



Hydraulic Fracturing in the Great Lakes Basin: The State of Play in Michigan and Ohio

A LEGAL ANALYSIS BY THE NATIONAL WILDLIFE FEDERATION



HYDRAULIC FRACTURING IN THE GREAT LAKES BASIN: THE STATE OF PLAY IN MICHIGAN AND OHIO

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ACKNOWLEDGMENTS

The report is the result of a legal research project co-sponsored by the **National Wildlife Federation** and the **University of Michigan Law School**. This publication was made possible through support provided by the U.S. Department of Commerce, NOAA, through The University of Mississippi under the terms of Grant No. NA09OAR4170200. The opinions expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or the University of Mississippi.

We would like to acknowledge the following reviewers:

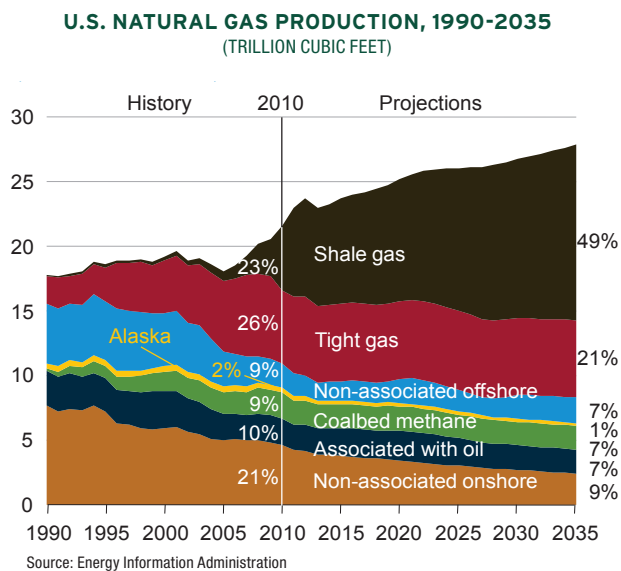
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The authors are solely responsible for the content of this report. The views expressed in this report are those of the authors and do not necessarily represent the views of, and in some cases conflict with, reviewers.

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The U.S. Energy Information Administration estimates that by 2035 almost half of the nation’s natural gas will be produced from shale formations, doubling the percentage produced in 2010.¹ Meanwhile, the percentage of crude oil obtained from “tight oil” sources, including shale, is estimated to more than double during the same time period, from 12% of onshore production to 31%.² To extract natural gas and oil from shale, energy companies use hydraulic fracturing—or “hydrofracking”—a controversial technique in which a mix of water, chemicals, and sand is injected at high pressures into a well to open fractures in the rock. Hydrofracking, particularly in deep shale, has raised many environmental concerns. These include the amount of water needed for the process as well as potential contamination of surface and groundwater from fracturing fluid and wastewater.



The Great Lakes comprise the Earth’s largest surface freshwater system, containing 84% of the continent’s surface freshwater and 21% of the world’s freshwater.³ The watershed that feeds the five Great Lakes extends across 295,000 square miles, eight states, and two Canadian provinces.⁴ Drilling underneath the Great Lakes themselves is prohibited in the United States.⁵ But there is significant potential for deep shale drilling in the rest of the Great Lakes Basin, particularly in shale plays that include both natural gas and liquid hydrocarbons. Operators that hydraulically fracture wells outside of the basin may also look to the basin for freshwater and wastewater disposal. These activities could have localized adverse impacts on freshwater resources and, depending on the scale of development, cumulative impacts on the basin’s interconnected ecosystem.

After describing the hydrofracking process in more detail, this report reviews shale development in the Great Lakes Basin and analyzes the three vectors of potential environmental harm to water resources: freshwater use, contamination from well activities, and wastewater disposal. The report then focuses on the legal framework governing hydraulic fracturing in Michigan and Ohio, two Great Lakes states that are at a critical stage in the development of deep shale reserves but have received less attention than the states to the east. For each vector of potential harm, the report discusses the applicable federal and state laws in each jurisdiction, including the recent steps taken by Michigan and Ohio to address the risks posed by hydrofracking. The report concludes that the legal framework in these states protects water resources in the Great Lakes Basin from some, but not all, of the risks. Finally, the report addresses the limitations in the regulatory framework by offering some recommendations for further improvement.

THE BASICS OF HYDRAULIC FRACTURING

Hydraulic fracturing is a well stimulation method used to extract oil and natural gas from shale formations and “tight” sources. Unlike “conventional” reservoirs, in

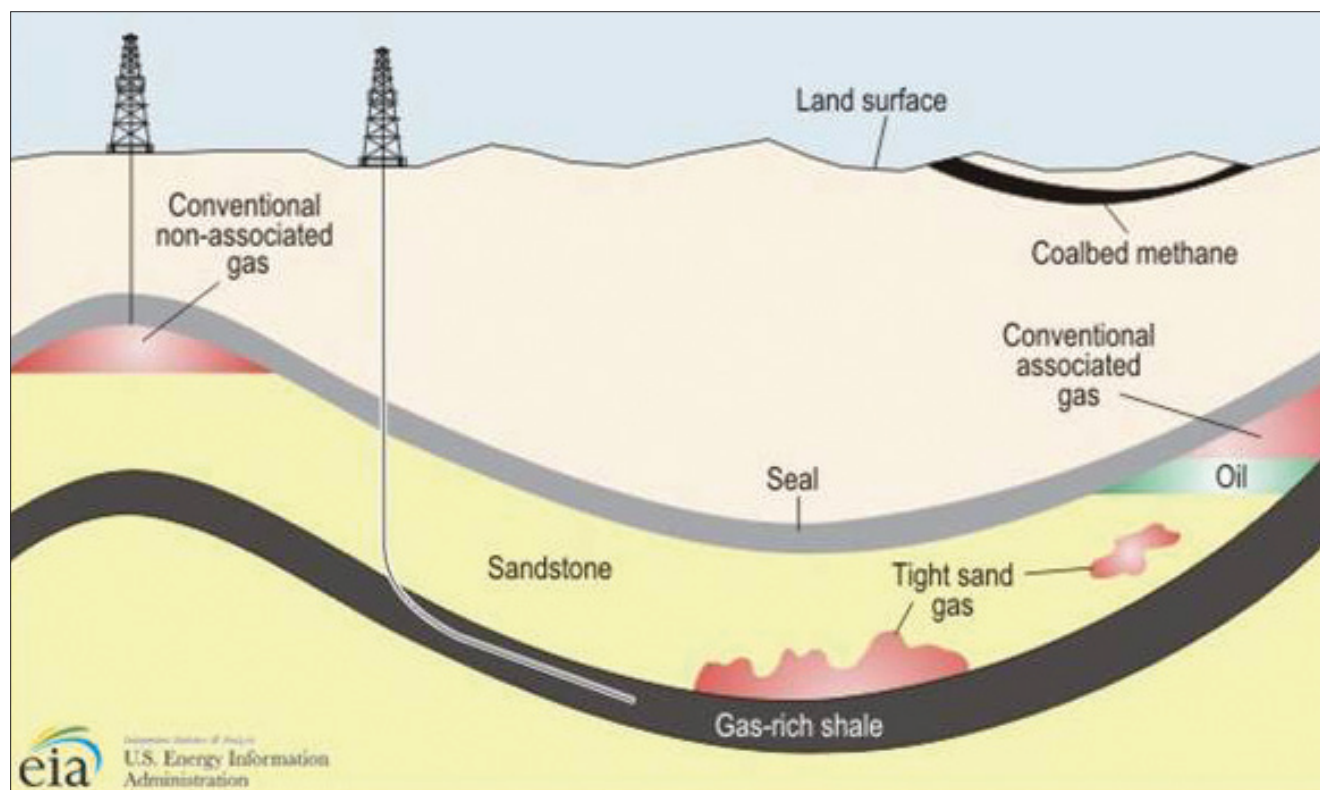
which the oil or gas collects in porous strata capped by an impermeable layer, the oil and gas in shale is trapped within tiny pores in fine-grained rock or attached to organic material within the shale. To develop a path for the hydrocarbons to flow out through the well, well operators create fractures in the formation. The most common method is to open cracks in the rock using a pressurized water-based solution. The more of the shale surface area that is opened to the well through drilling and fracturing, the better the flow potential.

While hydraulic fracturing is not a new technique, advances in the technology and in horizontal drilling have made many more areas of deep shale economically viable. Unlike conventional reservoirs with defined boundaries, promising areas of shale can extend across large areas. The abundance of shale makes the risk of exploratory activity low.⁶ But commercial production is harder to achieve. Even the most successful shale wells show a rapid decline in the initial production rate during the first year or two.⁷ Reported costs of drilling and completing a horizontal well vary, but appear to be at least \$3 to \$5 million. The economic viability of a well depends on the price of natural gas, oil, and any byproducts that can be sold commercially.⁸ Because the price of natural gas has dropped due to increased supply from shale development,

shale plays that contain oil or natural gas liquids are likely to be more profitable.⁹ For example, ethylene, a byproduct of the natural gas liquid ethane, is used to make a variety of industrial and commercial products.

Once the oil and gas company selects a shale well site, the operator begins by preparing the site for production. This includes building access roads to the site, clearing and leveling the site, and constructing a well pad for the equipment. Well sites may be four acres for a single well and five to six acres for multiple wells.¹⁰ At the height of activity on the site, the pad is filled with heavy equipment, earthen pits or metal tanks to store fluids and materials, and trucks with water, sand, and chemicals. A single vertical well could require 817 to 905 truck journeys to supply the equipment and materials, while a horizontally drilled well could require 1,420 to 1,979 truck journeys.¹¹ The number of journeys depends in significant part on how water is sourced. If water is transported to the site by truck, 90 of the journeys to a vertical well and 500 of the journeys to a horizontal well are to convey water.¹²

After the well site is prepared, the operator drills the well or wells. Drilling a single well takes approximately four to five weeks.¹³ To reach the most sub-surface area in the formation, the operator first drills vertically down



into the target formation, and then drills horizontally within the formation. These horizontal wells may be drilled more than a mile below the surface and up to two miles along the formation.¹⁴ In a deep shale formation, a horizontal well can replace many separate vertical wells, resulting in a smaller site footprint but more concentrated surface impacts. Water and chemicals are typically used as drilling fluid to bring the crushed rock, known as drill cuttings, to the surface, and to cool and lubricate the drilling equipment. As the drilling proceeds, the operator places successively smaller steel pipes known as casing strings into the wellbore. Each casing string is cemented to the formation or to the outside casing in order to seal the well and prevent fluids, oil, or gas from flowing around the well.

Once the operator finishes drilling the well, a service company hydraulically fractures the well over two to five days.¹⁵ The company separates the horizontally drilled wellbore into sections to be treated. Each treatment of a section—or stage—is composed of multiple sub-stages at high pressure. Before the treatment, a shape “gun” is lowered into the wellbore; the shots perforate the production casing and create holes through which the hydraulic fracturing fluid as well as natural gas or oil can flow.¹⁶ The company then usually injects a hydrochloric acid solution into the wellbore to dissolve cement and drilling mud that could block the shale pores. This solution is followed by the high-pressure injection of a “slickwater pad,” a fracturing fluid composed of water and certain chemical additives. When the shale fractures, the company injects more pulses of fracturing fluid containing a “proppant” to hold open the fractures; the proppant is usually silica, or sand. Finally, the company flushes the wellbore and equipment with an injection of water.

The amount of fresh or brackish water needed for drilling and fracturing varies by shale play and well length. A shale gas well typically uses 3 million gallons of water, although a well may use up to 10 million gallons.¹⁷ A far greater amount of water is used for fracturing than for drilling; depending on the shale formation, an operator may need only 60,000 gallons to 1 million gallons to drill the well.¹⁸ By volume, the fracturing fluid consists of approximately 98% to more than 99.5% water and proppant, and less than 0.5% to 2% chemical additives.¹⁹ The U.S. Environmental Protection Agency (EPA) estimates that a well stimulated using 3 million gallons of fracturing fluid would be injected with 15,000 to 60,000 gallons of chemical additives.²⁰

Once the hydraulic fracturing stages are completed, the pressure on the wellbore is removed. Over the next few weeks, some of the fracturing fluid, together with brines in the formation and dissolved substances, returns to the surface through the wellbore; the rate of return is highest during the first few days.²¹ Depending on the characteristics of the shale, this “flowback” can be as little as 3% of the amount of the fracturing fluid injected, or it can be greater than 80%.²² Once the well begins producing oil or natural gas, brines from the formation continue to rise through the wellbore; this “produced water” may also include some returned fracturing fluid.²³ The flowback and the continuing produced water must be treated or disposed of. The rest of the fracturing fluid remains underground in the pores of the shale or in closed fractures.

A shale well may produce oil or natural gas for twenty to thirty years, although the life span of any one well depends on the continued economic viability of production. If production declines unexpectedly, operators may choose to hydraulically fracture the well again to reopen cracks in the shale. Once a well is finished producing, the operator plugs the well by removing equipment in the wellbore; the cemented casing remains in place. The operator then fills the bore with cement, usually in combination with drilling mud or other fluid. Finally, the well site is restored by re-vegetating the area and in some cases by returning the land to its original contours.

SHALE DEVELOPMENT IN THE GREAT LAKES REGION

Almost all of the shale development in the Great Lakes Basin has been in the Antrim Shale, a shallow play underlying Michigan. The shale can be found 3,000 feet below the surface in the center of the state, but gradually rises in an arc around the edges of the state’s lower peninsula. The focus of Antrim development has been in the northern lower peninsula, where the shale is between 500 and 2,000 feet below the surface. Extensive drilling began in the late 1980s, and while wells are continuing to



be drilled, production peaked in 1998.²⁴ Of the approximately 12,000 wells that have been hydraulically fractured in Michigan, the vast majority are in the Antrim Shale.²⁵ According to a recent study by the Energy Institute at the University of Texas at Austin, the primary risks posed by Antrim wells, as measured by enforcement actions taken by the state, are related to inadequate site maintenance and surface spills of contaminants during drilling.²⁶ There were no reported violations specific to the hydraulic fracturing process itself.

Because Antrim wells are typically short, vertical wells, they are fractured on a much smaller scale than deep, horizontal shale wells. For this reason, the focus of this report is on potential development in deep shale plays, which can be found under much of the region. Underneath Michigan is the Utica Shale; together with an adjacent limestone formation known as the Collingwood, this shale play has potential for oil and gas at depths between 4,000 and 9,500 feet below the surface. The Utica Shale can also be found under eastern Ohio, most of Pennsylvania, southern New York, eastern Ontario, and the St. Lawrence River in southern Québec. The Utica Shale is deepest in southeastern Pennsylvania; it rises to 4,000 to 6,000 feet below the surface in eastern Ohio and to 2,000 feet in parts of New York and Canada.²⁷ In eastern Ohio, the Utica Shale overlies a formation of interlayered limestone and shale known as the Point Pleasant. The well-known Marcellus Shale is primarily to the east and south of the Great Lakes region, but there are potential areas of shallow Marcellus Shale in northeastern Ohio that are within the Great Lakes Basin.²⁸

So far, most of the deep shale development has concentrated just outside of the Great Lakes Basin. In the last five years, over 4,600 wells have been drilled in the Marcellus Shale in Pennsylvania; 1,920 were drilled in 2011 alone.²⁹ As of June 5, 2012, 207 permits have been granted for horizontal wells in the Utica/Point Pleasant

play in eastern Ohio, and 10 wells are currently producing.³⁰ But some development has occurred in the Great Lakes Basin in the states of Michigan and Ohio. After a discovery well in the Utica/Collingwood play showed early promise, the play attracted significant leasing interest. The state's lease sale in May 2010 garnered \$178 million, nearly as much as the \$190 million the state had received since it began to auction leases in 1929.³¹ As of June 12, 2012, Michigan has issued permits for 8 horizontal wells for the play; of these, one well is currently producing.³² Sixteen permit applications are currently pending.³³ In Ohio, one well is being drilled in the Utica/Point Pleasant play in the basin.³⁴

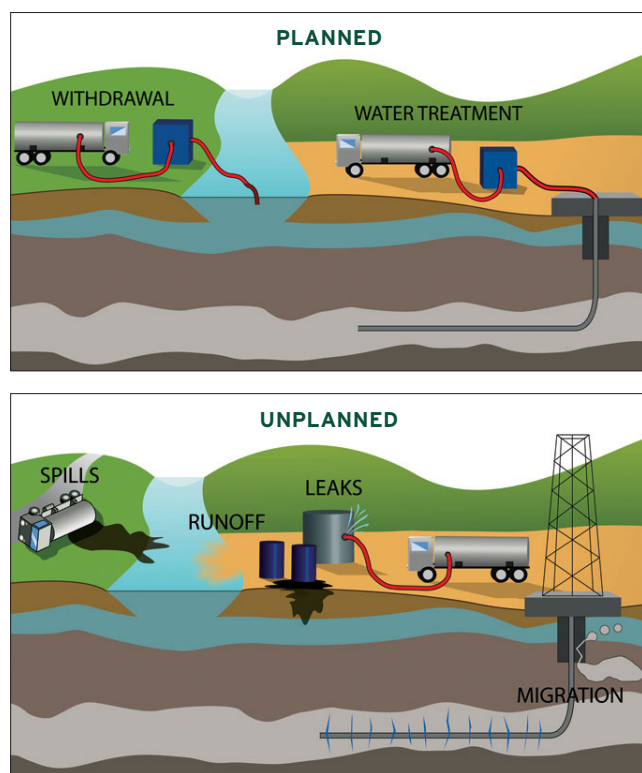
Because the Utica/Collingwood and Utica/Point Pleasant plays contain liquids as well as natural gas, they are generating substantial interest. Chesapeake Energy Corporation has leased approximately 1.3 million acres of mineral rights in the Utica/Point Pleasant play, including in northern Ohio counties within the Great Lakes Basin.³⁵ In March 2012, British Petroleum announced that it had leased 84,000 acres of mineral rights in Trumbull County, Ohio; although the company has not disclosed the lease locations, part of the county is in the Great Lakes Basin.³⁶ The Ohio Department of Natural Resources (ODNR) estimates that by 2015, approximately 2,250 horizontal wells will be drilled in the state.³⁷ In Michigan, Encana Corporation holds 43,000 acres of mineral rights in the Utica/Collingwood play. The company announced to investors in May 2012 that it intends to focus on liquids-rich plays such as the Utica/Collingwood, where it contends it has "first mover advantage."³⁸

Each Great Lakes state or province has made its own decisions as to the regulation of hydraulic fracturing. Michigan, Ohio, and Pennsylvania have allowed deep shale drilling to proceed. Michigan relied on its existing permitting programs to regulate the activity, but has supplemented the requirements with a permitting instruction issued in May 2011.³⁹ In Ohio, the law governing oil and gas production wells and disposal wells was amended in June 2012 to address many aspects of hydrofracking.⁴⁰ The state has also developed rules for well construction and proposed rules to address earthquakes caused by injection wells.⁴¹ Pennsylvania, which has been the center of deep shale drilling in the Marcellus, amended its rules in 2010 but only recently passed comprehensive amendments to its oil and gas law.⁴² In contrast, New York and Québec have placed a moratorium on the practice to consider how best to address the environmental impacts.⁴³ New York is currently weighing public

comments on a draft environmental impact statement on high-volume hydraulic fracturing.⁴⁴

POTENTIAL IMPACTS ON THE GREAT LAKES BASIN

Much of the debate over hydraulic fracturing has focused on possible groundwater contamination from injecting fracturing fluid into the well. But the potential effects of the practice on water resources extend beyond the injection itself. This report assesses the risks to water resources of the Great Lakes Basin through the entire life cycle of deep shale hydraulic fracturing: from the withdrawals of freshwater, to site activities, to the treatment and disposal of wastewater.⁴⁵



Riha & Rahm, Framework for Addressing Water Resource Impacts from Shale Gas Drilling (2010)

Water Use

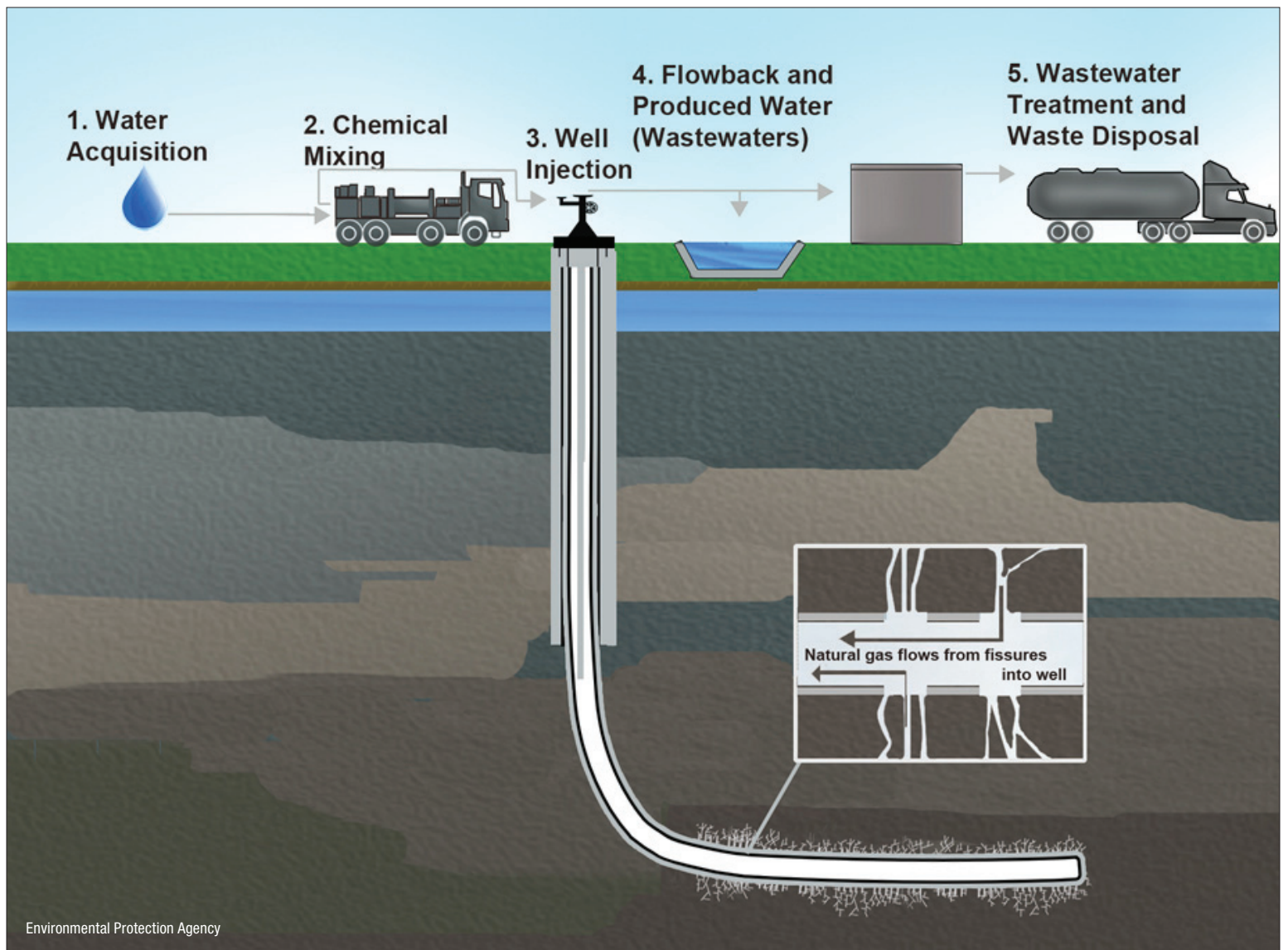
Most shale wells in the Utica plays use 2 to 6 million gallons of water,⁴⁶ although higher amounts have been

reported.⁴⁷ In general, more water is needed to hydraulically fracture a well with a longer wellbore. Well operators may obtain source water from surface waters such as rivers or lakes, groundwater, discharge from industrial or city wastewater treatment plants, or some combination of these sources.⁴⁸ Some operators source the water themselves; others purchase the water from existing water users, such as municipalities.⁴⁹ Water is sometimes withdrawn on site, but is more likely to be transported to the site through pipeline or tanker truck.

An industrial user such as a cement or paper manufacturer withdraws large amounts of water continuously over a long period of time and returns most of the withdrawn water to the source watershed after use.⁵⁰ A shale well operator needs only enough water to drill and fracture a set of wells on a well pad; thus, the amount withdrawn for a fracturing operation will be less than for a large industrial user. But almost all of the water withdrawn for hydraulic fracturing in the Great Lakes Basin will not be returned to the source watershed to replenish water resources; instead, the water will be placed underground during use or for disposal.⁵¹ In the Utica plays, much of the injected water remains underneath the surface after fracturing.⁵² Based on the current policies in the Great Lakes states, almost all of the water that returns to the surface in the flowback will be disposed of in underground injection wells.⁵³

To limit the amount of freshwater employed in hydraulic fracturing operations, flowback may be reused. In the Susquehanna River Basin, which includes the most productive part of the Marcellus Shale, an average of 12% of the total volume of water used to stimulate wells was reused from 2009-2011.⁵⁴ Chesapeake Energy Corporation recently announced that it has begun using a treatment system in Ohio to recycle flowback; however, it is unclear how widespread the practice is in the state or the extent to which flowback is being blended with freshwater for reuse.⁵⁵ It does not appear that operators are recycling flowback for deep shale wells in Michigan. Even if operators in the Great Lakes Basin recycled 100% of the flowback, however, that reuse is necessarily limited by the amount of the flowback. As discussed *infra*, only 15% to 20% of fracturing fluid is returned as flowback in the Utica shales.⁵⁶

As an admittedly rough estimate, if all of the land area of Ohio, Michigan, New York, and Pennsylvania within the Great Lakes-St. Lawrence River Basin experienced shale development similar to that of the Marcellus Shale, the total water use at peak drilling



Environmental Protection Agency

would be 26.94 to 37.31 billion gallons of water per year.⁵⁷ Even at the high end, this water use would be a very small percentage of the amounts withdrawn in these areas in 2009: 0.6% of the amount withdrawn by all users, 0.8% of the amount withdrawn by power plants, and 10% of the amount withdrawn by the industrial sector.⁵⁸ But the water used for fracturing would be a far greater percentage of the amount consumed in 2009: 8% of the consumptive use by all users, 25% of the consumptive use by power plants, and 74% of the consumptive use by industry.⁵⁹

As discussed *infra*, federal law prohibits water from being diverted out of the Great Lakes Basin for purposes such as hydraulic fracturing.⁶⁰ But particularly because of the water loss associated with the practice, withdrawals for wells within the basin could have significant impacts on already vulnerable watersheds. Hydraulic fracturing operations occur where and when natural gas reserves are found, not necessarily next to an abundant water

supply or at times when there is more flow in rivers or streams.⁶¹ Operators prefer to use nearby water sources to reduce transportation costs.⁶² Thus, depending on the pattern of well development and the prevalence of recycling, many small withdrawals could cumulatively impact a watershed. These impacts in turn could affect other parts of the larger basin ecosystem.

The Great Lakes Commission recently released the results of a study on power generation and water resources in the Great Lakes Basin.⁶³ As part of the study, the Commission used data on low flows, thermal sensitivity, and water quality impairment to identify watersheds in the basin that would be affected by additional water withdrawals and consumptive uses. The study shows that there are particularly vulnerable watersheds in mid-Michigan, most of northern Ohio, and parts of eastern New York.⁶⁴ If water is withdrawn from these watersheds for deep shale drilling, there could be significant adverse impacts.



Photo by Eric Kelly

Water Contamination from Well Activities

During well operations, a hydraulically fractured shale well differs from a conventional oil or natural gas well in two primary ways. First, a shale well uses significantly more amounts of chemicals than a conventional well. Even though chemical additives make up a tiny percentage of the fracturing fluid, the total volume of chemicals that must be managed is substantial. Operating a shale well thus poses risks to water resources in the Great Lakes Basin from potential release of chemicals into the environment, whether through surface spills or underground leaks. Second, hydraulic fracturing requires that the wellbore be placed under high pressure. This pressure could damage the integrity of well construction, leading to leaks of chemicals or hydrocarbons into groundwater in the Basin. The pressure could also lead to uncontrolled releases of chemicals and hydrocarbons out of the wellbore.

In the field of toxicology, it is a truism that “the dose makes the poison.” The greatest risk to health and the environment is likely to be from the undiluted chemicals managed on site. Once mixed with water in the fracturing fluid, the concentration of each chemical in the

fracturing fluid is small. But some chemicals can cause negative health or ecological effects in minute amounts, and multiple exposures may cumulatively cause such effects. Chemicals can also react with substances present in the formation to create hazardous products.⁶⁵ In addition, the hydrocarbons themselves are a concern. While methane, the primary component of natural gas, is not considered hazardous if ingested, methane can evaporate and cause asphyxiation in enclosed spaces, as well as explosions and fires.⁶⁶ The EPA is currently conducting a study to determine the impacts of hydraulic fracturing on drinking water resources, including the risk posed by additives and methane. The final results will be available in 2014.⁶⁷

There are thirteen different types of chemical additives that can be used in fracturing fluid, although not all may be used in any one well.⁶⁸ Acid dissolves cement and drilling mud, and clay stabilizers prevent clay in the formation from swelling; both help keep pores open in the shale. Gelling agents and cross-linkers thicken the fluid to carry the proppant, while “breakers” are added at the end of the process to thin the fluid again so that it will flow out of the wellbore. Iron control agents and scale inhibitors prevent materials from hardening and plugging the wellbore. Corrosion inhibi-

tors and oxygen scavengers protect the steel casing from deteriorating. Biocides minimize growth of bacteria in the well, which can contaminate the hydrocarbons. Finally, friction-reducing agents make the water “slick” so that it easily flows through the wellbore, surfactants reduce surface tension and increase fluid flow, solvents improve “wettability” of the fluid, and buffers control the pH of the entire solution.

The operator or a service company determines which additives are needed, and then chooses among several different products for each type of additive. In turn, each of the products may be formulated using many chemical constituents. According to a 2011 report by the Democratic members of the U.S. House Committee on Energy and Commerce, the leading 14 oil and gas service companies used 780 million gallons of hydraulic fracturing products between 2005 and 2009.⁶⁹ During this time the companies used more than 2,500 different products, which contained 750 chemical components.⁷⁰ 279 of the products included a chemical or mixture that was considered by the manufacturer to be proprietary or a trade secret.⁷¹

The chemical constituents in fracturing fluid range from benign substances, to those that have acute (short-term) health effects, to those that have chronic effects on organs and systems, to those that cause cancer.⁷² In the products reviewed by the U.S. House Committee Democrats, there were 13 carcinogens in 95 products, and 8 drinking water contaminants in 67 products.⁷³ Diesel, which contains carcinogens such as benzene, was present in 51 products.⁷⁴ A 2011 study by The Endocrine Disruption Exchange assessed 944 products used in natural gas well operations, primarily for hydraulic fracturing.⁷⁵ Of the 353 chemical constituents that had an identifying chemical number, more than 75% could cause acute effects such as eye and skin irritation, nausea, headaches, and convulsions;



Fracturing Fluid, Marcellus-Shale.us

more than 40% could cause chronic effects on organs and nervous and immune systems; more than 25% could cause cancer and mutations; and more than 40% could harm wildlife.⁷⁶ 421 of the 980 MSDSs examined disclosed less than 50 percent of the composition of the chemical substances within each product.⁷⁷

As an example, Encana Corporation hydraulically fractured the State Excelsior 1-13 HD1 well in Kalkaska County, Michigan, on October 25, 2011. Encana reports that it used seven types of chemical additives, which made up about 1% of the entire fracturing fluid by mass.⁷⁸ The additives include hydrochloric acid, corrosion inhibitors, biocides, clay stabilizers, friction reducers, iron control agents, and surfactants. According to The Endocrine Disruption Exchange, some of the constituents have a range of negative health effects and ecological effects. For example, a chemical in the corrosion inhibitor and surfactant, (2-BE) Ethylene glycol monobutyl ether, has effects across 14 possible endpoints, including cancer and ecological effects.⁷⁹

There are several possible ways in which chemical additives and hydrocarbons from well activities could be released into the environment and affect water resources in the Great Lakes Basin. Surface spills may release additives into nearby surface waters or reach aquifers through ground infiltration.⁸⁰ Such spills may occur through leaks in equipment such as pumps and hoses that transport the chemicals, through overflow or failures in impoundments, or through ruptures in tanks.⁸¹ More rarely, uncontrolled releases of fracturing fluid and wastewater from the wellbore may spill additives or hydrocarbons onto the surface.⁸² Underground wellbore leaks may also release additives or hydrocarbons into groundwater through poor quality casing or inadequate cementing, conditions that could be exacerbated by the high pressures of hydraulic fracturing.⁸³ Once contaminants enter the interconnected hydrologic system, they have the potential to affect both surface and groundwater.

Whether chemicals or hydrocarbons could migrate into the water table from the target formation as a result of fracturing itself is contested.⁸⁴ In 2011, the EPA released a controversial draft study that concluded that hydraulic fracturing was a likely source of chemical contamination of groundwater in Pavillion, Wyoming.⁸⁵ The study has been criticized by state authorities because of non-representative monitor well placement, questionable sampling methodology, and inability to replicate sample results.⁸⁶ If the study’s conclusion is confirmed through peer review and additional sampling,⁸⁷ it is not

clear that it would apply to hydraulic fracturing in the Great Lakes Basin. The fracturing in Pavillion occurred in the same target formation as groundwater, while the deep shale in the Basin is thousands of feet below groundwater.⁸⁸ Still, at this depth, nearby abandoned or active wells may act as a conduit to the freshwater strata if such wells are not properly reviewed and accounted for. More controversially, it may be possible for fracture networks to act as conduits.⁸⁹ A 2011 study by scientists at Duke University concluded that methane found in groundwater in Pennsylvania and New York most likely leaked through well casings or fracture networks created or enlarged by hydraulic fracturing in deep shale.⁹⁰ The study did not find any evidence of groundwater contamination from fracturing fluids or subsurface brines.⁹¹

Water Contamination from Wastewater Treatment and Disposal

In the Marcellus and Utica shales, the amount of flowback averages 15% to 20% of the total amount of water injected in fracturing fluid,⁹² although the percentage can be lower.⁹³ Assuming that most of the wells in these plays use 2 to 6 million gallons of water, a well may produce 300,000 to 1.2 million gallons of flowback in the first few weeks after the well is completed. An estimated 60% of the flowback is collected within the first four days; eventually, the flowback declines to a few barrels per day.⁹⁴ This amount of wastewater continues to flow out of the well as produced water during natural gas and oil production, and remains fairly constant through the life of the well. While the rate at which produced water flows out of the well is small, the total amount for each well can reach a million gallons.⁹⁵

The composition of wastewater from a shale well changes over time. When the well is first completed, the flowback is primarily composed of spent fracturing fluid. Over the next few weeks, the flowback contains more saline subsurface formation water known as “brine” and naturally occurring substances mobilized by hydraulic fracturing. By the time that production of natural gas or oil begins, the primary components of the produced water are brine and naturally occurring substances. Because of the influence of fracturing fluid, the characteristics of flowback can differ from those of produced water.⁹⁶ For this reason, as well as the volume of wastewater, the focus of risk management is often on flowback.

The EPA has identified approximately 120 substances that have been found in flowback and produced water.⁹⁷



Brine Disposal Truck, Marcellus-Shale.us

As part of its study on hydraulic fracturing, the EPA is reviewing the toxicity and mobility of these substances. Flowback includes injected chemical additives as well as new products caused by reactions within the fluid and reactions between the additives and naturally present substances in the formation.⁹⁸ Flowback also includes salts; trace elements such as mercury, lead, and arsenic; radioactive material such as radium and uranium; and organic materials such as organic acids and polycyclic aromatic hydrocarbons.⁹⁹ Volatile organic substances such as benzene and xylene have also been found in flowback.¹⁰⁰

Flowback contains high concentrations of total dissolved solids (TDS), pollutants that can negatively affect water resources. The levels of TDS increase over the flowback period.¹⁰¹ Typical concentrations from shale gas wells are 100,000 parts per million (ppm) and can be as high as 400,000 ppm; in contrast, sea water contains approximately 35,000 ppm.¹⁰² Sampling of flowback from Marcellus Shale gas wells shows concentrations as great as 261,000 ppm.¹⁰³ These concentrations are well above the recommended drinking water level of 500 ppm.¹⁰⁴ Concentrations of chloride, the primary component ion of TDS in flowback, can cause acute effects in aquatic insects, fish, and frogs.¹⁰⁵

In general, flowback may be treated in publicly owned treatment works or private centralized wastewater treatment facilities and discharged to surface waters; the flowback may also be injected into underground disposal wells.¹⁰⁶ Treatment or disposal may occur after reuse.¹⁰⁷ Of these options, treatment and discharge to surface waters poses the greatest risk. Most treatment facilities—particularly publicly owned treatment works—are unequipped to remove high concentrations of TDS or radionuclides.¹⁰⁸ In addition, bromides in the flowback may produce carcinogenic disinfection byproducts.¹⁰⁹ In contrast, disposing of the wastewater in underground injection wells is generally

considered to pose less risk.¹¹⁰ Flowback is injected into a permeable rock formation, capped by impermeable layers that isolate the fluid from groundwater.¹¹¹ However, like production wells, disposal wells do create risks for water resources; these risks include surface spills as well as underground leaks caused by poor well construction or migration of wastewater through nearby wells or fracture networks.

In the Great Lakes Basin, the risks posed by inadequate treatment of flowback are dependent on future regulation and shale development. It appears that flowback is not currently being treated by public or private treatment facilities in the basin. As discussed *infra*, flowback is injected into disposal wells in Michigan and Ohio.¹¹² While Ohio initially allowed a municipal treatment facility in Warren, Ohio, to accept flowback, it later determined that the permit was issued unlawfully.¹¹³ In New York, no publicly owned treatment works have permission to accept flowback, and no private facilities accept this wastewater.¹¹⁴ In Pennsylvania, well operators in the state did not report sending wastewater from Marcellus Shale wells to any treatment facilities within the basin in 2011; data for 2012 is not yet available.¹¹⁵ In the future, it is possible that flowback will be released into surface waters after treatment in the areas of the basin in New York and Pennsylvania. This will depend on the cost of treatment in comparison to other options, such as disposal wells. Pennsylvania's recently updated treatment requirements and New York's proposed requirements reduce the risk to water resources, although the requirements do not address all contaminants.¹¹⁶

The primary risks to the Great Lakes Basin posed by flowback thus stem from disposal wells. Michigan currently has approximately 860 disposal wells.¹¹⁷ Of 177 disposal wells within Ohio, 35 are within the basin.¹¹⁸ The potential scale of injection is a particular concern. If shale development increases in the basin, disposal wells will receive more flowback. The wells may also receive more flowback from development outside of the basin. New York and Pennsylvania have very few disposal wells. New York has only 3 disposal wells that accept oil and gas wastewater; the wells currently are limited to on-site production.¹¹⁹ Pennsylvania has 5 disposal wells that currently accept such wastewater.¹²⁰ As the options to treat flowback have become more limited and the volume of wastewater has increased, Pennsylvania operators have increasingly looked to disposal wells outside of the state.¹²¹ Of the approximately 35 Ohio

disposal wells that accepted Marcellus shale wastewater in the last six months of 2011, 8 are in the basin.¹²² At this stage, it is unclear whether more disposal wells will be drilled in New York or Pennsylvania.¹²³

REGULATION OF WATER USE

While the federal Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) protect surface waters and groundwater from contamination, there is no overarching federal law that protects the nation's waters from adverse impacts of withdrawals and consumptive uses. Instead, state common law and regulatory programs traditionally govern such impacts. In addition, states collect information on water uses through registration programs. In the Great Lakes Basin, water use is governed by the Great Lakes-St. Lawrence River Basin Water Resources Compact (Compact), an interstate compact among the eight Great Lakes states that came into effect in 2008.¹²⁴ After describing how the Compact applies to water use for hydraulic fracturing, this section of the report describes the state environmental assessment requirements for such use in Michigan and Ohio, as well as the state information and reporting requirements.

The Great Lakes Compact

The Compact governs water use through four primary mechanisms: (1) a prohibition on diversions; (2) state conservation and efficiency requirements; (3) state permitting requirements for water withdrawals and consumptive uses; and (4) registration and reporting requirements. As an interstate compact consented to by the U.S. Congress, the Great Lakes Compact is treated as federal law. The Great Lakes states, including Michigan and Ohio, may not pass state laws in conflict with the terms of the Compact.

First, the Compact prohibits new or increased diversions of water out of the Great Lakes Basin; well operators are thus prohibited from withdrawing water in the Great Lakes Basin and transferring the water outside the basin for hydraulic fracturing.¹²⁵ Diversions are defined as "a transfer of Water from the Basin into another watershed . . . by any means of transfer,

including but not limited to a pipeline [or] tanker truck.¹²⁶ While there are exceptions for near-basin communities and for water incorporated into products, these exceptions would not apply to well operators. The prohibition on diversions is particularly critical in Ohio, where extensive shale drilling is expected to occur just outside of the basin.

While the Compact also prohibits transfers of water between certain Great Lake watersheds, almost all shale well operators will meet the exception for small transfers.¹²⁷ Intrabasin transfers that result from a new or increased withdrawal of less than 100,000 gallons per day (gpd), averaged over 90 days, are left to state regulation.¹²⁸ Neither Michigan nor Ohio has chosen to regulate these withdrawals. While the Compact defines a withdrawal as the volume that supplies a common distribution system,¹²⁹ it is unlikely that a single withdrawal system for hydraulic fracturing would withdraw 9 million gallons in a 90-day period. In addition, transfers between the watersheds of Lake Michigan and Lake Huron are exempt from any requirements.¹³⁰ Since the Utica-Collingwood play in Michigan extends across both watersheds, operators may choose to source water in one watershed and transport it into the other.

Second, the Compact requires each state to create a voluntary or mandatory water conservation and efficiency program for all users within the Great Lakes Basin; this would include well operators.¹³¹ The program

must adjust to new demands and cumulative effects.¹³² In addition, each state must commit to promote “environmentally sound and economically feasible water conservation measures,” such as “[m]easures that promote efficient use of water,” “[i]dentification and sharing of best management practices and state of the art conservation and efficiency technologies,” and “[development, transfer and application of science and research.”¹³³ Even a state that has a voluntary conservation program must therefore address water use for hydraulic fracturing.

Third, by 2013, the Compact requires each state to create a water management program for proposed water withdrawals and consumptive uses.¹³⁴ Not all proposed uses must obtain a permit; a state may choose the scope and thresholds of its program, as long as the program ensures that water use is reasonable overall and that withdrawals overall do not have significant impacts on the Great Lakes Basin, the basins of each Great Lake, or direct stream tributaries.¹³⁵ Thus, if water use for hydraulic fracturing rises to this level, the Compact requires the state to include withdrawals in its program. Water uses subject to the program must, at minimum, meet the decision-making standard in the Compact. Under this standard, uses must (1) be accompanied by return of the withdrawn water to the source watershed less the amount consumed; (2) not result in individual or cumulative adverse resource impacts; (3) incorporate environmentally sound and economically feasible water





conservation measures; (4) comply with other laws and regional agreements; and (5) be reasonable.¹³⁶

Fourth, by 2013, the Compact requires any person who withdraws water in an amount of 100,000 gpd or greater average in any 30-day period to register the withdrawal with the state, provide information about the use, and report monthly withdrawal volumes each year.¹³⁷ Given the volume of water needed for a single shale well, a well operator will likely be required to register if the operator does not purchase the water from an existing user such as a municipality. The registrant must include the location and sources of the withdrawal, the capacity of the withdrawal, the use made of the water, places of use and places of discharge.¹³⁸ A well operator must therefore provide information not just on the withdrawal, but also on the water use and discharge of the wastewater.

State Environmental Assessment Requirements

MICHIGAN

In 2008, Michigan enacted Part 327 of the state's Natural Resources and Environmental Protection Act (NREPA) to comply with the Great Lakes Compact.¹³⁹ Under Part

327, a new or increased "large quantity withdrawal"—defined as "1 or more cumulative total withdrawals exceeding 100,000 gallons of water per day average in any consecutive 30-day period that supply a common distribution system"—is prohibited from causing an adverse resource impact.¹⁴⁰ An adverse resource impact is determined by the effect on fish populations of a decrease in stream flow or lake level; thus, the law allows withdrawals only if there is sufficient water available in the local watershed to support the ecosystem.¹⁴¹ Water withdrawals for oil and gas well activities are exempt from all Part 327 requirements.¹⁴²

Part 615 of NREPA governs oil and natural gas wells. While Part 615 does not directly apply to water use or the construction and operation of water wells,¹⁴³ it does prohibit a person from committing "waste" in the "exploration for or in the development [and] production" of oil or gas.¹⁴⁴ The Supervisor of Wells in the Michigan Department of Environmental Quality (MDEQ) has authority over "all matters relating to the prevention of waste."¹⁴⁵ "Waste" includes "[u]nreasonable damage to underground fresh . . . waters . . . from operations for the discovery, development, and production . . . of oil or gas;" "unnecessary damage to or destruction of the surface; . . . animal, fish, or aquatic life; property; or other environ-

mental values from or by oil and gas operations;” and the “unnecessary endangerment of public health, safety, or welfare from or by oil and gas operations.”¹⁴⁶ Under this broad authority, MDEQ has issued rules to ensure that on-site water wells for oil and gas operations do not contaminate groundwater and that groundwater is used as a drilling fluid to protect freshwater strata.¹⁴⁷ This requirement for drilling fluid does not apply, however, to completion operations such as hydraulic fracturing.

In order “to assure that a proposed withdrawal will not adversely affect surface waters or nearby freshwater wells,” the Supervisor of Wells issued an instruction to permittees in May 2011.¹⁴⁸ Instruction 1-2011 requires that a well operator that intends to make a “large volume water withdrawal” for well completion operations utilize the internet-based assessment tool and provide the MDEQ with the evaluation.¹⁴⁹ A “large volume water withdrawal” is defined as “a water withdrawal intended to produce a cumulative total of over 100,000 gallons of water per day when averaged over a consecutive 30-day period,” a threshold that is likely to capture most withdrawals for hydraulic fracturing. If the assessment tool determines that there may be an adverse resource impact, the well operator may request a site-specific review by the MDEQ. Instruction 1-2011 provides that “the ability to utilize an on-site water supply well(s) may be impacted” if the assessment tool or a site-specific review indicate that there may be an adverse resource impact. In a later description of the process, the MDEQ states that “[u]nder no circumstances will water withdrawals that are determined to create an actual ARI [adverse resource impact] be approved.”¹⁵⁰

OHIO

On June 4, 2012, Ohio passed legislation to implement the Great Lakes Compact requirements within the Lake Erie watershed. Under the law, the ODNR must establish a permitting program for certain proposed uses of water.¹⁵¹ The program will require permits for facilities that develop new or increased capacity for water withdrawals or consumptive uses of at least 2.5 million gpd from Lake Erie or a recognized navigation channel, and at least 1 million gpd from any river, stream, or groundwater.¹⁵² Permits will also be required to develop capacity of at least 100,000 gpd from any rivers or streams deemed “high quality water.”¹⁵³ Excepted from the permitting requirements are facilities in which the maximum daily withdrawal is less than the capacity threshold when averaged over any ninety-day period.¹⁵⁴ To protect small and medium-sized watersheds, the

exception is modified. If the withdrawal is from a high-quality stream or river in a watershed that is less than 100 square miles but greater than 50 square miles, the withdrawal is averaged over 45 days; if the withdrawal is from a high-quality stream or river in a watershed that is 50 square miles or less, there is no averaging at all.¹⁵⁵

Because operators usually withdraw water for hydraulic fracturing by well site, the permitting program is only likely to capture withdrawals from high-quality streams and rivers in small and medium-sized watersheds. For example, out of eleven Chesapeake Energy wells in Ohio that have reported water use on the FracFocus website, only one used enough water to trigger the threshold for a withdrawal from a high-quality stream or river in a large watershed, assuming the withdrawal capacity is greater than 100,000 gpd.¹⁵⁶ No wells triggered the threshold for a withdrawal from other rivers, streams, or groundwater, or from Lake Erie.

Those withdrawals that are required to obtain a permit must meet the requirements in the minimum decision-making standard in the Great Lakes Compact.¹⁵⁷ A water use is prohibited from causing significant adverse impacts on the Great Lakes Basin as a whole or the Lake Erie watershed as a whole.¹⁵⁸ If a water use causes significant adverse impacts on more localized areas, these impacts are assessed against factors such as economic development and social development in determining whether a water use is reasonable.¹⁵⁹ Withdrawals for hydraulic fracturing are thus likely to obtain a permit, as the impacts of an individual withdrawal are not necessarily perceptible at the Lake Erie watershed scale. Localized impacts may be outweighed by the more easily quantifiable economic and social benefits of energy production.

As in Michigan, Ohio’s statute governing oil and gas wells does not directly apply to water use or water wells.¹⁶⁰ Under an energy bill signed by Governor Kasich on June 11, 2012, however, the ODNR is directed to issue rules setting permit conditions for horizontal wells to protect the public and private water supply, including the amount of water used and the source or sources of the water.¹⁶¹ The ODNR also has broad authority to “specify practices to be followed in the drilling and treatment of wells [and] production of oil and gas . . . for protection of public health or safety or to prevent damage to natural resources.”¹⁶² This authority could presumably extend to practices involving water withdrawals for hydraulic fracturing.

State Information Requirements

MICHIGAN

Because withdrawals for oil and gas purposes are exempt from Part 327, they are not required to be registered.¹⁶³ However, Instruction 1-2011 requires that prior to a large volume water withdrawal for hydraulic fracturing, an oil or gas well operator must provide the MDEQ with information about the withdrawal, including the total volume of water needed for fracturing. In addition, the operator must submit a plat of the well site showing the proposed location of water withdrawal wells and all freshwater wells within 1,320 feet of the water withdrawal location.¹⁶⁴ This information must be either included with the application for a permit to drill or provided to the MDEQ at least 14 days before the water withdrawal begins.¹⁶⁵ There is no requirement that the operator provide the actual amount withdrawn.

If a freshwater well is within 1,320 feet of a water withdrawal well, the instruction also requires the operator to install a monitor well. The operator must measure and record the water level in this monitor well daily during the water withdrawal and then weekly until the water level stabilizes, and report this data to the MDEQ.¹⁶⁶ The MDEQ has indicated that if a monitoring well indicates a potential significant impact on another freshwater well, the well operator will be required to either “curtail the withdrawal or negotiate an agreement with the owner of the freshwater well to resolve the issue.”¹⁶⁷

OHIO

Ohio requires owners to register all facilities that have the capacity to withdraw water at a rate greater than 100,000 gpd averaged over 30 days with the ODNR Division of Water.¹⁶⁸ This registration requirement includes shale well operators. Persons with the capacity to withdraw more than 100,000 gpd are required to report the locations and sources of their water supply, withdrawal capacity per day and the amount withdrawn from each source, uses made of the water, place of use, and place of discharge.¹⁶⁹ Registrants must also report monthly withdrawal quantities on an annual form.¹⁷⁰ Withdrawals for hydraulic fracturing are likely to trigger these requirements, but are aggregated with other withdrawals for oil and gas operations.

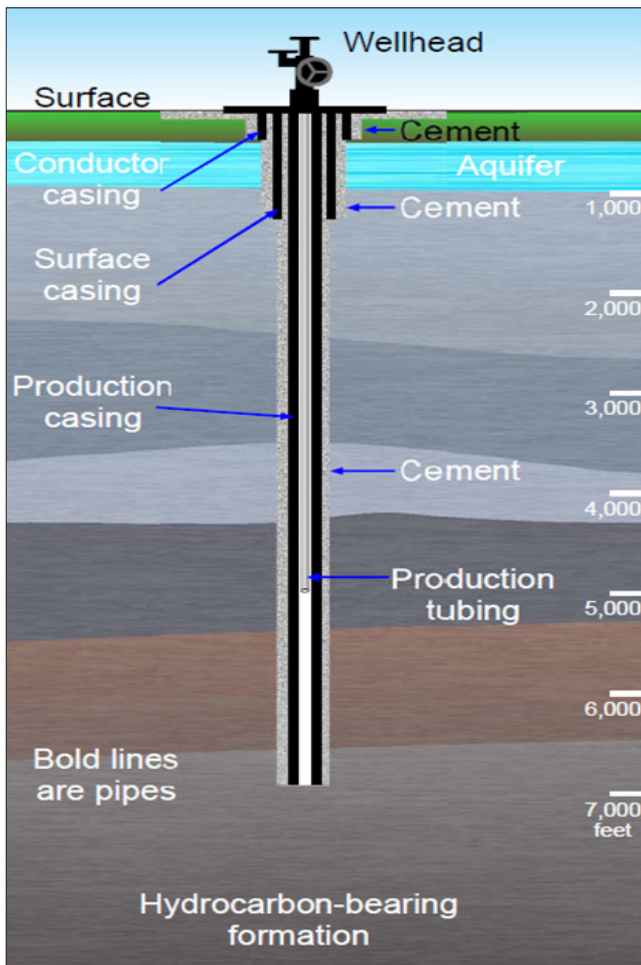
Under the recent amendments to Ohio’s oil and gas law, a well operator must provide the ODNR specific information on water use for all well operations as part of the operator’s permit application.¹⁷¹ The information

includes the identity of each proposed source of water that will be used, and whether the source is in the Great Lakes Basin. The operator must also provide the proposed estimated rate and volume of the water withdrawal, and the estimated volume of recycled water to be used. All information is to the best of the operator’s knowledge. If the information changes prior to a well permit being issued or well operations, the operator must provide the updated information to the ODNR.¹⁷² As in Michigan, there is no specific requirement that the actual amount of water withdrawn be reported. However, an operator is required to submit a report 60 days after a well is completed or re-fractured that includes the total amount of all “fluids and substances” and recycled fluid used in well drilling and well stimulation.¹⁷³

REGULATION OF WELL ACTIVITIES

Injection wells are regulated under the SDWA to ensure that injected fluid does not endanger drinking water sources. The process of injecting fracturing fluid into the target formation as part of oil or gas production, however, is exempted from these requirements unless the fluid contains diesel.¹⁷⁴ In May 2012, the EPA released draft guidance on how to apply the SDWA requirements to oil and gas wells that use diesel in hydraulic fracturing.¹⁷⁵ When finalized, this guidance will apply to states such as Michigan, in which EPA regulates injection wells. States such as Ohio that regulate injection wells through a delegated program may choose whether to follow the guidance; however, they must issue permits for the practice.

Oil and gas wells are traditionally regulated by the states, through detailed permitting programs. These programs govern the surface location of wells; well construction, such as casing and cementing requirements; drilling; well completion, including stimulation through hydraulic fracturing; production of oil and gas; and well plugging and restoration. The programs also govern site construction activities and surface facilities, such as storage tanks and earthen pits for fluids. Drilling underneath the Great Lakes is prohibited by federal and Michigan law.¹⁷⁶ This section details how the Michigan and Ohio permitting programs govern well site activity



Production Well Construction, Environmental Protection Agency

and chemical disclosure. At the end of the section is a table that compares the requirements in the EPA guidance with the requirements in the state programs.

Well Site Activities

MICHIGAN

As discussed *infra*, a well operator is prohibited under the state’s oil and gas law, Part 615 of NREPA, from causing waste.¹⁷⁷ This includes underground waste, such as “[u]nreasonable damage” to “fresh” groundwater, and “surface waste,” such as “unnecessary or excessive loss or destruction” of oil and gas through seepage or leakage and “unnecessary damage to or destruction of the surface; soils; animal, fish, or aquatic life; property; or other environmental values.”¹⁷⁸ To prevent waste, the Supervisor of Wells in the MDEQ is specifically authorized to ensure that wells are constructed and operated “to prevent the escape of oil or gas out of 1 stratum into another, or of water or brines into oil or gas strata” and “to prevent pollution of, damage to, or destruction of

fresh water supplies, including inland lakes and streams and the Great Lakes and connecting waters.”¹⁷⁹ The Supervisor is also authorized to “regulate the mechanical, physical, and chemical treatment of wells.”¹⁸⁰

Like other well operators, a shale well operator must obtain a permit to drill a well; a separate permit is required for a horizontal well.¹⁸¹ As part of the permit application, the operator must submit an environmental assessment and provide information on environmental features within 1,320 feet of the well, including surface waters and other environmentally sensitive areas, floodplains, wetlands, natural rivers, and threatened and endangered species.¹⁸² The well must be located at least 300 feet from freshwater wells utilized for human consumption.¹⁸³ When considering a permit application for a well that will be hydraulically fractured, MDEQ staff identifies recorded wellbores around the proposed well and determines whether these wells may provide a conduit for movement of fracturing fluids or produced fluids into freshwater strata.¹⁸⁴ For Utica/Collingwood wells, the radius of review is 660 to 1320 feet from the wellhead. If a potential conduit is identified, the applicant must relocate the proposed well, demonstrate that hydrofracking will not cause the movement of fracturing fluids or produced fluids into an aquifer, or provide a written plan to prevent the potential fluid movement of concern.

All oil and gas wells, including shale wells, are required to install casing from the surface to 100 feet below all freshwater strata; this “surface casing” must be completely cemented to the formation from the base of the casing to the ground surface.¹⁸⁵ Casing must be able to withstand 1.2 times the greatest expected wellbore pressure, and the casing must be pressure-tested prior to further drilling.¹⁸⁶ Additional casing is required through the permit approval process. This includes a production string that is set through the target zone if a well is potentially productive. The production string must be set and cemented before hydraulic fracturing is undertaken. An additional string of intermediate casing is required for all but the shallowest wells. A permittee is required to take “proper measures” to avoid an uncontrolled release from the well.¹⁸⁷ Blowout preventers and blowout equipment that is designed to handle at least the maximum anticipated surface pressure of the well must also be installed.¹⁸⁸

During high volume hydraulic fracturing operations, the operator must monitor and record the injection pressure.¹⁸⁹ Flowback must be placed in steel tanks; the

rules prohibit operators from using earthen pits to store the fluid.¹⁹⁰ Within sixty days after the well is completed, the operator is required to file a well completion report that includes data on perforating, acidizing, and fracturing.¹⁹¹ The MDEQ well instruction specifies that an operator that conducts high volume hydraulic fracturing must also submit the service company fracturing records and associated charts showing fracturing volumes, rates, and pressures; the pressures recorded during fracturing; and the total volume of flowback water at the date that the report is submitted.¹⁹² If requested by the operator, all well data and samples provided to the MDEQ are held confidential for 90 days after well completion.¹⁹³

Surface facilities—including piping and storage tanks for flowback—may not be located less than 300 feet from freshwater wells utilized for human consumption; in addition, storage tanks may not be located 800-1,200 feet from public water supply wells.¹⁹⁴ Before constructing the facilities, an operator must submit a “secondary containment” plan to ensure that spills do not enter the environment.¹⁹⁵ Underneath all surface facilities and the wellhead must be a containment structure with sidewalls that is sealed to prevent seepage.¹⁹⁶ Storage tanks for flowback must be elevated or constructed so

that leakage is easily detected. Among other requirements, the operator must conduct baseline testing of water quality in the facility area and install a groundwater monitoring well or another level of containment. The testing is limited to some ions and does not include chemicals found in hydraulic fracturing fluid or methane. Every six months, water samples must be collected and water level measurements taken.

Before surface facilities may be used, the MDEQ must approve a spill or loss response and remedial action plan. Spills of fracturing fluid, as well as spills of flowback of 42 gallons or greater, must be reported to the MDEQ within eight hours. If a spill of flowback is less than 42 gallons, the operator must report the spill within eight hours only if the flowback contacts surface waters, groundwater, or other environmentally sensitive resources, or is not completely contained and cleaned up within 48 hours.¹⁹⁷ Information about volumes, concentrations, and times of spills is not subject to the confidentiality requirement.¹⁹⁸ To ensure that the well is plugged, each operator must obtain a conformance bond or provide evidence of financial responsibility.¹⁹⁹ A bond of \$25,000-\$30,000 is required for an individual well in the Utica/Collingwood; an operator may choose to submit a blanket bond for up



to 100 wells of \$250,000.²⁰⁰ Among other requirements, an operator must demonstrate financial responsibility by showing assets of at least three times the amount of the conformance bond and a tangible net worth of \$2 million.

OHIO

The ODNR has exclusive control over the location, drilling, well stimulation, completion, and operation of oil and gas wells within the state.²⁰¹ To protect the public health or safety or to prevent damage to natural resources, the ODNR has general authority to specify practices operators must follow in the drilling and treatment of wells.²⁰² Under the new legislation, the ODNR is specifically directed to issue rules on horizontal wells in the Point Pleasant, Utica, or Marcellus shale formations that are stimulated, such as by hydraulic fracturing, and facilities associated with these wells.²⁰³ Among other requirements, the rules must address safety concerning the drilling or operation of a well, protection of the public and private water supply, and containment of wastes.

As in Michigan, an operator of an oil and gas well, including a shale well, is required to obtain a permit from the ODNR before the well is drilled.²⁰⁴ An applicant for a permit for a horizontal shale well must conduct baseline testing of water wells within 1,500 feet of the proposed wellhead and submit the information to ODNR.²⁰⁵ The ODNR may revise the distance if well site conditions warrant. Sampling must be in accordance with ODNR's best management practices, which currently require limited testing for ions of concern as well as total dissolved solids.²⁰⁶ As in Michigan, the operator need not test for chemicals found in hydraulic fracturing fluid or for methane.

Prior to issuing a permit for a horizontal well, the ODNR must conduct a site review to identify site-specific terms and conditions that may be in the permit.²⁰⁷ The ODNR must also conduct such a review if a well is to be placed in a one-hundred-year floodplain or within the five-year time of travel associated with a public drinking water supply.²⁰⁸ In the permit application, an operator is required to provide information on the location of streams within 200 feet of the proposed well site, as well as the distance of each stream from the site.²⁰⁹ A well may not be located within fifty feet of a stream, river, watercourse, water well, pond, lake, or other body of water, except if a shorter distance is necessary to reduce impacts to the owner of the land or to protect public safety or the environment.²¹⁰

In August 2012, detailed new rules on well construction will go into effect for well operators. Under these rules, the operator must submit a casing and cementing plan to the ODNR and inform the agency if hydraulic fracturing will be used.²¹¹ Surface casing must extend from the surface to at least fifty feet below the base of the deepest source of drinking water, or at least fifty feet into competent bedrock, whichever is deeper.²¹² This casing must be completely cemented to the formation.²¹³ Other types of casing may also be required, and used casing may be installed if it meets integrity requirements.²¹⁴ As in Michigan, casing must be able to withstand 1.2 times the maximum pressure to which the casing may be subjected; cemented casing longer than 200 feet must be pressure tested.²¹⁵ A blowout preventer is required only when drilling within 200 feet of an inhabited structure or in urbanized areas.²¹⁶

At least 24 hours prior to hydraulic fracturing, a well operator is required to give notice to the ODNR.²¹⁷ In general, hydraulic fracturing must be done in such a manner that it will not endanger underground sources of drinking water. Pressures in the well must be monitored during fracturing.²¹⁸ If damage occurs to the well during the process, the operator must notify the ODNR; the well must be plugged if the damage is irreparable.²¹⁹ Fracturing fluid may be placed in an earthen pit for temporary storage, but the pit must be drained and filled in after the fracturing process is terminated.²²⁰ Flowback may be placed in pits or in steel tanks; pits must be drained at least every six months.²²¹ All operators must file a well completion record with the ODNR within sixty days after completion of drilling operations. For wells that have been hydraulically fractured, the record must describe the "type and volume of fluid used to stimulate the reservoir of the well, the reservoir breakdown pressure, the method used for the containment of fluids recovered from the fracturing of the well . . . the average pumping rate of the well, and the name of the person that performed the well stimulation."²²²

Well operators are generally prohibited from conducting operations in a manner that will contaminate or pollute the land, surface waters or groundwater.²²³ In urbanized areas, equipment must be maintained "consistent with reasonably prudent operations" to ensure protection of public health or safety or to prevent damage to natural resources.²²⁴ An operator is prohibited from releasing fracturing fluids and flowback into the environment if it would result in pollution of drinking water under the standards of the SDWA or it would



damage public health or safety or the environment.²²⁵ There are no specific secondary containment requirements. Where a clear and present hazard exists, the ODNR may require an earthen dike or pit to be constructed to contain any spills from the wellhead and storage tanks.²²⁶

There is no requirement in ODNR's oil and gas program that the ODNR be notified of a spill at an oil and gas well site. An operator of a horizontal shale well must have liability insurance coverage of at least 5 million dollars for bodily injury and property damage to pay for damage caused by operations of all the operator's wells.²²⁷ The operator must also obtain a surety bond of \$5,000 for a single well or a blanket bond of \$15,000 for all wells to ensure that the wells are plugged, or demonstrate financial responsibility by showing a net financial worth that is twice the amount of the bond.²²⁸ If a property owner's water supply has been substantially disrupted by contamination from an oil or gas well operation, the well operator is required to replace the supply, or may elect to compensate the owner for the difference in fair market value of the property if less than the cost of replacement.²²⁹

Chemical Disclosure

Because hydraulic fracturing is exempted from the SDWA, there is no federal requirement that fracturing fluid be tested prior to injection into the well. In addition, well operators are not required to report releases of hazardous chemicals into the environment as part of the Toxics Release Inventory.²³⁰ State agencies that regulate oil and gas wells have responded to public concern about the nature of the fracturing fluid by requiring an operator to disclose information to the state about the chemical constituents. The amount of information disclosed varies, as does the extent to which the public is given access to the information. One method of disclosure is to require Material Safety Data Sheets (MSDSs), which are prepared by chemical manufacturers and importers under the Occupational Health and Safety Act and are provided to well operators by the service companies that conduct hydraulic fracturing.²³¹

MATERIAL SAFETY DATA SHEETS

Under the federal Occupational Health and Safety Administration's (OSHA's) Hazard Communication Rule (Rule), chemical manufacturers and importers must obtain or develop a MSDS for each hazardous chemical

that they produce or import, and provide the MSDS with a shipment.²³² For each chemical used, an employer must have an MSDS in the workplace. These sheets include information for employees who handle the chemicals, such as ingredients, physical and chemical properties, health effects, handling and storage, protective equipment, and emergency and first-aid measures. Ecological effects may be included.

The Rule defines a “hazardous chemical” to include any chemical that is a physical hazard or a health hazard.²³³ A “physical hazard” is a chemical that has physical effects such as being explosive or flammable. A “health hazard” is a chemical that has health effects such as death or other acute toxicity, skin and eye irritation, chronic organ toxicity, carcinogenicity, or reproductive toxicity. Chemicals that affect the environment but are not one of these types of hazards are not required to be on a MSDS.

Under the existing framework, manufacturers and importers are given broad discretion to “conduct a thorough evaluation” to determine whether a chemical is hazardous and must be disclosed, unless the chemical is on one of four lists.²³⁴ Manufacturers and importers are not required to follow any specific methods to evaluate a chemical as long as they can demonstrate that they have adequately ascertained the hazards.²³⁵ In addition, chemical ingredients that pose health hazards do not need to be disclosed on a MSDS if they are less than 1% of the total composition or mixture; for carcinogens, this *de minimis* exception applies if the ingredient is less than 0.1%.²³⁶

In March 2012, OSHA updated the Rule to harmonize U.S. requirements with international practice. Beginning in June 2015, manufacturers and importers must identify and consider the full range of available scientific literature and other evidence concerning the potential hazards to determine the hazard class of a chemical.²³⁷ For mixtures, all chemicals that are classified as health hazards and are present above a set cut-off value or concentration limit must be disclosed. These values vary based on the type of health effect, but remain 0.1% for carcinogens.²³⁸

Under both the existing and future requirements, a chemical manufacturer, importer, or employer may withhold the specific chemical identity, including the chemical name, other specific identification, or the exact concentration, from the MSDS as a trade secret. A trade secret is defined under the Rule as “any confidential formula, pattern, process, device, information or compilation of information that is used in an employer’s business,

and that gives the employer an opportunity to obtain an advantage over competitors who do not know or use it.”²³⁹ A claim that information is a trade secret must be “supported.”²⁴⁰ The properties and effects of the chemical must still be disclosed on the MSDS. In certain circumstances, the Rule requires disclosure of information about the trade secret chemical to health professionals and exposed employees or designated representatives.²⁴¹

MICHIGAN

Within 60 days of well completion, oil and gas well operators that conduct high volume hydraulic fracturing must provide the MDEQ with copies of MSDSs they received from service companies for the chemical additives used in the fracturing fluid and the volume of each chemical additive used.²⁴² The MDEQ is posting the MSDSs on its website for public review as they are received. As of June 14, 2012, the MSDSs for seven wells were available.²⁴³

OHIO

Under the new legislation, the operator of any well must submit information within sixty days after well completion on all products, fluids, and substances used to drill and stimulate the well.²⁴⁴ For each additive, the information must include the identity of the additive, a brief description of the purpose for which the additive is used, and the maximum concentration. The operator must also submit a list of all chemicals “intentionally added” to the fracturing fluid, including the specific chemical identification number and the maximum concentration for each chemical. An operator need not report chemicals that occur incidentally or in trace amounts.²⁴⁵ If the chemical information provided to the operator is incomplete or inaccurate, the operator must make reasonable efforts to obtain the information. The same information must be provided within sixty days after a well is refractured.²⁴⁶ If the ODNR does not have a MSDS for a chemical disclosed by the operator, the operator must give the ODNR a copy.²⁴⁷ An operator may submit the required chemical information on an ODNR form; through FracFocus, a website that is maintained by the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission; or by other approved means.²⁴⁸ The ODNR must also make the information and the MSDSs available on its website. As of June 14, 2012, the ODNR had posted MSDSs for ten service companies on its website; the website does not provide information on the chemicals used at any specific well.²⁴⁹

An operator must maintain records on all chemicals placed into a well for at least two years.²⁵⁰

An operator or a chemical supplier may withhold chemical information from the ODNR as a trade secret.²⁵¹ The withheld information may include the identity, amount, concentration, or purpose of a product or the chemical component of a product. The operator or supplier must maintain records on these chemicals for at least two years after they are placed in the well, and disclose these records to the ODNR if the information is necessary to respond to a spill, release, or investigation.²⁵²

The ODNR, however, may not disclose information designated as a trade secret to the public. The operator or chemical supplier must also provide the exact chemical composition of a product to a medical professional to assist in the diagnosis or treatment of a person affected by a well incident; the professional may not disclose the information for any purpose that is not related to the diagnosis or treatment.²⁵³ A property owner, adjacent property owner, or any person adversely affected by a product may challenge the trade secret claim in court after giving notice to the state.²⁵⁴

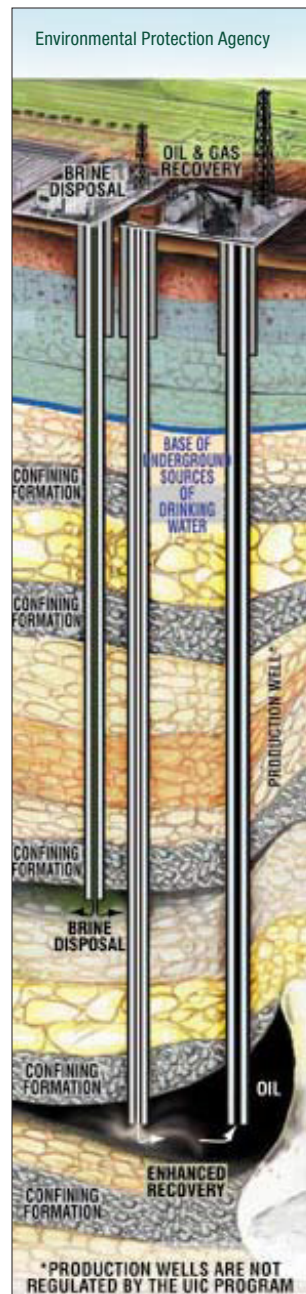
TABLE 1: REQUIREMENTS FOR OIL AND GAS PRODUCTION WELLS

Subject of Regulation	Production Well Requirement	EPA Class II Guidance for Diesel Fuels	Michigan Part 615	Ohio Chapter 1509
Well Location	Setback from environmental features	None	300 feet from freshwater wells; for storage tanks, 800-2,000 feet from public drinking water wells	50 feet from a water body
Permit Review	Area of review for possible conduits of fluid or methane	Modified 1/4 mile (1320 feet) around horizontally fractured bore	660-1320 feet around wellhead	None
	Baseline groundwater testing	May be required within area of review	For surface facility area only	Within 1500 feet of wellhead
Construction	Depth of surface casing	Below lowermost underground source of drinking water	100 feet below freshwater strata	50 feet below deepest drinking water source
	Blowout preventer	No specific rule; may be required	Required for all wells	In urbanized areas or within 200 feet of inhabited structure
	Mechanical integrity testing	Yes	No	No
Hydraulic Fracturing	Approval before fracturing	Yes	Notification only	Notification only, 24 hours before
	Information on fracturing fluid	Detailed chemical plan, including volume and concentrations, may be required in permit application	MSDSs and volume of fluid within 60 days after fracturing	List of chemicals intentionally added, including maximum concentrations, and MSDSs within 60 days after fracturing
	Testing of fluid	Complete characteristics with permit application; representative samples during operation	None	None
	Injection pressure	Limited so does not cause propagation of fractures in confining zone	Monitored only	Monitored only
Public Involvement	Public notice of permit application	Yes	Posted on website; hard copies upon request and to local government	Local government only; permit approval posted on website
	Opportunity for public comment	Yes, 30 day comment period	For local government only	No

REGULATION OF WASTEWATER TREATMENT AND DISPOSAL

Regardless of its hazardous characteristics, wastewater from oil and gas wells is exempted from the “cradle to grave” provisions governing generation, transportation, treatment, storage, and disposal of hazardous waste in the Resource, Conservation, and Recovery Act (RCRA).²⁵⁵ This categorical exemption includes flowback from hydraulically fractured wells. At the time EPA made its determination to exempt such wastewater in 1988, the agency estimated that 10% to 70% of drilling fluids and produced water “could potentially exhibit RCRA hazardous waste characteristics.”²⁵⁶ The EPA concluded, however, that the risk of exposure to toxic substances in the wastewater was small and the costs of compliance were large, and that the existing state regulatory programs were generally adequate to control the management of oil and gas wastes. Neither Michigan nor Ohio treats flowback as hazardous waste under state law. Transportation of flowback is regulated by the states through tracking requirements that are similar to, but less stringent than, those in RCRA.²⁵⁷

Treatment and disposal of flowback is subject to federal and state laws that are intended to protect water resources. The CWA governs treatment and discharge of wastewater into surface waters. Under the CWA, oil and gas well operators are prohibited from discharging wastewater, including flowback, into navigable waters of the United States.²⁵⁸ Although the CWA allows operators to discharge flowback through treatment facilities if certain requirements are met, discharge of flowback into surface waters is prohibited under Michigan and Ohio state laws.²⁵⁹ Land application of flowback is also not allowed in both states.²⁶⁰ Thus, oil and gas well operators who wish to dispose of flowback in Michigan and Ohio must use underground injection wells. The federal SDWA, discussed *infra*, governs underground injection of fluids.²⁶¹ In Michigan, the EPA regulates disposal wells through its Underground Injection Control (UIC) program; the state of Michigan also has separate permitting requirements under Part 615 of NREPA. In Ohio,



the state has “primacy” to administer its own UIC program.

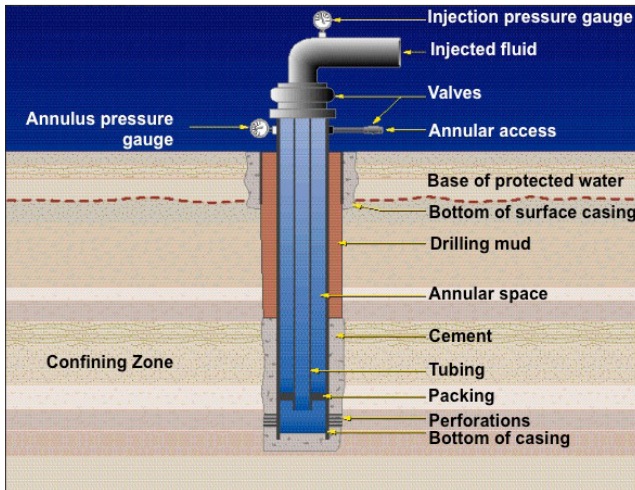
Disposal Wells

The SDWA prohibits an operator of an injection well from endangering underground sources of drinking water by contaminating groundwater “which supplies or can reasonably be expected to supply any public water system.”²⁶² In establishing regulatory programs under the Act, Congress directed the EPA and states to give special consideration to underground injection activities associated with oil and gas production, gas storage, and enhanced recovery. Federal and state delegated programs may not “interfere with or impede” underground injection for these activities “unless such requirements are essential to assure that underground sources of drinking water will not be endangered by such injection.”²⁶³ A state that

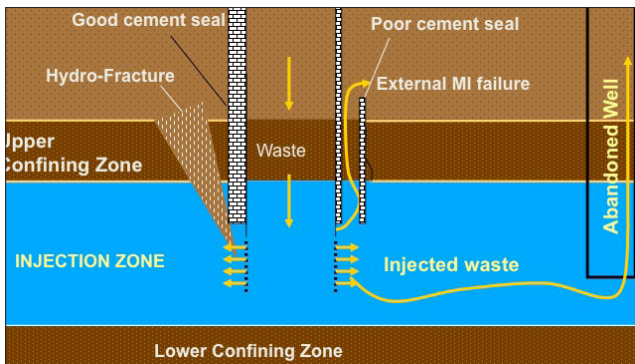
wishes to administer its own program for these activities need not meet minimum federal standards if the state demonstrates that its program is effective in preventing endangerment of drinking water sources.²⁶⁴

Injection wells are divided into six classes that cover industrial and municipal wastewater, hazardous and radioactive wastes, oil and gas wastewater, solution mining fluids, and carbon dioxide sequestration. Most municipal and industrial wastewater, including hazardous or radioactive waste, is placed into Class I wells.²⁶⁵ Class II wells are used for fluids associated with oil and gas activities, including wastewater “brought to the surface in connection with . . . oil or natural gas

CLASS II WELL CONSTRUCTION



EXTERNAL PATHWAYS OF CONTAMINATION



Environmental Protection Agency

production.”²⁶⁶ Flowback and produced water are placed into Class II wells because they are “brought to the surface” as part of oil and gas production and are categorically not considered hazardous waste.²⁶⁷ As the table at the end of this section shows, Class I wells that accept hazardous waste are subject to the most stringent requirements under SDWA. Class I wells that accept non-hazardous industrial and municipal wastewater are subject to less strict requirements, and Class II wells are subject to even less strict requirements. Michigan’s state program and Ohio’s UIC program are similar to the federal Class II program.

MICHIGAN

Each disposal well that accepts flowback must have a Class II well permit from the EPA.²⁶⁸ Wells in the same area and operated by the same entity may also be permitted under a single area permit.²⁶⁹ A disposal well owner or operator may not “construct, operate, maintain, convert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of fluid

containing any contaminant into underground sources of drinking water” if the contamination violates drinking water standards or adversely affects public health.²⁷⁰ When applying for a permit, an operator has the burden of demonstrating that the proposed well will not contaminate drinking water sources.²⁷¹ For a Class II well, a permit may be issued for the life of the well; however, the EPA must review the permit every five years.²⁷² Commercial Class II disposal wells that accept wastewater from other sources are subject to more stringent requirements under EPA Region 5 policy.²⁷³

A disposal well that accepts flowback must also have a permit from the MDEQ under Part 615 of NREPA.²⁷⁴ The MDEQ considers flowback a form of brine, which is defined in Part 615 as “all nonpotable water resulting, obtained, or produced from the exploration, drilling, or production of oil or gas, or both.”²⁷⁵ A permit is for the life of the well. Storage, transportation, or disposal of brine that results in, or may result in, pollution is prohibited.²⁷⁶ Some of the Part 615 requirements discussed in relation to production wells also apply to disposal wells, including secondary containment for surface facilities to protect against spills. Disposal wells need not, however, be set back from water wells.²⁷⁷

A disposal well that accepts flowback must be sited so that the wastewater will not migrate up into aquifers through natural or manmade conduits. New Class II wells must inject into a formation separated from any underground source of drinking water “by a confining zone that is free of known open faults or fractures within the area of review.”²⁷⁸ The “area of review” is a fixed radius of ¼ mile around the wellbore or a zone of endangering influence calculated using a mathematical model.²⁷⁹ Under Michigan’s program, brine wells must inject into a formation that is isolated from freshwater strata by an impervious confining formation.²⁸⁰ In addition, both programs require a disposal well operator to submit a corrective action plan for nearby wells that may act as conduits because they are improperly sealed, completed, or abandoned.²⁸¹

A disposal well that accepts flowback must also be constructed to prevent migration of wastewater. All Class II wells must “be cased and cemented to prevent movement of fluids into or between underground sources of drinking water.”²⁸² In addition, the “casing and cement used in the construction of each newly drilled well shall be designed for the life expectancy of the well.” In determining how a well is to be constructed, the EPA must consider certain factors, such as depth to the

injection zone and drinking water sources, and estimated injection pressures. Under Michigan's program, a disposal well must meet specific construction requirements applicable to all wells.²⁸³ As discussed *infra*, these include casing that extends from the surface to 100 feet below freshwater strata.²⁸⁴ In addition, fluid must be injected through "adequate" tubing inside the casing and through a "packer" that seals the bottom of the well.²⁸⁵

Before a well operator may begin injecting flowback, the disposal well must be approved by the EPA and the MDEQ.²⁸⁶ The operator must also demonstrate to both agencies that the well has mechanical integrity.²⁸⁷ Under the federal UIC program, the operator is required to show both internal mechanical integrity, defined as no significant leaks in the casing and other well components, as well as external mechanical integrity, defined as no significant fluid movement between the casing and the wellbore.²⁸⁸ Under Michigan's program, the operator need only demonstrate internal mechanical integrity by conducting a pressure test.²⁸⁹ Both programs also require that the operator continue to demonstrate mechanical integrity every five years.²⁹⁰ During operations, the operator may not exceed the maximum injection pressure set by both the federal and state permits.²⁹¹

A disposal well operator must submit information to both the EPA and the MDEQ on the source and chemical and physical characteristics of the flowback.²⁹² For commercial Class II disposal wells, a permit applicant is required to submit a chemical analysis of the normal brine constituents for each source.²⁹³ Michigan's program requires an applicant to submit a chemical analysis for a representative sample of each type of injected fluid. In addition, both programs require the well operator to monitor the injection pressure, flow rate, and cumulative volume of the flowback on a weekly basis.²⁹⁴ A Class II operator of a disposal well must also monitor the nature of the flowback "at time intervals sufficiently frequent to yield data representative of their characteristics" and annually submit information on any major changes in characteristics or sources of the wastewater.²⁹⁵ For commercial Class II disposal wells, the EPA requires a quarterly chemical analysis of each source and approval of all new sources.²⁹⁶ If there is evidence that a disposal well is leaking or other data indicates a malfunction, the operator must contact both agencies within 24 hours of discovery and submit a written report within five days.²⁹⁷

When a disposal well has reached the end of its life, both programs require the operator to plug the well with

cement and abandon it in accordance with a plan submitted at the time of the permit application.²⁹⁸ Under the federal UIC program, a well must be plugged using one of several methods and in a manner that will not allow the movement of flowback into underground sources of drinking water.²⁹⁹ In contrast, Michigan's plugging requirements, which apply to both production and disposal wells, detail the specific method and material to be used.³⁰⁰ Neither program requires continued monitoring of nearby aquifers. A well operator must provide the EPA and the MDEQ with evidence of sufficient financial means to plug the well.³⁰¹ Both programs require the operator to submit a financial instrument, such as a bond, or a statement of financial responsibility. Under the federal UIC program, the EPA determines the amount of the instrument and may revise it upward for inflation.³⁰² As discussed *infra*, Michigan's program requires a fixed bond amount based on the depth of the well; for wells deeper than 7,500 feet, the amount is \$30,000 for a single well or \$250,000 for all wells.³⁰³

OHIO

In 1983, the EPA gave Ohio primacy over Class II wells in the state.³⁰⁴ As noted above, Ohio was not required to adopt the federal minimum standards in the UIC program; the SDWA allows a state to regulate Class II wells if the program is effective in preventing endangerment of drinking water sources and includes inspection, monitoring, recordkeeping, and reporting requirements.³⁰⁵ Ohio's requirements, however, mirror many of the federal standards and in some cases exceed them. In addition to the requirements applicable to disposal well operators, an applicant for an oil or gas well permit must submit a plan for disposal of water and other waste substances, including identification of the disposal well or wells to be used.³⁰⁶

Under Ohio's law, all well operators that inject "brine or other waste substances resulting from, obtained from, or produced in connection with oil or gas drilling, exploration, or production" must obtain a permit from the ODNR.³⁰⁷ This includes a well operator that accepts flowback.³⁰⁸ A permit is for the life of a well; however, the permit expires if the operator fails to drill the well within twelve months.³⁰⁹ As in the federal UIC program, an applicant must demonstrate that injection will not result in contamination of "groundwater that supplies or can reasonably be expected to supply any public water system" and the contamination violates drinking water standards or adversely affects public health.³¹⁰ An

operator is also generally prohibited from conducting well operations in a manner that will contaminate or pollute land, surface waters, or groundwater.³¹¹

Like the federal UIC and Michigan programs, Ohio's program is designed to prevent flowback from migrating up into aquifers through natural or manmade conduits. There is no specific requirement that the operator of a disposal well inject into a formation separated from underground sources of drinking water. The operator is prohibited, however, from injecting flowback so as to allow movement of fluid into groundwater; in addition, flowback must be injected into an underground formation in a manner approved by the ODNR.³¹² If fluid could migrate into groundwater through other wells penetrating the proposed injection zone within the area of review, the operator must submit a corrective action plan.³¹³ The area of review for wells that inject greater than two hundred barrels per day per year average is ½ mile from the wellbore; for wells that inject less than this amount, the area is ¼ mile.³¹⁴ The ODNR may also designate another distance "for good cause shown."³¹⁵

As in the federal UIC and Michigan programs, Ohio's program requires a disposal well to be constructed to prevent migration of wastewater. In a permit application, the disposal well operator must submit a casing and cementing program to construct the well.³¹⁶ Beginning in August 2012, the new rules on well construction discussed *infra* will apply to all wells, including disposal wells.³¹⁷ There are also specific construction requirements for disposal wells in the existing rules. For wells permitted after 1982, surface casing must extend to at least 50 feet below the deepest underground source of drinking water; the casing must be cemented to the surface.³¹⁸ Cemented casing must also extend to at least 300 feet above the top of the injection zone.³¹⁹ Flowback must be injected through tubing and a packer set no more than 100 feet above the injection zone and installed under the supervision of the ODNR.³²⁰ The ODNR may grant a variance from these requirements for wells that inject less than 25 barrels a day at minimal pressures or if the construction will protect underground sources of drinking water in an equivalent manner.³²¹ In addition, all storage facilities must be constructed so as to "prevent pollution to surrounding surface and subsurface soils and waters."³²²

Prior to first injecting fluids, a disposal well operator is required to give reasonable notice to the ODNR and to test the internal mechanical integrity of the well through a pressure test supervised by the ODNR.³²³ The results

of the pressure test must be reported to the ODNR 30 days after completion of the injection well.³²⁴ During operations, the well pressure must be monitored at least monthly at a pressure sufficient to detect leaks, and the data must be annually reported to the ODNR.³²⁵ If such monitoring is not feasible, the operator is required to demonstrate mechanical integrity every five years by conducting a pressure test or other tests of internal or external integrity.³²⁶ An operator may not exceed the maximum injection pressure calculated for the well.³²⁷

An applicant for a disposal well permit must identify the composition of the liquid to be injected; unlike the federal UIC and Michigan programs, however, the ODNR does not require applicants to submit a chemical or physical analysis.³²⁸ During operations, the well operator must monitor injection pressures and volumes on a daily basis, and file an annual report with the ODNR.³²⁹ In addition, under the new legislation, the ODNR is directed to issue rules requiring a disposal well operator and transporters of brine to submit quarterly information concerning shipments of brine or other waste substances to a well.³³⁰ Unlike the federal UIC program, a well operator is not required to regularly test the characteristics of injected fluids. The ODNR may test injected fluids at any time.³³¹ If an operator discovers that a well was not adequately constructed, the operator must notify the ODNR within 24 hours of the discovery and immediately repair the well.³³² An injection well owner must cease operations immediately when "mechanical failures or downhole problems" cause contamination.³³³

Once a disposal well becomes incapable of receiving injected fluids, it must be plugged in accordance with a permit from the ODNR.³³⁴ The well operator is required to notify the ODNR a minimum of 24 hours prior to commencement of plugging operations, and an inspector must be present during plugging.³³⁵ Like Michigan's program, Ohio's program specifies the method, depth, and cement to be used.³³⁶ There is no requirement to monitor nearby aquifers. All well operators, including disposal well operators, must provide the ODNR with a surety bond of \$5,000 for a single well or a blanket bond of \$15,000 for all wells, or demonstrate financial responsibility by showing a net financial worth that is twice the amount of the bond.³³⁷ The operator must also have liability insurance coverage of at least \$1 million for bodily injury and property damage caused by operations of all the operator's wells; if the well is within an urbanized area, the coverage must be at least \$3 million.³³⁸

TABLE 2: REQUIREMENTS FOR DISPOSAL WELLS

Subject of Regulation	Disposal Well Requirement	EPA Class I Hazardous Well	EPA Class I Non-Hazardous Well	EPA Class II Well	Michigan Part 615	Ohio Class II Well
Well Location	Injection zone depth in relation to an underground source of drinking water (USDW)	Formation beneath the lowermost formation containing, within 1/4 mile of the wellbore, an USDW Confining zones separated from the base of the lowermost USDW by at least one sequence of permeable and less permeable strata	Formation beneath the lowermost formation containing, within 1/4 mile of the wellbore, an USDW	Formation separated from a USDW by a confining zone that is free of known open faults or fractures within area of review	Formation that is isolated from freshwater strata by an impervious confining formation	No provision
Permit Review	Area of review for possible conduits	Minimum 2 miles; Demonstration that no migration out of injection zone as long as remain hazardous	Minimum 1/4 of a mile; 2 miles in EPA Region 5	Usually 1/4 of a mile	1/4 of a mile	1/4 to 1/2 of a mile depending on injected volume
	Injected fluid information	Source Representative waste analysis, hazardous characteristics	Source Chemical, physical, radiological and biological characteristics	Source and physical and chemical characteristics	Chemical analysis for a representative sample of each type of injected fluid	Source of shipment Composition of liquid injected, but no analysis
	Permit term	10 years	10 years	Operating life	Operating life	Operating life
Construction	Casing	At least two layers of casing, inner casing cemented to surface Tubing and packer	At least two layers of casing, surface casing cemented to surface Tubing and packer	Varies	At least two layers of casing, surface casing cemented to surface Tubing and packer	At least two layers of casing, surface casing cemented to surface Tubing and packer
	Mechanical integrity testing	Continuous monitoring Internal testing every year, external testing every 5 years	Continuous monitoring and testing every 5 years	Testing prior to injection and every 5 years	Pressure test prior to injection and every five years	Pressure test prior to injection Monthly monitoring
Operation	Monitoring wells	May be installed in first aquifer immediately above injection zone	May be installed	May be installed	No provision	No provision
	Testing of fluid	Waste analysis plan, detailed chemical and physical analysis of a representative sample	Waste analysis plan, detailed chemical and physical analysis of a representative sample	Representative sample	No provision	No provision
	Maximum injection pressure	Does not fracture the injection zone or confining zone	Does not fracture the injection zone or confining zone	Does not fracture the confining zone	Calculated by formula	Calculated by formula
Plugging	Financial responsibility	Amount determined for each well and for post-closure; statement if net worth > \$10 million	Amount determined for each well; for statement, may require net worth > \$10 million	Amount determined for each well; statement if net worth > \$1 million	Up to \$30,000 Single bond; statement if net worth > \$2 million	\$5,000 single bond; statement if net worth > \$10,000; liability insurance

CONCLUSION

For most industrial activities, federal environmental law sets a floor for regulation; the states may impose stricter requirements if they choose. But in the case of hydraulic fracturing, there are very few federal requirements, both because of exemptions from applicable federal environmental laws and because the process is traditionally regulated by the states. The one exception is the federal UIC program, which governs disposal wells in Michigan. Thus, the individual policies of Michigan and Ohio determine in large part whether hydrofracking will negatively affect the water resources of the Great Lakes Basin. For each vector of potential harm explored in this report—freshwater use, contamination from well activities, and wastewater treatment and disposal—the protection provided by the states’ laws varies.

Water use for hydraulic fracturing is regulated the least stringently of all three vectors. The Great Lakes Compact prohibits a shale well operator from diverting water out of the Great Lakes Basin for hydraulic fracturing, but does not require the water loss in the basin to be regulated unless there are overall significant impacts. In Michigan, water withdrawals for oil and gas wells are exempt from the state’s water use law. The MDEQ uses its administrative authority to require the impacts of a withdrawal for hydraulic fracturing to be assessed in the same manner as under the water law, and to require the impacts on nearby water wells to be monitored. It is unclear, however, to what extent the agency will use its discretion to protect water resources when there is a close case or the withdrawal is off site. In Ohio, most withdrawals for hydraulic fracturing in the Lake Erie watershed will not be large enough to be regulated under the state’s new water use law. Even for those withdrawals that meet the permitting threshold, the program would allow adverse impacts to high-quality waters if those impacts are outweighed by the economic and social benefits of the water use.

Production well activities are regulated more comprehensively than water use. In Michigan and Ohio, oil and gas wells are prohibited from causing damage to the environment. Both states impose detailed requirements for well construction; in addition, Michigan has extensive requirements for surface facilities to prevent spills. The practice of hydraulic fracturing itself, however, is subject to limited regulation. Unlike the

EPA’s proposed guidance for shale wells that use diesel fuels, neither Michigan nor Ohio require the mechanical integrity of a well to be tested prior to hydraulic fracturing to ensure that the pressure will not cause the well to leak. In addition, neither state requires fracturing fluid to be tested for its chemical characteristics, or information to be provided to the state on the fluid constituents prior to hydrofracking. Instead, both states rely on the hazard information provided in MSDSs, which are submitted after fracturing occurs. Ohio also requires the operator to submit a list of constituents and maximum concentrations after fracturing. In both states, an operator or chemical supplier may withhold information about a substance by designating the information as a trade secret.

Wastewater is regulated the most stringently of all of the vectors. Michigan and Ohio require flowback to be disposed of in injection wells rather than discharged to surface waters after possibly inadequate treatment. All of the permitting programs generally prohibit endangerment of underground drinking water sources. The programs regulate the construction of a disposal well, assess possible ways in which flowback could migrate into aquifers, and require mechanical integrity testing of a well prior to injection of flowback. An applicant for a disposal well permit must provide information on flowback to the states and the EPA; however, only in Michigan must flowback be tested for its chemical characteristics prior to injection and at set intervals during operations. While the requirements imposed on wells that accept oil and gas wastewater such as flowback are extensive, they are less strict than those imposed on other wells that accept industrial wastewater. For example, other types of industrial wastewater must be placed further from underground drinking water sources, and operators of these wells must limit the injection pressure to ensure that the wastewater remains within the injection zone. Because flowback is exempt from the hazardous waste requirements under federal law regardless of its characteristics, the strictest requirements for hazardous wastewater wells do not apply.

POLICY RECOMMENDATIONS

Based on this review of laws governing the entire life cycle of hydraulic fracturing, the regulatory framework could be improved in the following ways:

GENERAL

- Given the public interest in shale wells, both Michigan and Ohio should give the public the formal opportunity to review and comment on permit applications for these types of production wells. Michigan should also give the public the same opportunity for brine disposal wells. While Ohio already provides the public with a 15-day period to comment on permit applications for brine disposal wells, the state should consider extending the period to 30 days to ensure that the public has adequate opportunity to comment.
- EPA, Michigan, and Ohio should ensure that the financial responsibility requirements for both production and injection wells are adequate to address the risks. Like Ohio, Michigan should require operators to obtain liability insurance for bodily injury and property damage. The states should increase the amount of the surety bond to encompass the true costs of plugging the wells. On a case-by-case basis, the EPA and the states should also consider increasing the amount of any financial instrument to include post-closure monitoring for contamination.

WATER USE

- At this early stage, there is very little information available to estimate the impacts of peak water use from deep shale hydraulic fracturing on sensitive watersheds in the Great Lakes Basin. The Great Lakes Commission or the states should conduct a basin-wide study to model these impacts, similar to the Commission's Great Lakes Energy-Water Nexus Initiative.
- Michigan's water use law, Part 327, should be amended to require freshwater withdrawals for oil and gas well activities to be regulated in the same manner as other withdrawals. While the MDEQ's well permitting instruction ensures that the impacts of water

withdrawals for hydraulic fracturing are assessed, direct statutory authority would be preferable. In addition, the instruction does not adequately substitute for all of the requirements in Part 327, such as registration and reporting.

- Ohio should lower the thresholds and averaging requirements in the state's new permitting program to include most water withdrawals for hydraulic fracturing. The permitting program should also assess the cumulative impacts of such water withdrawals on local watersheds. In the alternative, the ODNR should issue rules under its oil and gas well program to protect water resources from the impacts of these withdrawals.
- To comply with the Great Lakes Compact, both Michigan and Ohio should develop a water conservation and efficiency program for hydraulic fracturing. At the very least, the states should identify best management practices for well operators and encourage reuse of fracturing flowback. This is consistent with the hydraulic fracturing guidelines by STRONGER, Inc., a non-profit organization that reviews state programs.³³⁹

WELL ACTIVITIES

- Both Michigan and Ohio should incorporate the measures recommended by EPA in its draft UIC guidance on diesel fuels into regulation of all hydraulically fractured wells. For example, in determining whether to permit a shale well, Ohio should assess possible conduits around the well. Both states should also require mechanical integrity testing, a chemical analysis of fracturing fluid prior to fracturing, and sampling of the fluid during fracturing operations.
- Ohio should improve its regulation of surface activities at well sites. For example, the state should require fracturing fluid and flowback to be stored in steel tanks, and the state should specify secondary containment for surface facilities in its rules. The state should also require that surface spills be reported to the ODNR within a short period of time.
- In the face of uncertainty about the risks posed by chemicals in fracturing fluid, both Michigan and Ohio should take a precautionary approach and require a well operator to submit a list of potential chemical constituents to the state prior to hydraulic fracturing. After hydraulic fracturing occurs, the operator should submit a list of the chemical constituents actually used. All information about chemicals should be reported to

the state; if the state determines that the information is a trade secret, the state should take adequate measures to protect the information from being disclosed to the public.

- Both Michigan and Ohio should provide the public with a clear and understandable explanation of the potential risks of exposure to fracturing fluid. While MSDSs provide some information on possible health and environmental effects, they are designed to be used by workers, not the public.

WASTEWATER TREATMENT AND DISPOSAL

- Given the risks of improper treatment of flowback, both Michigan and Ohio should continue to prohibit treatment and discharge of flowback to surface waters. In Ohio, the ODNR should not approve any new technology or method of disposal for flowback unless the risks are at a similar level to those of underground injection.
- Flowback should be treated like other potentially hazardous substances and be placed in Class I

hazardous wells if it is found to exhibit any of the four hazardous waste characteristics under RCRA: ignitability, corrosivity, reactivity, or toxicity. The EPA, Michigan, and Ohio should require flowback to be tested for these characteristics prior to injection in a disposal well.

- Because of the potential negative effects of chemical additives in the flowback, some of the Class I requirements for non-hazardous industrial wastewater should be incorporated into the requirements for Class II wells that accept flowback. For example, the EPA and Ohio should require a Class II well to inject flowback into a formation that is beneath the lowermost formation containing, within 1/4 mile of the wellbore, an underground source of drinking water. The maximum injection pressure should be calculated to ensure that no fractures occur in the injection zone and the confining zone. Finally, a more comprehensive program for monitoring migration of injected waste should be developed.

ENDNOTES

- 1 U.S. ENERGY INFORMATION ADMINISTRATION, ANNUAL ENERGY OUTLOOK 2012 EARLY RELEASE OVERVIEW (2012), available at [http://www.eia.gov/forecasts/aeo/er/pdf/0383er\(2012\).pdf](http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2012).pdf).
- 2 *Id.* at 8.
- 3 *Great Lakes Basic Information*, U.S. ENVIRONMENTAL PROTECTION AGENCY, <http://www.epa.gov/greatlakes/basicinfo.html> (last visited June 10, 2012).
- 4 *Great Lakes Facts and Figures*, GREAT LAKES INFORMATION NETWORK, <http://www.great-lakes.net/lakes/ref/lakefact.html> (last visited June 10, 2012).
- 5 42 U.S.C. § 15941 (2006).
- 6 MASSACHUSETTS INSTITUTE OF TECHNOLOGY, THE FUTURE OF NATURAL GAS (2011), available at http://web.mit.edu/mitei/research/studies/documents/natural-gas-2011/NaturalGas_Report.pdf.
- 7 *Id.* at 36; Piccolo, *The Bakken Formation: How Much Will it Help?*, THE OIL DRUM (Apr. 26, 2008), <http://www.theoil Drum.com/node/3868>.
- 8 See Chris Perry & Larry Wickstrom, *The Marcellus Shale Play: Geology, History, and Oil & Gas Potential in Ohio*, 15 OHIO GEOLOGICAL SURVEY (Oct. 2010), http://www.dnr.state.oh.us/Portals/10/Energy/Marcellus/The_Marcellus_Shale_Play_Wickstrom_and_Perry.pdf.
- 9 See Larry Wickstrom et al., *The Utica-Point Pleasant Shale Play of Ohio*, OHIO GEOLOGICAL SURVEY (March 2012), http://www.dnr.state.oh.us/portals/10/energy/Utica-PointPleasant_presentation.pdf.
- 10 MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 6, at 8.
- 11 *Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program*, NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION 6-301 to 6-303 (Sept. 7, 2011), available at <http://www.dec.ny.gov/data/dmn/rdsgeisfull0911.pdf>. The estimates of truck trips vary. For other estimates, see MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 6, at 45.
- 12 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 6-301 to 6-303.
- 13 *Id.* at 5-27. According to an industry reviewer, wells are being drilled in two to four weeks in the Appalachian Basin.
- 14 *Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*, U.S. ENVIRONMENTAL PROTECTION AGENCY 13-14 (Nov. 2011), available at http://www.epa.gov/hfstudy/HF_Study__Plan_110211_FINAL_508.pdf [hereinafter EPA, *Draft Plan*].
- 15 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 5-94.
- 16 Brad Hansen, *Casing Perforating Overview*, DEVON ENERGY CORPORATION, available at <http://www.epa.gov/hfstudy/casingperforatedoverview.pdf>.
- 17 ALL CONSULTING AND THE GROUNDWATER PROTECTION COUNCIL, *Modern Shale Gas Development in the United States: A Primer*, prepared for the U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory, 64 (April 2009), available at http://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf; David M. Kargbo, Ron G. Wilhelm & David J. Campbell, *Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities*, ENVIRONMENTAL SCIENCE & TECHNOLOGY, available at <http://pubs.acs.org/doi/pdf/10.1021/es903811p>. Shale oil wells in the Bakken formation are estimated to use .5 million gallons to 3 million gallons of water per well. Bakken Water Opportunities Assessment—Phase 1, ENERGY & ENVIRONMENT RESEARCH CENTER 1, available at <https://cms.oilresearch.nd.gov/image/cache/g-018-036-fi.pdf>.
- 18 ALL CONSULTING, *supra* note 17, at 64.
- 19 EPA, *Draft Plan*, *supra* note 14, at 28.
- 20 *Id.* at 28.
- 21 *Id.* at 42-43.
- 22 *Fracturing Fluid Management*, FRACFOCUS, <http://fracfocus.org/hydraulic-fracturing-how-it-works/drilling-risks-safeguards> (last visited June 10, 2012).
- 23 EPA, *Draft Plan*, *supra* note 14, at 43. In the industry, flowback is considered a subset of produced water. This report will distinguish between flowback and later produced water because they have different characteristics that affect risk management.
- 24 Wayne R. Goodman & Timothy R. Maness, *Michigan's Antrim Gas Shale Play—A Two-Decade Template for Successful Devonian Gas Shale Development*, SEARCH AND DISCOVERY (2008), http://www.searchanddiscovery.com/documents/2008/08126goodman/ndx_goodman.pdf.
- 25 *Regulatory Response to Hydraulic Fracturing in Michigan*, MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY, http://www.michigan.gov/documents/deq/Regulatory_Response_376699_7.pdf.
- 26 ENERGY INSTITUTE, THE UNIVERSITY OF TEXAS AT AUSTIN, FACT BASED REGULATION FOR ENVIRONMENTAL PROTECTION IN SHALE GAS DEVELOPMENT Ch. 4 at 17 (2012), available at http://energy.utexas.edu/images/ei_shale_gas_regulation120215.pdf (analyzing 497 violations from 1999 to 2011).
- 27 Hobart King, *Utica Shale - The Natural Gas Giant Below the Marcellus?*, <http://geology.com/articles/utica-shale/> (last visited June 10, 2012).
- 28 For a map of the areas, see <http://ohiodnr.com/?TabId=23014> (scroll down to “Marcellus Shale Files for Download” and click on “Areas of Utica & Marcellus Potential in Ohio”).
- 29 *Marcellus Shale Wells*, MARCELLUS CENTER FOR OUTREACH AND RESEARCH, PENNSYLVANIA STATE UNIVERSITY, <http://www.marcellus.psu.edu/images/Wells-all.gif> (2007 to March 19, 2012).

- 30 For a map of the Utica wells, see *Marcellus and Utica Shales Data*, OHIO DEPARTMENT OF NATURAL RESOURCES, <http://ohiodnr.com/?TabId=23014> (scroll down to “Utica Shale Files for Download” and select “Map of Horizontal Utica-Pt. Pleasant Well Activity in Ohio”).
- 31 Memorandum from Viola Bay Wild, Senior Fiscal Analyst, Michigan House Fiscal Agency, to Interested Parties (May 12, 2010), *available at* <http://www.house.mi.gov/hfa/PDFs/DNRE%20Gas%20and%20Oil%20Royalties%205-2010.pdf>.
- 32 For a map of the Utica/Collingwood wells, see *Utica-Collingwood Permits and Applications*, MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY, http://www.michigan.gov/documents/deq/utica-_collingwood_activity_map3_354847_7.pdf (last visited June 13, 2012). Because the state permits both the vertical well and each horizontal leg, the total number of permits issued is 23.
- 33 *Id.*
- 34 The well is in Geauga County. See *Marcellus and Utica Shales Data*, *supra* note 30 (scroll down to “Utica Shale Files for Download” and select “Map of Horizontal Utica-Pt. Pleasant Well Activity in Ohio”).
- 35 *Chesapeake reports progress in wet gas window of Utica shale play*, OIL & GAS J., May 5, 2012, <http://www.ogj.com/articles/2012/05/chesapeake-reports-progress-in-wet-gas-window-of-utica-shale-play.html> (last visited June 13, 2012). The company recently announced that it plans to sell 337,481 acres of its mineral rights; included in the sale are areas within counties in the Great Lakes Basin. *Chesapeake Utica-Point Pleasant Trend Acreage*, MEAGHER ENERGY ADVISORS, <http://www.meagheradvisors.com/resources/project/Chesapeake%20Utica-Point%20Pleasant%20Trend%20Acreage/> (last visited June 13, 2012).
- 36 *BP Enters the Utica/Point Pleasant Shale in Ohio*, BRITISH PETROLEUM, <http://www.bp.com/genericarticle.do?categoryId=2012968&contentId=7074108> (last visited June 10, 2012).
- 37 HOUSE PUBLIC UTILITIES COMMITTEE PROPONENT TESTIMONY IN SUPPORT OF SUBSTITUTE SENATE BILL 315, OHIO DEPARTMENT OF NATURAL RESOURCES 1, *available at* <http://www.ohiodnr.com/Portals/11/oil/pdf/UpdatedSB315HouseProponentTestimonyofDirectorZehring.pdf>.
- 38 *Corporate Presentation*, ENCAN A CORPORATION, *available at* <http://www.encana.com/pdf/investors/presentations-events/corporate-presentation.pdf>.
- 39 Michigan Department of Environmental Quality, Supervisor of Wells Instruction 1-2011 (2011), *available at* http://www.michigan.gov/documents/deq/SI_1-2011_353936_7.pdf (effective June 22, 2011).
- 40 S.B. 315, 129th Leg. (Ohio 2012).
- 41 *See Well Construction Rule Package submitted to Joint Committee on Agency Rule Review*, OHIO DEPARTMENT OF NATURAL RESOURCES, <http://www.ohiodnr.com/tabid/23649/Default.aspx> (last visited June 10, 2012); *Proposed Underground Injection Control Rules submitted to the Common Sense Initiative*, OHIO DEPARTMENT OF NATURAL RESOURCES, <http://www.ohiodnr.com/tabid/24038/Default.aspx> (last visited June 10, 2012).
- 42 Oil and Gas Act, 2012 Pa. Laws 13.
- 43 Exec. Order No. 41(N.Y. 2010), *available at* <http://www.governor.ny.gov/archive/paterson/executiveorders/EO41.html>; Rebecca Penty, *Quebec bans any fracking pending studies*, CALGARY HERALD, Apr. 5, 2012, *available at* <http://www.calgaryherald.com/business/Quebec+bans+fracking+pending+studies/6407785/story.html>.
- 44 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11.
- 45 While hydrofracking has other potential impacts on the region—such as air pollution from well sites or the mining of sand as proppant—the focus of this report is on water resources.
- 46 *See Sources of Water for Hydraulic Fracturing Fluids*, OHIO ENVIRONMENTAL PROTECTION AGENCY (Apr. 2012), http://www.epa.state.oh.us/LinkClick.aspx?fileticket=sD7uTn_HXgE%3d&tabid=5339.
- 47 Encana Corporation reported using 8.5 million gallons to complete the State Excelsior 1-25 HD1 on November 8, 2011 in Kalkaska County, Michigan. *Find a Well*, FRACFOCUS, <http://www.hydraulicfracturingdisclosure.org/fracfocusfind/> (last visited June 10, 2012).
- 48 EPA, *Draft Plan*, *supra* note 14, at 23-24; OHIO ENVIRONMENTAL PROTECTION AGENCY, *supra* note 46, at 2.
- 49 OHIO ENVIRONMENTAL PROTECTION AGENCY, *supra* note 46, at 2.
- 50 *See, e.g.,* COUNCIL OF GREAT LAKES INDUSTRIES, OPTIMIZING INDUSTRY WATER USE (2012), *available at* http://www.cgli.org/waterfootprint/FinalCGLI_Rrt_PhaseII_May2012.pdf. The Great Lakes states estimate that industrial users in the Great Lakes Basin return 75% to 94% of the water withdrawn. GREAT LAKES COMMISSION, ANNUAL REPORT OF THE GREAT LAKES REGIONAL WATER USE DATABASE REPRESENTING 2009 WATER USE DATA 5 (2011).
- 51 Natural gas releases water vapor when combusted with oxygen. Depending on well production, the water vapor burned from the natural gas extracted from a shale well may be greater than the amount of water consumed for drilling and hydraulic fracturing. *Water Use in Association with Oil and Gas Activities Regulated by the Railroad Commission of Texas*, TEXAS SENATE (Jan. 10, 2012), *available at* <http://www.senate.state.tx.us/75r/Senate/commit/c510/handouts12/0110-RRC.pdf> (last visited June 10, 2012); *Turning Natural Gas Into Water: Hydraulic Fracturing Doesn't Deplete Water Supplies*, ENERGY IN DEPTH NORTHEAST MARCELLUS INITIATIVE, *available at* <http://eidmarcellus.org/marcellus-shale/turning-natural-gas-into-water-hydraulic-fracturing-doesnt-deplete-water-supplies/7713/>. But even if combustion overall results in more water in the hydrologic cycle, the water vapor is not necessarily returned to the source watershed.
- 52 *See* “Water Contamination from Wastewater Treatment and Disposal” subsection.
- 53 *See* “Water Contamination from Wastewater Treatment and Disposal” subsection.

- 54 Subcommittee on Water and Power, Senate Committee on Energy and Natural Resources, Hearing on Shale Gas Production and Water Resources in the Eastern United States, Oct. 20, 2011, at 9 (Remarks of Thomas W. Beauduy, Deputy Executive Director & Counsel, Susquehanna River Basin Commission), *available at* http://www.srbc.net/programs/docs/Water%20&%20Power%20Subcommittee%2010_20_11%20SRBC%20Beaudy%20Testimony.pdf (last visited June 10, 2012).
- 55 Bob Downing, *Chesapeake unveils system to recycle waste water from 'fracking' drill sites*, BEACON JOURNAL (Feb. 9, 2012), <http://www.ohio.com/news/local/chesapeake-unveils-system-to-recycle-waste-water-from-fracking-drill-sites-1.264011>.
- 56 See “Water Contamination from Wastewater Treatment and Disposal” subsection.
- 57 This calculation is based on two estimates of peak water use in the Marcellus. ARTHUR ET AL., WATER RESOURCES AND USE FOR HYDRAULIC FRACTURING IN THE MARCELLUS SHALE REGION 3 (2010), *available at* http://fracfocus.org/sites/default/files/publications/water_resources_and_use_for_hydraulic_fracturing_in_the_marcellus_shale_region.pdf (estimating peak use in the entire Marcellus shale, which covers 95,000 square miles, at 650 million barrels per year); Subcommittee on Water and Power, *supra* note 54, at 7 (estimating peak use in the Susquehanna River Basin, which covers 27,512 square miles, at 30 million gpd). Peak water use in the Marcellus Shale is thus expected to be 287,368 to 398,008 gallons per year per square mile. In the four states, approximately 93,750 square miles of land are within the basin. *Great Lakes Facts and Figures*, *supra* note 4 (Great Lakes); *NYS Watersheds*, NEW YORK DEPARTMENT OF ENVIRONMENTAL CONSERVATION, <http://www.dec.ny.gov/lands/60135> (last visited June 10, 2012) (St. Lawrence River). These calculations do not take into account the water vapor produced from combustion of natural gas.
- 58 GREAT LAKES COMMISSION, *supra* note 50, at 27, 35, 37, 49 (2011).
- 59 *Id.*
- 60 See “Great Lakes Compact” subsection, “Regulation of Water Use” section.
- 61 Subcommittee on Water and Power, *supra* note 54, at 4.
- 62 ARTHUR, *supra* note 57, at 2.
- 63 *Great Lakes Energy-Water Nexus (GLEW) Initiative*, GREAT LAKES COMMISSION, <http://www.glc.org/energy/glew/> (last visited June 10, 2012).
- 64 For a map showing these areas, see ECOLOGICALLY VULNERABLE HUC8 WATERSHEDS IN THE GREAT LAKES BASIN, GREAT LAKES COMMISSION (2011), *available at* http://www.glc.org/energy/glew/pdf/Multiple-vulnerabilities-map_top-22_11-8-11.pdf.
- 65 EPA, *Draft Plan*, *supra* note 14, at 40.
- 66 Stephen G. Osborn, Avner Vengosh, Nathaniel R. Warner & Robert B. Jackson, *Methane Contamination of Drinking Water Accompanying Gas-well Drilling and Hydraulic Fracturing*, 108 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 8172, 8173 (2011), *available at* <http://www.pnas.org/content/108/20/8172.full.pdf+html>.
- 67 EPA’s *Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources*, U.S. ENVIRONMENTAL PROTECTION AGENCY, <http://www.epa.gov/hfstudy/> (last visited June 10, 2012).
- 68 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 5-50.
- 69 H.R. REP. COMM. ON ENERGY AND COMMERCE MINORITY STAFF, CHEMICALS USED IN HYDRAULIC FRACTURING 1 (2011), *available at* <http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf>.
- 70 *Id.* at 1. Manufacturers have submitted 235 products to the New York Department of Environmental Conservation that may be used in natural gas wells in the state. NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 5-54.
- 71 H.R. REP. COMM. ON ENERGY AND COMMERCE, *supra* note 69, at 1.
- 72 *Id.*
- 73 *Id.*
- 74 *Id.* at 8.
- 75 Theo Colborn, Carol Kwiatkowski, Kim Schultz, & Mary Bachran, Natural Gas Operations from a Public Health Perspective, 17 J. HUMAN & ECOLOGICAL RISK ASSESSMENT 1039 (2011), *available at* <http://www.endocrinedisruption.com/files/GasManuscriptPreprintforweb12-5-11.pdf>.
- 76 A greater number of volatile chemicals—those that evaporate into the air—have health and environmental effects than do water-soluble chemicals. *Id.*
- 77 *Id.* at 1-2 (indicating that 421 of the 980 MSDSs in study disclosed less than 50 percent of the composition of the chemical substances within each product, and many MSDSs provided functional descriptions in place of chemical ingredients).
- 78 FRACFOCUS, *supra* note 47; Superior Well Services, Material Safety Data Sheets, *available at* http://www.michigan.gov/documents/deq/MSDS_St_Excelsior_13_Kalkaska_Co_366768_7.pdf.
- 79 *Chemicals in Natural Gas Operations*, THE ENDOCRINE DISRUPTION EXCHANGE, <http://www.endocrinedisruption.com/chemicals.multistate.php> (click on “spreadsheet”). According to the House Committee report, this chemical is used in 126 products across the country. H.R. REP. COMM. ON ENERGY AND COMMERCE MINORITY STAFF, *supra* note 69, at 7.
- 80 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 10.
- 81 MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 6; EPA, *Draft Plan*, *supra* note 14, at 28.
- 82 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 10-2 to 10-4.
- 83 EPA, *Draft Plan*, *supra* note 14, at 28.
- 84 For a list of possible contamination events, see Amy Mall, *Incidents where hydraulic fracturing is a suspected cause of drinking water contamination*, NATURAL RESOURCES DEFENSE COUNCIL (Dec. 19, 2011), http://switchboard.nrdc.org/blogs/amall/incidents_where_hydraulic_frac.html.

- 85 ENVIRONMENTAL PROTECTION AGENCY, DRAFT INVESTIGATION OF GROUNDWATER CONTAMINATION NEAR PAVILLION, WYOMING, (Dec. 2011), xiii, *available at* http://www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion_Dec-8-2011.pdf.
- 86 The study has also been criticized by industry. *See, e.g.*, S.S. PAPADOPULOUS & ASSOCIATES, INC., REVIEW OF U.S. EPA'S DECEMBER 2011 DRAFT REPORT (2012), *available at* https://images.magnetmail.net/images/clients/IPAA_comm/attach/PavillionReport2012.pdf.
- 87 EPA is conducting more sampling, after which the report will be subject to peer review. *Groundwater Investigation: Pavillion*, ENVIRONMENTAL PROTECTION AGENCY, <http://www.epa.gov/region8/superfund/wy/pavillion/> (last visited June 10, 2012).
- 88 A Perspective on the USEPA Study of Pavillion, Wyoming – Relevance and Lessons for NY, NEW YORK STATE WATER RESOURCES INSTITUTE 4 (Jan. 16, 2012), *available at* http://wri.eas.cornell.edu/index_26_820044830.pdf.
- 89 EPA, *Draft Plan*, *supra* note 14, at 37-38. *See also Fluid Flow in the Subsurface (Darcy's Law)*, FRACFOCUS, <http://fracfocus.org/groundwater-protection/fluid-flow-subsurface-darcys-law> (last visited June 10, 2012).
- 90 Osborn, *supra* note 66, at 8175. The study has been criticized by the oil and gas industry.
- 91 *Id.*
- 92 *Environmental Regulatory Basics*, OHIO ENVIRONMENTAL PROTECTION AGENCY, <http://www.epa.state.oh.us/shale.aspx> (last visited June 10, 2012) (click on “Basics,” then click on “What happens to water after hydraulic fracturing is complete?”)
- 93 The Marcellus Shale, particularly in Pennsylvania, is a “dessicated” formation that traps injected water. Matthew E. Mantell, Produced Water Reuse and Recycling Challenges and Opportunities Across Major Shale Plays, *available at* http://www.epa.gov/hfstudy/09_Mantell_-_Reuse_508.pdf. From 2009 to 2011, only 5% to 12% of the water injected for hydraulic fracturing in the Susquehanna River Basin flowed back to the surface. Subcommittee on Water and Power, *supra* note 54, at 8.
- 94 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 5-99 to 5-100. The amount of produced water ranges from 200 to 1,000 gallons per million cubic feet of natural gas; the Marcellus Shale has the lowest rate of the shale plays. Notice of Final 2010 Effluent Guidelines Program Plan, 76 Fed. Reg. 66286, 66295-96 (2011).
- 95 REBECCA HAMMER AND JEANNE VANBRIESEN, IN FRACKING'S WAKE: NEW RULES ARE NEEDED TO PROTECT OUR HEALTH AND ENVIRONMENT FROM CONTAMINATED WASTEWATER, NATURAL RESOURCES DEFENSE COUNCIL 11 (May 2012), *available at* <http://www.nrdc.org/energy/files/Fracking-Wastewater-FullReport.pdf>.
- 96 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 6-17. Small amounts of fracturing fluid may return to the surface long after completion, however.
- 97 EPA, *Draft Plan*, *supra* note 14, at 146-48.
- 98 *Id.* at 40.
- 99 *Id.* at 34-35. These substances are not necessarily unique to flowback; they may also be found in produced water.
- 100 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 5-102 to 5-105.
- 101 DANIEL J. SOEDER, RESOURCE AND ENVIRONMENTAL STUDIES ON THE MARCELLUS SHALE (2008), *available at* http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/Marcellus_GeoEnv_Soeder.pdf.
- 102 Notice of Final 2010 Effluent Guidelines Program Plan, 76 Fed. Reg. at 66296.
- 103 HAMMER, *supra* note 95, at 2.
- 104 Notice of Final 2010 Effluent Guidelines Program Plan, 76 Fed. Reg. at 66297.
- 105 *Id.*
- 106 EPA, *Draft Plan*, *supra* note 14, at 48-49.
- 107 Flowback in the Great Lakes region is diluted with freshwater to form new hydraulic fracturing fluid. Some flowback may be diluted without treatment; other flowback requires partial treatment. NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 5-118.
- 108 Notice of Final 2010 Effluent Guidelines Program Plan, 76 Fed. Reg. at 66296.
- 109 Notice of Final 2010 Effluent Guidelines Program Plan, 76 Fed. Reg. at 66297.
- 110 HAMMER, *supra* note 95, at 3.
- 111 ALL CONSULTING, *supra* note 17, at 68.
- 112 *See* “Regulation of Wastewater Treatment and Disposal” section.
- 113 Letter from Scott J. Nally, Director, Ohio Department of Environmental Quality, to David Mustine, Director, Ohio Department of Natural Resources (May 6, 2011), *available at* http://www.epa.ohio.gov/portals/35/pre-treatment/marcellus_shale/POTW_Brine_Disposal_Letter_may11.pdf. The revised permit for this facility prohibits flowback as of April 1, 2012. The state, the city, and a private treatment facility are engaged in ongoing litigation.
- 114 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 6-62; NEW YORK STATE WATER RESOURCES INSTITUTE, THE MARCELLUS SHALE AND NATURAL GAS 7 (Feb. 2012), *available at* http://www.shalegas.energy.gov/resources/tws_cornell_nyswri_marcellus.pdf. New York landfills within the Basin are accepting solid waste from Marcellus Shale well operators. For example, in the first six months of 2011, a landfill in Niagara Falls operated by Allied Waste Systems accepted waste. *Our Look at 2011 Waste & Wastewater Facilities (1st and 2nd quarters)*, MARCELLUS-SHALE.US, http://www.marcellus-shale.us/waste-wastewater_2011.htm (last visited June 12, 2012).
- 115 *Our Look at 2011*, *supra* note 114; *Our Look at 2011 Waste & Wastewater Facilities (3rd and 4th quarters)*, MARCELLUS-SHALE.US, http://www.marcellus-shale.us/waste-wastewater_2011b.htm (last visited June 12, 2012). Some of the facilities did not have specific locations in Pennsylvania. Of the publicly owned treatment works

- and private facilities that are exempt from Pennsylvania's new treatment standards, none of them are within the Basin. See HAMMER, *supra* note 95, at 27-31.
- 116 See HAMMER, *supra* note 95, at 60, 70-71.
- 117 Personal communication with Lisa Perenchio, Section Chief, Direct Implementation Section, EPA Region 3 (June 14, 2012).
- 118 For a map of these wells, see *Class II Brine Injection Wells of Ohio*, OHIO DEPARTMENT OF NATURAL RESOURCES, <http://www.dnr.state.oh.us/Portals/10/pdf/ClassIIWellsMap.pdf>.
- 119 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra* note 11, at 7-66.
- 120 Personal communication with David J. Rectenwald, Environmental Scientist/UIC Inspector, EPA Region 3 (June 6, 2012); HAMMER, *supra* note 95, at 19. The commercial well operated by Range Resources in Waterford, Pennsylvania was plugged in spring 2012.
- 121 HAMMER, *supra* note 95, at 4 (from the first half of 2011 to the second half of 2011, injection in disposal wells tripled).
- 122 *Our Look at 2011*, *supra* note 115 (B&R Injection Well – Pierpont, Ohio; Dietrich #1, Petrowater Inc. – Jefferson, Ohio; Parobek #2 (SWIW #12) - Ashtubula, Ohio; Renshaw / Bradnan #1 Disp Well – Ashtubula County, Ohio; Blazek Pump and Well – Hiram, Ohio; Miller #1 Disp Well – Portage County, Ohio; Saltys Disposal – Wilcox #1 – Rootstown, Ohio; Wilcox #1 – Rootstown, Ohio). This is only an approximation, as it is unclear whether some facilities are disposal wells and some did not have specific locations.
- 123 In 2009, a study by the Pennsylvania Department of Conservation and Natural Resources found that there is geological capacity in the western half of the state for carbon sequestration. PENNSYLVANIA DEPARTMENT OF CONSERVATION & NATURAL RESOURCES, *GEOLOGIC CARBON SEQUESTRATION OPPORTUNITIES IN PENNSYLVANIA (2009)*, available at <http://www.dcnr.state.pa.us/info/carbon/mastercstareport2.pdf>.
- 124 The party states are Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. A companion non-binding pact, the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, includes the Great Lakes provinces of Ontario and Québec.
- 125 Great Lakes-St. Lawrence River Basin Water Resources Compact, § 4.8, Dec. 13, 2005, available at http://www.cglg.org/projects/water/docs/12-13-05/Great_Lakes-St_Lawrence_River_Basin_Water_Resources_Compact.pdf. There is no prohibition on diverting water into the basin. However, in Ohio, a permit would be required for a diversion of more than 100,000 gpd from the Ohio River Basin to the Lake Erie Basin. H.B. 473, 129th Leg., § 1501.32(Ohio 2012).
- 126 Great Lakes-St. Lawrence River Basin Water Resources Compact § 1.2.
- 127 See Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.9.2.
- 128 Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.9.2.
- 129 Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.12.6.
- 130 Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.12.9.
- 131 Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.2.
- 132 *Id.*
- 133 *Id.*
- 134 Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.10.
- 135 See Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.10.
- 136 Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.11.
- 137 Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.1.
- 138 Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.1.3.
- 139 MICH. COMP. LAWS ANN. § 324.32701 *et seq.* (2011).
- 140 MICH. COMP. LAWS ANN. §§ 324.32701(aa), 324.32721 (2011).
- 141 MICH. COMP. LAWS ANN. § 324.32701(a) (2011).
- 142 MICH. COMP. LAWS ANN. § 324.32727 (2011) (exemption for “withdrawal undertaken as part of an activity authorized by the department” under Part 615, which governs oil and gas wells).
- 143 MICH. COMP. LAWS ANN. § 324.61527 (2011).
- 144 MICH. COMP. LAWS ANN. § 324.61504 (2011).
- 145 MICH. COMP. LAWS ANN. § 324.61505 (2011).
- 146 MICH. COMP. LAWS ANN. § 324.61501(q) (2011).
- 147 MICH. ADMIN. CODE r. 324.403, 324.404 (2011).
- 148 Supervisor of Wells Instruction 1-2011, *supra* note 39.
- 149 MICH. COMP. LAWS ANN. § 324.61501 *et seq.* (2011).
- 150 MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY, OFFICE OF GEOLOGIC SURVEY (DEQ-OGS), *WATER WITHDRAWAL ANALYSIS FOR HIGH VOLUME HYDRAULIC FRACTURING*, available at http://www.michigan.gov/documents/deq/Water_Withdrawal_Analysis_for_High_Volume_Hydrofracturing_363046_7.pdf.
- 151 A new or increased consumptive use of greater than 2 million gallons per day averaged over a 30-day period must also obtain a permit; however, the water loss for an individual set of withdrawals for hydraulic fracturing is unlikely to meet this threshold. See OHIO REV. CODE ANN. § 1501.33 (West 2011).
- 152 H.B. 473, 129th Leg., § 1522.12 (1)-(2) (Ohio 2012).
- 153 H.B. 473, 129th Leg., § 1522.12 (3)(a) (Ohio 2012). “High quality water” is defined as “a river or stream segment that has been designated . . . as an exceptional warm water habitat, cold water habitat, outstanding state water, or superior high-quality water.” H.B. 473, 129th Leg., § 1522.10 (j) (Ohio 2012).
- 154 H.B. 473, 129th Leg., § 1522.14(B)(1) (Ohio 2012).
- 155 H.B. 473, 129th Leg., § 1522.14(B)(2)(Ohio 2012).
- 156 The CALVIN MANGUN 8H well in Carroll County used the most water, 10,559,094 gallons. The other wells’

- water use ranged from over 400,000 gallons to 8.2 million gallons of water; 471,534 gallons were used for the HOSEY POR 6H-X well in Portage County; 3,135,006 gallons were used for the WEST 4-15-5 3H well in Carroll County; 4,043,382 gallons were used for the BROWN 36-11-3 10H well in Jefferson County; 4,411,554 gallons were used for the BUCEY 3H well in Carroll County; 4,297,188 gallons were used for the BUCEY 21-14-4 3H M well in Carroll County; 4,471,740 gallons were used for the CONIGLIO 7-14-4 6H well in Carroll County; 4,752,384 gallons were used for the DREVON 29-18-7 8H well in Stark County; 5,145,000 gallons were used for the HARVEY 8H well in Carroll County; 5,738,166 gallons were used for the NEIDER 3H well in Carroll County; and 8,291,304 gallons were used for the BURGETT 7-15-6 8H RS well in Carroll County (listed in order by volume of water used). See *FracFocus*, *supra* note 47.
- 157 H.B. 473, 129th Leg., § 1522.13 (A) (Ohio 2012).
- 158 H.B. 473, 129th Leg., § 1522.13(B) (Ohio 2012). Within 18 months, an advisory group must issue recommendations on how to apply this standard; the Ohio Department of Natural Resources will then make recommendations to the General Assembly, taking into consideration the economic consequences. H.B. 473, 129th Leg. § 3 (Ohio 2012).
- 159 H.B. 473, 129th Leg., § 1522.13(C) (Ohio 2012); Great Lakes-St. Lawrence River Basin Water Resources Compact § 4.11.5.
- 160 OHIO REV. CODE ANN. § 1509.01(A) (West 2011).
- 161 S.B. 315, 129th Leg. § 1509.03(A) (Ohio 2012). A horizontal well is defined as «a well that is drilled for the production of oil or gas in which the wellbore reaches a horizontal or near horizontal position in the Point Pleasant, Utica, or Marcellus formation and the well is stimulated.» S.B. 315, 129th Leg. § 1509.01(GG) (Ohio 2012).
- 162 OHIO REV. CODE ANN. § 1509.23(A) (West 2011).
- 163 The MDEQ has stated that it will keep an informal record of the withdrawals. Letter from Harold R. Fitch, Chief, Resource Management Division of the Office of Geological Survey, to the DEQ, to Grenetta Thomassey, Program Director, Tip of the Mitt Watershed Council (July 6, 2011).
- 164 Supervisor of Wells Instruction 1-2011, *supra* note 39.
- 165 *Id.*
- 166 Supervisor of Wells Instruction 1-2011, *supra* note 39.
- 167 Letter from Harold R. Fitch to Grenetta Thomassey, *supra* note 163.
- 168 See OHIO REV. CODE ANN. § 1521.16 (West 2011).
- 169 OHIO REV. CODE ANN. § 1521.16(A) (West 2011).
- 170 OHIO DEPARTMENT OF NATURAL RESOURCES, WATER WITHDRAWAL MANAGEMENT PROGRAM REPORT (Dec. 8, 2009), *available at* <http://dnr.state.oh.us/LinkClick.aspx?fileticket=VkJt7NRn4hA%3D&tabid=4048>.
- 171 S.B. 315, 129th Leg., § 1509.06(A)(8)(a) (Ohio 2012) (applying to all production operations, defined broadly to include all operations and activities and all related equipment, facilities, and other structures that may be used in or associated with the exploration and production of oil, gas, or other mineral resources).
- 172 S.B. 315, 129th Leg., § 1509.06(A)(8)(a), (K) (Ohio 2012).
- 173 S.B. 315, 129th Leg., § 1509.10(A)(9)-(10), (B)(3) (Ohio 2012) (the “type and volume of fluid used to stimulate the well” is also required).
- 174 42 U.S.C. § 300h(d)(1)(B)(ii) (2006). As discussed *infra*, the disposal of flowback is regulated under the SDWA. See “Regulation of Wastewater Treatment and Disposal” section.
- 175 EPA, PERMITTING GUIDANCE FOR OIL AND GAS HYDRAULIC FRACTURING ACTIVITIES USING DIESEL FUELS—DRAFT: UNDERGROUND INJECTION CONTROL PROGRAM GUIDANCE #84 (May 2012), *available at* <http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/hfdieselfuelsguidance508.pdf>.
- 176 42 U.S.C. § 15941 (2006); MICH. COMP. LAWS ANN. § 324.61505a (2011).
- 177 See “Regulation of Water Use” section.
- 178 MICH. COMP. LAWS ANN. § 324.61501(q) (2011).
- 179 MICH. COMP. LAWS ANN. § 324.61506(c) (2011).
- 180 MICH. COMP. LAWS ANN. § 324.61506(h) (2011).
- 181 MICH. ADMIN. CODE r. 324.201(1), (3) (2011).
- 182 MICH. ADMIN. CODE r. 324.201(2) (2011).
- 183 MICH. ADMIN. CODE r. 324.301(1)(b)(v) (2011).
- 184 Michigan Department of Environmental Quality, Supervisor of Wells Letter No. 2011-1 (2011), *available at* http://www.michigan.gov/documents/deq/SL_2011-1_353937_7.pdf.
- 185 MICH. ADMIN. CODE r. 324.408(1) (2011).
- 186 MICH. ADMIN. CODE r. 324.410, 324.411 (2011).
- 187 MICH. ADMIN. CODE r. 324.503 (2011).
- 188 MICH. ADMIN. CODE r. 324.406 (2011).
- 189 Supervisor of Wells Instruction 1-2011, *supra* note 39.
- 190 MICH. ADMIN. CODE r. 324.503 (2011).
- 191 MICH. ADMIN. CODE r. 324.418(b) (2011).
- 192 Supervisor of Wells Instruction 1-2011, *supra* note 39.
- 193 MICH. ADMIN. CODE r. 324.416(3) (2011).
- 194 MICH. ADMIN. CODE r. 324.301(1)(b)(vi), 324.504 (2011). There is an exception for the setback from freshwater wells if there is written consent by the owners of the wells or the Supervisor of Wells determines that the location will prevent waste, protect environmental values, and not compromise public safety. MICH. ADMIN. CODE r. 324.504 (2011).
- 195 MICH. ADMIN. CODE r. 324.1002 (2011).
- 196 MICH. ADMIN. CODE r. 324.504, 324.1002 (2011).
- 197 MICH. ADMIN. CODE r. 324.1008 (2011).
- 198 MICH. ADMIN. CODE r. 324.416(3) (2011).
- 199 MICH. ADMIN. CODE r. 324.210 (2011).
- 200 MICH. ADMIN. CODE r. 324.212 (2011).
- 201 OHIO REV. CODE ANN. § 1509.02 (West 2011).
- 202 OHIO REV. CODE ANN. § 1509.23 (West 2011).
- 203 S.B. 315, 129th Leg., §§ 1509.01(GG), 1509.03(A) (Ohio 2012).
- 204 OHIO REV. CODE ANN. § 1509.05 (West 2011).
- 205 S.B. 315, 129th Leg., § 1509.06(A)(8)(c) (Ohio 2012).

- 206 OHIO DEPARTMENT OF NATURAL RESOURCES, BEST MANAGEMENT PRACTICES FOR PRE-DRILLING WATER SAMPLING 3 (Apr. 28, 2005), *available at* http://www.dnr.state.oh.us/Portals/12/docs/BMP_PRE-DRILLING_WATER_SAMPLING.pdf.
- 207 S.B. 315, 129th Leg., § 1509.06(H)(1) (Ohio 2012).
- 208 S.B. 315, 129th Leg., § 1509.06(H)(2) (Ohio 2012).
- 209 OHIO REV. CODE ANN. § 1509.06 (West 2011); OHIO ADMIN. CODE § 1501:9-1-02(A)(5)(d) (2011).
- 210 OHIO REV. CODE ANN. § 1509.021(L) (West 2011).
- 211 See *Well Construction Rule Package*, OHIO DEPARTMENT OF NATURAL RESOURCES, *supra* note 41 (OHIO ADMIN. CODE § 1501:9-1-02(A)(6)).
- 212 *Id.* (OHIO ADMIN. CODE § 1501:9-1-08(M)(4)).
- 213 *Id.* (OHIO ADMIN. CODE § 1501:9-1-08(M)(4)).
- 214 *Id.* (OHIO ADMIN. CODE § 1501:9-1-08(D)(1), (D)(3), (M)(3), (M)(6)).
- 215 *Id.* (OHIO ADMIN. CODE § 1501:9-1-08(D)).
- 216 OHIO ADMIN. CODE § 1501:9-9-03(C)-(E) (2011).
- 217 OHIO REV. CODE ANN. § 1509.19 (West 2011).
- 218 See *Well Construction Rule Package*, OHIO DEPARTMENT OF NATURAL RESOURCES, *supra* note 41 (OHIO ADMIN. CODE § 1501:9-1-08(N)(5)).
- 219 OHIO REV. CODE ANN. § 1509.19 (West 2011).
- 220 OHIO ADMIN. CODE § 1501:9-3-08(C) (2011).
- 221 OHIO REV. CODE ANN. § 1509.22(B) (West 2011); OHIO ADMIN. CODE § 1501:9-3-08(A) (2011).
- 222 OHIO REV. CODE ANN. § 1509.10(A)(9) (West 2011).
- 223 OHIO ADMIN. CODE § 1501:9-1-07(A) (2011); OHIO REV. CODE ANN. § 1509.072 (West 2011).
- 224 OHIO ADMIN. CODE § 1501:9-9-05(E)(5)(C) (2011).
- 225 OHIO REV. CODE ANN. § 1509.22(A) (West 2011).
- 226 OHIO ADMIN. CODE § 1501:9-9-05(A)(9) (2011).
- 227 S.B. 315, 129th Leg., § 1509.07(A)(2) (Ohio 2012).
- 228 OHIO REV. CODE ANN. § 1509.07 (West 2011); OHIO ADMIN. CODE § 1501:9-1-03(A) (2011).
- 229 OHIO REV. CODE ANN. § 1509.22(f) (West 2011).
- 230 See *TRI Covered Industries*, UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, <http://www.epa.gov/tri/lawsandregs/naic/ncodes.htm>.
- 231 The MSDS is now referred to as the Safety Data Sheet (SDS); however, because state law continues to refer to the document as a MSDS, this report will do the same.
- 232 29 C.F.R. § 1910.1200(g)(1) (2011).
- 233 See 29 C.F.R. § 1910.1200(c) (2011).
- 234 29 C.F.R. §§ 1910.1200, at App. B, 1910.1200(d)(3)-(4) (2011) (previous version) (chemical manufacturers must treat a chemical as hazardous and list it on an MSDS if it is listed (1) in 29 C.F.R. part 1910, subpart Z, (2) on the Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, American Conference of Governmental Industrial Hygienists (latest edition), (3) as a carcinogen by the National Toxicology Program, or (4) as a carcinogen by the Annual Report on Carcinogens, International Agency for Research on Cancer Monographs).
- 235 29 C.F.R. § 1910.1200, at App. B (2011) (previous version).
- 236 29 C.F.R. § 1910.1200(g)(2)(i)(C)(1) (2011) (previous version).
- 237 29 C.F.R. § 1910.1200(d) (2011).
- 238 29 C.F.R. § 1910.1200, at App. A (2011).
- 239 29 C.F.R. § 1910.1200(c) (2011).
- 240 See 29 C.F.R. § 1910.1200(i)(1)-(2) (2011).
- 241 29 C.F.R. § 1910.1200(i)(2)-(13) (2011).
- 242 Supervisor of Wells Instruction 1-2011, *supra* note 39.
- 243 *Hydraulic Fracturing in Michigan*, MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY, http://www.michigan.gov/deq/0,4561,7-135-3311_4111_4231-262172--,00.html (last visited June 14, 2012).
- 244 S.B. 315, 129th Leg., § 1509.10(A)(10)(a)-(b) (Ohio 2012). Cement and its constituents, as well as “lost circulation materials,” are exempt.
- 245 S.B. 315, 129th Leg., § 1509.10(K) (Ohio 2012).
- 246 S.B. 315, 129th Leg., § 1509.10(B)(3) (Ohio 2012).
- 247 S.B. 315, 129th Leg., § 1509.10(E) (Ohio 2012).
- 248 S.B. 315, 129th Leg., § 1509.10(F) (Ohio 2012).
- 249 See *Material Safety Data Sheets*, OHIO DEPARTMENT OF NATURAL RESOURCES, <http://www.ohiodnr.com/oil/msdssheets/tabid/22968/Default.aspx> (last visited June 14, 2012).
- 250 S.B. 315, 129th Leg., § 1509.10(J)(1) (Ohio 2012).
- 251 S.B. 315, 129th Leg., § 1509.10(I) (Ohio 2012).
- 252 S.B. 315, 129th Leg., § 1509.10(J)(2) (Ohio 2012).
- 253 S.B. 315, 129th Leg., § 1509.10(H) (Ohio 2012).
- 254 S.B. 315, 129th Leg., § 1509.10(I) (Ohio 2012).
- 255 40 C.F.R. § 261.4(b)(5) (2011). See also 42 U.S.C. §§ 6921(b)(2), 6982(m) (2006).
- 256 Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes, 53 Fed. Reg. 25447 (1988).
- 257 MICH. COMP. LAWS ANN. § 324.12101 *et seq.* (2011); OHIO REV. CODE ANN. § 1509.222-.223 (West 2011).
- 258 40 C.F.R. §§ 435.30, 435.32 (2011). There is an exception for so-called “stripper wells,” wells at the end of their useful life that produce 10 barrels of crude oil or less per day. 40 C.F.R. § 435.60 (2011).
- 259 OHIO REV. CODE ANN. § 1509.22(C)(1) (West 2011). While this provision allows disposal by other methods approved by the chief for testing or implementing a new technology or method of disposal, treatment and discharge is not considered such a method by the state. See Letter from Scott J. Nally, *supra* note 113.
- 260 MICH. ADMIN. CODE r. 324.705(2) (2011) (allowing use for ice and dust control only upon approval of MDEQ); OHIO REV. CODE ANN. §§ 1509.22(C)(1), 1509.226(B)(10) (West 2011).
- 261 See “Regulation of Well Activities” section.
- 262 42 U.S.C. §§ 300h, 300h-1 (2006). See also 40 C.F.R. § 144.3 (2011) (defining an “underground source of drinking water (USDW)” as “an aquifer or its portion: (a)(1) Which supplies any public water system; or (2) Which contains a sufficient quantity of ground water to supply a public water system; and (i) Currently supplies drinking water for human consumption; or (ii) Contains fewer than 10,000 mg/l total dissolved solids; and (b) Which is not an exempted aquifer”).
- 263 42 U.S.C. §§ 300h(b)(2), 300h-1(c) (2006).
- 264 42 U.S.C. § 300h-4(a) (2006).

- 265 40 C.F.R. § 144.6(a) (2011).
- 266 40 C.F.R. § 144.6(b) (2011).
- 267 *See* 40 C.F.R. § 144.3 (2011) (defining hazardous waste to be the same as in the RCRA regulations).
- 268 40 C.F.R. §§ 144.11, 144.31 (2011).
- 269 40 C.F.R. § 144.33 (2011).
- 270 40 C.F.R. § 144.12(a) (2011).
- 271 40 C.F.R. § 144.12(a) (2011).
- 272 40 C.F.R. § 144.36 (2011).
- 273 *Requirements for Commercial Underground Injection Control Class II Wells*, ENVIRONMENTAL PROTECTION AGENCY, <http://www.epa.gov/region5/water/uic/forms/commercial.htm> (last visited June 13, 2012).
- 274 MICH. ADMIN. CODE r. 324.201(1)(c) (2011).
- 275 MICH. ADMIN. CODE r. 324.102(f) (2011).
- 276 MICH. ADMIN. CODE r. 324.701 (2011).
- 277 MICH. ADMIN. CODE r. 324.301(1) (2011).
- 278 40 C.F.R. § 146.22(a) (2011).
- 279 40 C.F.R. § 146.6 (2011).
- 280 MICH. ADMIN. CODE r. 324.703, 324.705(3) (2011).
- 281 40 C.F.R. §§ 146.24(a)(2)-(3), 144.55 (2011); MICH. ADMIN. CODE r. 324.201(j) (2011).
- 282 40 C.F.R. § 146.22(b) (2011).
- 283 *See* MICH. ADMIN. CODE r. 324.408, 324.410-11 (2011).
- 284 *See* “Regulation of Well Activities” section.
- 285 MICH. ADMIN. CODE r. 324.801 (2011); *see* GROUND WATER PROTECTION COUNCIL, INJECTION WELLS: AN INTRODUCTION TO THEIR USE, OPERATION, AND REGULATION 10, *available at* http://www.gwpc.org/sites/default/files/injection_wells_-_an_introduction_to_their_use_operation_and_regulation.pdf (last visited June 13, 2012).
- 286 40 C.F.R. § 144.51(m) (2011); MICH. ADMIN. CODE r. 803 (2011).
- 287 40 C.F.R. §§ 144.51(q), 146.8(a) (2011); MICH. ADMIN. CODE r. 803 (2011).
- 288 40 C.F.R. § 146.8(b)-(c) (2011).
- 289 MICH. ADMIN. CODE r. 803 (2011).
- 290 40 C.F.R. § 146.23(b)(3) (2011); MICH. ADMIN. CODE r. 805 (2011).
- 291 40 C.F.R. §§ 144.52(a)(3), 146.23(a) (2011); MICH. ADMIN. CODE r. 324.804 (2011).
- 292 40 C.F.R. § 146.24(a)(4) (2011); MICH. ADMIN. CODE r. 324.201(j) (2011).
- 293 *Requirements for Commercial Underground Injection Control Class II Wells*, *supra* note 273.
- 294 40 C.F.R. § 146.23(b) (2011); MICH. ADMIN. CODE r. 806 (2011).
- 295 40 C.F.R. § 146.23(b)-(c) (2011).
- 296 *Requirements for Commercial Underground Injection Control Class II Wells*, *supra* note 273.
- 297 40 C.F.R. § 144.51(l)(6) (2011); MICH. ADMIN. CODE r. 807 (2011).
- 298 40 C.F.R. §§ 144.31(e)(10), 144.52(a)(6) (2011); MICH. ADMIN. CODE r. 201(j), 903 (2011).
- 299 40 C.F.R. § 146.10(a) (2011).
- 300 MICH. ADMIN. CODE r. 902 (2011).
- 301 40 C.F.R. § 144.52(a)(7) (2011); MICH. ADMIN. CODE r. 324.210 (2011).
- 302 ENVIRONMENTAL PROTECTION AGENCY, FEDERAL FINANCIAL RESPONSIBILITY DEMONSTRATIONS FOR OWNERS AND OPERATORS OF CLASS II OIL- AND GAS-RELATED INJECTION WELLS 17 (May 1990), *available at* <http://www.epa.gov/r5water/uic/forms/ffrdooc2.pdf>.
- 303 MICH. ADMIN. CODE r. 324.210(2), 324.212 (2011). *See* “Regulation of Well Activities” section.
- 304 Ohio Department of Natural Resources Underground Injection Control; Program Approval, 48 Fed. Reg. 38238 (1983).
- 305 42 U.S.C. § 300h-4(a) (2006).
- 306 OHIO ADMIN. CODE § 1501:9-1-02(A)(3) (2011).
- 307 OHIO REV. CODE ANN. § 1509.22(D) (West 2011).
- 308 The statute defines “brine” to mean “saline geological formation water.” OHIO REV. CODE ANN. § 1509.01(U) (West 2011). The ODNr’s regulations in some cases reference “saltwater,” defined as “nonpotable water,” and in other cases reference “brine.” *See* OHIO ADMIN. CODE § 1501:9-3-01(E) (2011). For purposes of this report, “brine” is assumed to include flowback.
- 309 OHIO ADMIN. CODE § 1501:9-3-06(I) (2011). Under rules drafted by the ODNr in response to concerns about seismic activity, an operator in a non-urban area would have 24 months to drill the well. DRAFT RULE OHIO. REV. CODE. 1501:9-3-06, OHIO DEPARTMENT OF NATURAL RESOURCES (June 6, 2012) *available at* http://www.ohiodnr.com/portals/11/oil/pdf/uic_1501_9-3-06_5-year-rule_review_CSI.pdf.
- 310 OHIO REV. CODE ANN. § 1509.22(D) (West 2011).
- 311 OHIO ADMIN. CODE § 1501:9-3-04(A) (2011).
- 312 OHIO ADMIN. CODE § 1501:9-3-12 (2011).
- 313 OHIO ADMIN. CODE § 1501:9-3-06(C)(9) (2011).
- 314 OHIO ADMIN. CODE § 1501:9-3-06(B)(1)-(2) (2011).
- 315 OHIO ADMIN. CODE § 1501:9-3-06(B)(3) (2011).
- 316 OHIO ADMIN. CODE § 1501:9-3-06(C)(8) (2011).
- 317 *See* “Regulation of Well Activities” section.
- 318 OHIO ADMIN. CODE § 1501:9-3-05(A)(1) (2011).
- 319 OHIO ADMIN. CODE § 1501:9-3-05(A)(2) (2011).
- 320 OHIO ADMIN. CODE § 1501:9-3-05(A)(3) (2011).
- 321 OHIO ADMIN. CODE § 1501:9-3-05(A)(7) (2011).
- 322 OHIO ADMIN. CODE § 1501:9-3-05(A)(6) (2011).
- 323 OHIO ADMIN. CODE §§ 1501:9-3-05(A)(5), 1501:9-3-05(C), 1501:9-3-07(B) (2011).
- 324 OHIO ADMIN. CODE § 1501:9-3-07(A) (2011).
- 325 OHIO ADMIN. CODE § 1501:9-3-07(F) (2011). Under rules drafted by the ODNr in response to concerns about seismic activity, continuous monitoring would be required for all new wells. DRAFT RULE OHIO. REV. CODE. 1501:9-3-07, OHIO DEPARTMENT OF NATURAL RESOURCES (June 6, 2012), *available at* http://www.ohiodnr.com/portals/11/oil/pdf/uic_1501_9-3-07_5-year-rule_review_CSI.pdf.
- 326 OHIO ADMIN. CODE § 1501:9-3-07(G) (2011).
- 327 OHIO ADMIN. CODE § 1501:9-3-07(D) (2011).
- 328 S.B. 315, 129th Leg., § 1509.06(A)(6)(b) (Ohio 2012).
- 329 OHIO ADMIN. CODE § 1501:9-3-07(E) (2011).
- 330 S.B. 315, 129th Leg., § 1509.22(D)(1)(c)-(d) (Ohio 2012).
- 331 OHIO ADMIN. CODE § 1501:9-3-07(I) (2011).

- 332 OHIO REV. CODE ANN. § 1509.12(A) (West 2011).
- 333 OHIO ADMIN. CODE § 1501:9-3-07(H) (2011).
- 334 OHIO ADMIN. CODE § 1501:9-3-07(I); OHIO REV. CODE ANN. § 1509.13(A) (West 2011).
- 335 OHIO REV. CODE ANN. § 1509.13(C) (West 2011); OHIO ADMIN. CODE § 1501:9-11-04 (2011).
- 336 *See* OHIO ADMIN. CODE §§ 1501:9-11-07 to -08 (2011).
- 337 OHIO REV. CODE ANN. § 1509.07 (West 2011); OHIO ADMIN. CODE §§ 1501:9-1-03(A), 1501:9-3-06(F) (2011).
- 338 S.B. 315, 129th Leg., § 1509.07(A)(1) (Ohio 2012).
- 339 *See* STRONGER, INC., SECTION X: HYDRAULIC FRACTURING X.3 (2010), *available at* <http://www.strongerinc.org/documents/HF%20Guideline%20Web%20posting.pdf> (“The availability and use of alternative water sources, including recycled water, should be encouraged.”).



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