

CONSIDERING SHALE GAS EXTRACTION IN NORTH CAROLINA: LESSONS FROM OTHER STATES

SARAH K. ADAIR, BROOKS RAINEY PEARSON, JONAS MONAST,
AVNER VENGOSH & ROBERT B. JACKSON[†]

INTRODUCTION

In 2009, the North Carolina Geological Survey (NCGS) announced the existence of shale gas underlying the Deep and Dan River Basins in twelve North Carolina counties, including Lee, Chatham, and Moore.¹ Following NCGS's initial announcement, several small companies began leasing mineral rights from landowners in Lee County,² and the state legislature began to consider policy changes that would be necessary to develop the shale gas resource. To this end, on June 23, 2011, Governor Beverly Perdue signed Session Law 2011-276, which directs the North Carolina Department of Environment and Natural Resources (DENR) to conduct a study and hold public hearings on the issues of horizontal drilling and hydraulic fracturing for shale gas extraction.³ Unlike

[†] Sarah Adair (formerly Plikunas) is an Associate in Research at the Duke University Nicholas Institute for Environmental Policy Solutions; Brooks Rainey Pearson is Policy Counsel for Energy and Climate at the Nicholas Institute; Jonas Monast is Director of the Climate and Energy Program at the Nicholas Institute; Avner Vengosh is a Professor at the Duke University Nicholas School of the Environment; and Rob Jackson is a Professor at the Nicholas School of the Environment and Director of the Duke University Center on Global Change. The authors would like to thank Richard Newell of the Nicholas School of the Environment and Susan Tierney of the Natural Gas Subcommittee of the Secretary of Energy Advisory Board for their helpful comments.

1. JEFFREY C. REID & KENNETH B. TAYLOR, N.C. GEOLOGICAL SURVEY, SHALE GAS POTENTIAL IN THE TRIASSIC STRATA OF THE DEEP RIVER BASIN, LEE AND CHATHAM COUNTIES, NORTH CAROLINA WITH PIPELINE AND INFRASTRUCTURE DATA (2009), available at http://www.geology.enr.state.nc.us/pubs/PDF/NCGS_OFR_2009-01_20090709.pdf.

2. John Murawski, *Natural Gas Rights Going Fast in Lee County*, NEWS & OBSERVER (June 26, 2010), <http://www.newsobserver.com/2010/06/26/552175/gas-rights-going-fast-in-lee.html#storylink=misearch>.

3. Act of June 17, 2011, §§ 4-6, 2011 N.C. Sess. Laws 276. DENR published a draft of the study in March 2012. See N.C. DEP'T OF ENV'T & NATURAL RES., N.C. DEP'T OF COMMERCE,

conventional natural gas resources, shale gas is contained in relatively impermeable source rock, which means that it does not migrate out of the source rock and into a reservoir where drillers can easily access it.⁴ Large-scale production of shale gas has only become economically viable in recent years due to advances in horizontal drilling and hydraulic fracturing techniques, which can dramatically increase the flow of gas.⁵

The DENR study was released to the legislature in May 2012.⁶ In conducting the study, DENR was required to investigate and report on the following: North Carolina's potential oil and gas resources; methods of exploration and production; impacts on infrastructure and water resources; environmental, economic, and social impacts; administrative issues associated with a regulatory program for the oil and gas industry; consumer protection and legal considerations; and other pertinent issues.⁷ DENR's study addresses some categories of environmental impacts of natural gas extraction in North Carolina that are not addressed in this article, including stormwater management, impacts on fish and wildlife, and reclamation of drilling sites.⁸ Session Law 2011-276 followed a robust debate regarding natural gas exploration in the state, and the legislature may revisit the issue now that DENR has released its study.

Session Law 2011-276 is a significant step because North Carolina law currently prohibits both horizontal drilling and the injection of waste (including hydraulic fracturing fluids) into wells, creating a de facto ban on hydraulic fracturing.⁹ North Carolina also

N.C. DEP'T OF JUSTICE & RAFI-USA, DRAFT NORTH CAROLINA OIL AND GAS STUDY UNDER SESSION LAW 2011-276 (2012), available at <http://portal.ncdenr.org/web/guest/denr-study>.

4. *Energy in Brief: What Is Shale Gas and Why Is It Important?*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/energy_in_brief/about_shale_gas.cfm (last updated Feb. 14, 2012).

5. *Id.*

6. N.C. DEP'T ENV'T & NATURAL RES. & N.C. DEP'T OF COMMERCE, NORTH CAROLINA OIL AND GAS STUDY UNDER SESSION LAW 2011-276 (2012), available at <http://portal.ncdenr.org/web/guest/denr-study>.

7. Act of June 17, 2011, §§ 4–6; see also *Shale Gas: Overview/Introduction*, N.C. DEP'T ENV'T & NATURAL RES., <http://portal.ncdenr.org/web/guest/shale-gas> (last visited Feb. 10, 2012) (introducing the DENR study). DENR has released a draft study plan and has solicited public comments on the plan both in writing and at a public meeting. *Shale Gas: DENR Study*, N.C. DEP'T ENV'T & NATURAL RES., <http://portal.ncdenr.org/web/guest/denr-study> (last visited Feb. 22, 2012).

8. See *Shale Gas: DENR Study*, *supra* note 7 (outlining the study plan).

9. N.C. GEN. STAT. § 113-390 (2010) (prohibiting the “waste of oil or gas as defined in this law”); *id.* § 113-389(14)(f) (defining waste as including, inter alia, “drowning with water of any stratum or part thereof capable of producing oil or gas”); *id.* § 113-393(d) (prohibiting oil and

has no active oil and gas production and no comprehensive regulatory framework for this industry. Therefore, North Carolina policymakers have the opportunity to evaluate concerns regarding shale gas extraction—including environmental and economic consequences as well as impacts on local communities—and to determine whether this activity is appropriate for the state. If they choose to allow shale gas extraction in the state, they can create a regulatory structure that will address potential environmental, health, and safety risks at the outset, before any shale gas wells are drilled.

The experiences of other states can provide valuable insight into the risks that accompany shale gas extraction, and the policy decisions that those states have made in an attempt to mitigate those risks can inform North Carolina lawmakers as they consider whether and under what conditions to allow shale gas extraction. Specifically, these experiences can help North Carolina policymakers define the risks that an effective regulatory program would need to address. If North Carolina's elected officials determine that shale gas extraction is appropriate for the state, policymakers should take full advantage of the opportunity to build a regulatory program from the ground up and should carefully consider all opportunities to improve upon current practices.

Such a careful perspective is especially important because North Carolina policy makers are already introducing fast-track bills to legalize horizontal drilling and hydraulic fracturing in the state. In April 2012, State Senator Robert Rucho introduced a draft bill that would legalize both processes immediately, subject to a temporary, two-year moratorium to be lifted in 2014.¹⁰ The Rucho bill also proposes to establish an independent Oil and Gas Board, removing environmental oversight from DENR.¹¹

This article does not take a position on the effectiveness of any state's regulatory program or on the merits of natural gas exploration in North Carolina. Instead, it focuses on the range of environmental issues that North Carolina lawmakers will need to understand as they consider allowing natural gas production through horizontal drilling and hydraulic fracturing.

gas wells that “vary from the vertical”); *see also* 15 N.C. ADMIN. CODE 02C.0209 (2011) (prohibiting injection wells); 15A N.C. ADMIN. CODE 05D.0107(e) (allowing a maximum variation from the vertical of three degrees).

10. S. 820, Gen. Assemb., Sess. 2011–12 (N.C. 2012), *available at* <http://www.ncleg.net/gascripts/BillLookUp/BillLookUp.pl?Session=2011&BillID=S820>.

11. *Id.*

Many states with shale gas resources are experiencing dramatic increases in gas production. Policymakers in those states are developing regulatory structures to address the local and regional impacts of shale gas extraction, which is a relatively new practice. This article groups the challenges facing these states into three broad categories: (1) pre-drilling information needs and regulatory structure, (2) regulation and drilling operations, and (3) addressing spills and other accidents.

First, the article will discuss pre-drilling information needs and regulatory structure. In many states, existing oil and gas regulatory programs allow shale gas extraction. Some of these states are retrospectively identifying a need for comprehensive baseline data and sufficient staff and funding to accommodate the rapidly growing shale gas industry. This section of the article discusses the need for baseline data regarding water quality, disclosure of chemicals used during hydraulic fracturing, and the development and funding of a regulatory program.

Second, the article addresses regulation of drilling operations. Shale gas extraction has the potential to damage the environment and compete with other land uses at each stage of the drilling and production process. Some states are now revisiting their oil and gas regulations to account for increased risks associated with hydraulic fracturing and horizontal drilling. This section of the article discusses issues associated with normal shale gas extraction operations, including impacts on water supply; land-use impacts and property rights; impacts from wastewater storage, treatment, and disposal; and air-quality impacts.

Third, the article will examine the prevention of and response to spills and other accidents. Accidents and equipment failures can cause leaks, spills, and environmental contamination even under the most effective regulatory programs. This section of the article addresses risks associated with shale gas production, including incidents during the drilling process—such as well blowouts and well casing or cementing failures—and improper disposal or spills of wastes, including drill cuttings and mud. It describes how other states are responding to reduce the occurrence of spills and accidents and how they are handling spill-response planning and liability.

In the context of each of these challenges, this article summarizes both the issues that may arise as a result of shale gas drilling and the regulatory approaches taken by other states, including pending regulations. In addition, the article discusses recommendations by the

State Review of Oil and Natural Gas Environmental Regulations (STRONGER)—a non-profit partnership of the federal government, industry, and states that conducts reviews of existing state oil and gas regulations¹²—and recommendations by the U.S. Department of Energy’s Secretary of Energy Advisory Board (SEAB) Shale Gas Subcommittee.¹³ This information can provide a foundation for North Carolina policymakers, citizens, and industry leaders to evaluate and avoid or mitigate negative impacts of shale gas extraction, keeping in mind that industry practices and regulatory approaches are rapidly evolving and that there is significant regional variation in the geology of shale deposits.

I. SHALE GAS OVERVIEW

A. *What Is Shale Gas?*

Conventional natural gas reservoirs form when gas migrates toward the Earth’s surface from organic-rich source rock and becomes trapped by a layer of impermeable rock.¹⁴ Producers can access the gas by drilling vertical wells into the area where the gas is present, allowing it to flow to the surface. Shale gas resources, however, are contained within relatively impermeable source rock, meaning that the gas does not migrate out of the source rock and into a reservoir where drillers can easily access it.¹⁵ Pairing horizontal wells with hydraulic fracturing allows for natural gas recovery in areas where it was previously uneconomical.¹⁶ Because widespread extraction of shale gas is relatively new, shale gas is—along with tight gas and coalbed methane—often referred to as “unconventional” natural gas.

To drill and fracture a shale gas well, operators first drill down vertically until they reach the shale formation. Within the target shale formation, the operators then drill horizontally and create a lateral

12. *An Overview of Stronger*, STRONGER, <http://www.strongerinc.org/about/overview.asp> (last visited Mar. 17, 2012).

13. *About the Subcommittee*, NATURAL GAS SUBCOMM., SEC’Y OF ENERGY ADVISORY BD., <http://www.shalegas.energy.gov/aboutus/index.html> (last visited Mar. 17, 2012).

14. *See Energy in Brief*, *supra* note 4.

15. *Id.*

16. *See* GROUND WATER PROT. COUNCIL & ALL CONSULTING, MODERN SHALE GAS DEVELOPMENT IN THE UNITED STATES: A PRIMER, at ES-5, 9 (2009), *available at* www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf.

well through the shale rock.¹⁷ In Pennsylvania's Marcellus Shale formation, for example, a typical horizontal well extends from 2000 to 6000 feet.¹⁸ Once the horizontal well is complete, producers pump fracturing fluid into it at a pressure sufficient to create fractures in the rock formation. These fractures allow the gas to flow from the pockets in the formation into the well.¹⁹ Fracturing fluid is composed of up to ninety-nine percent water, but it also contains hundreds of thousands of pounds of both chemical additives and propping agents (also called "proppants").²⁰ The chemicals added to fracturing fluid include friction reducers, surfactants, gelling agents, scale inhibitors, pH-adjusting agents, corrosion inhibitors, antibacterial agents, and clay stabilizers.²¹ Injecting propping agents, typically sand, into the fractures created by the injected fluid ensures that the fractures remain open during extraction.²² Operators can re-fracture a well many times to stimulate the flow of additional gas from the same formation.²³

B. The Expansion of Shale Gas Extraction

The extraction of natural gas from shale formations is one of the fastest-growing trends in American onshore domestic oil and gas production.²⁴ Unconventional natural gas is expected to contribute an increasingly large percentage of domestic natural gas production in

17. See, e.g., David D. Cramer, *Stimulating Unconventional Reservoirs: Lessons Learned, Successful Practices, Areas for Improvement 2-3* (Soc'y of Petroleum Eng'rs Paper SPE 114172, 2008).

18. J. DANIEL ARTHUR ET AL., AN OVERVIEW OF MODERN SHALE GAS DEVELOPMENT IN THE UNITED STATES 18 (2008), available at <http://www.all-llc.com/publicdownloads/ALLShaleOverviewFINAL.pdf>.

19. GROUND WATER PROT. COUNCIL, STATE OIL AND NATURAL GAS REGULATIONS DESIGNED TO PROTECT WATER RESOURCES 21 (2009), available at [http://www.gwpc.org/e-library/documents/general/State Oil and Gas Regulations Designed to Protect Water Resources.pdf](http://www.gwpc.org/e-library/documents/general/State%20Oil%20and%20Gas%20Regulations%20Designed%20to%20Protect%20Water%20Resources.pdf).

20. See U.S. ENVTL. PROT. AGENCY, HYDRAULIC FRACTURING RESEARCH STUDY 1-2 (2010) [hereinafter EPA, FRACTURING RESEARCH STUDY], available at <http://www.epa.gov/safewater/uic/pdfs/hfresearchstudyfs.pdf>.

21. See generally P. Kaufman et al., *Critical Evaluations of Additives Used in Shale Slickwater Fracs* (Soc'y of Petroleum Eng'rs, Paper SPE 119900, 2008) (describing the various categories of additives).

22. Travis Zeik, Student Work, *Hydraulic Fracturing Goes to Court: How Texas Jurisprudence on Subsurface Trespass Will Influence West Virginia Oil and Gas Law*, 112 W. VA. L. REV. 599, 604 (2010).

23. LISA SUMI, EARTHWORKS, SHALE GAS: FOCUS ON THE MARCELLUS SHALE 11 (2008).

24. See *id.* at 7 (graphing the trend in onshore unconventional gas extraction).

the coming years.²⁵ The U.S. Energy Information Administration predicts an almost four-fold increase in shale gas production between 2009 and 2035.²⁶

The boom in natural gas production can be attributed to technological improvements in directional drilling and hydraulic fracturing.²⁷ The combination of the two activities maximizes the extraction of natural gas from unconventional sources.²⁸ The activity in Pennsylvania's Marcellus Shale basin is a prime example of the rapid expansion of shale gas extraction in recent years: 195 wells were drilled in 2008, 768 in 2009, 1386 in 2010, and 1937 in 2011.²⁹

C. Shale Gas Resources in North Carolina

North Carolina state geologists recently identified a layer of shale rock that may contain producible natural gas resources in the Triassic strata of both the Deep River and Dan River Basins.³⁰ To date, exploratory drilling has not found commercially producible oil or gas anywhere in the state.³¹ However, test results from several wells in Lee County have documented the presence of natural gas.³² In 2011, NCGS estimated the natural gas potential of 59,000 acres below Lee, Moore, and Sanford counties and sent the results to the U.S. Geological Survey (USGS) for a second opinion.³³ As of the time of publication, the NCGS estimate has not been made public, and the USGS has not yet produced its own estimate.³⁴

25. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2011 WITH PROJECTIONS TO 2035, at 2 (2011).

26. *Id.*

27. *See* GROUND WATER PROT. COUNCIL & ALL CONSULTING, *supra* note 16, at ES-3 to ES-4, 56-57.

28. *Id.* at ES-3 to ES-4.

29. Judy Chambers, *Marcellus Shale Natural Gas: What the 'Gold Rush' Means for Us*, PENN STATE EXTENSION (May 16, 2011), <http://extension.psu.edu/adams/news/2011/marcellus-shale-natural-gas-what-the-2018gold-rush2019-means-for-us>; *Marcellus Shale Permits Issued & Wells Drilled*, BUREAU OF OIL & GAS MGMT., DEP'T OF ENVTL. PROT. (Jan. 12, 2012), <http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/2012/2011Wellspermitte-drilled.pdf>.

30. JEFFREY C. REID, N.C. GEOLOGICAL SURVEY, INFORMATION CIRCULAR 36: NATURAL GAS AND OIL IN NORTH CAROLINA 3 (2009), *available at* www.geology.enr.state.nc.us/pubs/PDF/NCGS_IC_36_Oil_and_Gas.pdf.

31. *See generally id.* (describing North Carolina geology and noting that oil and gas "are not currently produced in the state").

32. *See id.*

33. Michael Futch, *The Shale Gas Boom: Energy Exploration in Carolina*, FAYETTEVILLE OBSERVER (May 22, 2011), <http://fayobserver.com/articles/2011/05/22/1084179?sac=Home>.

34. *See id.*

North Carolina's natural gas production potential is small compared to that of other states. The Marcellus Shale basin, which comprises 60.8 million acres underneath Pennsylvania, New York, and West Virginia, is three orders of magnitude larger than North Carolina's Sanford sub-basin.³⁵ The second-largest shale gas plays in the United States, the Haynesville and Barnett shale basins, span nearly 5.8 million and 3.2 million acres, respectively.³⁶

North Carolina's shale rock formations differ from the shale gas plays currently active in the United States in that they formed from organic matter associated with a freshwater environment rather than a marine environment.³⁷ It is unclear how North Carolina's freshwater formations would affect the shale gas production process. The geology of the formations may affect the types of chemicals that will need to be used during the drilling and fracturing process, as well as the environmental impacts of materials removed from the well along with natural gas, such as drill cuttings and wastewater.³⁸

D. Opportunity for Development of a Legal Framework for Shale Gas Extraction in North Carolina

Large-scale unconventional natural gas extraction presents a number of new environmental challenges to be addressed by state policymakers. These challenges include securing critical baseline data on pre-drilling water quality, funding regulatory programs, minimizing risks of spills and contamination, assuring attainment of federal ground-level air quality standards, and identifying options for wastewater treatment. States are responding to these challenges with a range of policies and regulations aimed at reducing the environmental impacts of shale gas extraction while keeping the costs of extraction as low as possible.

35. Elwin Green, *Marcellus Shale Could Be a Boon or Bane for Landowners*, PITT. POST-GAZETTE (Feb. 28, 2010), <http://www.post-gazette.com/pg/10059/1038976-28.stm>.

36. GROUND WATER PROT. COUNCIL & ALL CONSULTING, *supra* note 16, at 18, 20; *Barnett Shale Information*, R.R. COMM'N TEX., <http://www.rrc.state.tx.us/barnettshale/index.php> (last updated Feb. 17, 2012); *see also* U.S. ENERGY INFO. ADMIN., REVIEW OF EMERGING RESOURCES: U.S. SHALE GAS AND SHALE OIL PLAYS 37, 51 (2011) (providing a larger estimate of the Barnett shale basin at 4.1 million acres).

37. Paul E. Olsen et al., *Rift Basins of Early Mesozoic Age*, in THE GEOLOGY OF THE CAROLINAS 142 (J. Wright Horton, Jr. & Victor A. Zullo eds., 1991).

38. JEFFREY C. REID ET AL., NATURAL GAS POTENTIAL OF THE SANFORD SUB-BASIN, DEEP RIVER BASIN, NORTH CAROLINA (2011), *available at* http://www.searchanddiscovery.com/documents/2011/10366reid/ndx_reid.pdf.

Because North Carolina has no active oil and gas industry, it also lacks a comprehensive oil and gas regulatory program. If North Carolina lawmakers choose to allow shale gas production, they could learn from the experiences of other states, with the understanding that the relevant practices and regulations are constantly evolving. In developing its regulations, North Carolina would have the opportunity to design a comprehensive and streamlined program that addresses the environmental and public-health risks associated with shale gas extraction. In addition to designing a regulatory program, the state would have to decide whether to house it within an existing agency—such as DENR—or to create an independent regulatory commission, as proposed in Senator Robert Rucho’s draft bill, noted above.³⁹

III. PRE-DRILLING: INFORMATION NEEDS AND REGULATORY STRUCTURE

A. *Baseline Data on Water Quality*

Baseline data are critical for determining whether shale gas production is a source of water contamination, and if so, at what stage of the extraction process does the contamination occur. The ability to compare water samples collected before, during, and after each stage of drilling allows industry and regulators to identify and address problems early on. Baseline data can also help both landowners and industry avoid lengthy litigation regarding the source of the water pollution.

To our knowledge, no state has collected comprehensive baseline data at each stage of shale gas production. However, some states are beginning to respond to the need for additional scientific information by encouraging the industry to gather information before drilling new wells and to disclose chemicals used during the fracturing process. Because North Carolina’s existing law creates an effective ban on shale gas extraction,⁴⁰ the state has the opportunity to require collection of critical baseline information and establishment of protocols for water-quality monitoring throughout the drilling process before allowing any shale gas wells to be drilled.

39. S. 820, Gen. Assemb., Sess. 2011–12 (N.C. 2012), available at <http://www.ncleg.net/gascrpts/BillLookUp/BillLookUp.pl?Session=2011&BillID=S820>.

40. See *supra* note 9 and accompanying text.

1. Experiences in Other States

Numerous claims have been made that hydraulic fracturing has resulted in the contamination of private water wells and other groundwater resources.⁴¹ Landowners near shale gas operations have reported the presence of odors, silt, discoloration, methane gas, and chemicals such as benzene, mercury, naphthalene, and selenium in their tap water.⁴² A recent EPA investigation conducted near Pavillion, Wyoming, concludes that scientific evidence links groundwater contamination there to hydraulic fracturing; however, it is still under debate what conclusions can be drawn from the study results.⁴³ Without reliable baseline data, regulators find it difficult to distinguish between cases of pre-existing contamination and cases of contamination traceable to hydraulic fracturing. Gathering baseline data is complicated by the fact that many wells in rural areas are private, and the ability of state or federal agencies to conduct baseline studies is therefore limited by private property rights and the willingness of private landowners to participate.

Determining whether shale gas production causes groundwater contamination is further complicated by the fact that various pollutants are associated with the production process and that those pollutants can reach water supplies through multiple pathways, such as natural fractures and abandoned wells.⁴⁴ Over years of gas production, a single well can produce millions of gallons of waste fluids that can contain many pollutants, including naturally occurring chemicals derived from formation water as well as synthetic chemicals added to fracturing fluid.⁴⁵

41. See, e.g., Amy Mall, *Incidents Where Hydraulic Fracturing Is a Suspected Cause of Drinking Water Contamination*, SWITCHBOARD, http://switchboard.nrdc.org/blogs/amall/incidents_where_hydraulic_frac.html (last updated Dec. 19, 2011); BRYAN SWISTOCK, PENN. ST. SCH. OF FOREST RES., *GAS WELL DRILLING AND YOUR PRIVATE WATER SUPPLY 1* (2011), available at extension.psu.edu/water/marcellus-shale/drinking-water/gas-well-drilling-and-your-private-water-supply-2.

42. Mall, *supra* note 41.

43. See DOMINIC C. DIGILIO ET AL., U.S. ENVTL. PROT. AGENCY, *DRAFT INVESTIGATION OF GROUND WATER CONTAMINATION NEAR PAVILLION, WYOMING* (2011).

44. JOHN W. UBINGER ET AL., PENN. ENVTL. COUNCIL, *DEVELOPING THE MARCELLUS SHALE: ENVIRONMENTAL POLICY AND PLANNING RECOMMENDATIONS FOR THE DEVELOPMENT OF THE MARCELLUS SHALE PLAY IN PENNSYLVANIA 17* (2010), available at <http://marcellus.pecpa.org/wp-content/uploads/2011/06/Developing-the-Marcellus-Shale.pdf>.

45. SWISTOCK, *supra* note 41, at 1; EPA, *FRACTURING RESEARCH STUDY*, *supra* note 20, at 2.

The migration of methane and other gases to nearby private drinking-water wells is an additional concern with hydraulic fracturing. Methane is the primary constituent of shale gas, typically comprising more than ninety percent of the shale-gas mixture.⁴⁶ A recent peer-reviewed study conducted by researchers at Duke University provides the first systematic evidence of high methane concentrations in drinking water near shale gas wells in Pennsylvania and New York.⁴⁷ The methane found in those wells has a similar geochemical makeup as the methane found in shale gas reservoirs, as opposed to methane occurring naturally in some shallow waters.⁴⁸ However, the study did not determine the exact mechanism of methane contamination or whether the methane in the drinking water resulted from leaky well casings or poor cement quality, both of which are more likely than a third possibility, migration from a depth associated with hydraulic fracturing.⁴⁹

2. Overview of Regulatory Action

Some states are creating or expanding incentives for industry to test wells, or are using state funds to pay for testing. In addition, some states are also requiring companies to disclose the chemicals used in fracturing fluid. Pre-drilling tests can then check for the presence of specific chemicals that will be injected into the ground during hydraulic fracturing, and the results can be used as a baseline against which to compare samples collected later in the drilling process.

a. Pre-Drilling Water Quality Testing

The U.S. Department of Energy's SEAB Shale Gas Subcommittee recently released its draft recommendations for reducing the environmental impact and improving the safety of shale gas production.⁵⁰ One of these recommendations is that state regulators adopt requirements for background water-quality measurements and reporting of results prior to shale gas production.⁵¹

46. Creties D. Jenkins & Charles M. Boyer II, *Coalbed- and Shale-Gas Reservoirs*, 60 J. PETROLEUM TECH. 92, 92 (2008).

47. Stephen G. Osborn et al., *Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing*, 108 PROC. NAT'L ACAD. SCI. 8172 (2011).

48. *Id.* at 8172.

49. *See id.* at 8175 (outlining three possible mechanisms of contamination).

50. SEC'Y OF ENERGY ADVISORY BD., *THE SHALE GAS PRODUCTION SUBCOMMITTEE NINETY-DAY REPORT* (2011), available at www.shalegas.energy.gov/resources/081111_90_day_report.pdf.

51. *Id.* at 23.

States are addressing the need for baseline water-quality data by creating mandatory or voluntary pre-drilling well testing programs, or by establishing a presumption of liability if a pollutant associated with hydraulic fracturing is found within a certain distance to a gas well.⁵²

- i. **Mandatory Testing:** In Ohio, state permitting geologists have the authority to require operators to collect water-quality samples before drilling takes place and to submit laboratory tests to the state.⁵³
- ii. **Voluntary Testing:** Colorado recently announced a water sampling program jointly administered by industry and the state. Upon a landowner's request, the voluntary program will test the landowner's drinking water supplies before and after hydraulic fracturing operations. A third party will collect the samples with oversight from the state Department of Public Health and Environment.⁵⁴
- iii. **Presumptive Liability:** Pennsylvania and West Virginia both assume that a drilling operator is legally responsible for water contamination within a specified distance of a well if the contamination occurs within a certain timeframe (for example, in Pennsylvania, the contamination must occur within twelve months of completion of the well).⁵⁵ The operator must demonstrate that it is not responsible for

52. In Pennsylvania, the rebuttable presumption of liability applies to "a well operator who affects a public or private water supply by pollution or diminution." Act No. 13, 2012 Pa. ALS 13 (LEXIS) (to be codified at 58 PA. STAT. ANN. § 3218(a), (c) (2012)). In West Virginia, the presumption protects against "contamination or deprivation of [a] fresh water source or supply." W. VA. CODE § 22-6-35 (2010). Methane is generally not regulated as a pollutant unless it reaches concentrations high enough to create an asphyxiation or explosion hazard. *See, e.g.*, OFFICE OF SURFACE MINING RECLAMATION & ENFORCEMENT, U.S. DEP'T OF THE INTERIOR, TECHNICAL MEASURES FOR THE INVESTIGATION AND MITIGATION OF FUGITIVE METHANE HAZARDS IN AREAS OF COAL MINING 36-37 (2001), *available at* <http://www.osmre.gov/resources/newsroom/News/Archive/2001/090601.pdf> (stating that methane is generally not regulated under the Surface Mining Control and Reclamation Act, and recommending action level for future methane regulation).

53. OHIO ADMIN. CODE 1501:9-1-02(F) (2011); *see also* OHIO DEP'T OF NATURAL RES., BEST MANAGEMENT PRACTICES FOR PRE-DRILLING WATER SAMPLING 2 (2005), *available at* http://www.dnr.state.oh.us/Portals/12/docs/BMP_PRE-DRILLING_WATER_SAMPLING.pdf (outlining the water sampling procedure).

54. COLO. OIL & GAS ASS'N, VOLUNTARY BASELINE GROUNDWATER QUALITY SAMPLING PROGRAM 3 (2011); Eunice Bridges, *Colorado Announces Water-Sampling Effort To Fight Fracking Fears*, PLATTS (Aug. 2, 2011, 5:51 PM), <http://www.platts.com/RSSFeedDetailedNews/RSSFeed/NaturalGas/6339937>.

55. Act No. 13, 2012 Pa. ALS 13 (LEXIS) (to be codified at 58 PA. STAT. ANN. § 3218(c)(2)(ii)); W. VA. CODE § 22-6-35 (2010).

contamination to avoid liability. Consequently, well operators have an incentive to test water supplies within the area of presumptive liability before starting to drill. West Virginia lawmakers recently expanded the range of presumptive liability from 1000 to 1500 feet,⁵⁶ and Pennsylvania expanded the range to 2500 feet in February of 2012,⁵⁷ consistent with recommendations from Duke University.⁵⁸

b. Disclosure of Chemicals Used in Fracturing Fluid

Fracturing fluid can contain up to forty chemical additives, the combination of which varies depending on the operator's preferences and the geologic characteristics of the site.⁵⁹ The U.S. House of Representatives Committee on Energy and Commerce recently found that 750 chemicals were used in hydraulic fracturing processes between 2005 and 2009.⁶⁰ Of those, twenty-nine chemicals are known or possible human carcinogens that are regulated under the Safe Drinking Water Act (SDWA) or are listed as hazardous air pollutants under the Clean Air Act.⁶¹

Although the chemical makeup of fracturing fluids has long been protected as a trade secret, some states now require varying degrees of disclosure.

- i. **Partial Disclosure: Arkansas, Michigan, and Pennsylvania** have partial disclosure policies. For example, Michigan now

56. H.B. 401, 2011 Leg., 4th Extraordinary Sess. (W. Va. Acts 2011) (codified at W. VA. CODE § 22-6A-18 (2012)).

57. Act No. 13, 2012 Pa. ALS 13 (LEXIS) (to be codified at 58 PA. STAT. ANN. § 3218(c)(2)(i)); Robert Swift, *DEP Recommends Gas Act Overhaul To Protect Water Resources from Drilling*, SCRANTON TIMES-TRIB. (June 3, 2011), <http://thetimes-tribune.com/news/gas-drilling/dep-recommends-gas-act-overhaul-to-protect-water-sources-from-drilling-1.1156315#axzz1m17n13E>.

58. See ROBERT B. JACKSON ET AL., CTR. ON GLOBAL CHANGE, DUKE UNIV., RESEARCH AND POLICY RECOMMENDATIONS FOR HYDRAULIC FRACTURING AND SHALE-GAS EXTRACTION 7 (2011), available at <http://www.nicholas.duke.edu/cgc/HydraulicFracturingWhitepaper2011.pdf> (suggesting that 3000 feet would be the suitable range of presumptive liability based on scientific data).

59. Theo Colborn et al., *Natural Gas Operations from a Public Health Perspective*, 17 HUM. & ECOLOGICAL RISK ASSESSMENT 1039, 1048-49 (2011) (analyzing forty chemicals found in evaporation pits of expired drilling sites in New Mexico); see also GROUND WATER PROT. COUNCIL & ALL CONSULTING, *supra* note 16, at 61-64 (claiming that fracking fluids only contain between three and twelve chemicals).

60. Staff of H. Comm. on Energy & Commerce, 112th Cong., *Chemicals Used in Hydraulic Fracturing* (2011).

61. *Id.*

requires compilation of material safety data sheets (MSDSs) for additives used in fracturing fluids and posts the data online for public review.⁶² (The U.S. Occupational Safety and Health Administration requires that the data sheets, which contain information on the additives' chemical properties and potential harms, be made available to employees who handle these substances, to local emergency response planning officials, and to fire departments.⁶³) However, MSDSs do not contain proprietary information, including the chemical ingredients of many fracturing fluid additives.⁶⁴ In Arkansas, regulators post information online about chemicals used in each well; however, approved trade secrets are listed only by chemical family.⁶⁵

- ii. Full Disclosure to Regulators, Partial or No Disclosure to the General Public: Texas and Wyoming require well operators to provide regulators with a list of all chemicals used in hydraulic fracturing in the state and to keep that list up to date.⁶⁶ Both states prohibit public disclosure of proprietary information to comply with state open-record laws, and companies can apply to receive confidentiality protection for information contained in their submission to the regulators.⁶⁷
- iii. Disclosure of Chemicals and Concentrations: Colorado regulators strengthened the state's partial disclosure policy

62. MICH. DEP'T OF ENVTL. QUALITY, SUPERVISOR OF WELLS INSTRUCTION 1-2011, at 3 (2011), available at www.michigan.gov/documents/deq/SI_1-2011_353936_7.pdf; Press Release, Mich. Dep't of Env'tl. Quality, Michigan Issues New Orders for Fracking (May 25, 2011), available at <http://www.michigan.gov/deq/0,1607,7-135-256844-,00.html>.

63. 29 C.F.R. § 1910.1200(g) (2011); see also *Emergency Planning and Community Right-To-Know Act (EPCRA) Hazardous Chemical Storage Reporting Requirements*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/oem/content/epcra/epcra_storage.htm (last visited Mar. 20, 2012) ("For any hazardous chemical used or stored in the workplace, facilities must maintain a material safety data sheet (MSDS), and submit the MSDSs (or a list of the chemicals) to their State Emergency Response Commission (SERC), Local Emergency Planning Committee (LEPC) and local fire department.").

64. 29 C.F.R. § 1910.1200(i).

65. ARK. OIL & GAS COMM'N, GENERAL RULES AND REGULATIONS 75, r. B-19(k)(4)-(8) (2012), available at <http://www.aogc.state.ar.us/OnlineData/Forms/Rules and Regulations.pdf>.

66. H.B. 3328, 82nd Leg., 1st Sess. (Tex. 2011); WYO. OIL & GAS COMM'N, OPERATION RULES AND DRILLING RULES, CH. 3 § 45(d), (f) at 3-62 to -63 (2010), available at <http://soswy.state.wy.us/Rules/RULES/7928.pdf>.

67. H.B. 3328; WYO. OIL & GAS COMM'N, OPERATION RULES AND DRILLING RULES, CH. 3 § 45(d), at 3-62.

in December 2011.⁶⁸ Under the new rules, operators have sixty days after fracturing a well to disclose all of the chemicals used in fracturing fluid as well as their concentrations, although they may list only the chemical family if a chemical is considered proprietary.⁶⁹ The list must also be filed with FracFocus.org, a publically available online database.⁷⁰ Operators are required to file a claim with the commission if they consider information proprietary, asserting under penalty of perjury that the chemical is a trade secret.⁷¹

In late 2011, the EPA accepted a petition to require disclosure of hydraulic fracturing fluid components under the federal Toxic Substances Control Act. In a letter to petitioners, the EPA indicated that the agency intends to publish an advance notice of proposed rulemaking and convene a stakeholder process to develop an overall disclosure approach that would minimize reporting burdens and costs, take advantage of existing information, and avoid duplication of efforts.⁷²

B. Regulatory Structure and Agency Resources

On private property and non-federal public lands, states are the primary regulators of oil and gas extraction. Accordingly, states must develop, staff, and fund their regulatory programs. In recent years, the rapid expansion of shale gas extraction has led to a corresponding increase in permit applications for natural gas extraction, putting a strain on regulators responsible for active shale gas plays. If North Carolina lawmakers allow hydraulic fracturing in the state, they will have to select an existing agency or create a new authority to carry out a regulatory program, and they will also have to ensure an adequate level of funding.

68. Changes to the Rules of Practice & Procedure of the Oil & Gas Conservation Comm'n of Colo., Order No. 1R-114 (Oil & Gas Conservation Comm'n of Colo., Dec. 13, 2011) (amending Commission Rules 205 and 205A).

69. *Id.* at 4-5.

70. *Id.* at 10.

71. *Id.* at 16.

72. Mark Drajem, *EPA Accepts Environmental Petition on Fracking Chemicals*, BLOOMBERG (Nov. 23, 2011), <http://www.bloomberg.com/news/2011-11-23/epa-partially-approves-petition-on-fracking-chemicals.html>; Letter from Steven A. Owens, Assistant Adm'r, Env'tl. Prot. Agency, to Deborah Goldberg, EarthJustice (Nov. 23, 2011), *available at* http://www.epa.gov/oppt/chemtest/pubs/EPA_Letter_to_Earthjustice_on_TSCA_Petition.pdf.

1. Experiences in Other States

Some states with active shale gas plays have had difficulty keeping up with the rapid proliferation of new wells.⁷³ According to regulators in Pennsylvania and West Virginia, shale gas production implicates new and expanded environmental considerations and thus requires more attention than conventional drilling permits.⁷⁴ In some states, such as Oklahoma, regulatory agencies deploy field inspectors to oversee key aspects of the drilling process, such as casing and cementing the well.⁷⁵ In other states, such as West Virginia, operators are required to notify the regulatory agency before they begin the casing and cementing process, but the law does not require an inspector to be on site during that process.⁷⁶ A sharp increase in new permits without a corresponding increase in regulatory staff decreases the percentage of operations that inspectors can observe.

In many states, the increased administrative burden of regulating an active shale gas industry coincides with a period of decreased funding. Although state lawmakers have not yet decided who would regulate shale gas drilling in North Carolina, one likely candidate, DENR, has faced recent budget cuts. In its 2011–2012 budget, North Carolina cut funding to the department by 12%, resulting in the elimination of 160 agency jobs.⁷⁷

73. PA. BUDGET & POL'Y CTR., TALL TALES ABOUT DEEP WELLS: PART 1, at 1 (2010), available at <http://pennbpc.org/sites/pennbpc.org/files/Drilling-west-virginia.pdf> (noting that West Virginia's Department of Environmental Protection saw an increase in Marcellus Shale drilling applications in 2009 and 2010, with around fifty permits issued each quarter in 2008 and more than 100 issued each quarter in 2009); PA. DEP'T. LABOR & INDUS., MARCELLUS SHALE FAST FACTS (2011), available at http://www.marcellus.psu.edu/resources/PDFs/fastfacts_labor.pdf (noting that the Pennsylvania Department of Environmental Protection issued 451 permits for wells in the Marcellus Shale in 2008 and 3314 permits in 2010).

74. See EXECUTIVE SUMMARY: OIL AND GAS WELL PERMIT FEES (AMENDMENTS TO 25 PA CODE, CHAPTER 78), at 1, available at http://www.portal.state.pa.us/portal/server.pt/document/504351/executivesummary_revised_generalfund_pdf?qid=88791603&rank=8 (noting that the Pennsylvania Department of Environmental Protection needs additional staff and funding to accommodate shale gas drilling); *DEP May Need Second Framework To Handle Gas Rush*, CHARLESTON GAZETTE (W. Va.) (Sept. 3, 2010), <http://www.wvgazette.com/ap/ApTopStories/201009030146> (reporting that West Virginia regulators told the press that the current staff of eighteen inspectors was insufficient to monitor 1000 new shale gas wells in addition to the existing conventional oil and gas drilling in the state).

75. See OKLA. ADMIN. CODE § 165:10-1-6 (2011).

76. W. Va. C.S.R. § 35-8-4.4.b.3 (2010) (effective Aug. 29, 2011); *DEP May Need Second Framework To Handle Gas Rush*, *supra* note 74.

77. See Act of June 15, 2011, § 2.1, 2011 N.C. Sess. Laws 145; Rebecca Putterman & Kelley Wollman, *Budget Slashes Environmental Regulations*, REESENEWS (Jun. 27, 2011) <http://reesenews.org/2011/06/27/denr/16882>.

2. Overview of Regulatory Action

In some states where shale gas extraction is expanding rapidly and increasing the administrative burden on regulatory agencies, lawmakers have turned to the natural gas industry to help cover the costs of increased regulatory activities through fees and severance taxes.

- i. **Permit Fees:** States typically charge permit fees for oil and gas activities. Pennsylvania, for example, recently increased fees for conventional wells and created a new fee covering horizontal well applications.⁷⁸
- ii. **New Fee Structures:** Ohio recently increased fees to support permitting, monitoring, and enforcement activities.⁷⁹ Rather than simply increasing permitting fees, however, the state chose to break down those fees to reflect the administrative burden of each particular well. For example, a brine disposal fee applies when produced water is injected into a disposal well.⁸⁰
- iii. **Severance Tax on Natural Gas:** Most states with an active oil and gas industry levy a severance tax on natural gas after it is removed from the ground, but this revenue is often sent to the state's general fund or dedicated to conservation or to local governments.⁸¹ Indiana is one state that uses a severance tax to directly fund the administration of its oil and gas program. Indiana appropriates the money for its Department of Natural Resources to administer the oil and gas regulatory program and to research exploration,

78. See 25 PA. CODE § 78.19 (2009).

79. E.g., Sub. S.B. 165, 128th Gen. Assemb. §§ 1509.06(G)(1),(4), 1509.062(E)-(F), 1509.071 (Ohio) (enacted June 20, 2010); STATE REV. OIL & NAT. GAS ENVTL. REG. (STRONGER), OHIO HYDRAULIC FRACTURING STATE REVIEW 6 (2011), available at http://www.strongerinc.org/documents/Final_Report_of_2011_OH_HF_Review.pdf [hereinafter OHIO STRONGER REVIEW].

80. Sub. S.B. 165, 128th Gen. Assemb. § 1509.22 (Ohio) (enacted June 30, 2010); *Ohio Department of Natural Resources: Hearing on S.B. 165 Before the S. Env't & Nat. Res. Comm.*, 128th Sess. 8 (Ohio 2009) (statement of Sean Logan, Director, Ohio Department of Natural Resources).

81. Judy Zelio & Lisa Houlihan, *State Energy Revenues Update*, NAT'L CONF. STATE LEGISLATURES (June 2008), <http://www.ncsl.org/issues-research/budget-tax/state-energy-revenues-update.aspx>.

development, and wise use of oil and gas resources in the state.⁸²

IV. REGULATION OF DRILLING OPERATIONS

A. Impacts on Water Supply

The Groundwater Protection Council, a non-profit association of state groundwater regulators, estimates that drilling and hydraulic fracturing of a single well requires between two and four million gallons of water.⁸³ Pennsylvania's Marcellus Shale Advisory Commission found that a single well may use more than five million gallons per fracturing.⁸⁴ The volume of water required varies with the geologic formation, depth and lateral length of the well, and the number of times it is fractured.⁸⁵ As a result, some wells use significantly more water than others.

Natural gas producers frequently draw water for drilling and hydraulic fracturing from nearby surface waters, including rivers and lakes.⁸⁶ Some drilling operations also take water directly from groundwater or municipal water supplies. Others reuse wastewater from previous drilling operations for at least a portion of their water supply,⁸⁷ though the quality of the produced water limits its reusability as a source of fracturing fluid.

The water required to bring a shale gas well online is used within a moderately short timeframe, and it usually amounts to a relatively small percentage of an area's water supply. However, if drilling and production occur in time of drought or low stream flow, the withdrawals can create pressure on other uses, including municipal water supply, industrial operations such as cooling power plants, and irrigation.⁸⁸

North Carolina is a relatively water-rich state, but the amount of water needed to fracture a well in the Deep or Dan River Basins is not known. North Carolina's potential shale gas resources are

82. IND. CODE § 6-8-1-27 (2011).

83. GROUND WATER PROT. COUNCIL & ALL CONSULTING, *supra* note 16, at ES-4.

84. GOVERNOR'S MARCELLUS SHALE ADVISORY COMM'N, GOVERNOR'S MARCELLUS SHALE ADVISORY COMMISSION REPORT 73 (2011).

85. GROUND WATER PROT. COUNCIL & ALL CONSULTING, *supra* note 16, at ES-4 (stating that the necessary amount of water varies significantly).

86. *Id.* at 65.

87. *Id.* at 69 ex.39.

88. *Id.*

primarily located within the fastest-growing region of the state—a large swath between Raleigh and Charlotte—where water demands are rapidly increasing.⁸⁹

1. Experiences in Other States

The current drought in Texas is a highly publicized example of how shale gas extraction can compete with other uses of water, including municipal supply and irrigation.⁹⁰ Although water availability varies from state to state, considering the potential water supply impacts of shale gas extraction is important in any region. Southeastern states have experienced severe droughts in recent years,⁹¹ and the energy sector in North Carolina has struggled with water shortages during those times.⁹² North Carolina currently ranks among the top ten states in the nation for energy-related water withdrawals.⁹³ Of the fifteen billion gallons of water withdrawn daily in North Carolina, fourteen billion gallons are used for cooling thermoelectric power plants or producing hydroelectric power.⁹⁴

2. Overview of Regulatory Action

Other states, in addition to Texas, are considering policies to protect against water shortages, including strategies to encourage wastewater recycling and to provide additional oversight when water is withdrawn.

- i. Remove Barriers to and Create Incentives for Recycling Wastewater: Some states have removed regulatory barriers to the reuse of wastewater. For example, the Susquehanna

89. N.C. DEP'T NATURAL RES., THE WATER CONNECTION 12 (Carla Burgess ed., 2009), available at http://www.ncwater.org/Reports_and_Publications/primer/The_Water_Connection_Booklet.pdf.

90. See Tracy Idell Hamilton, *Drought Spurring Fracking Concerns*, SAN ANTONIO EXPRESS-NEWS (Jul. 3, 2011), <http://www.mysanantonio.com/news/energy/article/Droughtspurringfrackingconcerns-1450808.php>.

91. See *Drought Monitor Archives*, NAT'L DROUGHT MITIGATION CTR., <http://droughtmonitor.unl.edu/archive.html> (last visited Feb. 4, 2012) (providing weekly data on drought severity from January 2000 to present).

92. See *Southern Drought Could Dry Up Coolant Water and Force Nuclear Plants To Shut Down*, BOS. HERALD (Jan. 23, 2008), <http://www.bostonherald.com/news/national/south/view.bg?articleid=1068621&srvc=rss>.

93. SUSAN S. HUTSON ET AL., ESTIMATED USE OF WATER IN THE UNITED STATES IN 2000, at tbl.13 (2005), available at <http://pubs.usgs.gov/circ/2004/circ1268/htdocs/table13.html>.

94. *Statewide Water Withdrawals*, N.C. DIV. WATER RES., <http://www.ncwater.org/Water-Withdrawals/> (last visited Feb. 13, 2012).

River Basin Commission (SRBC), which regulates areas of Maryland, New York, and Pennsylvania, generally prohibits diversion of water from one watershed to another.⁹⁵ The commission recently issued an executive order waiving the rule for all transfers of wastewater between well pads for the purpose of reuse.⁹⁶ Similarly, Louisiana only recently allowed recycling of flow-back fluids. However, the state now encourages recycling of produced water, rainwater, and drilling fluids for hydraulic fracturing purposes.⁹⁷ Recycling reduces the use of fresh water and the volume of waste. However, companies must remove some elements of wastewater before reuse, producing a brine concentrate that can be dangerous to human health and the environment.⁹⁸

- ii. **Prioritize Withdrawal Sources:** In Louisiana, the Office of Conservation issued a nonbinding advisory opinion that operators should not use water from a main drinking-water aquifer, but should instead use lower-quality aquifers and other sources, such as recycled water.⁹⁹
- iii. **Require Approval or Reporting of Withdrawals:** The SRBC now requires approval for all water withdrawn for use in hydrocarbon exploration and production. Approval is contingent on the determination that its use will not cause significant adverse impacts to the water resources of the basin.¹⁰⁰ Louisiana requires operators to report all water used in hydraulic fracturing.¹⁰¹ Michigan requires operators to report where they plan to source fresh water using the Department of Environmental Quality's water withdrawal tool to ensure that nearby water wells and surface water will

95. SUSQUEHANNA RIVER BASIN COMM'N, PAD-TO-PAD TRANSFERS OF FLOWBACK FOR NATURAL GAS WELL DEVELOPMENT (2011), available at [http://www.srbcc.net/policies/docs/2011-01 Pad To Pad Interbasin Transfers of Flowback For Natural Gas Well Development Policy.pdf](http://www.srbcc.net/policies/docs/2011-01%20Pad%20To%20Pad%20Interbasin%20Transfers%20of%20Flowback%20For%20Natural%20Gas%20Well%20Development%20Policy.pdf).

96. See *id.*

97. See LA. ADMIN. CODE tit. 43, pt. XIX, § 313(J)(1) (2011).

98. Ian Urbina, *Wastewater Recycling No Cure-All in Gas Process*, N.Y. TIMES, Mar. 2, 2011, at A1.

99. See STRONGER, LOUISIANA HYDRAULIC FRACTURING STATE REVIEW 4 (2011) [hereinafter LOUISIANA STRONGER REVIEW]; see also *State Office of Conservation Requiring Reporting of Water Source in Hydraulic Fracturing Operations*, LA. DEP'T NATURAL RES. (Oct. 8, 2009), <http://dnr.louisiana.gov/index.cfm?md=newsroom&tmp=detail&aid=398>.

100. 18 C.F.R. § 806.5(a)(4) (2011).

101. LA. DEP'T NATURAL RES., *supra* note 99.

not be affected.¹⁰² Under New York's proposed regulations, operators will need a permit to withdraw large volumes of water for industrial and commercial purposes, including hydraulic fracturing.¹⁰³

The STRONGER guidelines broadly recommend that states evaluate and address the availability of water needed for hydraulic fracturing in the context of competing uses and environmental impacts, and they also suggest that states encourage the use of recycled or reused water.¹⁰⁴

B. Impacts on Communities and Landowners

With the rise of high-volume hydraulic fracturing and horizontal drilling, oil and gas exploration now occurs in new areas where state and local governments may not have experience with regulating the industry.¹⁰⁵ States must decide how to address the interests of local governments and individual landowners. This includes addressing the amount of authority that should be given to local governments so that they can control the conditions under which drilling can occur within their borders. Policymakers also face the task of ensuring that shale gas development does not interfere with existing land uses, such as residential uses, or with other natural resource industries, such as timber harvesting. Regulating the natural gas industry would be a new role for both state agencies and local governments in North Carolina.

1. Experiences in Other States

Natural gas drilling can have significant cumulative impacts on communities. Examples of such impacts include increased truck traffic, loud noise, bright lights to enable twenty-four-hour operations, and odors from chemicals used on site.¹⁰⁶ The degree to which a local government is able to exert control over drilling activities varies from state to state. For example, Pennsylvania

102. *Michigan Issues New Orders for Fracking*, MICH. DEP'T ENVTL. QUALITY (May. 25, 2011), <http://www.michigan.gov/deq/0,1607,7-135-256844-,00.html>.

103. N.Y. A.B. 5318, 234 Leg. (proposed Mar. 9, 2011).

104. STRONGER, HYDRAULIC FRACTURING GUIDELINES § X.3 (2010), *available at* http://www.strongerinc.org/documents/HF_Guideline_Web_posting.pdf.

105. See SEC'Y OF ENERGY ADVISORY BD., *supra* note 51, at 8.

106. MARK ZOBACK ET AL., WORLD WATCH INST., BRIEFING PAPER 1: ADDRESSING THE ENVIRONMENTAL RISKS FROM SHALE GAS DEVELOPMENT 14 (2010), *available at* <http://www.worldwatch.org/files/pdf/Hydraulic%20Fracturing%20Paper.pdf>.

expressly preempts municipal oversight of oil and gas drilling to the extent that it addresses aspects of oil and gas drilling that are already regulated at the state level.¹⁰⁷ North Carolina's constitution similarly preempts municipal ordinances that overlap with state law.¹⁰⁸

2. Overview of Regulatory Action

Municipalities in Pennsylvania and New York are attempting to utilize local zoning ordinances¹⁰⁹ to prevent drilling operations from disturbing residents with excessive noise and light and from engaging in other activities that the municipalities consider incompatible with existing land uses.¹¹⁰ For example, some municipalities have attempted to control the parameters of drilling operations by passing ordinances that make gas drilling a conditional use rather than a permitted use.¹¹¹ Permitted uses are allowed as a matter of right within a zoning district, whereas conditional uses are recognized as potentially consistent with the zone but must be evaluated on a case-by-case basis. Conditional use permitting allows a municipality to exercise some control over land use, for example, by requiring a public hearing or a review by the municipal planning commission.¹¹² Several mechanisms address impacts on local communities and landowners.

- i. **Setback Requirements:** The minimum required distance between a well and municipal water supply intakes and reservoirs, private water wells, private property lines, protected lands, floodplains, and other valuable land uses depends on the state's expectations about the extent of the drilling impact. The Pennsylvania Governor's Marcellus

107. Act No. 13, 2012 Pa. ALS 13 (LEXIS) (to be codified at 58 PA. STAT. ANN. § 3303 (2012)).

108. See N.C. CONST. art. II, § 24.

109. In Pennsylvania and New York, it is still unclear to what extent state regulation will preempt local governments' ability to use zoning ordinances to regulate shale gas extraction within their borders. However, New York state courts recently held that state law does not preempt city zoning ordinances that in effect prohibit hydraulic fracturing. See *Anschutz Exploration Corp. v. Town of Dryden*, No. 2011-0902 (N.Y. Sup. Ct. Feb. 21, 2012); *Cooperstown Holstein Corp. v. Town of Middlefield*, No. 2011-0930 (N.Y. Sup. Ct. Feb. 24, 2012).

110. Anthony S. Guardino, *Marcellus Shale 'Gas Rush' Raises Local Zoning Issues*, N.Y.L.J., Sept. 22, 2010, at 2; Daveen Rae Kurutz, *Officials Try To Establish Gas Balance*, YOUR MURRYSVILLE (Jul. 7, 2011), <http://www.yourmurrysville.com/node/11952>.

111. John M. Smith, *The Prodigal Son Returns: Oil and Gas Drillers Return to Pennsylvania with a Vengeance—Are Municipalities Prepared?*, 49 DUQ. L. REV. 1, 14 (2011).

112. *Id.*

Shale Advisory Commission, the Pennsylvania Department of Environmental Protection, the New York Department of Environmental Conservation, and the Delaware River Basin Commission (DRBC) have all recommended extending setback requirements for shale gas activities in their respective states.¹¹³

- ii. **Operating Requirements:** Louisiana's Office of Conservation has established regulations for the production of gas from urban areas of the Haynesville shale formation, including a mandate to manage the site to minimize standing water, weeds, trash, dust, vibration, and odors; a prohibition on construction activities at night; and noise restrictions.¹¹⁴ The Ohio Department of Natural Resources can set enforceable noise standards,¹¹⁵ and although the standards are not tailored to the needs of each particular municipality, this policy allows the state to require operators to adopt less noisy technology. New York's revised draft Supplemental Generic Environmental Impact Statement (SGEIS) addresses the impact of truck traffic on local roads by requiring operators to develop local transportation plans that "reduce the impacts . . . to the maximum extent feasible."¹¹⁶
- iii. **Bans on Hydraulic Fracturing Within Municipalities:** Some municipalities in Pennsylvania, New York, and West Virginia have banned hydraulic fracturing within and around their borders.¹¹⁷ A state court recently overturned

113. DELAWARE RIVER BASIN COMM'N, REVISED DRAFT NATURAL GAS DEVELOPMENT REGULATIONS, pt. 3, art. 7, § 7.5(d)(1)(iii) (proposed Nov. 8, 2011), *available at* <http://www.nj.gov/drbc/library/documents/naturalgas-REVISEDdraftregs110811.pdf>; Press Release, New York Dep't of Env'tl. Conservation, New Recommendations Issued in Hydraulic Fracturing Review (June 30, 2011), *available at* <http://www.dec.ny.gov/press/75403.html>; GOVERNOR'S MARCELLUS SHALE ADVISORY COMM'N, *supra* note 84, at 107; Swift, *supra* note 57.

114. La. Office of Conservation, Order No. U-HS (May 21, 2009) (establishing practices for fracking on the Haynesville Shale).

115. S. Res. 165, 128th Sess. (Ohio 2010).

116. N.Y. STATE DEP'T ENVTL. CONSERVATION, REVISED DRAFT SUPPLEMENTAL GENERAL ENVIRONMENTAL IMPACT STATEMENT ON THE OIL, GAS, AND SOLUTION MINING REGULATORY PROGRAM (2011) [hereinafter NYSDEC SGEIS], *available at* <http://www.dec.ny.gov/energy/75370.html>.

117. *See, e.g.*, MORGANTOWN, W. VA., CODE § 721.03 (passed June 21, 2011) (prohibiting all drilling using horizontal methods or fracturing within city limits); PITTSBURGH, PA., CODE §

one such ban in Morgantown, West Virginia.¹¹⁸ The judge held that a municipality did not have the authority to preempt the Department of Environmental Protection's drilling regulations.¹¹⁹ In contrast, municipal bans in both Dryden and Middlefield, New York, were upheld by New York state courts in February 2012.¹²⁰ Whether such bans will prevail in court under various state constitutions is unclear.

C. Impacts from Wastewater Storage, Treatment, and Disposal

Normal operation of shale gas production facilities can pose significant risks to water quality. Three key aspects of the production process contribute to these risks: wastewater storage, treatment, and disposal; drill cuttings and mud storage, treatment, and disposal; and well casing and cementing. This section discusses risks and existing policy responses associated with wastewater storage, treatment, and disposal.

Two primary sources of wastewater are associated with hydraulic fracturing: flow-back fluid and produced water.

Flow-back fluid is fracturing fluid that returns to the surface after being injected into a well. An estimated ten to forty percent of injected water flows back to the surface in the days and weeks following hydraulic fracturing.¹²¹ The components of flow-back fluid vary depending on the additives in the original fluid and the quality of the original water in the shale formation, which is typically a brine solution with high concentrations of salts, metals, radionuclides, oils, greases, and volatile and semi-volatile organic compounds.¹²²

618.04 (effective Dec. 1, 2010) (prohibiting corporations from extracting natural gas within city limits).

118. *Ne. Natural Energy, LLC v. City of Morgantown*, Civ. Action No. 11-C-411, slip op. at 10 (W. Va. Cir. Ct. Aug. 12, 2011).

119. *Id.* at 9–10.

120. *Anschutz Exploration Corp. v. Town of Dryden*, No. 2011-0902 (N.Y. Sup. Ct. Feb. 21, 2012); *Cooperstown Holstein Corp. v. Town of Middlefield*, No. 2011-0930 (N.Y. Sup. Ct. Feb. 24, 2012).

121. U.S. ENVTL. PROT. AGENCY, DRAFT PLAN TO STUDY THE POTENTIAL IMPACTS OF HYDRAULIC FRACTURING ON DRINKING WATER RESOURCES (2011), available at [http://yosemite.epa.gov/sab/sabproduct.nsf/0/D3483AB445AE61418525775900603E79/\\$File/Draft+Plan+to+Study+the+Potential+Impacts+of+Hydraulic+Fracturing+on+Drinking+Water+Resources-February+2011.pdf](http://yosemite.epa.gov/sab/sabproduct.nsf/0/D3483AB445AE61418525775900603E79/$File/Draft+Plan+to+Study+the+Potential+Impacts+of+Hydraulic+Fracturing+on+Drinking+Water+Resources-February+2011.pdf).

122. Kelvin B. Gregory et al., *Water Management Challenges Associated with the Production of Shale Gas by Hydraulic Fracturing*, 7 *ELEMENTS* 181, 182–83 (2011).

Produced water (also known as brine, saltwater, or formation water) occurs naturally within the shale formation and is brought to the surface during the gas extraction process. The makeup of produced water depends on the location of the field and the type of geologic formation. Produced water may contain oil and grease, inorganic and organic compounds introduced as chemical additives to drilling fluid, and naturally occurring radioactive material.¹²³ Produced water typically has very high levels of total dissolved solids (TDS or salts), which are difficult and expensive to remove.¹²⁴ As noted above, North Carolina's shale rock formations formed from organic matter associated with a freshwater environment rather than a marine environment,¹²⁵ and the makeup of produced water in North Carolina, including the level of TDS, is therefore unknown.

Federal hazardous waste storage, transportation, and disposal requirements do not apply to wastewater produced through shale gas extraction, and regulatory decisions regarding wastewater treatment and disposal are therefore left to the states.¹²⁶ Regulators in states that allow hydraulic fracturing are responsible for disposing of significant amounts of waste, but they may have limited disposal options.¹²⁷ Current wastewater disposal technology offers no single best practice.

1. Experiences in Other States

The options for wastewater disposal include injection into underground disposal wells, partial treatment at publicly owned treatment works (POTWs) followed by discharge into nearby surface water, land application, commercial wastewater treatment, and reuse in future hydraulic fracturing operations.¹²⁸

123. *Id.*

124. C.E. CLARK & J.A. VEIL, ARGONNE NAT'L LAB., PRODUCED WATER VOLUMES AND MANAGEMENT PRACTICES IN THE UNITED STATES (2009), *available at* http://www.evs.anl.gov/pub/doc/ANL_EVS__R09_produced_water_volume_report_2437.pdf.

125. Olson et al., *supra* note 37.

126. U.S. ENVTL. PROT. AGENCY, EXEMPTION OF OIL AND GAS EXPLORATION AND PRODUCTION WASTES FROM FEDERAL HAZARDOUS WASTE REGULATIONS 20 (2002) [hereinafter EPA, EXEMPTION OF OIL AND GAS E&P WASTES], *available at* <http://epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf>.

127. *Energy in Brief*, *supra* note 4.

128. EPA, FRACTURING RESEARCH STUDY, *supra* note 20; PENN STATE EXTENSION, MARCELLUS SHALE WASTEWATER ISSUES IN PENNSYLVANIA—CURRENT AND EMERGING TREATMENT AND DISPOSAL TECHNOLOGIES 4 (2011), *available at* http://www.cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/marcellus_wastewater_fact_sheet%5B1%5D.pdf.

a. Underground Injection

Underground injection (also known as deep well injection) is the most common disposal strategy for flow-back fluid.¹²⁹ The Argonne National Laboratory estimates that operators inject ninety-eight percent of all U.S. produced water from oil and gas drilling into disposal wells regulated by the EPA Underground Injection Control Program.¹³⁰ Although underground injection is considered a safe disposal method, it is not without risk. For example, the high pressure used to inject wastewater into disposal wells has been linked to earthquakes in Ohio, New York, Texas, and Arkansas.¹³¹ Areas that already experience regular seismic activity are more prone to induced seismic events from wastewater injection.¹³²

Underground injection of wastewater is currently illegal in North Carolina.¹³³ Even if the ban were lifted, the state may not possess suitable geologic storage formations. An EPA assessment of industrial waste injection sites nationwide classified western and central North Carolina as “unfavorable under all conditions” and coastal North Carolina as “generally unfavorable.”¹³⁴ Therefore, if the state did lift the ban on underground injection, other disposal methods for wastewater produced through shale extraction may be necessary.

129. CLARK & VEIL, *supra* note 124.

130. *Id.*

131. See Paleontological Research Inst., *Making the Earth Shake: Understanding the Induced Seismicity*, MARCELLUS SHALE, May 2011, at 1, 6–7 (citing studies linking recent seismic activity to high-pressure fluid injection); see also *Arkansas: Disposal Well Is Ordered Closed*, N.Y. TIMES, July 28, 2011, at A20 (reporting that in the summer of 2011, Arkansas officials ordered two companies to stop injecting wastewater and voted to ban any future injection in the Guy-Greenbrier area of the Fayetteville Shale as a result of ongoing earthquake activity); Daniel Gilbert, *Ohio Shuts Wells Following Quakes*, WALL ST. J., Jan. 3, 2012, at A3 (“Ohio became the latest state to take action on the possible link between seismic activity and wells used to dispose of waste water from oil and gas production when state officials ordered a halt to the practice near Youngstown this weekend after several minor earthquakes.”).

132. See generally Paleontological Research Inst., *supra* note 131, at 4 (“Induced earthquakes are triggered when the natural stress is already close to failure, the point at which a fault becomes active and causes an earthquake.”).

133. N.C. GEN. STAT. § 113-390 (2010) (prohibiting the “waste of oil or gas as defined in this law”); *id.* § 113-389(14)(f) (defining waste to including, inter alia, “drowning with water of any stratum or part thereof capable of producing oil or gas”); see also 15 N.C. ADMIN. CODE 02C.0209 (2011) (prohibiting injection wells).

134. U.S. ENVTL. PROT. AGENCY, ASSESSING THE GEOCHEMICAL FATE OF DEEP-WELL-INJECTED HAZARDOUS WASTE: A REFERENCE GUIDE 54 fig.3-2 (1990).

b. Treatment at Publicly or Privately Owned Treatment Facilities

In states with limited capacity for underground injection, such as Pennsylvania, operators must use alternative disposal methods. Pennsylvania allowed operators to send wastewater to POTWs until the spring of 2011, when the state stopped the practice due to water quality concerns.¹³⁵ Most POTWs cannot remove the high concentrations of TDS from wastewater.¹³⁶ High TDS discharges to surface water can impair water quality and kill aquatic life.¹³⁷ When wastewater is treated for use as drinking water, high TDS concentrations can interact with the disinfection process and create byproducts that are harmful to human health.¹³⁸

A number of existing and developing technologies can treat TDS in wastewater, but none is without limitations. For example, desalinization through reverse osmosis can separate high-quality water from a brine concentrate, which must then be disposed of. This process is energy-intensive, however, and is generally considered economically infeasible for treating flow-back fluid with high TDS.¹³⁹ Another treatment method is distillation and crystallization, but current systems can only accept up to 300 cubic meters of fluid per day, whereas a typical hydraulic fracturing operation can produce 3000 cubic meters or more of flow-back fluid per day.¹⁴⁰ In addition to POTWs, some states utilize privately-owned treatment facilities. Pennsylvania, for example, has several existing brine treatment plants that treat wastewater from the oil and gas industry before discharging it to surface waters.¹⁴¹ These plants have been unable to meet rising demand, and twenty-five new treatment facilities have been proposed.¹⁴²

135. 025 PA. CODE § 95.10 (effective Aug. 21, 2010).

136. Gregory et al., *supra* note 122, at 184.

137. *See id.* at 185–86 (noting that water with high TDS concentrations can harm the aquatic environment and that treatment options such as artificial wetlands “are greatly limited by the salinity tolerance of plant and animal life”).

138. PAUL HANDKE, PA. DEP’T OF ENVTL PROT., TRIHALOMETHANE SPECIATION AND THE RELATIONSHIP TO ELEVATED TOTAL DISSOLVED SOLID CONCENTRATIONS AFFECTING DRINKING WATER QUALITY AT SYSTEMS UTILIZING THE MONONGAHELA RIVER AS A PRIMARY SOURCE DURING THE 3RD AND 4TH QUARTERS OF 2008 (2010), available at http://files.dep.state.pa.us/Water/Wastewater%20Management/WastewaterPortalFiles/MarcellusShaleWastewaterPartnership/dbp_mon_report__dbp_correlation.pdf.

139. Gregory et al., *supra* note 122, at 184.

140. *Id.* at 185.

141. PENN STATE EXTENSION, *supra* note 128, at 5.

142. *Id.*

The EPA recently announced plans to develop regulations under the Clean Water Act to create a pretreatment standard for wastewater that is sent to POTWs. The EPA plans to propose this rule in 2014 as part of a larger rulemaking for shale gas extraction.¹⁴³

c. Land Application

A recent peer-reviewed publication by the U.S. Forest Service found that land application of wastewater from oil and gas drilling operations can have negative environmental effects. The study focused on the land application of 303,000 liters of flow-back fluid on 0.20 hectares of forest in West Virginia and found that hundreds of trees had lost their foliage within days.¹⁴⁴ Two years later, fifty-six percent of trees in the area were dead and sodium and chloride levels in the soil increased fifty-fold.¹⁴⁵ The experimental land application was authorized by the Forest Service and required that the company spread fracturing fluid over a smaller area than is typically used.¹⁴⁶ An industry trade group responded that had an area three to five times larger than the one allowed in the state forest been used, no negative effect on the local environment would be expected.¹⁴⁷

d. Reuse of Wastewater

Some experts suggest that reusing wastewater as fracturing fluid in other wells is the best practice to reduce both the volume of wastewater and need for fresh water.¹⁴⁸ However, some additives commonly used in fracturing fluid can interact with the TDS in the wastewater, which reduces their effectiveness.¹⁴⁹ TDS interactions with the shale formation itself may also reduce gas production from the well.¹⁵⁰ Development of salt-tolerant fracturing fluids would help

143. Press Release, U.S. Env'tl. Prot. Agency, EPA Announces Schedule To Develop Natural Gas Wastewater Standards (Oct. 20, 2011), *available at* <http://yosemite.epa.gov/opa/admpress.nsf/0/91E7FADB4B114C4A8525792F00542001>.

144. Mary Beth Adams, *Land Application of Hydraulic Fracturing Fluids Damages a Deciduous Forest in West Virginia*, 40 J. ENVTL. QUALITY 1340, 1340 (2011).

145. *Id.*

146. *Id.*

147. Donald Gilliland, *Fracking Water Test Leaves Salty Aftertaste*, PATRIOT-NEWS (July 10, 2011), http://www.pennlive.com/midstate/index.ssf/2011/07/fracking_water_test_leaves_sal.html.

148. Gregory et al., *supra* note 122, at 185.

149. *Id.*

150. *Id.*

expand reuse.¹⁵¹ However, wastewater recycling does not entirely eliminate disposal concerns, because companies must remove certain substances, such as barium, strontium, and radioactive elements, from wastewater before reuse.¹⁵²

2. Overview of Regulatory Action

Oil- and gas-producing states often set standards for wastewater storage facilities and disposal methods for oil and gas operations.¹⁵³ A few states have revised these standards for hydraulic fracturing sites in response to heightened wastewater storage, treatment, and disposal concerns described above.

- i. **Wastewater Storage:** Colorado revised its oil and gas rules, including individual permitting requirements for pits storing produced water; lining specifications for pits storing certain harmful materials; and new response and reporting procedures for spills and releases.¹⁵⁴ The New York Department of Environmental Conservation proposed regulations that ban open containment of wastewater stored on site, such as storage in open pits. Instead, the regulations would require all flow-back fluid to be contained in watertight tanks within a secondary containment area.¹⁵⁵ STRONGER also has a set of recommendations for state regulation of wastewater storage.¹⁵⁶

151. *Id.*

152. Urbina, *supra* note 98; URS CORP., WATER-RELATED ISSUES ASSOCIATED WITH GAS PRODUCTION IN THE MARCELLUS SHALE 5-1 (2011), available at <http://www.nyscrda.ny.gov/en/Publications/NYSERDA-General-Reports/~media/Files/Publications/NYSERDA/ng/urs-report-11-3-25.ashx>.

153. See GROUND WATER PROT. COUNCIL, *supra* note 19, at 29–31.

154. 2 CODE COLO. REGS. 404-1-900 (2011).

155. *High Volume Hydraulic Fracturing Proposed Regulations*, N.Y. STATE DEP'T ENVTL. CONSERVATION, <http://www.dec.ny.gov/regulations/77401.html> (last visited Feb. 12, 2012).

156. STRONGER recommends that all surface controls used in hydraulic fracturing operations, including dikes, pits, and tanks, comply with its general revised guidelines for oil and gas operations. These guidelines include the use of a permitting and review process for all pits; construction standards that take into account the amount of precipitation, underlying soil, and type of waste contained; the need for fencing, netting, or caging to protect wildlife; preventative maintenance and inspection requirements for tanks; the use of secondary containment systems for all tanks; and requirements that states have information on locations, use, capacity, age, and construction materials of all tanks. STRONGER, REVISED HYDRAULIC FRACTURING GUIDELINES §§ 5.5.2–5.5.4, 5.9.2–5.9.3 (2005), available at <http://www.strongerinc.org/documents/Revised%20guidelines.pdf>.

- ii. Treatment at Publicly or Privately Owned Treatment Facilities: Pennsylvania recently issued regulations to address TDS in wastewater.¹⁵⁷ The regulations allow already-approved TDS discharges to continue but require that new and expanding TDS discharges meet average monthly flow standards.¹⁵⁸ Ohio similarly does not authorize POTWs to receive hydraulic fracturing wastewater with high TDS concentrations and requires approval before they can receive flow-back wastewater with lower TDS concentrations.¹⁵⁹ West Virginia regulators proposed a maximum in-stream standard for TDS, as opposed to regulating point sources, but the standard has not gained support from the legislature.¹⁶⁰
- iii. Land Application: Louisiana and Pennsylvania prohibit land application of all drilling wastewater.¹⁶¹ Arkansas allows land application of produced water but not of flow-back fluids, which contain chemical additives used during hydraulic fracturing.¹⁶²
- iv. Wastewater Reuse: Pennsylvania now requires operators to develop and submit a source-reduction strategy to maximize recycling of wastewater. Operators must also report the volume of wastewater recycled from each well.¹⁶³

In addition, some states have recognized the need for a water supply and disposal registry to track water as it moves through the hydraulic fracturing process. The Pennsylvania Department of Environmental Protection proposed a tracking scheme for hydraulic fracturing wastewater that would create a manifest system for wells that produce more than a minimum volume of wastewater. This system would be similar to the hazardous-waste tracking system

157. See 25 PA. CODE § 95.10 (2010).

158. *Id.*

159. OHIO ENVTL. PROT. AGENCY, DRILLING FOR NATURAL GAS IN THE MARCELLUS AND UTICA SHALES: ENVIRONMENTAL REGULATORY BASICS 2–3 (2010), available at http://www.ohiodnr.com/portals/11/publications/pdf/Marcellus_Shale_Fact_Sheet.pdf.

160. See Walt Williams, *Effort To Toughen Water Quality Standards Stalls*, STATE J. (Mar. 10, 2011), <http://www.statejournal.com/Global/story.asp?S=15781369>.

161. LA. ADMIN. CODE tit. 33, pt. IX, § 708(C)(2)(a)(ii); Gilliland, *supra* note 147.

162. *Land Application of Water-Based Drilling Fluids—00000-WG-LA*, NO DISCHARGE PERMITS SECTION, WATER DIV., ARK. DEP'T OF ENVTL. QUALITY, http://www.adeq.state.ar.us/water/branch_permits/nodischarge_permits/default.htm#Permits_for_Land_AAapplicatio_of_wa ter_based_drilling_fluids (last visited Feb. 17, 2012).

163. 25 PA. CODE § 95.10(b)(2) (2010).

under the federal Resource Conservation and Recovery Act (RCRA),¹⁶⁴ which does not apply to waste from oil and gas activities.¹⁶⁵ Colorado requires well operators to maintain a record of the volume of transported wastewater, the pickup date, and the identity of the transporter.¹⁶⁶

The EPA recently initiated an inquiry to collect information, review existing technologies, and develop regulatory options to control the discharge of wastewater pollutants associated with the shale gas extraction industry. The agency expects to begin the rulemaking process in 2014.¹⁶⁷

D. Impacts on Air Quality

Activities related to shale gas drilling and production are a source of air pollutants, including nitrous oxides (NOx) and volatile organic compounds (VOCs) (both are precursors to ground-level ozone), hazardous air pollutants (HAPs), and greenhouse gases (GHGs).¹⁶⁸ Most of these emissions occur during the “flow-back period” following the hydraulic fracturing process, during which chemical-laden water flows out of the well.¹⁶⁹ Other sources of air pollutants include truck traffic and idling, drilling equipment, natural gas compression, and pressure regulation inside the well. Methane from wells is another potential source of air pollution, as operators sometimes vent wells to control pressure.¹⁷⁰

Air pollutants from natural gas wells may contribute to poor air quality and interfere with the ability of localities to meet National Ambient Air Quality Standards (NAAQS) as required by the Clean

164. 42 U.S.C. §§ 6901–6992k (2006).

165. 40 C.F.R. § 261.4(b)(5) (2011); MARCELLUS SHALE ADVISORY COMM’N, DRAFT RECOMMENDATIONS FROM MEMBERS: PUBLIC HEALTH, SAFETY, AND ENVIRONMENTAL PROTECTION 39 (2011), available at http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/Public_Health_Safety_Environmental_Protection.pdf; Swift, *supra* note 57; EPA, EXEMPTION OF OIL AND GAS E&P WASTES, *supra* note 126.

166. 2 COLO. CODE REGS. § 404-1-907(b) (2011).

167. *Pretreatment Standards for the Shale Gas Extraction Industry*, U.S. ENVTL. PROT. AGENCY, <http://yosemite.epa.gov/opei/rulegate.nsf/byRIN/2040-AF34> (last updated Jan. 29, 2012).

168. See U.S. ENVTL. PROT. AGENCY, PROPOSED AMENDMENTS TO AIR REGULATIONS FOR THE OIL AND NATURAL GAS INDUSTRY 2 (2011) [hereinafter EPA, PROPOSED AMENDMENTS], available at <http://epa.gov/airquality/oilandgas/pdfs/20110728factsheet.pdf>.

169. *Id.*

170. Robert W. Howarth & Anthony Ingraffea, Comment, *Natural Gas: Should Fracking Stop?*, 477 NATURE 271, 272–73 (2011).

Air Act.¹⁷¹ Ground-level ozone, in particular, is a concern around shale gas plays.¹⁷² North Carolina's potential shale gas development areas are located upwind of an area that already does not meet the short-term ozone standard. If shale gas extraction is permitted in North Carolina, the potential impact on ground-level ozone pollution will be an important consideration for regulators, including whether shale gas production could expand the existing non-attainment zone or create new non-attainment zones in the state.¹⁷³

The EPA recently issued draft federal air regulations tailored to hydraulic fracturing. The draft rule includes new source performance standards (NSPS) for VOCs and sulfur dioxide as well as a more stringent air toxic standard for benzene.¹⁷⁴ The NSPS for VOCs would create pollution reduction standards for well completions, compressors, pneumatic devices, condensate storage tanks, and natural gas processing plants. The EPA plans to release the final rule in February 2012.¹⁷⁵

1. Experiences in Other States

In 2008, rural Sublette County, Wyoming, became an ozone non-attainment area. The Wyoming Department of Environmental Quality attributes this re-classification to shale gas production and meteorological conditions favorable to ozone formation.¹⁷⁶ In Colorado, emissions from oil and gas operations exceed total motor vehicle emissions for the state.¹⁷⁷

2. Overview of Regulatory Action

In the absence of federal standards, a few states have responded to deteriorating air quality around natural gas plays by revising their

171. Clean Air Act, 42 U.S.C. §§ 7409–7410 (2006).

172. See Colborn et al., *supra* note 59, at 1042 (describing the sources of ground-level ozone associated with gas extraction and the harmful effects of ozone on human health).

173. *Ozone Non-Attainment Areas*, DIV. AIR QUALITY, N.C. DEP'T OF ENV'T & NAT. RES., <http://daq.state.nc.us/planning/ozone/> (last updated Jan. 19, 2012).

174. Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews, 76 Fed. Reg. 52,737 (proposed Aug. 23, 2011); EPA, PROPOSED AMENDMENTS, *supra* note 168.

175. EPA, PROPOSED AMENDMENTS, *supra* note 168, at 7.

176. AIR QUALITY DIV., WYO. DEP'T OF ENVTL. QUALITY, TECHNICAL SUPPORT DOCUMENT I FOR RECOMMENDED 8-HOUR OZONE DESIGNATION FOR THE UPPER GREEN RIVER BASIN, WY, at vii (2009).

177. AIR POLLUTION CONTROL DIV., COLO. DEP'T OF PUB. HEALTH & ENV'T, OIL AND GAS EXPLORATION AND PRODUCTION EMISSION SOURCES: PRESENTATION FOR THE AIR QUALITY CONTROL COMMISSION RETREAT 2 (2008).

state implementation plans under the Clean Air Act and applying standards beyond the current federal minimums.¹⁷⁸ Some states are also tightening regulations on specific sources of emissions associated with shale gas extraction, such as pneumatic devices, natural gas dehydration units, condensate, and well completions.

- i. **Apply More Stringent Emissions Limits:** Wyoming now requires ozone offsets for any new or modified sources in Sublette County.¹⁷⁹
- ii. **Regulate Emissions from Pneumatic Devices:** The oil and gas industry frequently uses pneumatic devices to manage liquid level controllers, pressure regulators, and valve controllers.¹⁸⁰ These devices are typically powered by natural gas combustion and are designed to vent methane as part of normal operations.¹⁸¹ Colorado addresses emissions from pneumatic devices through its NO_x and VOC regulations.¹⁸² Wyoming regulates pneumatic devices through its VOC and HAP programs.¹⁸³

178. See EPA, PROPOSED AMENDMENTS, *supra* note 168. Wyoming applies BACT standards to all oil and gas production units including both major and minor sources. Both Wyoming and Colorado require green completions, which are not yet required at the federal level. See *infra* notes 187–188 and accompanying text.

179. INTERIM POLICY ON DEMONSTRATION OF COMPLIANCE WITH WAQSR CHAPTER 6, SECTION 2(C)(ii) FOR SOURCES IN SUBLETTE COUNTY (issued July 21, 2008), <http://deq.state.wy.us/aqd/Ozone/Interim%20Permit%20Policy.pdf>; see also AIR QUALITY DIV., *supra* note 176, at 88. The Clean Air Act requires offsets for major sources of criteria pollutants in non-attainment areas. 42 U.S.C. §§ 7503(c) (2006).

180. U.S. ENVTL. PROT. AGENCY, LESSONS LEARNED FROM NATURAL GAS STAR PARTNERS: OPTIONS FOR REDUCING METHANE EMISSIONS FROM PNEUMATIC DEVICES IN THE NATURAL GAS INDUSTRY 1 (2006) [hereinafter EPA, LESSONS LEARNED], available at www.epa.gov/gasstar/documents/ll_pneumatics.pdf.

181. Emissions from pneumatic devices, well cleanups, and well completions account for the majority of methane emissions from field production of natural gas. See U.S. ENVTL. PROT. AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS 1990–2009, at 3-50 (2011), available at http://epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Complete_Report.pdf (noting that pneumatic devices accounted for more than a quarter of methane emissions from natural gas production in 2007); see also U.S. ENVTL. PROT. AGENCY, OPTIONS FOR REDUCING EMISSIONS FROM PNEUMATIC DEVICES: LESSONS LEARNED FROM THE NATURAL GAS STAR PROGRAM: PRESENTATION TO PRODUCERS TECHNOLOGY TRANSFER WORKSHOP 2 (2010), available at http://www.epa.gov/gasstar/documents/workshops/vernal-2010/07_pneumatics.pdf.

182. See 5 COLO. CODE REGS. § 1001-9, ch. XVIII (2011).

183. See WYO. DEP'T OF ENVTL. QUALITY, OIL AND GAS PRODUCTION FACILITIES CHAPTER 6, SECTION 2 PERMITTING GUIDANCE 9–11 (2010), available at [http://deq.state.wy.us/aqd/Oil and Gas/March 2010 FINAL O&G GUIDANCE.pdf](http://deq.state.wy.us/aqd/Oil%20and%20Gas/March%202010%20FINAL%20O&G%20GUIDANCE.pdf).

- iii. Efficiency Standards for Natural Gas Dehydration Units: Natural gas dehydration units remove water from natural gas prior to transmission. Wyoming and Colorado both impose efficiency requirements on these units.¹⁸⁴
- iv. Efficiency Standards for Condensate: Some natural gas wells produce condensate as a byproduct of gas extraction. Condensate is composed of hydrocarbons and aromatic hydrocarbons that are in a gaseous state in the reservoir and that become liquid as a result of the gas production process. Tanks used to store condensate may be sources of VOC emissions.¹⁸⁵ Colorado and Wyoming both impose control efficiency standards on such tanks.¹⁸⁶
- v. Well Completion: The well completion process releases VOCs, HAPs, and methane when gases and liquids are brought to the surface. Operators can adopt special completion methods, referred to as “green completions” or “green flow-back methods,” to reduce these emissions.¹⁸⁷ Colorado requires the use of green completions where technically feasible, and Wyoming addresses this issue by including best management practices (BMPs) in its permitting process.¹⁸⁸

The EPA also administers a voluntary partnership called the Natural Gas STAR Program, which recommends technologies and best practices to reduce methane emissions from natural gas operations.¹⁸⁹ Many of the state requirements discussed above are reflected in the EPA recommendations, but the EPA goes beyond

184. *See id.* at 6; 5 COLO. CODE REGS. § 1001-9, § XII. C.1.a (2011).

185. U.S. ENVTL. PROT. AGENCY, INSTALL PRESSURIZED STORAGE OF CONDENSATE: PRO FACT SHEET NO. 501 (2004), *available at* <http://www.epa.gov/gasstar/documents/installpressurized.pdf>.

186. 5 COLO. CODE REGS. § 1001-9, ch. XII, C.1.a (2011); AIR QUALITY DIV., *supra* note 176.

187. EPA, LESSONS LEARNED, *supra* note 180, at 3. Generally, “green” completion methods employ special temporary equipment at the well site designed to collect the gases and liquids being produced, filter them, and place them in production pipelines and tanks instead of being vented, dumped, or flared. U.S. ENVTL. PROT. AGENCY, REDUCED EMISSION COMPLETIONS FOR HYDRAULICALLY FRACTURED NATURAL GAS WELLS 1 (2001) [hereinafter EPA, REDUCED EMISSION COMPLETIONS], *available at* http://www.epa.gov/gasstar/documents/reduced_emissions_completions.pdf.

188. AIR QUALITY DIV., *supra* note 176.

189. *Natural Gas STAR Program: Recommended Technologies and Practices*, U.S. ENVTL. PROT. AGENCY, <http://www.epa.gov/gasstar/tools/recommended.html> (last updated Sept. 15, 2011).

these primarily technology-based requirements to recommend proper use of technology to further reduce air-quality impacts. The EPA estimates the payback period for recommended technologies and practices (benefits come from the increased production of natural gas, as some of the gas that would otherwise be wasted is recovered by emissions controls) and clearly demonstrates that a range of cost-effective strategies is available to reduce the air quality impacts of natural gas drilling.¹⁹⁰ Although the Natural Gas STAR Program focuses on the climate-change impacts of methane in the atmosphere, its strategies for reducing methane emissions also reduce VOC and HAP emissions.¹⁹¹

V. ADDRESSING SPILLS AND OTHER ACCIDENTS

Accidents and equipment failures can cause leaks, spills, and environmental contamination even under effective regulatory programs. Although accidents can occur at any stage of the gas production process, they most often occur during drilling and fracturing, or when wastes are improperly managed.¹⁹² Some states are beginning to respond to the risks most commonly associated with shale gas production with technical standards for drilling procedures, requirements for spill-prevention and cleanup plans, and financial responsibility for damages.

A. Drilling

Accidents and equipment failures during drilling can lead to dangerous releases of natural gas, extremely salty water or “brine,” and toxic substances. These failures can occur when operators encounter unexpected pockets of pressurized gas before reaching the target formation, or when higher-than-anticipated pressures occur during the fracturing, flow-back, or production phases. Both scenarios can cause the release of gas as well as naturally occurring brine and any chemicals injected during drilling. Improper well casing and cementing can also create underground conduits through which

190. *See id.*

191. *See, e.g.*, EPA, REDUCED EMISSION COMPLETIONS, *supra* note 187, at 1.

192. *See, e.g.*, NYSDEC SGEIS: REVIEW OF SELECT NON-ROUTINE INCIDENTS IN PENNSYLVANIA 10-4 (2011), available at http://www.dec.ny.gov/docs/materials_minerals_pdf/rdsgeisch100911.pdf.

fracturing fluid, hydrocarbons, brine, and other substances can leak into the surrounding environment.¹⁹³

1. Experiences in Other States

New York regulators studying the hydraulic fracturing industry found that three accidents occurred at a single shale gas well pad in Dimock Township, Pennsylvania, due to equipment failures when pressure ratings were exceeded.¹⁹⁴ In Lawrence Township, Pennsylvania, another operator lost control of a wellbore during post-fracturing activities, resulting in a release of natural gas, flow-back fluid, and brine. In this case, insufficient blowout-prevention equipment and the absence of certified well-control personnel on site contributed to the accident.¹⁹⁵ More recently, another blowout of a shale gas well in Pennsylvania sent fracturing fluid and natural gas seventy-five feet into the air over the course of approximately sixteen hours.¹⁹⁶

The Groundwater Protection Council, a national association of state groundwater and underground-injection-control agencies, recommends that operators use an appropriate cement evaluation tool when a well is hydraulically fractured near an underground source of drinking water, and that regulators approve the results prior to fracturing.¹⁹⁷ STRONGER also suggests that regulators identify and address potential conduits of fluid migration during the permitting process.¹⁹⁸ The U.S. Department of Energy's SEAB Shale Gas Subcommittee recommends that regulators and industry adopt best practices for well development and construction, including casing, cementing, and pressure management.¹⁹⁹

193. See, e.g., DIV. OF MINERAL RES. MGMT., OHIO DEP'T OF ENV'T & NATURAL RES., REPORT ON THE INVESTIGATION OF NATURAL GAS INVASION OF AQUIFERS IN BAINBRIDGE TOWNSHIP OF GEAUGA COUNTY, OHIO (2008), available at http://s3.amazonaws.com/publica/assets/natural_gas/ohio_methane_report_080901.pdf; Press Release, Pa. Dep't of Env'tl. Prot., DEP Fines Chesapeake Energy More Than \$1 million: Penalties Address Violations in Bradford, Washington Counties (May 17, 2011), available at <http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=17405&typeid=1>.

194. NYSDEC SGEIS, *supra* note 192, at 10-2.

195. *Id.*

196. GOVERNOR'S MARCELLUS SHALE ADVISORY COMM'N, *supra* note 84, at 75.

197. GROUND WATER PROT. COUNCIL, *supra* note 19, at 40.

198. See STRONGER, *supra* note 79, at 22.

199. SEC'Y OF ENERGY ADVISORY BD., *supra* note 50, at 2.

2. Overview of Regulatory Action

States with a long history of oil and gas production have safety requirements to minimize drilling accidents.²⁰⁰ However, with the proliferation of horizontal drilling and hydraulic fracturing in shale gas extraction, many states are now revising their requirements to address the increased risks associated with the high pressures encountered during the fracturing process.²⁰¹

- i. **Blowout Prevention:** Colorado's recently revised rule for oil and gas drilling requires operators to install blowout-prevention equipment on any well expected to flow due to high pressure, to inspect the equipment daily, to check that the equipment has a sufficient rating to meet the anticipated pressure, and to ensure that rig operators have proper training.²⁰² Regulations proposed by the New York Department of Environmental Conservation require pressure-testing of blowout-prevention equipment, the use of at least two mechanical barriers, and the use of specialized equipment designed to enter the wellbore when high pressure is anticipated. The New York regulations would also require the onsite presence of a certified well-control specialist to address the risk of releases due to equipment failure under pressure.²⁰³
- ii. **Well Casing and Cementing:** Most states with oil and gas production have minimum standards for well casing and cementing,²⁰⁴ but some states are revising their regulations to address the high pressures associated with hydraulic fracturing. Oklahoma recently adopted new casing and cementing standards that require operators to install casings reaching to greater depths to protect the water table, to complete surface casing prior to drilling past a certain depth, and to alert regulators at least twenty-four hours before casing and cementing so they can dispatch an inspector to

200. See, e.g., 2 COLO. CODE REGS. §§ 404-1:317, 404-1:603(i) (2011); HARVEY CONSULTING, RECOMMENDATIONS FOR PENNSYLVANIA'S PROPOSED CHANGES TO OIL AND GAS WELL CONSTRUCTION REGULATIONS: REPORT TO EARTHJUSTICE AND SIERRA CLUB 3 (2010), available at <http://www.sierraclub.org/naturalgas/rulemaking/documents/PA.Chapter78/2010.8.9.PADEP.CasingComments.pdf>.

201. See 2 COLO. CODE REGS. §§ 404-1:317, 404-1:603(i).

202. *Id.*

203. NYSDEC SGEIS, *supra* note 192, at 10-4.

204. GROUND WATER PROT. COUNCIL, *supra* note 19, at 19-21.

observe the process.²⁰⁵ Colorado also revised its casing requirements to prevent migration of oil, gas, and other contaminants and to mandate pressure tests prior to operation.²⁰⁶

- iii. **Underground Injection Control:** The SDWA regulates underground injection of fluids through the Underground Injection Control (UIC) Program.²⁰⁷ However, the Energy Policy Act of 2005 excluded the practice of hydraulic fracturing from the SDWA,²⁰⁸ and attempts to reverse the exclusion have been unsuccessful.²⁰⁹ Nevertheless, states could choose to regulate hydraulic fracturing through their UIC programs.

B. Drill Cuttings and Mud

Drilling mud (or “drilling fluid”) is a substance used to control subsurface pressures, lubricate the drill bit, stabilize the wellbore, and carry cuttings to the surface.²¹⁰ Drilling mud can be water-based, oil-based, or synthetic oil-based.²¹¹ Water-based muds are relatively benign and can be disposed of on site. However, operators often favor oil-based muds for horizontal drilling.²¹² Oil-based muds contain diesel, mineral oil, or synthetic alternatives that can contaminate the local environment.²¹³ Generally, operators do one of three things: (1) bury cuttings on site; (2) send them to a commercial disposal facility; or (3) remove the mud and sell the cuttings for road spreading, as fill material, to cover landfills, or as an aggregate or filler in concrete, brick, or block manufacturing.²¹⁴

205. OKLA. ADMIN. CODE § 165:10-3-4 (2011).

206. 2 COLO. CODE REGS. § 404-1-317(B).

207. 42 U.S.C. § 1421(a)(1) (2006).

208. Energy Policy Act of 2005, Pub. L. No. 109-58, 119 Stat. 594, § 322 (2005) (codified at 13 U.S.C. § 1362 (2006)).

209. See, e.g., Fracturing Responsibility and Awareness of Chemicals (FRAC) Act, S. 1215, 111th Cong. (2009); H.R. 2766, 111th Cong. (2009).

210. *Fact Sheet—Step 1: Separation of Mud from Cuttings*, DRILLING WASTE MGMT. INFO. SYS., <http://web.ead.anl.gov/dwm/techdesc/sep/index.cfm> (last visited Feb. 1, 2012).

211. *Fact Sheet—Using Muds and Additives with Lower Environmental Impacts*, DRILLING WASTE MGMT. INFO. SYS., <http://web.ead.anl.gov/dwm/techdesc/lower/index.cfm> (last visited Feb. 1, 2012).

212. *Id.*

213. *Id.*

214. See *Fact Sheet—Beneficial Reuse of Drilling Waste*, DRILLING WASTE MGMT. INFO. SYS., <http://web.ead.anl.gov/dwm/techdesc/reuse/index.cfm> (last visited Feb. 1, 2012); see also

Horizontal wells generally produce forty percent more cuttings than vertical gas wells, creating more waste that has to be stored, transported, treated, and disposed of safely.²¹⁵ If handled improperly, heavy metals and other components of drill mud and cuttings can leach into groundwater or have adverse impacts on soil.²¹⁶ Drill cuttings can also contain materials that lead to acid rock drainage (highly acidic water laden with heavy metals, such as pyrite).²¹⁷

The components of drill cuttings that would be brought to the surface if shale gas extraction takes place in North Carolina are unknown. Data collection prior to the establishment of a regulatory program could help inform the levels of protection needed for the handling and disposal of these cuttings.

1. Experiences in Other States

At a storage site for shale drill cuttings in Clearfield County, Pennsylvania, a pit liner tore, releasing leachate into the groundwater. The leachate contaminated a nearby spring, where tests found levels of barium four times above those considered safe for drinking water.²¹⁸

2. Overview of Regulatory Action

Drilling muds and other wastes associated with the exploration, development, or production of crude oil or natural gas are exempt from federal regulation under RCRA, which sets standards for the storage, transportation, treatment, and disposal of hazardous wastes.²¹⁹ States with oil and gas drilling typically regulate the types of pits and tanks that operators can use to store drill cuttings and mud, as well as the options for their disposal or reuse.

Fact Sheet—Commercial Disposal Facilities, DRILLING WASTE MGMT. INFO. SYS., <http://web.ead.anl.gov/dwm/techdesc/commercial/index.cfm> (last visited Feb. 1, 2012).

215. NYSDEC SGEIS: NATURAL GAS DEVELOPMENT ACTIVITIES & HIGH-VOLUME HYDRAULIC FRACTURING 5-34 (2011), available at http://www.dec.ny.gov/docs/materials_minerals_pdf/rdsgeisch50911.pdf.

216. See *Waste Management of Cuttings, Drilling Fluids, Hydrofrack Water and Produced Water*, N.Y. STATE WATER RES. INST., http://wri.eas.cornell.edu/gas_wells_waste.html (last visited Feb. 1, 2012) (discussing heavy metal concentrations and the risk of spills).

217. GROUND WATER PROT. COUNCIL & ALI CONSULTING, *supra* note 16, at ES-4 to -5.

218. Laura Legere, *Hazards Posed by Natural Gas Drilling Not Always Underground*, SCRANTON TIMES-TRIB. (June 21, 2010), <http://thetimes-tribune.com/news/hazards-posed-by-natural-gas-drilling-not-always-underground-1.857452#axzz119sBu6j4>.

219. 40 C.F.R. § 261.4(b)(5) (2011); EPA, EXEMPTION OF OIL AND GAS E&P WASTES, *supra* note 126, at 10.

In response to increased volumes of drill mud and cuttings, some states are reconsidering their regulations of this waste stream. West Virginia lawmakers recently established a requirement that drill cuttings and mud must be managed offsite in an approved solid-waste facility unless the surface owner consents to onsite management.²²⁰ The New York Department of Environmental Conservation proposed regulations that would require oil-based muds to be managed in closed-loop tank systems and disposed of offsite. The proposed regulations would also require plans to mitigate acid rock drainage by, for example, adding carbonate such as limestone to drill cuttings to neutralize any acid that can leach into water along with heavy metals.²²¹

Although the EPA does not regulate hazardous waste that results from the exploration or production of natural gas, it has issued a list of suggested management practices for drill cuttings and mud.²²²

C. Spill Response Planning and Liability

Drilling carries the risk of widespread damage to natural resources and, with it, the question of who is responsible if damage occurs. At the federal level, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) establishes cleanup standards and liability for hazardous waste contamination.²²³ However, CERCLA expressly does not apply to petroleum and natural gas contamination.²²⁴ As a result, state regulators face the task of assigning financial and remedial responsibility.

1. Experiences in Other States

State agencies have the authority to levy fines on operators for violations of permitting requirements or regulations as a means of mitigating cost when accidents occur. On May 17, 2011, the Pennsylvania Department of Environmental Protection fined Chesapeake Energy \$1,088,000 for violations related to natural gas

220. H.B. 401, 2011 Leg., 4th Extraordinary Sess. (W. Va. 2011).

221. *High Volume Hydraulic Fracturing*, *supra* note 155.

222. See EPA, EXEMPTION OF OIL AND GAS E&P WASTES, *supra* note 126, at 25–26 (suggesting waste management practices).

223. CERCLA Overview, U.S. ENVTL. PROT. AGENCY, <http://www.epa.gov/superfund/policy/cercla.htm> (last visited Feb. 2, 2012).

224. 42 U.S.C. § 9601 (2006); EPA, EXEMPTION OF OIL AND GAS E&P WASTES, *supra* note 126, at 30.

drilling activities.²²⁵ In August 2004, Colorado's Oil and Gas Conservation Commission (COGCC) fined Encana Oil and Gas \$371,200 for violations of well-cementing requirements that resulted in water contamination.²²⁶ In addition to retroactive actions, many states have, or are beginning to develop, a more proactive approach to spill response and liability.

2. Overview of Regulatory Action

- i. **Spill Response or Contingency Plans:** States often require operators to submit spill-response or contingency plans at some stage of the permitting process to ensure that the operator is ready to respond if an incident occurs.²²⁷ Some states are using these plans as a tool to address new risks from shale gas production. For example, Pennsylvania requires that operators submit preparedness, prevention, and contingency (PPC) plans before drilling and operating oil and gas wells or brine disposal wells and before spreading oil and gas waste on roads.²²⁸ In one instance, regulators ordered Cabot Oil and Gas Corporation to shut down operations following three separate spills that occurred in less than one week, and they mandated that the company conduct an engineering study to update its PPC plan before resuming operations.²²⁹
- ii. **Bonding Requirements:** States that allow natural gas drilling typically demand bonds, paid at the time of permitting, from well operators to cover the cost of cleanup in case the well is not plugged or the site is not properly reclaimed.²³⁰ Bonding requirements typically vary with well depth. Pennsylvania

225. Press Release, Pa. Dep't Env'tl. Conservation, *supra* note 193.

226. Encana Oil and Gas (USA), Inc., Colo. Oil & Gas Conservation Comm'n, No. 0408-OV-27 (June 14, 2004), *available at* http://cogcc.state.co.us/Hearings/Notices/2004/Aug_04/0408OV27.htm.

227. GROUND WATER PROT. COUNCIL & ALL CONSULTING, *supra* note 16, at 34 (noting the federal requirements of oil Spill Prevention, Control and Countermeasure (SPCC) plan).

228. 25 PA. CODE § 91.34 (2011) ("Control and Disposal Plan"); *id.* § 78.55 ("Activities Utilizing Pollutants").

229. Press Release, Pa. Dep't Env'tl. Conservation, DEP Orders Cabot Oil and Gas To Cease All Gas Well Fracking in Susquehanna County (Sept. 25, 2009), *available at* http://s3.amazonaws.com/propublica/assets/natural_gas/dep_cabot_order_090925.pdf.

230. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-245, OIL AND GAS BONDS: BONDING REQUIREMENTS AND BLM EXPENDITURES TO RECLAIM ORPHANED WELLS 20-22 (2010), *available at* <http://www.gao.gov/assets/310/300218.pdf>.

and the DRBC are considering raising bond requirements for wells that are hydraulically fractured.²³¹

- iii. **Strict Liability:** Plaintiffs have recently brought suit in Arkansas, Louisiana, and Pennsylvania, alleging that various aspects of hydraulic fracturing constitute an “ultrahazardous activity” to which strict liability (that is, liability regardless of whether the defendant is negligent) should apply.²³² Some states, such as Texas, have determined that the storage of produced fluid for underground injection does not constitute an ultrahazardous activity.²³³ Other states, such as New York, are currently considering application of strict liability to natural gas drilling.²³⁴

231. Pennsylvania’s Marcellus Shale Advisory Commission suggested creating a two-tiered bonding system based on the total (vertical and horizontal) length of the well. The system would establish bonding amounts for wells up to 6000 feet and exceeding 6000 feet and raise the current blanket bond from \$25,000 to \$250,000. GOVERNOR’S MARCELLUS SHALE ADVISORY COMM’N, *supra* note 84, § 9.2.9. The Commission also recommended reevaluating and revising bond amounts every three years. *Id.* The DRBC is also considering implementing a new financial assurance requirement, which would require bonds for capping and closure (\$25,000 per well or up to \$250,000 total); remediation of accidental spills and releases (\$5 million for individual well pads not within an approved Natural Gas Development Plan (NGDP), and \$8000 per acre with a maximum of \$25 million for lands within an approved NGDP); and mitigation (for the estimated cost of completing the mitigation and restoration, which will be specified in the particular NGDP for the site). DELAWARE RIVER BASIN COMM’N, *supra* note 113, pt. 3, art. 7.3(j)(7)(i)–(v). The proposed regulations remove the processes by which bond requirements may be reduced by the Executive Director. DELAWARE RIVER BASIN COMM’N, REVISED DRAFT NATURAL GAS DEVELOPMENT REGULATIONS “AT-A-GLANCE” FACT SHEET 3 (2011), available at <http://www.state.nj.us/drbc/library/documents/naturalgas-REVISEDdraftregs-factsheet110811corrected.pdf> (corrected after original posting). At the federal level, oil and gas minimum bond requirements have not been raised since 1960. A recent Government Accountability Office report found that the Bureau of Land Management spent about \$3.8 million to reclaim orphaned wells between 1988 and 2009. U.S. GOV’T ACCOUNTABILITY OFFICE, *supra* note 230, at 1.

232. See *Legal Updates: Hydraulic Fracturing Cases in Arkansas Seeking Class Action Status*, MCGUIREWOODS (June 28, 2011), <http://www.mcguirewoods.com/news-resources/item.asp?item=5933>; David R. Dugas, *Is Shale Gas Fracking an Ultrahazardous Activity*, MARTINDALE (Mar. 16, 2011), http://www.martindale.com/energy-law/article_McGlinchey-Stafford-PLLC_1255718.htm.

233. Keith B. Hall, *Hydraulic Fracturing Litigation: Defenses to “Abnormally Dangerous” Activity Claims*, OIL & GAS L. BRIEF (July 29, 2011), <http://www.oilgaslawbrief.com/hydraulic-fracturing/hydraulic-fracturing-litigation—defenses-to-abnormally-dangerous-activity-claims>.

234. New York Comptroller Thomas P. DiNapoli recently announced that he will propose an industry-supported fund “to remediate contamination and . . . recover damages caused by accidents related to natural gas production.” *DiNapoli Plan Provides Response for New Yorkers in Case of Natural Gas Accidents*, OFFICE OF THE N. Y. STATE COMPTROLLER (Aug. 9, 2011), <http://www.osc.state.ny.us/press/releases/aug11/080911.htm>. DiNapoli’s plan would impose a surcharge on drilling permits to establish a Natural Gas Damage Recovery Fund, empower the

- iv. **Anti-Indemnity Acts:** Several states, including Louisiana, New Mexico, Texas, and Wyoming, passed similar oilfield anti-indemnity acts to limit the ability of well operators to protect themselves against liability when their negligence is the sole cause of harm.²³⁵ These laws ensure that contractors do not sign agreements that leave them without legal recourse if injured by the negligence of the company operating the well on which they work.
- v. **Presumptive Liability:** As noted in part III.A. above, states such as Michigan, Pennsylvania, and West Virginia have established presumptions of liability when water contamination occurs within a specified distance of an oil or gas well.²³⁶ Holding drilling companies responsible for nearby contamination if they cannot prove otherwise can create an incentive for them to invest in pre-testing and to protect landowners when drilling damages water supplies.

North Carolina's Session Law 2011-276, which became law in June 2011, includes several provisions that affect how liability will be managed if shale gas drilling is allowed in North Carolina.²³⁷ Section 113-378 sets a bond requirement of \$5000 plus \$1 per linear foot of the well.²³⁸ The shale formations in Lee County are estimated to lie at a depth of less than 3000 feet,²³⁹ meaning that the bonds would equal less than \$8000 plus an additional \$1 for each foot drilled laterally. Section 113-421 requires oil and gas developers to compensate landowners for harm to their water supply or damage to their property due to the operators' activity.²⁴⁰

Department of Environmental Conservation to order immediate cleanup or to take over sites for cleanup, require natural gas operators to post surety bonds to cover any difference between Fund resources and cleanup costs, and apply strict liability to natural gas drilling. *Id.*

235. LA. REV. STAT. ANN. § 9:2780 (2011); N.M. STAT. ANN. § 56-7-2 (2011); TEX. CIV. PRAC. & REM. §§ 127.001-.007; WYO. STAT. ANN. § 30-1-131; Robert Redfearn, Jr., *Oilfield Anti-Indemnity Acts and Their Impact on Insurance Coverage: A Comparative Analysis*, INS. J. (Aug. 22, 2005), available at <http://www.insurancejournal.com/magazines/features/2005/08/22/59608.htm>.

236. See *supra* note 55 and accompanying text.

237. Act of June 17, 2011, 2011 N.C. Sess. Laws 276.

238. *Id.* § 113-378.

239. REID & TAYLOR, *supra* note 1, at 2.

240. Act of June 17, 2011, § 113-421.

CONCLUSION

As North Carolina lawmakers consider whether and under what conditions to allow shale gas extraction, they can learn from the policy decisions that other states have made about collecting baseline information, funding regulatory programs, addressing water and air quality and water supply, managing impacts on municipalities, and addressing liability concerns. Because state oil and gas regulatory programs have not kept pace with the rapid expansion of shale gas extraction, the issues that other states have encountered while bringing their policy up to date can provide valuable insight for North Carolina. Specifically, these experiences can help North Carolina policymakers define the risks that an effective regulatory program would need to address.

Because North Carolina has no active oil and gas production and no existing regulatory framework for this industry, the state has a unique opportunity to build a program from the ground up. Industry practices and regulatory approaches are rapidly evolving, and regional variation in the geology of shale deposits is high. Therefore, as elected officials and regulators consider their policy options, they will need to carefully evaluate the experiences of other states, the recommendations of stakeholder groups, and the unique local environment.

For example, if North Carolina lawmakers decide that the ability to determine whether instances of groundwater contamination are caused by drilling or are pre-existing is a regulatory priority, they might consider requiring periodic isotopic analysis of natural gas at the wellhead to facilitate the identification of the source of any methane found in drinking water. They may also consider requiring the addition of non-toxic tracers to fracturing fluid to help state regulators track and test for contaminants in drinking water supplies.

Similarly, North Carolina lawmakers might consider addressing potential impacts from spills and accidents through a number of strategies that, to our knowledge, have not been implemented in other states. Such strategies may include: instituting more stringent setback requirements from properties that are not subject to a mineral rights lease, which would help minimize the impacts of drilling on neighboring property owners who have chosen not to lease their mineral rights; establishing a cradle-to-grave waste management and tracking system for wastewater similar to the federal manifest system for hazardous waste under RCRA; and creating a “mini-

Superfund” or other industry-funded mechanism to prevent cleanup costs from falling to taxpayers.

This article presents only a handful of the many ways in which North Carolina lawmakers could build on the experience of other states to develop an effective and locally appropriate regulatory structure for shale gas extraction. If North Carolina’s elected officials determine that shale gas extraction is appropriate for the state, policymakers should take full advantage of the opportunity to build a regulatory program from the ground up and should carefully consider all opportunities to improve upon current practices.