Online Appendix

This Online Appendix provides additional descriptive evidence, background information as well as supplemental analyses and additional descriptive statistics.

Section OA – Descriptive or anecdotal evidence and background information

Section OB – Supplemental analysis

Section OC – Additional descriptive statistics for data used in the paper

OA1 – Examples for the Demand for HF Fluid Disclosures

Calls for more transparency

Outlet	Date	*Title* / Quotes
Pennlive	September 5, 2010	*'Gasland,' a documentary about the natural gas industry in Pennsylvania, is a national hit* The movie "Gasland" — about the environmental hazards of drilling and fracking shale for natural gas — has become a national sensation. The documentary has aired repeatedly on HBO in recent months. Critics, including some Pennsylvania government officials, say it's a shameless piece of propaganda riddled with inaccuracies. Fans say it opened their eyes to what really happens when drillers come to town. Either way, it has become a force to be reckoned with in the ongoing political debate over Marcellus Shale in Pennsylvania. (…) Q: The film focuses on the secrecy surrounding the chemicals used in fracking. Range Resources and several other companies have since begun publicly posting the fracking recipe for each of their wells in Pennsylvania. Your thoughts on that? A: They're clearly afraid of federal regulation. They're trying to get out ahead of the curve. The governor of Wyoming publicly stated (his state) passed this (fracking disclosure) law to keep the EPA out. That Wyoming law requires the industry to disclose the chemicals to the state, but not to the people. There has to be a federal standard in America. ... Right now, the gas industry is exempt from the Clean Water Act, the Safe Drinking Water Act, the Clean Air Act. ... We shouldn't be having any discussion of drilling until those exemptions are reversed.
Huffington Post	November 21, 2012	*Fracking's Toxic Secret: Lack of Transparency Over Natural Gas Drilling Endangers Public Health, Advocates Say* (…) The disclosing of chemicals used by the industry remains seriously incomplete. Couple that with the incomplete reports on water tests and it aggravates a situation where landowners don't have a full picture of what is going on," said Kate Sinding, a senior attorney with the Natural Resources Defence Council. David Headley, of Smithfield, Penn, is one of those that's been getting incomplete information about contaminates in his water. In April 2010, four years after the first natural gas well was drilled near his home, the DEP tested Headley's drinking water and reported low levels of barium, strontium and manganese. "We were told the water was safe to drink," David Headley said. "But we had an infant in the house, and a pre-teen. We weren't about to let them drink it." (…)
National Geographic	March, 2013	*The New Oil Landscape* (…) Of special concern are the hundreds of fracking components, some of which contain chemicals known to be or suspected of being carcinogenic or otherwise toxic. Increasing the likelihood of unwanted environmental effects is the so-called Halliburton loophole, named after the company that patented an early version of hydraulic fracturing. Passed during the Bush-Cheney Administration, the loophole exempts the oil and gas industry from the requirements of the Safe Drinking Water Act. What's more, manufacturers and operators are not required to disclose all their ingredients, on the principle that trade secrets might be revealed. Even George P. Mitchell, the Texas wildcatter who pioneered the use of fracking, has called for more transparency and tighter regulation. In the absence of well-defined federal oversight, states are starting to assert control. In 2011 the North Dakota legislature passed a bill that said, in effect, fracking is safe, end of discussion. (…)

Demand from local communities, NGOs, and environmental activists

Outlet	Date	*Title* / Quotes
The Bismarck Tribune	April 1, 2012	*Environmentalists sue over fracking fluids* CHEYENNE, Wyo. (AP) – Environmentalists are suing the Wyoming Oil and Gas Conservation Commission, saying the regulatory agency hasn't done enough to justify honoring requests by companies to keep the public from reviewing ingredients in hydraulic fracturing fluids. The groups Powder River Basin Resource Council, Wyoming Outdoor Council, Earthworks and OMB Watch sued in Natrona County District Court on Monday. They allege the commission denied their state open records requests to review fracking fluid ingredients. Hydraulic fracturing involves pumping water, sand and chemicals into oil and gas wells to crack open fissures. Wyoming has required oilfield service companies to disclose to state officials the ingredients in their fracking fluids since 2010. Environmentalists have raised alarm for years that fracking could contaminate groundwater. Few if any such cases are confirmed although last year the U.S. Environmental Protection Agency theorized that fracking may have contaminated the groundwater near Pavillion, a small community in central Fremont County. Testing groundwater for fracking-related pollution gets complicated because what goes into fracking fluids isn't generally known outside the companies that make it. Wyoming's open records law provides an exception for public disclosure of trade secrets. The groups say the commission has repeatedly allowed companies to invoke the exception - on flimsy grounds - to keep fracking fluid ingredients out of the public realm. He pointed out that companies must also track fracking fluids after they've been used and account for their reuse, storage or disposal. Wyoming led the nation in its fracking disclosure regulations and other states are following suit, Gov. Matt Mead said in a statement. "Wyoming and the additional states requiring disclosure believe it is the states rather than the federal government that should regulate hydraulic fracturing," said Mead, who as governor is chairman of the commission. "We will watch this case closely to determine if either the rules or the administration of the rules need work. If improvements need to be made we will make them."

Demand from policy makers and regulators

The Obama Administration attempted to introduce federal legislation on HF fluid disclosures, but the effort eventually failed.

Outlet	Date	*Title* / Quotes
Gas Daily	May 4, 2011	*Maryland to sue Chesapeake over Pa. fluid spill* The state of Maryland intends to sue Chesapeake Energy for allegedly violating federal environmental laws when hydraulic fracturing fluids from one of its Marcellus Shale gas wells spilled into a north-eastern Pennsylvania creek. "Companies cannot expose citizens to dangerous chemicals that pose serious health risks to the environment and to public health," Maryland Attorney General Douglas Gansler said late Monday. "We are using all resources available to hold Chesapeake Energy accountable for its actions." Gansler said in a letter to Oklahoma City-based Chesapeake that he plans to sue the company and its affiliates for violating the federal Resource Conservation and Recovery Act and the Clean Water Act. Federal law mandates that Gansler give the company 90 days notice of his intent. On April 19, thousands of gallons of fracking fluid were released from the Bradford County well into Towanda Creek, a tributary of the Susquehanna River, which supplies drinking water to about 6.2 million people in Pennsylvania, Delaware and Maryland (GD 4/20). "Exposure to toxic and carcinogenic chemicals in unknown quantities creates a risk of imminent and substantial endangerment to humans using Maryland waterways for recreation and to the environment," Gansler said. "Although the precise mixture of these fracking fluids is not known, a recent congressional study found that they contain 750 chemicals and other components, including several extremely toxic compounds. High levels of these contaminants remain in the fracking fluid that returns to the surface as wastewater after a well has been hydrofracked." He said radioactivity levels in Pennsylvania's fracking wastewater "have sometimes been thousands of times above the maximum allowed by federal standards for drinking water."
Reuters	January 25, 2012	*Obama backs shale gas drilling* Improvements in drilling techniques have transformed the U.S. energy landscape in recent years by unlocking the country's immense shale oil and gas reserves. But the drilling boom has raised concerns about the safety of natural gas extraction techniques like hydraulic fracturing, or fracking, which environmentalists say could pollute water supplies. Still, with fracking mostly exempt from federal oversight and most shale gas production occurring on private lands, the Obama administration is limited in its authority over the practice. Obama said the administration would move forward with rules that would require companies to disclose chemicals used during the fracking process on public lands. In wide-ranging comments about the energy industry, Obama also said he would direct his administration to open 75 percent of the country's potential offshore oil and gas resources to drilling. This proposal would be carried out in the latest offshore drilling plan released by the Interior Department in November.
The Tampa Tribune	March 21, 2015	*Fracking chemicals must be disclosed; New rule requires drillers to be more transparent* The Obama administration said Friday it is requiring companies that drill for oil and natural gas on federal lands to disclose chemicals used in hydraulic fracturing, the first major federal regulation of the controversial drilling technique that has sparked an ongoing boom in natural gas production but raised widespread concerns about possible groundwater contamination. A rule to take effect in June also updates requirements for well construction and disposal of water and other fluids used in fracking, as the drilling method is more commonly known. The rule has been under consideration for more than three years, drawing criticism from the oil and gas industry and environmental groups alike. The industry fears federal regulation could duplicate efforts by states and hinder the drilling boom, while some environmental groups worry that lenient rules could allow unsafe drilling techniques to pollute groundwater.

	Reaction to the rule was immediate. An industry group announced it was filing a lawsuit to block the regulation and the Republican chairman of the Senate Environment and Public Works Committee announced legislation to keep fracking regulations under state management. The final rule hews closely to a draft that has lingered since the Obama administration proposed it in May 2013. The rule relies on an online database used by at least 16 states to track the chemicals used in fracking operations. The website, FracFocus.org, was formed by industry and intergovernmental groups in 2011 and allows users to gather well-specific data on tens of thousands of drilling sites across the country. Companies will have to disclose the chemicals they use within 30 days of the fracking operation. Interior Secretary Sally Jewell said the rule will allow for continued responsible development of federal oil and gas resources on millions of acres of public lands while assuring the public that transparent and effective safety and environmental protections are in place. Jewell, who worked on fracking operations in Oklahoma long before joining the government in 2013, said decades-old federal regulations have failed to keep pace with modern technological advances. The League of Conservation Voters called the bill an important step forward to regulate fracking.

Demand from shareholders

Shareholders request information on HF to assess the potential for reputational risks and vulnerability to litigation, as illustrated below:

Outlet	**Date**	***Title* / Quotes**
ExxonMobil - DEFINITIVE PROXY STATEMENT	April 13, 2010	*ExxonMobil - DEFINITIVE PROXY STATEMENT, filed 2010-04-13* ITEM 10 – REPORT ON NATURAL GAS PRODUCTION This proposal was submitted by The Park Foundation, 311 California St., Suite 510, San Francisco, CA 94104, as lead proponent of a filing group. Fracturing operations can have significant impacts on surrounding communities including the potential for increased incidents of toxic spills, impacts to local water quantity and quality, and degradation of air quality. Government officials in Ohio, Pennsylvania and Colorado have documented methane gas linked to fracturing operations in drinking water. In Wyoming, the US Environmental Protection Agency (EPA) recently found a chemical known to be used in fracturing in at least three wells adjacent to drilling operations. There is virtually no public disclosure of chemicals used at fracturing locations. The Energy Policy Act of 2005 stripped EPA of its authority to regulate fracturing under the Safe Drinking Water Act and state regulation is uneven and limited. But recently, some new federal and state regulations have been proposed. In June 2009, federal legislation to reinstate EPA authority to regulate fracturing was introduced. In September 2009, the New York State Department of Environmental Conservation released draft permit conditions that would require disclosure of chemicals used, specific well construction protocols, and baseline pre-testing of surrounding drinking water wells. New York sits above part of the Marcellus Shale, which some believe to be the largest onshore natural gas reserve. Media attention has increased exponentially. A search of the Nexis Mega-News library on November 11, 2009 found 1807 articles mentioning ‘hydraulic fracturing’ and environment in the last two years, a 265 percent increase over the prior three years. Because of public concern, in September 2009, some natural gas operators and drillers began advocating greater disclosure of the chemical constituents used in fracturing. In the proponents’ opinion, emerging technologies to track ‘chemical signatures’ from drilling activities increase the potential for reputational damage and vulnerability to litigation. Furthermore, we believe uneven regulatory controls and reported contamination incidents compel companies to protect their long-term financial interests by taking measures beyond regulatory requirements to reduce environmental hazards. Therefore, be it resolved, Shareholders request that the Board of Directors prepare a report by October 1, 2010, at reasonable cost and omitting proprietary information, summarizing 1. the environmental impact of fracturing operations of ExxonMobil; 2. potential policies for the company to adopt, above and beyond regulatory requirements, to reduce or eliminate hazards to air, water, and soil quality from fracturing. Supporting statement: Proponents believe the policies explored by the report should include, among other things, use of less toxic fracturing fluids, recycling or reuse of waste fluids, and other structural or procedural strategies to reduce fracturing hazards.” The Board recommends you vote AGAINST this proposal for the following reasons: ExxonMobil’s Environmental Policy states that we will comply with all applicable laws and regulations and apply responsible standards where laws do not exist, including precautions specific to hydraulic fracturing. The Board believes

		the minimal environmental impacts of hydraulic fracturing have been well-documented and regulatory protections are well-established; therefore, an additional report is not necessary. ExxonMobil supports the disclosure of the identity of the ingredients being used in fracturing fluids at each site. While we understand the intellectual property concerns of service companies when it comes to disclosing the proprietary formulations in their exact amounts, we believe the concerns of community members can be alleviated by the disclosure of all ingredients used in these fluids. We understand that some communities and homeowners new to drilling operations may have concerns. We are committed to working with them to demonstrate that we can address environmental concerns they may have, while providing good jobs and income associated with the safe and efficient production of natural gas.
Multiple Shareholder Proposals	Multiple dates	Several other companies are targeted by shareholder proposals related to HF disclosures

Company	**Year**	**Outcome**	**Votes %**
ANADARKO PETROLEUM CORP.	2012	Withdrawn	
CABOT OIL & GAS CORPORATION	2010	Voted	35.9
CABOT OIL & GAS CORPORATION	2013	Withdrawn	
CHESAPEAKE ENERGY CORP.	2012	Withdrawn	
CHEVRON CORPORATION	2012	Voted	27.9
CHEVRON CORPORATION	2013	Voted	30.2
CHEVRON CORPORATION	2014	Voted	26.6
EL PASO CORPORATION	2010	Withdrawn	
ENERGEN CORPORATION	2010	Withdrawn	
EOG RESOURCES, INC.	2010	Voted	30.9
EOG RESOURCES, INC.	2012	Withdrawn	
EOG RESOURCES, INC.	2013	Withdrawn	
EOG RESOURCES, INC.	2014	Voted	28
EQT CORPORATION	2010	Omitted	
EQT CORPORATION	2014	Withdrawn	
EXXON MOBIL CORPORATION	2010	Voted	26.3
EXXON MOBIL CORPORATION	2011	Voted	28.2
EXXON MOBIL CORPORATION	2012	Voted	29.6
EXXON MOBIL CORPORATION	2013	Voted	30.2
HESS CORPORATION	2010	Withdrawn	
NOBLE ENERGY, INC.	2012	Withdrawn	
OCCIDENTAL PETROLEUM CORP.	2014	Withdrawn	
PIONEER NATURAL RESOURCES COMPANY	2013	Voted	41.7
RANGE RESOURCES CORPORATION	2010	Withdrawn	

Withdrawn proposals are those for which the company has agreed to take action ahead of the vote at the annual general meeting. Omitted proposal are those for which the company has petitioned the SEC to be authorized to exclude the proposal from the proxy statement (see SEC rule 14a-8)

Demand from potential plaintiffs

HF fluid information can help plaintiffs to prove contamination and establish causation. In the following example, an article in a local newspaper explains how landowners (in the proximity of HF wells) can use HF disclosures.

Outlet	**Date**	***Title* / Quotes**
Great Falls Tribune	January 19, 2017	*Fracking chemicals focus of lawsuit seeking more disclosure* Landowners are being denied information needed in order to test for the presence of fracking chemicals in their water before fracking occurs, which is essential to establish baseline information should contamination problems occur later, O'Brien said. Fracking chemicals are toxic or carcinogenic to humans, who may be exposed to the chemicals through surface spills of fracking fluids, groundwater contamination and chemical releases into the air, the lawsuit says. The plaintiffs argue the trade information should be disclosed to a state regulator, who could then make a determination whether trade secrets are involved. "The constitutional right-to-know provision does not mandate disclosure of bona fide de trade secrets, but it creates an express presumption in favor of public access to information and places the burden of establishing trade secret status on the entity seeking to withhold information from public disclosure," the lawsuit says. The first recorded hydraulic fracturing operation in Montana was in the 1950s, Halvorson said. "We are aware of no chemicals related to the hydraulic fracturing process being detected in groundwater," he said. A well hasn't been fracked in more than a year as the state has seen a decline in oil and gas production due to lower oil prices. It doesn't make sense for the public to wait until activity picks up to seek changes, O'Brien said. "It's hard to ask regulators to make changes in a boom," she said. If chemicals are secret, O'Brien said, it's impossible to determine whether contamination, should it occur, is caused by hydraulic fracturing or something else. Board members examined the evidence submitted in the rulemaking petition to the board seeking more disclosure including technical papers and concluded no evidence was presented that the rules were inadequate, Halvorson said. An incident in North Dakota in which chemicals were detected in the groundwater was presented in the petition, Halvorson said. That incident occurred prior to the current hydraulic fracturing rule that the board adopted in 2011, he said. The incident that lead to that problem would have been addressed by the 2011 Montana rule, he said. The lawsuit calls the board's reasons for denying the rulemaking petition "factually erroneous, unsupported, and irrational." The board will discuss the MEIC filing and the request for rulemaking contained the filling at its Feb. 2 meeting, Halvorson said. The plaintiffs Montana Environmental Information Center, Natural Resources Defense Council, Dr. Mary Anne Mercer, David Katz, Anne Moses, Jack and Bonnie, Martinell, Dr. Willis Weight, and Dr. David Lehnherr.

OA2 – Examples for the Regulatory and Public Debate on HF Disclosures

Regulatory Pressures

Outlet	Date	*Title* / Quotes
Congressional research on HF and disclosure requirement (Murril and Vann, 2012)	May 2012	*Congressional research on HF and disclosure requirements* In his 2012 State of the Union Address, Obama said he would obligate "all companies that drill for gas on public lands to disclose the chemicals they use," citing health and safety concerns. In May 2012, the Bureau of Land Management (BLM) published a proposed rule that would require companies employing hydraulic fracturing on lands managed by BLM to disclose the content of the fracturing fluid. In addition, there have been legislative efforts in the 112th Congress. H.R. 1084 and S. 587, the Fracturing Responsibility and Awareness of Chemicals Act (FRAC Act), would create more broadly applicable disclosure requirements for parties engaged in hydraulic fracturing (…). We also note that regulatory risk arises from the pressure on states and local authority to implement stricter regulations on HF:
Environment	March 27, 2012	*Groups seek fuller disclosure of fracking in Wyoming* SALMON, Idaho (Reuters) - Environmental groups are asking a state court to force Wyoming to provide a more complete list of chemicals used in hydraulic fracturing, or fracking, a drilling technique vital to natural gas and oil production in the state. Wyoming in 2010 became the first state to require disclosure of chemicals that energy companies inject - along with sand and water - deep underground to free gas or oil from rock. But the state exempted products and chemicals that qualified as confidential commercial information, or trade secrets. The Wyoming Outdoor Council and others contend in a legal petition in state court that the Wyoming Oil and Gas Conservation Commission has illegally allowed energy drillers to claim exemptions where they were not warranted. The groups claim such secrecy is impeding efforts to protect public health and water quality. There are 150 chemicals in Wyoming that these companies have asked to be protected under trade secret status," said Steve Jones, watershed program protection attorney for the Wyoming Outdoor Council. Since these chemicals pose a potential threat to ground water and to people's heath, we need to know what they are." The court challenge in Wyoming may have broader implications as other states, including Pennsylvania and Texas, have adopted similar standards for disclosure. Fracking and other drilling advancements have unlocked vast supplies of domestic natural gas, but health and environmental groups worry fracking operations near homes and schools can pollute air and water. The effort to force disclosure comes after the U.S. Environmental Protection Agency agreed earlier this month to work with Wyoming to retest water supplies in Pavillion, the Wyoming town where a 2011 EPA draft study linked natural gas fracking to pollution of a nearby aquifer. Industry representatives said disclosure of so-called "recipes" will hamper market place driven efforts to develop more benign - or greener - fracking chemistry. If companies can't get the benefit of their intellectual capital, we don't get the benefit of their innovation," said energy company advisor Jason Hutt of Bracewell & Giuliani LLP, an international law firm headquartered in Texas. The outdoor council, Powder River Basin Resource Council and others are asking a Wyoming judge to find that the state Oil and Gas Conservation Commission's actions in granting trade secret exemptions in certain cases were "arbitrary, capricious, an abuse of discretion" or otherwise illegal.

Outlet	**Date**	***Title* / Quotes**
The New York Post	December 18, 2014	*A pain in the gas! NY bans fracking, but don't blame me* 'Would I let my child play in a school field nearby, drink water from the tap or grow vegetables from the soil? My answer is no.' - Health Commissioner Dr. Howard Zucker. Get the frack outta here! After two years of studying the politically explosive issue, the Cuomo administration announced Wednesday that it won't allow hydraulic fracking in New York. Gov. Cuomo - who waited six weeks after his re-election to disclose the decision - insisted it was the environmental and health experts in his administration who made the call. "I had nothing to do with it," insisted the governor, who has a reputation as the decider-in-chief when it comes to other projects. The administration's experts cited safety concerns for dousing the controversial but potentially lucrative gas-extraction process. "Would I live in a community [with fracking] based on the facts I have now?" Dr. Howard Zucker, the state health commissioner, asked rhetorically at a Cabinet meeting in Albany. "Would I let my child play in a school field nearby, drink water from the tap or grow vegetables from the soil? . . . My answer is no." Zucker spoke at length about scientific studies he said found "significant public health risks" with fracking, even while conceding many of the studies were inconclusive. "Relying on limited data would be negligent on my part," Zucker added. "I cannot support high-volume hydraulic fracturing in the great state of New York." Cuomo praised Zucker's presentation as "highly effective," "powerful" and "poignant." The state has been evaluating fracking since before Cuomo took office in 2010. Agencies in his own administration have been studying the issue intensely for two years. But the governor said that he adopted a neutral, hands-off approach and that politics had nothing to do with the results. "My answer has been I don't know, and it's not what I do," he said. "Let's bring the emotion down. Let's ask the qualified experts what their opinion is. All things being equal, I will be bound by what the experts say. I am not in a position to second-guess them." Fracking advocates blasted the outcome as an economic disaster for upstate towns. "Our rural communities are dying a slow, painful, poverty-stricken death and hope is scarce," said state Sen. Cathy Young (R-Jamestown). "Gov. Cuomo's decision to ban exploration of our natural gas resources is a punch in the gut to the Southern Tier." Former Pennsylvania Gov. Ed Rendell, who legalized fracking in his state, said Cuomo was making a mistake. "If you put the right regulations in place, you can protect the environment," he said. "There's no form of energy produced today that doesn't have potential to cause environmental problems." Environmental advocates, meanwhile, were celebrating. "The governor promised he would make his decision on the science, and he kept his promise," said Riverkeeper head Paul Gallay.

Investor Pressures

Outlet	**Date**	***Title* / Quotes**
Disclosing the facts	November 7, 2013	*A coalition of investors organized a campaign on "Disclosing the Facts" Campaign* [As you Sow (shareholder advocacy organization), Boston Common Asset Management, LLC (Investment management group), Green Century Capital Management (financial advisory firm), the Investor Environmental Health Network (collaborative partnership of investment managers and advisors)]. The campaign aims at scoring companies based on their disclosure practices (including chemical use and whether companies report quantitatively on reduction of toxic chemical use). Extracts from the "Disclosing the facts 2019" press release: "*The best companies are increasing their water efficiency, re-using water from operations, using non-potable waste streams, and even treating wastewater*" - "*Our report shows that smart use of water and chemicals continues to evolve, but more needs to be done*." "*This enables investors to assess and compare how well companies are reducing costs and risks*." (Investors have concerns and see risks) HYDRAULIC FRACTURING REPORT CARD: I INDUSTRY SCORES "F" ON RISK DISCLOSURES TO INVESTORS *Shareholder analysis of 24 companies finds energy producers – with BP, Exxon Mobil and Occidental at the bottom failing to adequately report efforts to reduce environmental and community impacts.* BOSTON, MA – November 7, 2013 - The oil & gas production industry is consistently failing to report measurable reductions of its impacts on communities and the environment from hydraulic fracturing operations, according to a scorecard report released today by As You Sow, Boston Common Asset Management, Green Century Capital Management (Green Century), and the Investor Environmental Health Network (IEHN). Available online at disclosingthefacts.org, the report, *Disclosing the Facts: Transparency and Risk in Hydraulic Fracturing Operations*, benchmarks 24 companies engaged in hydraulic fracturing against investor needs for disclosure of operational impacts and mitigation efforts. (See full company list below). While scores varied, no firm succeeded in disclosing information on even half of the selected 32 indicators related to management of toxic chemicals, water and waste, air emissions, community impacts, and governance. Even the highest scoring company, Encana Corporation (ECA) provided sufficient disclosure on just 14 of the 32 indicators. The lowest scoring companies were: BHP Billiton Ltd. (BHP) (2 of out 32 indicators); BP plc (BP) (2 out of 32 indicators); Exxon Mobil Corporation (XOM) (2 out of 32 indicators); Occidental Petroleum Corporation (OXY) (2 out of 32 indicators); Southwestern Energy Co. (SWN) (2 out of 32 indicators); and, in last place, QEP Resources, Inc. (QEP) (1 out of 32 indicators). (See full rankings below.) The report notes that measurement and disclosure of best management practices and impacts is the primary means by which investors can assess how companies are managing the impacts of their hydraulic fracturing operations on communities and the environment. "The results of this scorecard show that companies are failing to rigorously disclose the impacts of their hydraulic fracturing operations on communities and the environment", said Richard Liroff, executive director of IEHN. "Data on key metrics remain largely absent, making it difficult for investors and the public to assess and compare companies' performance." "Leaks, spills, and explosions continue to make headlines and demonstrate the risks of hydraulic fracturing," noted Lucia von Reusner, shareholder advocate for Green Century Capital Management. "Unfortunately

companies are failing to provide enough evidence to assure shareholders and the public regarding steps being taken to protect communities and the environment from the adverse impacts of hydraulic fracturing."

Institutional investors have been pressing oil and gas companies since 2009 for greater disclosure of their risk management practices. Investors have engaged over two dozen companies, filing nearly 40 shareholder proposals on these issues to date. The shareholder proposals have led to improved disclosures at many of the companies, but the scorecard report notes that much of this disclosure is narrative and qualitative in form, while quantifiable data are lacking.

"The oil and gas industry's hydraulic fracturing operations are under intense scrutiny for potential harm to neighboring communities and the environment – from air and water pollution to increased noise, traffic, and crime," said Danielle Fugere, president of As You Sow. "If companies are not tracking these potential problems, it is difficult to demonstrate to investors, regulators, or the public that the problems are being avoided or resolved."

Of the 32 indicators against which companies were scored, companies performed best on questions regarding disclosures on broader qualitative policies but worst on those questions about quantitative goals and progress metrics. The authors point to reports urging greater quantitative disclosure from authoritative voices such as the International Energy Agency and the Natural Gas Subcommittee of the U.S. Secretary of Energy's Advisory Board as evidence of the need for more rigorous reporting.

"We believe there is a great deal of good work being done in the industry to improve environmental performance of hydraulic fracturing operations and also lower their costs," said Steven Heim, a managing director of Boston Common Asset Management. "Absent disclosure however, investors have no way of knowing and crediting those companies making meaningful efforts to adopt best practices and mitigate their impacts on communities and the environment."

The industry most commonly reported on three metrics: whether executive compensation is linked to health, environment, and safety performance (71 percent); use of pipelines to transport water in lieu of diesel trucks to lower air emissions (62 percent); and company policies on use of non-potable water for hydraulic fracturing (46 percent). The report notes that companies are least transparent on their process for systematically identifying and addressing operational impacts on local communities, even though unaddressed community concerns are among the leading drivers of bans and moratoria.

COMPANY	SCORE (OUT OF POSSIBLE 32 POINTS)
Encana Corp. (ECA)	14
Apache Corp. (APA)	10
Ultra Petroleum Corp. (UPL)*	10
Hess Corp. (HES)	8
Noble Energy, Inc. (NBL)	7
Royal Dutch Shell plc (RDS)	7
EOG Resources, Inc. (EOG)	6
Cabot Oil & Gas Corp. (COG)	5
Chesapeake Energy Corp. (CHK)	5
ConocoPhillips Corp. (COP)	5

CONSOL Energy, Inc. (CNX)	5
EQT Corp. (EQT)	5
Anadarko Petroleum Corp. (APC)	4
Devon Energy Corp. (DVN)	4
Chevron Corp. (CVX)	3
Range Resources Corp. (RRC)	3
Talisman Energy, Inc. (TLM)	3
WPX Energy, Inc. (WPX)	3
BHP Billiton Ltd. (BHP)	2
BP plc (BP)	2
Exxon Mobil Corp. (XOM)	2
Occidental Petroleum Corp. (OXY)	2
Southwestern Energy Co. (SWN)	2
QEP Resources, Inc. (QEP)	1

*"Many of the questions in the scorecard seek play-by-play disclosure. Ultra Petroleum reports that it has active completion operations in only one play in 2012 and 2013".

The report also highlights noteworthy practices disclosed by 13 companies. These include: Apache Corp.'s review of its chemical use with the goal of relying solely on safer alternatives designated under US EPA's "Design for the Environment" Program; Anadarko Petroleum Corp.'s use of "green completions" at wells to reduce methane emissions by 2 billion cubic feet annually; Encana's use of treated industrial effluent for fracturing in the Haynesville Shale; and Devon Energy Corp.'s replacing 700 "high-bleed" valves with valves reducing methane emissions by about 50 metric tons of CO_2 equivalent per valve. Devon plans to replace 3,000 additional valves, recouping the cost of each within two months.

Legal Pressures related to HF Disclosures

Outlet	Date	***Title* / Quotes**
Great Falls Tribune	January 19, 2017	*Fracking chemicals focus of lawsuit seeking more disclosure* A lawsuit against the Board of Oil and Gas seeks to require more disclosure of chemicals used in hydraulic fracturing jobs in Montana, arguing the state's own records fail to provide key information to landowners, but a state official says current rules are sufficient. The lawsuit seeks to reform rules requiring disclosure of the types of chemicals used during "fracking," the process of pumping large volumes of water, sand and chemicals at high pressure to free oil and gas trapped in porous rock. "In Montana there's no ability for the public to scrutinize these trade secret claims," said Katherine O'Brien, an Earthjustice attorney, who is representing the plaintiffs, Montana Environmental Information Center, Natural Resources Defense Council and seven individuals. Operators currently can cite trade secrets to avoid disclosing specific chemicals, she said. In Wyoming, by contrast, oil and gas operators must explain in an affidavit why the chemicals involved are a trade secret, and then the state's oil and gas supervisor makes a ruling whether a trade secret exists, O'Brien said. In Montana, oil and gas operators don't have to prove that the chemical mixture is in fact a trade secret, O'Brien said. "The board's fracking chemical rules in contrast just create an honor system" O'Brien said. In an effort to provide more transparency, the Montana Board of Oil and Gas passed new rules in 2011 that required companies to publicly disclose the generic names of chemicals they pump into the ground to remove oil and gas from rock. "The board feels that the disclosure requirements adopted in 2011 are adequate," said Jim Halvorson, administrator for Montana Board of Oil and Gas. The plaintiffs in the lawsuit petitioned the board in July 2016 to close what they call gaps in the disclosure rules and require operators to disclose specific chemical information before fracking occurs and justify trade secret claims. "The framework for exempting trade secrets under the Board's current disclosure rules contravenes the fundamental purpose of the constitutional right-to-know provision and violates the specific requirements established by the Supreme Court to implement that right when alleged trade secret information is at issue," the lawsuit says. Under current rules, oil and gas operators are not required to share specific ingredients of a fracking operation until after the job is completed, O'Brien said. That's a problem for landowners with property near the operation if they want to educate themselves about the risk, O'Brien said. Also, under a trade secret provision, some chemicals are exempt from disclosure, even to board members, and even after the job is completed, O'Brien said. "The board's longstanding position is we need to know as much information as we can about the well location at the time a well is permitted," said Halvorson of the Board of Oil and Gas. "Because an aquifer at risk from hydraulic fracturing could also be at risk from any number of activities related to drilling and production operations. Isolating a requirement to hydraulic fracturing activities doesn't allow the board the opportunity to review potential risks from any other activities.
The Philadelphia Inquirer	August 26, 2012.	*Long fight over fracking still divides Pa. town* The DEP's investigation eventually concluded that Cabot's poorly constructed wells were to blame. It said Cabot's contractors had failed to properly seal off the wells with concrete. Natural gas was able to migrate upward through voids outside the steel casing that lined the wells, providing a pathway for methane to leak into shallow aquifers and then into private water wells. But the DEP's investigation took a long time to reach a conclusion, and Cabot's response to the residents seemed cold and indifferent. Some Dimock residents, who were angry they had signed leases for small

		sums before the scale of the Marcellus discovery was known, sued Cabot in November 2009, claiming their property and health were affected. The DEP concluded that 18 water wells serving 19 households had been contaminated and ordered Cabot to fix its gas wells. When the repairs failed to eliminate the methane problem, it ordered Cabot to plug three wells in 2010. "The evidence that we had marshalled at that point was in my view pretty overwhelming," said Hanger. Investigators could actually see natural gas bubbling to the surface around the wells. The DEP's experience in Dimock prompted the state to rewrite its well-construction standards, and to enlarge the area that drillers are presumed liable for impairing water quality, from 1,000 feet to 2,500 feet from a gas well. Drillers now typically test water in private wells within a half-mile of their drill sites, to establish a baseline should problems arise. Even after Cabot was forced to repair its wells, methane continued to be a problem with some Dimock residents. The Rendell administration ordered Cabot to pay for a $12 million pipeline to bring fresh water to 19 households. Cabot objected, and so did some residents in Susquehanna County, who saw the project as excessive, and feared they would be left paying the cost. "The pipeline made no sense," said Bill Aileo, a retired Army lawyer who organized a group called Enough Is Enough to protest the expensive pipeline project. The incoming Corbett administration was certain to kill the pipeline project, so Hanger negotiated an alternative agreement with Cabot. The company would set aside $4.1 million to pay each of the 19 households two times the value of their homes and install a water-treatment system to remove methane from their water. The families that weren't part of the lawsuit accepted Cabot's money, but only one of the 11 families in the lawsuit agreed to accept the offer of a water system. "You sort of have to give them the opportunity to fix your water," said Ely, explaining why he was the only litigant to accept the system. "It's all about the water; it's not about the money." Ely walked a visitor last week through the $30,000 system, which is contained in a shed outside his house. Though Cabot tests his system weekly, he still does not trust it. "Once your water is bad, it's hard to get back to drinking it," he said. But extensive testing conducted by the state and the U.S. Environmental Protection Agency found that the water posed no health risks. Though the tests showed the presence of some contaminants - arsenic, barium, sodium, manganese - none of the materials were linked to drilling. The high methane levels can be controlled by a treatment system.
Reuters	September 26, 2017.	*Cabot Oil & Gas Co. [COG.N] has settled a lawsuit filed by two families in Dimock* HARRISBURG, Pa. (Reuters) – Cabot Oil & Gas Co. [COG.N] has settled a lawsuit filed by two families in Dimock, Pennsylvania, who alleged their homes’ drinking water became contaminated with methane not long after the company began drilling for natural gas in 2007. The Ely and Hulbert families initially won $4.2 million in damages in a federal jury trial in Scranton last year, but Magistrate Judge Martin Carlson threw out the verdict as unjustified and ordered the parties to begin settlement talks. The terms of the settlement have not been made public. Leslie Lewis, the New York lawyer who represented the families, declined on Tuesday to comment on the terms. “After nine long years, the plaintiffs are happy and relieved to put the matter behind them,” Lewis told Reuters. Neither Cabot Oil & Gas spokesman George Stark nor the company’s lead lawyer, Stephen Dillard, could be reached for comment on Tuesday.

OA3 – Summary of other Major Changes in State-Level Oil & Gas Regulations related to HF

<table>
<tr><th>State</th><th colspan="5">Wastewater Disposal</th><th colspan="3">HF Drilling Standards</th></tr>
<tr><th></th><th>Discharge Prohibited</th><th>Injection Well</th><th>Pit Siting</th><th>Pit Liner</th><th>Pit Freeboard</th><th>Well Casing</th><th>BOP (Blowout Control)</th><th>Mechanical Integrity Test</th></tr>
<tr><td>Arkansas</td><td></td><td></td><td>RULE B-17
2010/10/31</td><td></td><td></td><td>RULE B-18
2006/9/16</td><td>RULE B-16
2006/10/15</td><td></td></tr>
<tr><td>Colorado</td><td></td><td>RULE 905
2009/4/1</td><td>RULE 603-604
2013/8/1</td><td colspan="2">RULE 904
2009/4/1</td><td colspan="2">RULE 317
2014/9/30 (3)</td><td>RULE 326
2014/9/30</td></tr>
<tr><td>Kansas</td><td>RULE 28-29-1600/28-29-1608
2013/10/11</td><td></td><td></td><td colspan="2">RULE 82-3-601 2004/4/23</td><td>RULE 82-3-105/106
2002/10/29</td><td></td><td>RULE 82-3-1005
2004/7/1</td></tr>
<tr><td>Kentucky</td><td></td><td>Section 805 KAR 1:110
2008/2/4</td><td></td><td></td><td></td><td></td><td>Section 805 KAR 1:130
2007/8/9</td><td></td></tr>
<tr><td>Louisiana</td><td>Title 43 Part XIX Subpart 1 Chapter 3 Section 313
2007/8/1</td><td>Title 43 Part XIX Subpart 1 Chapter 3 Section 315
2000/12/1</td><td></td><td colspan="2">Title 43 Part XIX Subpart 1 Chapter 3 Section 313
2007/8/1</td><td>Title 43 Part XIX Subpart 1 Chapter 3 Section 109
1999/8/1</td><td colspan="2">Title 43 Part XIX Subpart 1 Chapter 3 Section 111
2008/12/1</td></tr>
<tr><td>Mississippi</td><td>RULE 45 SECTION III 7
1995/7/1</td><td></td><td></td><td></td><td>RULE 45 SECTION III 3-7
1995/7/1</td><td>RULE 13
1972/1/1</td><td>RULE 13
2014/6/16</td><td></td></tr>
<tr><td>Montana</td><td></td><td>RULE 36.22.1226
1992/4/1</td><td></td><td>RULE 36.22.1226
1992/4/1</td><td></td><td>RULE 36.22.1001
1992/4/1</td><td>RULE 36.22.1014
1992/4/1</td><td>RULE 13
1996/5/10</td></tr>
<tr><td>New Mexico</td><td></td><td>RULE 19.015.0035
2008/12/1</td><td>RULE 19.15.17.10
2013/6/28</td><td>RULE 19.15.17.11
2013/6/28</td><td>RULE 19.15.17.11
2013/6/28 (2)</td><td colspan="2">RULE 19.15.16
2008/12/1</td><td></td></tr>
<tr><td>North Dakota</td><td>RULE 43-02-03-19.2
2012/4/1</td><td></td><td></td><td></td><td></td><td>RULE 43-02-03-21
2012/4/1</td><td>RULE 43-02-03-23
2002/7/1</td><td>RULE 43-02-03-22
2012/4/1</td></tr>
<tr><td>Ohio</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">RULE 1501:9-9-03
2005/8/11</td><td></td></tr>
<tr><td>Oklahoma</td><td>RULE 165:10-7-16
2010/8/21</td><td>RULE 165:10-5-5
2009/7/11</td><td></td><td>RULE 165:10-7-16
1999/7/1</td><td>RULE 165:10-7-16
2008/7/11</td><td colspan="2">RULE 165:10-3-4
2011/7/11</td><td>RULE 165:10-3-4
1981/12/2</td></tr>
</table>

<table>
<tr><th>State</th><th colspan="5">Wastewater Disposal</th><th colspan="3">HF Drilling Standards</th></tr>
<tr><th></th><th>Discharge Prohibited</th><th>Injection Well</th><th>Pit Siting</th><th>Pit Liner</th><th>Pit Freeboard</th><th>Well Casing</th><th>BOP (Blowout Control)</th><th>Mechanical Integrity Test</th></tr>
<tr><td>Pennsylvania</td><td>SECTION 95.10/SECTION 78.60
1989/7/29</td><td></td><td>RULE 3215
2012/4/16</td><td colspan="2">SECTION 78.56
2013/12/13 (1)</td><td colspan="3">SECTION 3211-3227
2012/4/16(3)</td></tr>
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2014/11/17</td><td></td><td colspan="2">SECTION 3.8
2013/4/15(2)</td><td colspan="3">SECTION 3.13
2014/1/1(4)</td></tr>
<tr><td>Utah</td><td>CODE 649-9-3
2013/8/1</td><td>CODE 649-3-39
2012/11/1</td><td>CODE 649-3-16/CODE 649-9-3
2013/8/1</td><td colspan="2">CODE 649-9-4
2013/8/1(2)</td><td colspan="2">CODE 649-3-8
1989/3/17</td><td>CODE 649-3-13
1989/3/17</td></tr>
<tr><td>West Virginia</td><td></td><td></td><td></td><td>SECTION 35-8-17
2016/6/9(2)</td><td></td><td colspan="2">SECTION 22-6-21-30
2011/2/14</td><td></td></tr>
<tr><td>Wyoming</td><td></td><td>CHAPTER 4 SECTION 4
2005/1/1</td><td>CHAPTER 4 SECTION 1
2015/6/4</td><td>CHAPTER 4 SECTION 1
2015/6/4</td><td></td><td>CHAPTER 3 SECTION 4
2010/8/17</td><td>CHAPTER 3 SECTION 28
2010/8/17</td><td>CHAPTER 18 SECTION 9
2018/11/13</td></tr>
</table>

(1) The same Section includes an additional provision on the overflow system.
(2) The same Section/Rule/Code includes an additional provision on the leak detections system.
(3) The same Section/Rule includes an additional provision on proximity to water bodies.
(4) Section 3.8 of the same regulation includes an additional provision on proximity to water bodies.

This table presents a summary of other major changes in the O&G state legislations over hydraulic fracturing (HF) along with the respective adoption dates. Besides disclosure rules, there are two major aspects of HF legislations that might influence the environmental impact of HF, namely, wastewater disposal, and HF construction and operating standards. As wastewater disposal and HF standards are two major areas that include various regulations targeting different aspects of HF activities, we further divide them into sub-categories that, to our best knowledge, capture the essence of these regulations. For example, under wastewater disposal rules, we read all the related regulatory changes and identified the most prevalent and relevant changes in the 15 states in the sample, i.e., discharge prohibited (whether discharge or land-spread is allowed with a permit), injection well (whether there are substantial rules regulating injection well usage for wastewater disposal), pit siting (whether there are substantial restrictions to the location of the pits), pit liner (whether pits must be lined), pit freeboard (whether pits must have freeboard). We followed the same procedure to classify the rules on HF standards. We then hand-collected the effective dates of the corresponding sub-category regulatory changes from the regulatory texts either from the official state legislation website or Nexis Uni, a research database that contains the administrative codes, regulatory texts, and regulatory tracking for all U.S. states. The cells in the table record the corresponding regulatory change as well as its effective date. Using the data in this table we build the three variables used in Table 5 in the paper: *HUC10_HF×CUM_WASTEWATER* counts the cumulative number of regulations related to wastewater disposals at a point in time; *HUC10_HF×CUM_HF_STANDARDS* counts the cumulative number of regulations on HF drilling standards; HUC10_HF×CUM_HF_REG combines the two previous counts for regulations related to wastewater disposal and HF drilling standards.

OA4 – Summary of the Trade Secret Regulations

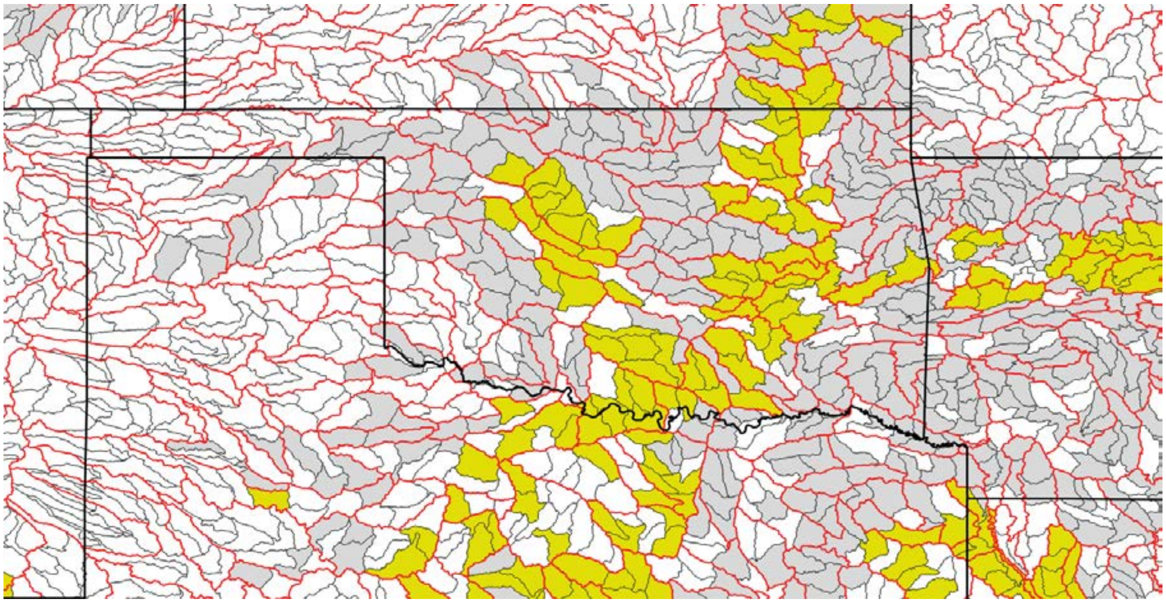
	(1) Submission to claim trade secret	(2) Factual justification	(3) Obligation to provide trade secret information	(4) Process for evaluating trade secret claim	(5) Standards for showing trade secret protection is justified
Arkansas[1]	1	1	1	0	1
Colorado[2]	1	1	0	0	1
Kansas[3]	1	1	0	0	0
Kentucky[4]	1	1	1	0	0
Louisiana[5]	0	0	0	0	0
Mississippi[6]	1	1	0	0	0
Montana[7]	0	0	0	0	0
New Mexico[8]	0	0	0	0	0
North Dakota[9]	1	0	0	0	1
Ohio[10]	1	1	0	0	0
Oklahoma[11]	1	0	0	0	1
Pennsylvania[12]	1	0	0	0	0
Texas[13]	0	0	0	0	1
Utah[14]	0	0	0	0	0
West Virginia[15]	1	0	1	0	0
Wyoming[16]	1	1	1	1	1

1 *Arkansas Oil&Gas Commission Rule B-19*
2 *Colorado Oil&Gas Conservation Commission Rule 205A*
3 *Kansas Admin. Reg. 82-3-1401*
4 *Kentucky Revised Statutes Chapter 353.6604*
5 *Louisiana Administrative Code Title 43, Part XIX, §118.2.a*
6 *Mississippi Oil&Gas Board Rule 1.26*
7 *Mont. Admin. R. 36.22.608, 36.22.1015 & 1016*
8 *New Mexico Code R. 19.15.16.19 (b)*
9 *North Dakota Admin. Code 43-02-03-27.1 (1)(g)&(2)(i)*
10 *Senate Bill 315*
11 *Revised Oklahoma Admin. Code. 165:10-3-10*
12 *Pa. Legis. Serv. 2012-13 (HB 1950) §3222.1*
13 *Texas Admin. Code 3.29*
14 *Utah Admin. Code 649-3-39*
15 *CSR 8-5.6&8-10.1*
16 *Wyoming Oil&Gas Conservation Commission Rules, Chapter 3,45*

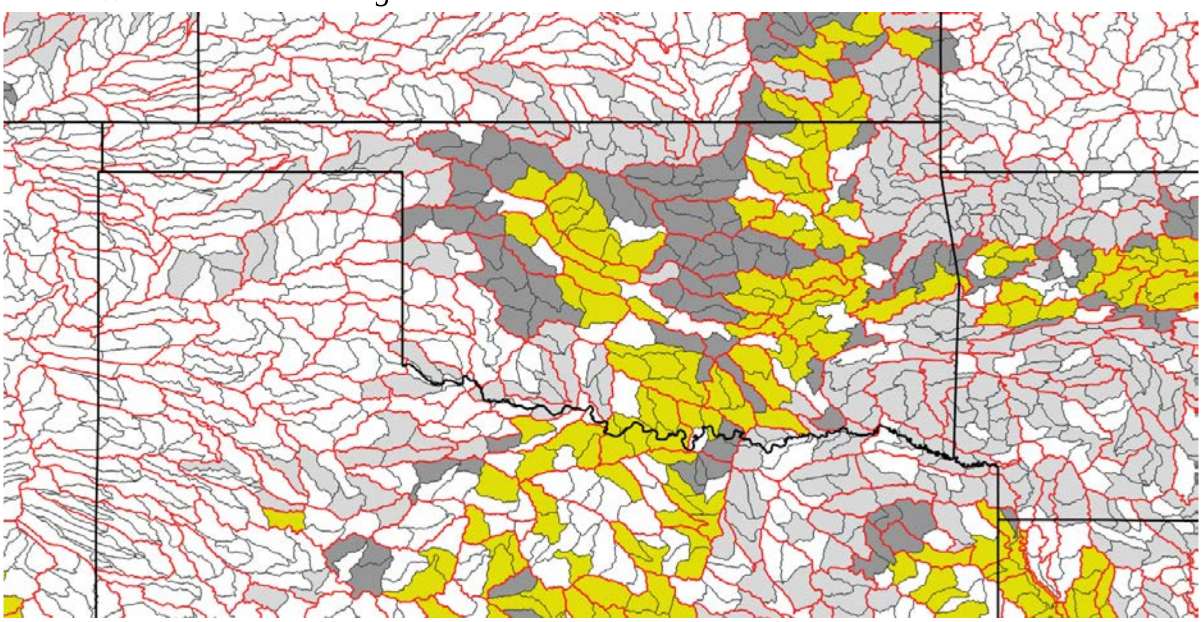
This table presents a summary of the trade secrets on the chemicals used by HF operators. Using McFeeley (2012) and cross-checking with states' regulations, we identify five conditions that vary across states when operators submit the claim for a trade-secret exemption: (1) the trade secret exemption requires the submission of a formal claim request; (2) the submission requires a factual justification; (3) operators have to provide supporting information (for example from suppliers and manufacturers who claim the trade secret); (4) there is a process for evaluating the trade secret claim; (5) operators have to follow specific standards to prove that the trade secret exemption is justified. For example, Arkansas and Colorado both require standards borrowed by the Emergency Planning and Community Right to Know Act.

OB1. Identification Maps

Panel A: Within state design



Panel B: Within sub-basin design



The figure illustrates how our identification strategy exploits variation across treated and control watersheds (HUC10s) using Oklahoma as an example. Panel A visually shows the within-state design. Watersheds with HF in the pre-period (treatment) are in yellow. Watersheds with no HF in the pre-period (control) are in light gray. Watersheds with no water measurements are in white. The black (red) lines depict HUC10 (HUC8) borders.

Panel B visually shows the within-HUC8 design. Watersheds with HF in the pre-period (treatment) are in yellow. Watersheds with no HF in the pre-period (control) are in dark gray. Watersheds with no water measurements are in white. HUC10s that do not contribute to identification in this design are in light gray. The black (red) lines depict HUC10 (HUC8) borders.

OB2. Robustness to Sample Selection Choices

We examine whether our inferences are robust to alternative sample selection choices. Specifically, we re-estimate Eq. (1) for the following alternative samples: (i) Using all HUC10s in treated states; (ii) all HUC10s that are in treated HUC4s with HF activity; (iii) all HUC10s in treated states or HUC4s (essentially combining (i) and (ii)). A HUC4 is treated if it is at least partially in a state that adopts a disclosure mandate. In our main analysis, we exclude control HUC10s from treated HUC4s that are not in a treated state. The results in Table B1 are aligned with the paper's main inferences.

Table B1 – Disclosure Mandates and Water Quality

	All Ions pooled (μg/l)					
	Sample: *HUC10s in Treated States*		Sample: *HUC10s in HUC4s with HF Activity*		Sample: *HUC10s in HUC4s with HF Activity or in Treated States*	
	(1)	(2)	(3)	(4)	(5)	(6)
HUC10_HF×POST	**-0.2492*****	**-0.0985*****	**-0.1801*****	**-0.0959*****	**-0.2394*****	**-0.0831****
	[0.0447]	**[0.0373]**	**[0.0396]**	**[0.0363]**	**[0.0432]**	**[0.0330]**
Observations	451,431	417,731	393,512	370,425	522,599	487,793
R-squared	0.949	0.962	0.960	0.970	0.952	0.964
Treatment Sample	HUC10s with HF at least in the pre-disclosure period					
Monitoring station FE	Yes	Yes	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes
State×Month×Year FE	Yes	No	Yes	No	Yes	No
HUC8×Month	Yes	No	Yes	No	Yes	No
HUC8×Month×Year FE	No	Yes	No	Yes	No	Yes

This table reports OLS estimates for the impact of the disclosure mandates on ion concentrations In Columns (1) – (2), the sample includes all HUC10s in treated states. In Columns (3) – (4), the sample includes all HUC10s located over treated sub-regions (HUC4s). In Columns (5) – (6), the sample includes all HUC10s in treated states or treated HUC4s. Standard errors (in parentheses) clustered by watershed (HUC10) are reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

OB3. Other Robustness Tests

OB.3.1 Clustering of standard errors

We examine whether our inferences are robust to alternative clustering choices. Specifically, we re-estimate Eq. (1) for the following clustering strategies: (i) HUC8-state level; (ii) state-level. Note that HUC8s can cross state lines. The effects in Table B2 remain statistically significant even with the fairly conservative clustering by state.

Table B2 – Disclosure Mandates and Water Quality

	All Ions pooled (μg/l)			
	Clustering at the HUC8-State Level		*Clustering at the State-Level*	
	(1)	(2)	(3)	(4)
HUC10_HF×POST	**-0.1802*** [0.0462]**	**-0.0982** [0.0459]**	**-0.1802* [0.0916]**	**-0.0982* [0.0539]**
Observations	334,713	312,294	334,713	312,294
R-squared	0.957	0.969	0.957	0.969
	HUC10s with HF at least in the pre-disclosure period			
Monitoring station FE	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes
State×Month×Year FE	Yes	No	Yes	No
HUC8×Month	Yes	No	Yes	No
HUC8×Month×Year FE	No	Yes	No	Yes

This table reports OLS estimates for the impact of the disclosure mandates on ion concentrations The sample includes a treatment sample of HUC10s with HF at least in the pre-disclosure period and a control sample of HUC10s without HF in the pre- and post-disclosure period and located over Sub-Region (HUC4s) in treated states. In Columns (1) – (2), standard errors (in parentheses) clustered by sub-basin (HUC8)-state are reported below the coefficients. In Columns (3) – (4), standard errors (in parentheses) clustered by state are reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

OB.3.2 Truncation of ion concentration measurements

We examine whether our inferences are robust to alternative truncation choices for the ion concentration measurements. Specifically, we re-estimate Eq. (1) for the following truncation choices: (i) we truncate the sample at the 95th percentile per ion at the HUC4 level; (ii) we truncate the sample at the 99th percentile per ion; (iii) we truncate the sample at the 95th percentile per ion. The results in Table B4 are aligned with the paper's main inferences.

Table B4 – Disclosure Mandates and Water Quality

	All Ions pooled (μg/l) truncation at P95 by HUC4		All Ions pooled (μg/l) truncation at P99 over the full sample		All Ions pooled (μg/l) truncation at P95 over the full sample	
	(1)	(2)	(3)	(4)	(5)	(6)
HUC10_HF×POST	**-0.1346***** **[0.0365]**	**-0.0821**** **[0.0373]**	**-0.1433***** **[0.0371]**	**-0.0921**** **[0.0358]**	**-0.1367***** **[0.0371]**	**-0.0767**** **[0.0371]**
Observations	309,748	288,073	324,055	302,164	316,928	295,673
R-squared	0.961	0.972	0.961	0.971	0.960	0.971
Monitoring station FE	Yes	Yes	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes
State×Month×Year FE	Yes	No	Yes	No	Yes	No
HUC8×Month	Yes	No	Yes	No	Yes	No
HUC8×Month×Year FE	No	Yes	No	Yes	No	Yes

This table reports OLS estimates for the impact of the disclosure mandates on ion concentrations. The sample includes a treatment sample of HUC10s with HF in the pre-period and a control sample of HUC10s without HF in the pre- and post-disclosure period and located over sub-regions (HUC4s) in treated states. Standard errors (in parentheses) clustered by watershed (HUC10) are reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

OB.3.3 Alternative ways of dealing with missing ion concentration measurements

We examine whether our inferences are robust to alternative ways of dealing with missing ion concentration measurements. Some water measurements are reported as missing in the NWIS and STORET databases with a flag stating that the measurement has been taken, but the concentration value is *below the detection level (BDL)*, *not detected (ND)* or *not reported (NR)*. In our main analyses (V1):

a) We replace a missing measurement value with the numerical value reported in the "Result Detection Condition Text", following Vidic et al. (2013). There are only very few of these assignments in our sample. In the raw data, for Barium, we have 48 observations for which the value has been replaced, for Chloride we have 213 replacements, for Bromide we have 53 replacements, and for Strontium we have 8 replacements;
b) We assign a value of zero to any measurement, for which the "Result Detection Condition Text" shows "Not Detected";
c) We assign a missing value, if the "Result Detection Condition Text" equals "Not Reported" or "Present Below Quantification Limit", but only if condition a) does not apply.[35]

In the second version (V2), we assign missing values to any measurement that has a non-missing "Result Detection Condition Text." This approach basically eliminates all concentrations marked as BDL/LD/ND/NR, which is similar to using only uncensored data, as discussed in Niu et al. (2018). While this approach avoids the use of ambiguous data, it could work in favor of finding results. This is why it is not our preferred version. We use V2 only to gauge the sensitivity of our results to different ways of dealing with BDL/LD/ND/NR measurements.

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[35] We do the same for measurements for which the "Result Detection Condition Text" equals "NA", "Present Above Quantification Limit" and "Systematic Contamination". But these cases do not end up in our sample.

In the third version (V3), we also include readings where the database indicates that the ion was present but below the detection limit and code them as zeros. This approach is the most inclusive:

a) Same as V1;

b) We assign a value of zero to any measurement, for which the "Result Detection Condition Text" equals "Not Detected" or "Present Below Quantification Limit";

c) We assign a value of missing if the "Result Detection Condition Text" flag equals to "Not Reported", but only if condition a) does not apply.

We then re-estimate Eq. (1) using V2 and V3. Table B5 shows results in line with our main inferences and suggests that our choice of measurement (V1) for the main analysis is conservative.

Table B5 – Disclosure of Mandates and Water Quality

	All Ions pooled (μg/l)			
	Concentration Version 2		*Concentration Version 3*	
	(1)	(2)	(3)	(4)
HUC10_HF×POST	**-0.0694***** **[0.0168]**	**-0.0553**** **[0.0279]**	**-0.1302***** **[0.0424]**	**-0.0692*** **[0.0475]**
Observations	319,941	298,001	347,922	324,373
R-squared	0.982	0.987	0.961	0.972
Monitoring station FE	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes
State×Month×Year FE	Yes	No	Yes	No
HUC8×Month	Yes	No	Yes	No
HUC8×Month×Year FE	No	Yes	No	Yes

This table reports OLS estimates for the impact of the disclosure mandates on ion concentrations using measurements from V2 or V3. The sample includes a treatment sample of HUC10s with HF at least in the pre-disclosure period and a control sample of HUC10s without HF in the pre- and post-disclosure period and located over sub-regions (HUC4s) in treated states. Standard errors (in parentheses) clustered by watershed (HUC10) are reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

OB4. Controlling for Agricultural Activity

We provide a robustness test controlling for agricultural activity, which is another source of water pollution. We collect data on the fraction of land devoted to agriculture from the Census of Agriculture (National Agricultural Statistics Service) and compute the fraction of land in a HUC10 devoted to agricultural activity in 2007. Then, we split the treatment sample of HUC10s with HF in the pre-period into two non-overlapping groups based on the sample median of this variable. HUC10s with an above (below) the median level of agriculture are classified in the *High_Agr* group (*Low_Agr* group). Table B6 reports OLS coefficients estimating Eq. (1) and replacing the variable, *POST×HUC10_HF*, with two non-overlapping variables marking observations in the post-disclosure period in the respective group, *High_Agr* (*Low_Agr*). Table B6 suggests that our results do not stem from areas with more agriculture.

Table B6 – HF Activity and Water Quality – Controlling for Agricultural Activity

	Bromide (μg/l) (1)	Chloride (μg/l) (2)	Barium (μg/l) (3)	Strontium (μg/l) (4)	All Ions pooled (μg/l) (5)
POST×HUC10_HF×High_Agr	0.0233	**-0.2043****	**-0.1177****	0.0032	**-0.1486****
	[0.1079]	**[0.1026]**	**[0.0499]**	[0.0336]	**[0.0654]**
POST×HUC10_HF×Low_Agr	**-0.1914*****	**-0.1813*****	**-0.0706***	**-0.0716*****	**-0.1486*****
	[0.0681]	**[0.0396]**	**[0.0388]**	**[0.0260]**	**[0.0294]**
Observations	7,333	125,596	49,063	30,226	212,218
R-squared	0.875	0.852	0.794	0.964	0.950
Treatment Sample	HUC10s with HF at least in the pre-disclosure period				
Monitoring station FE	Yes	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes	Yes
HUC8×Month	Yes	Yes	Yes	Yes	Yes
State×Month×Year FE	Yes	Yes	Yes	Yes	Yes

This Table reports OLS estimates from an alternative version of Eq. (1) in which we replace the interaction variable, *POST×HUC10_HF*, with two non-overlapping variables marking observations in the post-disclosure period in HUC10s with an above (below) median level of land devoted to agricultural activity, *High_Agr* (*Low_Agr*), in the pre-disclosure period. *HUC10_HF* marks treated watersheds (HUC10s). *POST* is a binary variable marking water quality observations in the post-disclosure period. The sample includes a treatment sample of HUC10s with HF at least in the pre-disclosure period and a control sample of HUC10s without HF in the pre- and post-disclosure period and located over sub-regions (HUC4s) in treated states. Standard errors (in parentheses) clustered by watershed (HUC10) are reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

OB5. Disclosure Mandates and Public Pressure

The core idea of the paper is that disclosure regulation creates public pressure, which in turn incentivizes HF operators to change their behaviors. In this section, we provide further evidence that disclosure regulation increases public pressure. The analyses are in the spirit of a first-stage model and show that the disclosure mandates are associated with increases in public pressure. We use two proxies to measure changes in public pressure.

Our first proxy is based on media coverage of HF-related environmental consequences or water impact around the adoption of the disclosure mandates. We identify and download newspaper articles from Lexis-Nexis between January 2005 and December 2016, which contain the following keywords in the headline: "Hydraulic fracturing" and ("*pollut*" or "*health*" or "*contaminat*" or "*environment*" or "*water*") or "*Fracturing*" and ("*pollut*" or "*health*" or "*contaminat*" or "*environment*" or "*water*") or "*Fracking*" and ("*pollut*" or "*health*" or "*contaminat*" or "*environment*" or "*water*") or "*Fracing*" & ("*pollut*" | "*health*" or "*contaminat*" or "*environment*" or "*water*"). Next, we separate local and national newspapers and assign local newspapers to the counties in which each newspaper circulates following Gentzkow and Shapiro (2010). We then count the number of articles by county-month-year and take the natural logarithm. The second proxy is based on state-specific Google search trends for the term "fracking."

We restrict the sample to counties located over shales in the treated states and regress the two proxies on a binary indicator variable marking those months after the disclosure regulation has come into force, *POST*, and county and year-month FEs. The inferences are based on standard errors clustered at the state-level.

Table B7 reports the estimation results. We observe a significant increase in the number of newspaper articles discussing HF as a source of water pollution after the disclosure mandate

(Column (1)). Moreover, the estimated coefficient is virtually unaffected when we control for HF activity (Column (2)) suggesting that the increase in media coverage is due to the new disclosure regime and not driven by an increase in HF activity over time. We observe a greater increase in media coverage in counties where the population is more educated (Columns (3)), which is what we would expect to see.

We obtain similar results using Google search trends.[36] We observe a significant increase in Google searches after the disclosure mandates come into force (Column (4)). Again, the estimated coefficient is virtually unaffected when we control for HF activity (Column (5)) suggesting that the increase in media coverage is due to the new disclosure regime and not driven by an increase in HF activity over time. Lastly, we observe a greater increase in Google searches when the population is more educated (Column (6)), which is reassuring.

Taken together, the results in Table B7 suggest the disclosure mandates increase public pressure. In Section V.E, we then examine whether the water quality effects of the disclosure mandates are larger in areas with greater increases in public pressure to show that mandatory disclosure operates through public pressure.

[36] We do not include county and month×year fixed effects when we use Google search trends as a dependent variable because these trends are standardized by state and time.

Table B7 – Disclosure Mandates and Public Pressure

	Log(1+#newspaper articles)			*Google Searches*		
	(1)	(2)	(3)	(4)	(5)	(6)
POST	**0.1077***** **[0.0270]**	**0.1077***** **[0.0268]**		**27.4992***** **[2.2367]**	**27.4971***** **[2.2459]**	
#WELLS_HF		**0.0013**** **[0.0005]**			0.0018 [0.0561]	
POST_HIGH_EDUC			**0.1690***** **[0.0524]**			**31.6911***** **[2.9368]**
POST_LOW_EDUC			**0.0436*** **[0.0228]**			**22.4456***** **[3.8477]**
Observations	6,732	6,732	6,732	6,732	6,732	6,732
R-squared	0.354	0.355	0.363	0.312	0.312	0.327
	Counties over shales					
County FE	Yes	Yes	Yes	No	No	No
Month×Year FE	Yes	Yes	Yes	No	No	No

This table reports OLS estimates of the impact of the disclosure mandates on public pressure, measured as either media coverage or google searches. The dependent variable in Column (1)–(3) is the logarithm of one plus the number of newspaper articles pointing to HF as a source of water pollution by county-year-month. The dependent variable in Column (4)–(6) are Google searches for the term "fracking". We do not include county or month×year fixed effects in these models since Google searches are standardized by state and time. In Columns (2) and (4) we control for the number of newly fractured HF wells in a county-year-month. In Columns (3) and (6) we replace the *Post* binary variable with two non-overlapping binary variables marking in the post-disclosure period counties with an above (below) the pre-disclosure period median level of education, *POST_HIGH_EDUC* (*POST_LOW_EDUC*). The level of education is the share of the population that has at least a college degree. *POST* is a binary variable marking observations in the post-disclosure period. *#WELLS_HF* is the number of new wells being spudded in a given HUC10-Month-Year. The sample comprises counties over shales. Standard errors (in parentheses) clustered by state are reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

OB6. Patterns in Water Measurement

In this section, we explore patterns in water measurement. Given the increase in public pressure, it would not be surprising if water measurements increase with mandatory disclosure. We re-shape the data at the HUC10-month level and code up a variable counting the number of water quality readings (for any of the four chemicals) in a given month. We assign a value of zero to the HUC10-months with no water readings. Then, we regress the number of water quality readings on *HUC10_HF×POST*. Table B8, Columns (1) and (3) show that, within state, there is an increase in the frequency of water measurement in HUC10s with HF relative to HUC10s without HF. However, as shown in Columns (2) and (4), this association is no longer present in the tighter within-HUC8 design. Next, we add the number of new wells being spudded in a given HUC10-month-year (*#WELLS_HF*). The results suggest that new wells do not systematically increase water measurement. Based on Table B8, it is unlikely that patterns in water measurement play into our main results.

Table B8 – Patterns in Water Measurements

	#readings (1)	#readings (2)	#readings (3)	#readings (4)
HUC10_HF×POST	**0.2187****	0.0099	**0.2122****	0.0055
	[0.0925]	[0.1104]	**[0.0925]**	[0.1107]
#WELLS_HF			0.0266	0.0182
			[0.0169]	[0.0152]
Observations	455,616	432,768	455,616	432,768
R-squared	0.224	0.466	0.224	0.466
HUC10 FE	Yes	Yes	Yes	Yes
State×Month×Year FE	Yes	No	Yes	No
HUC8×Month	Yes	No	Yes	No
HUC8×Month×Year FE	No	Yes	No	Yes

This table reports OLS estimates from models predicting water measurement at the HUC10-Month-Year level. *#readings* is a variable counting the number of water quality readings (for any of the four chemicals) in a given month. *HUC10_HF* marks treated watersheds (HUC10s). *POST* is a binary variable marking observations in the post-disclosure period. *#WELLS_HF* is the number of new wells being spudded in a given HUC10-month-year. Standard errors (in parentheses) clustered by watershed (HUC10) are reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

OB7. WLS to give more weight to areas with more data

Since water quality data can be sparse (see Tables 1 and 2), it is possible that we cannot estimate reliable ion concentration baselines for some geographic areas. As our estimation is at the HUC10 level, we re-estimate Eq. (1) by WLS using as weights the number of HUC10s in each state-year-month (in the models with state×year×month FEs) and the number of HUC10s in each HUC8-year-month (in the models with HUC8×year×month FEs). In this way, we give more weight to areas with more data where ion concentration baselines can be better estimated. Table B9 shows that the results are similar using WLS models.

Table B9 – Disclosure Mandates and Water Quality – WLS

	Bromide (μg/l)		Chloride (μg/l)		Barium (μg/l)		Strontium (μg/l)		All Ions pooled (μg/l)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
HUC10_HF×POST	**-0.1559****	0.0655	**-0.1430*****	-0.0812	**-0.0718****	**-0.0564***	**-0.0553****	-0.0398	**-0.1204*****	**-0.0701***
	[0.0729]	[0.1343]	**[0.0436]**	[0.0574]	**[0.0296]**	**[0.0326]**	**[0.0243]**	[0.0313]	**[0.0338]**	**[0.0399]**
Observations	15,783	14,538	188,329	176,729	72,703	65,812	48,536	46,308	325,351	303,387
R-squared	0.835	0.897	0.865	0.895	0.820	0.822	0.962	0.971	0.959	0.967
Treatment Sample	HUC10s with HF activity in the pre-disclosure period									
Full Sample	All HUC10s in sub-regions (HUC4s) in treated states with some HF activity									
Monitoring station FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State×Month×Year FE	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
HUC8×Month	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
HUC8×Month×Year FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Table B9 reports WLS coefficients estimating Eq. (1). We use as weights either the number of HUC10s in each State-year-month (Columns (1), (3), (5), (7), (9)) or the number of HUC10s in each HUC8-year-month (Columns (2), (4), (6), (8), (10)). The models in Columns (9)-(10) pool all four ion concentrations in one model, as described in Section IV. In Columns (1)-(10), the sample consists of treatment HUC10s with HF activity in the pre-disclosure period and control HUC10s without HF activity in the pre- and post-disclosure period that are located in treated states and within sub-regions (HUC4s) with some HF activity. *HUC10_HF* is a binary indicator marking watersheds with HF activity (treated HUC10s). *POST* is a binary variable marking water quality measurements taken in the post-disclosure period. The sub-panel at the bottom indicates the fixed effects (FE) included in the model. Standard errors (in parentheses) are clustered by HUC10 and reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

OB8. Endogeneity of Disclosure Adoption Dates

In this section, we explore the potential endogeneity of the adoption dates for the disclosure mandates. We propose four tests. First, we examine whether our results are robust to lagged changes in ion concentrations since states might choose to adopt the disclosure requirements in response to shocks to local water quality. We augment Eq. (1) by including the lagged change of ion concentration at the HUC10 level (i.e., % change in the average ion concentration in a given HUC10 between year $t-1$ and year $t-2$). Table B10 shows that our results continue to hold when we control for lagged changes in ion concentrations.

Second, we examine whether we can predict the relative timing of states' disclosure rules based on variables that reflect prior public pressure, economic and political differences, and HF activity intensity in the state. Such correlations could indicate that the relative timing of the disclosure mandates is not plausibly exogenous. To test this, we compute the difference (in days) between each state's disclosure implementation date and January 2010. We then regress this variable on the state-level differences in the timing of the peak in Google searches (relative to January 2010 or the global minimum between January 2010 and December 2020), income per capita as of 2010, the fraction of people with a college degree as of 2010, employment rate as of 2010, the total number of HF wells fractured up to 2010, an indicator variable marking whether the state was leaning democratic in the 2010 house election. The results in Table B11 do not reveal significant associations, suggesting that it is difficult to predict when states adopt the rules, consistent with the assumption that states' relative timing is plausibly exogenous.

Third, we run a test in the spirit of Altonji, Elder, and Taber (2005). We first identify variables that capture local factors to which lawmakers might respond when introducing the disclosure mandates. We propose the following variables: the monthly fracking-related google searches at the state-level, the monthly number of newspaper articles pointing to HF as a source of water pollution by county, the monthly cumulative number of HF wells in a state, and the number of water readings in a state-year-month. These variables should broadly capture HF-related pressures that lawmakers might have experienced due to HF activity in their state.

Next, we exclude the variable of interest (i.e., *HUC10_HF×POST*) from Eq. (1) and instead add these variables to Eq. (1). We store the predicted values (for the water measurements) from these regressions and then re-estimate Eq. (1) by replacing actual ion concentrations with the predicted values. If our results were largely driven by local factors to which state lawmakers respond, we should see that using the predicted values produces very similar results. However, the results in Table B12 show, especially for the tighter within-HUC8 model, that the predicted values generated with these local factors explain only a small portion of the effect estimated in Table 3 (i.e., roughly 2.2 percent of effect in the within-HUC8 models 10 and 12). In un-tabulated analyses, we also include the controls for other HF regulations (from Table 5) that were adopted within 360 days before or after the respective state's disclosure mandate in the estimation of the predicted values. We obtain similar results.

Four, we employ the methodology proposed by Oster (2019) to more formally assess the role of the local factors to which lawmakers might respond. The key idea of the test proposed by Oster (2019) is that the potential omitted variable bias in a model is proportional to the movement in the coefficient of interest between the baseline model and a model that includes potential *observed* confounders (which in turn are informative about potential *unobserved* confounders), relative to the change in the explanatory power of the two models.

To implement this statistic, we estimate an alternative version of Eq. (1) in which we include the potential confounders considered in Table B12. This regression yields an $\text{R-squared}_{\text{controlled}}$ of

0.9548 and a coefficient on *HUC10_HF×POST* (i.e., $\beta_{controlled}$) of –0.1086 (*t*-stat -3.04). We then use these estimates to compute the δ (i.e., relative degree of selection) using the following formula: $\delta = \beta_{controlled} \times (\text{R-squared}_{controlled} - \text{R-squared}_{uncontrolled}) / [(\beta_{uncontrolled} - \beta_{controlled}) \times (\text{R-squared}_{MAX} - \text{R-squared}_{controlled})]$, where $\beta_{uncontrolled}$ and $\text{R-squared}_{uncontrolled}$ are the coefficient on *HUC10_HF×POST* and the R-squared from Table 3 Column (9). We assume an R-squared_{MAX} equal to 0.96. We obtain a δ of 1.75. This value suggests that there would have to be a relatively large degree of selection by unobservables to explain our results, which is reassuring.

Table B10 – Disclosure Mandates and Water Quality – Controlling for Lagged Changes in Water Quality

	Bromide (µg/l)		Chloride (µg/l)		Barium (µg/l)		Strontium (µg/l)		All Ions pooled (µg/l)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
HUC10_HF×POST	**-0.1167***	0.0493	**-0.1926*****	**-0.1166****	**-0.0969*****	**-0.0589***	**-0.0448****	-0.0382	**-0.1509*****	**-0.0928****
	[0.0685]	[0.1193]	**[0.0551]**	**[0.0517]**	**[0.0352]**	**[0.0346]**	**[0.0223]**	[0.0290]	**[0.0386]**	**[0.0363]**
Δ Ions Concentrations[t-1]	**0.4120****	**0.2164****	0.0938	0.0508	0.0009	0.0008	**-0.0020****	**-0.0022*****	0.0031	0.0015
	[0.2027]	**[0.0993]**	[0.0718]	[0.0538]	[0.0008]	[0.0007]	**[0.0010]**	**[0.0005]**	[0.0024]	[0.0011]
Observations	15,783	14,538	188,329	176,729	72,703	65,812	48,536	46,308	325,351	303,387
R-squared	0.860	0.916	0.865	0.903	0.834	0.867	0.968	0.976	0.961	0.971
Treatment Sample	HUC10s with HF activity in the pre-disclosure period									
Full Sample	All HUC10s in sub-regions (HUC4s) in treated states with some HF activity									
Monitoring station FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State×Month×Year FE	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
HUC8×Month	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
HUC8×Month×Year FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Table B10 reports OLS coefficients estimating Eq. (1) controlling for lagged changes in ion concentration. The models in Columns (9)-(10) pool all four ion concentrations in one model, as described in Section IV. In Columns (1)-(10), the sample consists of treatment HUC10s with HF activity in the pre-disclosure period and control HUC10s without HF activity in the pre- and post-disclosure period that are located in treated states and within sub-regions (HUC4s) with some HF activity. *HUC10_HF* is a binary indicator marking watersheds with HF activity (treated HUC10s). *POST* is a binary variable marking water quality measurements taken in the post-disclosure period. *Δ Ions Concentrations[t-1]* is % change in the average ion concentration in a given HUC10 between year *t* – 1 and year *t* – 2. The sub-panel at the bottom indicates the fixed effects (FE) included in the model. Standard errors (in parentheses) are clustered by HUC10 and reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

Table B11 – Analysis of the Relative Timing of the Adoption Dates

	Disclosure Timing (1)	Disclosure Timing (2)	Disclosure Timing (3)	Disclosure Timing (4)
GS_peak relative_2010	0.1727		-0.0246	
	[2.1635]		[2.1972]	
GS_peak relative_min		-0.8960		-0.9549
		[2.8306]		[2.8564]
Income_per_Capita_2010	-0.6387	-0.9785	-2.4775	-2.6264
	[5.3356]	[4.8012]	[5.7718]	[5.1725]
College_2010	1.4989	1.9195	0.9993	1.2207
	[5.2509]	[4.7582]	[5.3349]	[4.8617]
Democratic_House_2010	30.0562	31.7567	36.8161	39.5207
	[55.6495]	[55.2309]	[56.7358]	[56.3728]
Employment_Rate_2010	-232.3729	-215.9353	-102.3224	-88.9070
	[489.7814]	[486.3205]	[515.9006]	[510.1809]
HF_Total_Count_2010			0.0031	0.0031
			[0.0035]	[0.0035]
Observations	16	16	16	16
R-squared	0.176	0.183	0.243	0.252

This table reports OLS estimates from models predicting timing of the disclosure rules (relative to Jan 2010). *Disclosure Timing* is the difference (in days) between each state disclosure implementation date and January 2010; *GS_peak relative_2010* is state-level difference in timing of peak in Google searches relative to the January 2010; *GS_peak relative_min* is state-level difference in timing of peak in Google searches relative to the global minimum between January 2010 and December 2020; *Income_per_Capita_2010* is the state-level income per capita as of 2010; *College_2010* is the state-level fraction of people with a college degree as of 2010; *Democratic_House_2010* is dummy marking whether the state is leaning democratic in 2010 house election; *Employment_Rate_2010* is the state-level employment rate as of 2010; *HF_Total_Count_2010* is total number of HF wells fractured up to 2010. Standard errors (in parentheses) are reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

Table B12 – Gauging the Endogeneity of Adoption Dates (in spirit of Altonji et al. 2005)

.	All Ions pooled (μg/l) (1)	$\widehat{\text{All Ions}}$ pooled (μg/l) (2)	All Ions pooled (μg/l) (3)	$\widehat{\text{All Ions}}$ pooled (μg/l) (4)	All Ions pooled (μg/l) (5)	$\widehat{\text{All Ions}}$ pooled (μg/l) (6)	All Ions pooled (μg/l) (7)	$\widehat{\text{All Ions}}$ pooled (μg/l) (8)
HUC10_HF×GS_HF	**-0.0011*****		-0.0003		**-0.0009****		-0.0003	
	[0.0004]		[0.0005]		**[0.0004]**		[0.0005]	
HUC10_HF×Local Media Coverage	-0.0074		0.0086		0.0057		0.0100	
	[0.0295]		[0.0562]		[0.0325]		[0.0574]	
HUC10_HF×CUM_WELLS_HF	**-0.0002***		0.0002		-0.0001		0.0002	
	[0.0001]		[0.0001]		[0.0001]		[0.0001]	
HUC10_HF×#Readings	**0.0004****		0.0004		**0.0004****		0.0004	
	[0.0002]		[0.0002]		**[0.0002]**		[0.0002]	
HUC10_HF×POST		**-0.0316*****		-0.0017		**-0.0236*****		-0.0015
		[0.0017]		[0.0018]		**[0.0013]**		[0.0018]
Observations	325,351	325,351	303,387	303,387	211,273	211,273	198,258	198,258
R-squared	0.961	0.995	0.971	0.999	0.962	0.994	0.972	0.998
Coef. *HUC10_HF×POST* (Table 3)		**-0.1509*****		**-0.0928****		**-0.1476*****		**-0.0925****
Treatment Sample	HUC10s with HF activity in the pre-disclosure period							
Full Sample	All HUC10s in sub-regions (HUC4s) in treated states with some HF activity				HUC10s over shales in treated states			
Monitoring station FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State×Month×Year FE	Yes	Yes	No	No	Yes	Yes	No	No
HUC8×Month	Yes	Yes	No	No	Yes	Yes	No	No
HUC8×Month×Year FE	No	No	Yes	Yes	No	No	Yes	Yes

This table reports OLS estimates from a test in the spirit of Altonji, Elder, and Taber (2005). In Columns (1), (3), (5), (7) we estimate an alternative version of Eq. (1) where we add the following variables: the monthly fracking-related google searches at the state-level (*GS_HF*); the monthly number of newspaper articles pointing to HF as a source of pollution by county (*Local Media Coverage*); the monthly cumulative number of HF wells in a state (*CUM_WELLS_HF*); the number of water readings in a state-year-month (*#Readings*). In Columns (2), (4), (6), (8) we re-estimate Eq. (1) by replacing Ions concentration measures with predicted values from Columns (1), (3), (5), (7). *HUC10_HF* is a binary indicator marking watersheds with HF activity (treated HUC10s). *POST* is a binary variable marking water quality measurements taken in the post-disclosure period. Standard errors (in parentheses) are clustered by HUC10 and reported below the coefficients. *, **, *** denote statistical significance at the 10%, 5%, and 1% level (two-tailed), respectively.

OB9. Robustness Tests for Staggered Diff-in-Diff Analyses with Heterogeneous Effects

A recent literature in econometrics (D'Chaisemartin and D'Haultfoeuille, 2022) highlights that difference-in-differences (DiD) analyses with two-way fixed effects (one for time and one for group) can produce biased estimates in the presence of heterogeneous treatment effects. With staggered treatments, the problem arises because DiD estimates based on two-way fixed effects are essentially weighted averages of many comparisons, including those that use post-treatment observations from earlier treatments as controls for later-treated observations, and vice versa. Heterogeneity in treatment effects can lead to negative weights attached to specific group-period estimates. We thus assess whether our inferences are affected by these potential issues, considering that Table 11 documents heterogeneous treatment effects across areas.

To gauge this issue and circumvent the comparison problem, we employ a "stacked" regression approach proposed by Cengiz et al. (2019). Specifically, we estimate Eq. (1) 16 × 2 times (i.e., two per each state) using two alternative control samples: (i) control HUC10s in the state; (ii) all control HUC10s (across all states). This approach exploits only not-yet treated watersheds and never-treated watersheds as controls. Already-treated watersheds are removed from the sample. We find that the averaged coefficients from these regressions are, if anything, larger than those reported in Table 3. Moreover, the weighted averaged coefficients from these regressions (using as weights the numbers of HUC10s in the state) are very similar to those reported in Table 3.

To further explore the issue, we execute the diagnostic test proposed by de Chaisemartin and D'Haultfoeuille (2020). When estimating the weights of the group-period clusters for model 9 (10) in Table 3, we find that 792 of the 2,709 ATTs receive a negative weight (1,450 out of 13,763 ATTs in the within-HUC8 model). We investigate the source of the negative weights and find that they are particularly frequent after 2016 (>50 percent). As all states adopted their mandates before

2016, we can remove years after 2016 from the analysis. After removing these later years, only 305 ATTs out of 2,790 receive negative weights in the within-state model, which sum to only -0.027. For the within-HUC8 model, the number drops to 457 out of 13,763, which sum to -0.011. Reassuringly, our main results in Table 3 and inferences do not change when excluding years after 2016.

OB10. Changes in the Dissemination of HF Disclosures via FracFocus

To link the improvements in water quality to the adoption of the disclosure rules, we exploit inter alia changes in the dissemination of the HF disclosures via FracFocus (see Section V.E). After the initial creation in 2011, FracFocus has implemented several changes to its website to improve the dissemination of the HF disclosures. We identify three major changes during our sample period. In June 2013, the release of FracFocus 2.0 allows "users to more efficiently search for well site chemical information". In July 2015, FracFocus starts releasing disclosure data to the public in machine-readable (SQL) format. In June 2016, the release of FracFocus 3.0 provides a stronger "validation processes to improve data integrity, a new format for reporting company data entry, and newly designed forms to improve the company and regulatory agency user experiences when checking and completing disclosures." We exploit each of these three changes and examine whether these changes are associated with further improvements in water quality (Table 11 and Section V.E.).

OC1. Descriptive Information on the Disclosed Chemicals used in Fracking Fluids

The table below reports the most common hazardous chemicals reported in the disclosures for HF fluids (Chloride-related hazardous chemicals are reported in **bold**). Hazardous chemicals are those (i) regulated as primary contaminants by the Safe Drinking Water Act; (ii) regulated as Priority Toxic Pollutants for ecological toxicity under the Clean Water Act; or (iii) classified as diesel fuel under EPA guidance on HF operations (USEPA, 2012a, 2014).

Table C1 – Most Common Hazardous Chemicals in the Disclosure for HF Fluids

Chemical name	Toxicology
1,4-dioxane	Dioxane is irritating to the eyes and respiratory tract. Exposure may cause damage to the central nervous system, liver and kidneys. Dioxane is classified by the National Toxicology Program as "reasonably anticipated to be a human carcinogen". It is also classified by the IARC as a Group 2B carcinogen: *possibly carcinogenic to humans* because it is a known carcinogen in other animals. The United States Environmental Protection Agency classifies dioxane as a probable human carcinogen, and a known irritant at concentrations significantly higher than those found in commercial product.
Acrylamide	Acrylamide is classified as an extremely hazardous substance in the United States as defined in Section 302 of the U.S. Emergency Planning and Community Right-to-Know Act (42 U.S.C. 11002) and is subject to strict reporting requirements by facilities which produce, store, or use it in significant quantities. Acrylamide is considered a potential occupational carcinogen by U.S. government agencies and classified as a Group 2A carcinogen by the IARC. The Occupational Safety and Health Administration and the National Institute for Occupational Safety and Health have set dermal occupational exposure limits at 0.03 mg/m^3 over an eight-hour workday.
Benzyl chloride	Benzyl chloride is an alkylating agent. Indicative of its high reactivity (relative to alkyl chlorides), benzyl chloride reacts with water in a hydrolysis reaction to form benzyl alcohol and hydrochloric acid. In contact with mucous membranes, hydrolysis produces hydrochloric acid. Thus, benzyl chloride is a lachrymator and has been used in chemical warfare. It is also very irritating to the skin. It is classified as an extremely hazardous substance in the United States as defined in Section 302 of the U.S. Emergency Planning and Community Right-to-Know Act (42 U.S.C. 11002) and is subject to strict reporting requirements by facilities which produce, store, or use it in significant quantities.
Calcium chloride anhydrous	Although non-toxic in small quantities when wet, the strongly hygroscopic properties of the non-hydrated salt present some hazards. Calcium chloride can act as an irritant by desiccating moist skin. Solid calcium chloride dissolves exothermically, and burns can result in the mouth and esophagus if it is ingested. Ingestion of concentrated solutions or solid products may cause gastrointestinal irritation or ulceration. Consumption of calcium chloride can lead to hypercalcemia.
Chlorine dioxide	Chlorine dioxide is toxic, and limits on human exposure are required to ensure its safe use. The United States Environmental Protection Agency has set a maximum level of 0.8 mg/L for chlorine dioxide in drinking water. The Occupational Safety and Health Administration (OSHA), an agency of the United States Department of Labor, has set an 8-hour permissible exposure limit of 0.1 ppm in air (0.3 mg/m^3) for people working with chlorine dioxide.

Choline chloride	Irritating to eyes, respiratory system and skin. Toxic to aquatic organisms. Accidental ingestion of the material may be damaging to the health of the individual. Nausea, vomiting, gastro-intestinal discomfort and diarrhea have been reported after large doses of choline.
Cupric chloride	Cupric chloride can be toxic. Only concentrations below 5 ppm are allowed in drinking water by the US Environmental Protection Agency.
Dazomet	Dazomet is irritating to the eyes and its degradation product, MITC, is a dermal sensitizer. Dazomet is very toxic to aquatic organisms, and acutely toxic to mammals. Exposure to dazomet can occur through several means; interaction with unincorporated granules, inhalation of its decomposition product, MITC, and/or water runoff.
Didecyl dimethyl ammonium chloride	In mice this disinfectant was found to cause infertility and birth defects when combined with Alkyl (60% C14, 25% C12, 15% C16) dimethyl benzyl ammonium chloride (ADBAC). These studies contradict the older toxicology data set on quaternary ammonia compounds which was reviewed by the U.S. Environmental Protection Agency (U.S. EPA) and the EU Commission.
Dimethylformamide	Reactions including the use of sodium hydride in DMF as a solvent are somewhat hazardous; exothermic decompositions have been reported at temperatures as low as 26 °C. On a laboratory scale any thermal runaway is (usually) quickly noticed and brought under control with an ice bath and this remains a popular combination of reagents.
Ethylene glycol	Ethylene glycol has relatively high mammalian toxicity when ingested, roughly on par with methanol. Upon ingestion, ethylene glycol is oxidized to glycolic acid, which is, in turn, oxidized to oxalic acid, which is toxic. It and its toxic byproducts first affect the central nervous system, then the heart, and finally the kidneys. Ingestion of sufficient amounts is fatal if untreated. Several deaths are recorded annually in the U.S. alone.
Ethylene glycol mono-n-butyl ether	2-Butoxyethanol has a low acute toxicity, with LD_{50} of 2.5 g/kg in rats. Laboratory tests by the U.S. National Toxicology Program have shown that only sustained exposure to high concentrations (100–500 ppm) of 2-butoxyethanol can cause adrenal tumors in animals. OSHA does not regulate 2-butoxyethanol as a carcinogen.
Ehylene oxide	Ethylene oxide causes acute poisoning, accompanied by a variety of symptoms. Central nervous system effects are frequently associated with human exposure to ethylene oxide in occupational settings. Headache, nausea, and vomiting have been reported. Peripheral neuropathy, impaired hand-eye coordination and memory loss have been reported in more recent case studies of chronically-exposed workers at estimated average exposure levels as low as 3 ppm (with possible short-term peaks as high as 700 ppm). The metabolism of ethylene oxide is not completely known. Data from animal studies indicate two possible pathways for the metabolism of ethylene oxide: hydrolysis to ethylene glycol and glutathione conjugation to form mercapturic acid and meththio-metabolites. Ethylene oxide easily penetrates through ordinary clothing and footwear, causing skin irritation and dermatitis with the formation of blisters, fever and leukocytosis.
Formaldehyde	In view of its widespread use, toxicity, and volatility, formaldehyde poses a significant danger to human health. In 2011, the US National Toxicology Program described formaldehyde as "known to be a human carcinogen". The CDC considers formaldehyde as a systemic poison. Formaldehyde poisoning can cause permanent changes in the nervous system's functions.
Formic acid	Formic acid has low toxicity (hence its use as a food additive), with an LD_{50} of 1.8 g/kg (tested orally on mice). The concentrated acid is corrosive to the skin. Formic acid is readily metabolized and eliminated by the body. Nonetheless, it has specific toxic effects; the formic acid and formaldehyde produced as metabolites of methanol are responsible for

	the optic nerve damage, causing blindness, seen in methanol poisoning. Chronic exposure in humans may cause kidney damage. Another possible effect of chronic exposure is development of a skin allergy that manifests upon re-exposure to the chemical. Concentrated formic acid slowly decomposes to carbon monoxide and water, leading to pressure buildup in the containing vessel. The hazards of solutions of formic acid depend on the concentration. The principal danger from formic acid is from skin or eye contact with the concentrated liquid or vapors. The U.S. OSHA Permissible Exposure Level (PEL) of formic acid vapor in the work environment is 5 parts per million parts of air (ppm).
Hydrochloric acid	Being a strong acid, hydrochloric acid is corrosive to living tissue and to many materials, but not to rubber. Typically, rubber protective gloves and related protective gear are used when handling concentrated solutions.
Isopropyl alcohol	Isopropyl alcohol vapor is denser than air and is flammable, with a flammability range of between 2 and 12.7% in air. Isopropyl alcohol causes eye irritation and is a potential allergen. Isopropyl alcohol, via its metabolites, is somewhat more toxic than ethanol, but considerably less toxic than ethylene glycol or methanol. Death from ingestion or absorption of even relatively large quantities is rare. Both isopropyl alcohol and its metabolite, acetone, act as central nervous system (CNS) depressants. Poisoning can occur from ingestion, inhalation, or skin absorption. Symptoms of isopropyl alcohol poisoning include flushing, headache, dizziness, CNS depression, nausea, vomiting, anesthesia, hypothermia, low blood pressure, shock, respiratory depression, and coma. Overdoses may cause a fruity odor on the breath as a result of its metabolism to acetone. Isopropyl alcohol does not cause an anion gap acidosis, but it produces an osmolal gap between the calculated and measured osmolalities of serum, as do the other alcohols. Isopropyl alcohol is oxidized to form acetone by alcohol dehydrogenase in the liver and has a biological half-life in humans between 2.5 and 8.0 hours.
Magnesium nitrate	May cause irritation of the digestive tract. May be harmful if swallowed. Ingestion of nitrate containing compounds can lead to methemoglobinemia. Inhalation: Causes respiratory tract irritation.
Methyl isobutyl ketone	Exposure to high concentrations can cause you to feel dizzy and lightheaded, and to pass out. Prolonged contact can cause a skin rash, dryness and redness. Methyl Isobutyl Ketone may damage the liver and kidneys.
Naphthalene	Exposure to large amounts of naphthalene may damage or destroy red blood cells, most commonly in people with the inherited condition known as glucose-6-phosphate dehydrogenase (G6PD) deficiency, which over 400 million people suffer from. Humans, in particular children, have developed the condition known as hemolytic anemia, after ingesting mothballs or deodorant blocks containing naphthalene. Symptoms include fatigue, lack of appetite, restlessness, and pale skin. Exposure to large amounts of naphthalene may cause confusion, nausea, vomiting, diarrhea, blood in the urine, and jaundice (yellow coloration of the skin due to dysfunction of the liver). The International Agency for Research on Cancer (IARC) classifies naphthalene as possibly carcinogenic to humans and animals (Group 2B). Under California's Proposition 65, naphthalene is listed as "known to the State to cause cancer". A probable mechanism for the carcinogenic effects of mothballs and some types of air fresheners containing naphthalene has been identified. US government agencies have set occupational exposure limits to naphthalene exposure. The Occupational Safety and Health Administration has set a permissible exposure limit at 10 ppm (50 mg/m^3) over an eight-hour time-weighted

	average. The National Institute for Occupational Safety and Health has set a recommended exposure limit at 10 ppm (50 mg/m^3) over an eight-hour time-weighted average, as well as a short-term exposure limit at 15 ppm (75 mg/m^3). Naphthalene's minimum odor threshold is 0.084 ppm for humans.
Phosphoric acid	Phosphoric acid is not a strong acid. However, at moderate concentrations phosphoric acid solutions are irritating to the skin. Contact with concentrated solutions can cause severe skin burns and permanent eye damage. A link has been shown between long-term regular cola intake and osteoporosis in later middle age in women (but not men).
Sulfuric acid	Sulfuric acid can cause very severe burns, especially when it is at high concentrations. In common with other corrosive acids and alkali, it readily decomposes proteins and lipids through amide and ester hydrolysis upon contact with living tissues, such as skin and flesh. In addition, it exhibits a strong dehydrating property on carbohydrates, liberating extra heat and causing secondary thermal burns. Accordingly, it rapidly attacks the cornea and can induce permanent blindness if splashed onto eyes. If ingested, it damages internal organs irreversibly and may even be fatal.
Titanium dioxide	Titanium dioxide dust, when inhaled, has been classified by the International Agency for Research on Cancer (IARC) as an IARC Group 2B carcinogen, meaning it is *possibly carcinogenic to humans*.
Xylenes	Xylene is flammable but of modest acute toxicity, with LD_{50} ranges from 200 to 5000 mg/kg for animals. Oral LD_{50} for rats is 4300 mg/kg. The principal mechanism of detoxification is oxidation to methylbenzoic acid and hydroxylation to hydroxylene. The main effect of inhaling xylene vapor is depression of the central nervous system (CNS), with symptoms such as headache, dizziness, nausea and vomiting. At an exposure of 100 ppm, one may experience nausea or a headache. At an exposure between 200 and 500 ppm, symptoms can include feeling "high", dizziness, weakness, irritability, vomiting, and slowed reaction time.

Table C2 – Descriptive Statistics for the Chemical Variables used in Table 9

Variables	N	Mean	p25	p50	p75	SD
All Hazardous Chemicals	15,608	0.0096	0.0002	0.0015	0.0044	0.0401
Chloride-related Chemicals	15,608	0.0045	0.0000	0.0009	0.0031	0.0259

Table OC2 reports descriptive statistics on the variables used in Table 9. The variables are constructed at the HUC10 level, averaging over all HF well disclosures for each HUC10-month-year. We compute averages for the amount of all hazardous chemicals, chloride-related chemicals, respectively. For each HF well, we scale the respective amount by the total amount of fluids injected. Hazardous chemicals are those (i) regulated as primary contaminants by the Safe Drinking Water Act; (ii) regulated as Priority Toxic Pollutants for ecological toxicity under the Clean Water Act; or (iii) classified as diesel fuel under EPA guidance on HF operations (USEPA, 2012a, 2014). For the pre-period, we use voluntary disclosures to calculate HUC10-month-year averages, following Fetter (2017).

OC2. Descriptive Statistics for the Spill Data

The table below reports descriptive statistics for the variables used in Table 10. Our sample includes 2,667 spills from Colorado, North Dakota, New Mexico and Pennsylvania between January 2005 and December 2015. We only retain spills of HF chemicals and wastewater.

Table C3. Descriptive Statistics for the Spill Data used in Table 10

Variables	N	Mean	p25	p50	p75	SD
All incidents	7,562	0.172	0.000	0.000	0.000	0.413
Wastewater disposal incidents	6,440	0.093	0.000	0.000	0.000	0.283

Table OC3 reports descriptive statistics for the dependent variables used in Table 10. *All incidents* is the logarithm of one plus the number of HF-related incidents in a given HUC10-month-year. *Wastewater disposal incidents* is the logarithm of one plus the number of disposal of wastewater incidents in a given HUC10-month-year.