica-shale-development-continues-slow-steady-progress-in-ohio-.361753>

¹⁸² Stewart, T. April 15, 2013. “Oil, gas severance tax hike in Ohio ill-advised,” *Youngstown Vindicator*. <http://www.vindy.com/news/2013/apr/15/oil-gas-severance-tax-hike-in-ohio-ill-a/?newswatch>

¹⁸³ Begos, K. February 14, 2013. “Marcellus shale gas boom expected to slow in 2013,” *Associated Press*. Available at: <http://www.dailylocal.com/article/20130215/NEWS03/130219731/marcellus-shale-gas-boom-expected-to-slow-in-2013>

¹⁸⁴ Kasey, P. March 23, 2013. “DEP’s late drilling studies: quality is important, but so is speed,” *State Journal*. <http://www.statejournal.com/story/21299956/dep-late-horizontal-drilling-studies-quality-important-so-is-speed>

¹⁸⁵ Sinding, K. Nov. 9, 2012. “Growing trend in support of municipal anti-fracking initiatives,” Natural Resources Defense Council. http://switchboard.nrdc.org/blogs/ksinding/growing_trend_in_support_of_mu.html

¹⁸⁶ Ditrick, P. May 2, 2013. “New york appeals court says town can ban hydraulic fracturing,” *Oil and Gas Journal*. <http://www.ogi.com/articles/2013/05/new-york-appeals-court-says-towns-can-ban-hydraulic-fracturing.html?mpid=EnDailyMay22013>

¹⁸⁷ In 2011, Summit County Common Pleas Judge Mary Margaret Rowlands ruled Beck Energy Corp. needed to follow city rules required of all developers, which included paying application fees and acquiring a performance bond. An appeals court later restricted the areas where municipalities could regulate drillers to excavation and rights-of-way. (Downing, B. June 20, 2013. “Ohio Supreme Court agrees to heard drilling appeal from Munroe Falls,” *Akron Beacon Journal*.

<http://www.ohio.com/news/local/ohio-supreme-court-agrees-to-hear-drilling-appeal-from-munroe-falls-1.407534>)

¹⁸⁸ FracTracker web site: “Current High Volume Horizontal Hydraulic Fracturing Drilling Bans and Moratoria in NY State.” Updated June 6, 2013. <http://www.fracktracker.org/maps/ny-moratoria/#.UK067LM-Pcw.wordpress>

¹⁸⁹ Downing, B. Nov. 8, 2012. “Broadview Heights, Mansfield approve anti-drilling provisions,” *Akron Beacon Journal*. <http://www.ohio.com/blogs/drilling/ohio-utica-shale-1.291290/broadview-heights-mansfield-approve-anti-drilling-provisions-1.348611> and DeWitt, D. May 8, 2013. “City backs statewide injection-well ban,” *Athens News*.

<http://www.athensnews.com/ohio/article-39784-city-backs-statewide-injection-well-ban.html>

¹⁹⁰ See: Food and Water Watch web site: “Local actions against fracking,”

<http://www.foodandwaterwatch.org/water/fracking/fracking-action-center/local-action-documents/>; Concerned Citizens of Medina County web site: “Existing bans on hydrofracking in Ohio,” <http://fracking.weebly.com/existing-bans.html>; Network for Oil and Gas Accountability and Protection. April 2012. “Partial list (unofficial) of bans and moratoria on hydrofracking,” <http://www.neogap.org/neogap/wp-content/uploads/2012/04/1305-Bans-and-Moratoria-Revised.categories-4-5-12.doc>

¹⁹¹ Henkel, K., Starmack, J. and Luthern, A. Jan. 1, 2012. “Ohio bans injection wells near D&L site in Youngstown,” *Youngstown Vindicator*. <http://www.vindy.com/news/2012/jan/01/ohio-bans-injection-wells-near-dl-site-youngstown/>

¹⁹² Downing, B. Aug. 2, 2012. “Cincinnati bans injection wells, an Ohio first,” *Akron Beacon Journal*. <http://www.ohio.com/blogs/drilling/ohio-utica-shale-1.291290/cincinnati-bans-injection-wells-an-ohio-first-1.324187>

¹⁹³ Community Environmental Legal Defense Fund web site: Ordinances. Oil and Gas Drilling. <http://celdf.org/ordinance-archive?preview=1&cache=0>

¹⁹⁴ National Conference of State Legislators web site: Pless, J. July 2011. “Fracking Update: What states are doing to ensure safe natural gas extraction.” <http://www.ncsl.org/issues-research/energyhome/fracking-update-what-states-are-doing.aspx>

¹⁹⁵ Brown, E., Hartman, K., Borick, C., Rab, B. and Ivacko, T. May 2013. *Public Opinion on Fracking: Perspectives from Michigan and Pennsylvania*. p. 19. <http://closup.umich.edu/files/nsee-fracking-fall-2012.pdf>

¹⁹⁶ New York’s Department of Environmental Conservation (“DEC”) has been studying the potential adverse effects of hydraulic fracturing since 2008. In 2010, the NY Assembly and Senate passed temporary bans on hydraulic fracturing so that the state could investigate the safety and environmental concerns. Then NY governor David Paterson issued an executive order prohibiting hydraulic fracturing in New York until DEC completed a comprehensive review of hydraulic fracturing and its potential impacts. (Hoye, S. Dec. 13, 2010. “New York governor pauses ‘fracking’,” *CNN*. <http://www.cnn.com/2010/US/12/13/new.york.fracking.moratorium/index.html>)

¹⁹⁷ New York Department of Environmental Conservation. Sept. 20, 2012. “Commissioner Martens Rejects Call for “Independent” Health Study of High Volume Hydraulic Fracturing - Announces State Health Commissioner to Assess Health Impacts,” Press Release. <http://www.dec.ny.gov/press/85071.html>

¹⁹⁸ Sinding, K. Feb. 13, 2013. "Doctor's orders; no decisions on fracking in NY until health impacts are more fully considered." Natural Resources Defense Council Switchboard.

http://switchboard.nrdc.org/blogs/ksinding/doctors_orders_no_decisions_on.html

¹⁹⁹ Bieniek, M. March 6, 2013. "Natural gas fracking ban dies, moratorium still considered." *Cumberland Times-News*.

<http://times-news.com/local/x657747706/Natural-gas-fracking-ban-dies-moratorium-still-considered>

²⁰⁰ Hallenbeck, T. May 16, 2012. "Vermont Governor signs bill banning hydraulic fracturing," *Burlington Free Press*. Available at: <http://www.damascuscitizensforsustainability.org/2012/05/vermont-governor-signs-bill-banning-hydraulic-fracturing/>

²⁰¹ Vardon, J. July 12, 2012. "Kasich prohibits drilling in or under Lake Erie," *The Columbus Dispatch*.

<http://www.dispatch.com/content/stories/local/2012/07/12/kasich-prohibits-drilling-in-under-lake-erie.html>

²⁰² Campbell, J. March 7, 2013. "Assembly passes 2-year fracking moratorium," *WGRZ News*.

<http://www.wgrz.com/news/article/204405/1/Assembly-Passes-2-Year-Fracking-Moratorium>

²⁰³ New York State Senator Cecilia Tkaczyk web site: May 15, 2013. "Tkaczyk proposes ban on hazardous fracking waste being shipped into New York." <http://www.nysenate.gov/press-release/tkaczyk-proposes-ban-hazardous-fracking-waste-being-shipped-new-york-state>

²⁰⁴ O'Neill, J. June 18, 2013. "Activists keep pushing for N.J. ban on fracking waste," *NorthJersey.com*.

http://www.northjersey.com/news/212099301_Activists_keep_pushing_for_N_J_ban_on_fracking_waste.html

²⁰⁵ Augenstein, S. June 20, 2013. "Fracking waste ban in N.J. pushed by lobbyists as Legislature considers bill," *New Jersey.com*.

http://www.nj.com/news/index.ssf/2013/06/fracking_waste_ban_in_nj_pushed_by_lobbyists_as_legislature_considers_bill.html

²⁰⁶ Morgan, R. June 4, 2013. "Ohio legislators trying to ban injection wells," *Shale Reporter*.

http://www.shalereporter.com/government/article_4063cb3e-cd14-11e2-986b-0019bb30f31a.html View bill at 130th General Assembly of the State of Ohio web site: http://www.legislature.state.oh.us/bills.cfm?ID=130_HB_148 and see Status Report of Legislation: <http://lsc.state.oh.us/coderev/hou130.nsf/House+Bill+Number/0148?OpenDocument>

²⁰⁷ Gray, K. April 17, 2013. "Fracking opponents can start gathering signatures for a 2014 ballot proposal," *Detroit Free Press*.

<http://www.freep.com/article/20130417/NEWS15/304170109/fracking-ban-supporters-in-MIchigan-can-gather-signature-2014-ballot>

²⁰⁸ State Senator Jim Ferlo web site: April 30, 2013. "Senator Ferlo announces legislation for shale drilling moratorium."

<http://www.senatorferlo.com/senator-ferlo-announces-legislation-for-shale-drilling-moratorium>

²⁰⁹ LegiScan web site: Search Pennsylvania, moratorium. <http://legiscan.com/gaits/search?state=PA&keyword=moratorium>