PRIVATE ENVIRONMENTAL GOVERNANCE IN OIL AND GAS: UNLOCKING THE COMPLEX UNIVERSE OF LEADING MANAGEMENT PRACTICES

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INTRODUCTION

Since the mid-2000s, the United States has witnessed a significant expansion of onshore fracturing and horizontal

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drilling technologies.[1] This expansion sparked a fervent national debate and calls for greater control of industry impacts. Some states have responded with regulatory changes and updates, although these vary substantially by jurisdiction.[2] Meanwhile, buffeted by debate about federal oversight of oil and gas production, the Obama Administration took only modest steps to regulate, focusing on hydraulic fracturing on public lands and air pollution from this industry.[3] Alongside these fractured regulatory efforts, a broad private governance movement has emerged in North America, with environmental groups,[4] industries,[5] government-appointed advisory commissions,[6] government agencies,[7] and others encouraging the adoption of voluntary measures—often called "best management practices" (BMPs)—to control environmental and social impacts. The extent to which operators have adopted these practices is

1. *See* Hannah J. Wiseman, *Risk and Response in Fracturing Policy*, 84 U. COLO. L. REV. 729 (2013); *see also* Tu Tran & Justine Barden, *U.S. Boosts Natural Gas Output and Use Since 2005, While OECD Europe Scales Back*, U.S. ENERGY INFO. ADMIN. (Jan. 14, 2014), https://www.eia.gov/todayinenergy/detail.php?id=14591#.

2. *See, e.g.*, NATHAN RICHARDSON ET AL., RESOURCES FOR THE FUTURE, THE STATE OF STATE SHALE GAS REGULATION (2013) (describing state regulations and their varying stringency).

3. *See, e.g.*, Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews, 77 Fed. Reg. 49,490 (Aug. 16, 2012) (to be codified at 40 C.F.R. pts. 60 & 63) (requiring control of volatile organic compound emissions from fractured gas wells); Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources, 81 Fed. Reg. 35,824 (June 3, 2016) (codified at 40 C.F.R. pt. 60) (regulating methane emissions from fractured oil and natural gas wells).

4. *See, e.g.*, MARK ZOBACK ET AL., ADDRESSING THE ENVIRONMENTAL RISKS FROM SHALE GAS DEVELOPMENT (2010), https://www.worldwatch.org/files/pdf/Hydraulic%20Fracturing%20Paper.pdf; THOMAS DARIN & TRAVIS STILLS, PRESERVING OUR PUBLIC LANDS: A CITIZEN'S GUIDE TO UNDERSTANDING AND PARTICIPATING IN OIL AND GAS DECISIONS AFFECTING OUR PUBLIC LANDS (2002).

5. *See, e.g.*, AM. PETROL. INST., API GUIDANCE DOCUMENT HF1, HYDRAULIC FRACTURING OPERATIONS—WELL CONSTRUCTION AND INTEGRITY GUIDELINES (1st ed. 2009).

6. *See, e.g.*, SEC'Y OF ENERGY ADVISORY BD., U.S. DEP'T OF ENERGY, SHALE GAS PRODUCTION SUBCOMMITTEE SECOND NINETY-DAY REPORT (Nov. 18, 2011), https://energy.gov/sites/prod/files/90day_Report_Second_11.18.11.pdf [hereinafter SECOND NINETY-DAY REPORT].

7. *See, e.g.*, MD. DEP'T OF THE ENV'T, DRAFT FOR PUBLIC COMMENT, MARCELLUS SHALE SAFE DRILLING INITIATIVE STUDY PART II: BEST PRACTICES (2013), http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/Draft_for_Public_Comment_6.24.2013.pdf [hereinafter MARYLAND BEST PRACTICES]; W. VA. DEP'T OF ENVTL. PROT., INDUSTRY GUIDANCE, GAS WELL DRILLING/COMPLETION LARGE WATER VOLUME FRACTURE TREATMENTS (2010), http://www.dep.wv.gov/oil-and-gas/GI/Documents/Marcellus%20Guidance%201-8-10%20Final.pdf [hereinafter WEST VIRGINIA, INDUSTRY GUIDANCE].

unclear.[8] But the growth of published BMPs is impressive, and suggests an important trend.

A survey of fifty-four sets of BMPs for onshore oil and natural gas production demonstrates that private governance is not new for this industry (the earliest set of standards reviewed for this paper dates to 1991;[9] the author of these standards, the American Petroleum Institute, has been setting standards since the 1920s).[10] However, BMPs from many sources proliferated with the start of the unconventional boom and persisted in their growth and geographic expansion for nearly a decade, until sustained low commodity prices drove down new well starts. Notwithstanding global efforts to reduce greenhouse gas emissions,[11] market projections[12] and U.S. policies of aggressive de-regulation and "energy dominance"[13] may drive an uptick in production—and private governance regimes—in the near future.[14]

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8. *See, e.g.*, Abrahm Lustgarten, *Underused Drilling Practices Could Avoid Pollution,* PROPUBLICA (Dec. 14, 2009), https://www.propublica.org/article/underused-drilling-practices-could-avoid-pollution-1214 (suggesting that BMPs are not readily adopted); Alexandra S. Wawryk, *International Environmental Standards in the Oil Industry: Improving the Operations of Transnational Oil Companies in Emerging Economies*, 20 J. ENERGY & NAT. RESOURCES L. 402, 420 (noting that the United States' fragmented governance system makes it difficult to determine uptake of particular practices); PAUL C. STERN, NAT'L RESEARCH COUNCIL, RISKS AND RISK GOVERNANCE IN SHALE GAS DEVELOPMENT: SUMMARY OF TWO WORKSHOPS 68 (2014) [hereinafter RISKS AND RISK GOVERNANCE] (audience discussion with presenters noting that data is not available to show whether industry actors are observing good practices).

9. AM. PETROL. INST., API PUBL. 302, WASTE MINIMIZATION IN THE PETROLEUM INDUSTRY: A COMPENDIUM OF PRACTICES (1991).

10. AM. PETROL. INST., THE OIL AND NATURAL GAS INDUSTRY'S MOST VALUABLE RESOURCE (2014), http://www.api.org/publications-standards-and-statistics/standards/~/media/Files/Publications/FAQ/valueofstandards.ashx [hereinafter API, MOST VALUABLE RESOURCE].

11. *See* Paris Agreement, *adopted* Dec. 12, 2015, T.I.A.S. No. 16-1104 (entered into force Nov. 4, 2016) (describing member party obligations to report greenhouse gases and set "nationally determined contributions" to climate mitigation, including economy-wide absolute emission reduction targets by developed countries); *but see* Michael D. Shear, *Trump Will Withdraw U.S. From Paris Climate Agreement*, N.Y. TIMES, June 1, 2017, https://www.nytimes.com/2017/06/01/climate/trump-paris-climate-agreement.html.

12. ENERGY INFO. ADMIN., SHORT-TERM ENERGY OUTLOOK: NATURAL GAS (2018), https://www.eia.gov/outlooks/steo/report/natgas.php.

13. *See, e.g.*, Press Release, Dep't of the Interior, Secretary Zinke Announces Plan for Unleashing America's Offshore Oil and Gas Potential (Jan. 4, 2018), https://www.doi.gov/pressreleases/secretary-zinke-announces-plan-unleashing-americas-offshore-oil-and-gas-potential.

14. *See, e.g.*, Press Release, Am. Petrol. Inst., Natural Gas, Oil Industry Launch Environmental Partnership to Accelerate Reductions in Methane, VOCs (Dec. 5, 2017), http://www.api.org/news-policy-and-issues/news/2017/12/04/natural-gas-oil-environmental-partnership-accelerate-reductions-methane-vocs.

The private governance movement in oil and gas over the last decade calls for extensive legal and economic analysis. The literature in this field is thin,[15] and has yet to define the universe of suggested voluntary measures, much less identify common or conflicting elements,[16] analyze the degree of compliance with these measures, or determine whether measures actually reduce environmental risk. Moreover, it is unclear to what extent the creation and adoption of BMPs informs or forestalls regulatory standards—and when these outcomes are positive or negative for environmental performance. This essay takes two steps toward filling in some of the private governance gaps in scholarship. First, it provides a descriptive framework to explore reasons for the rise of oil and gas BMPs, and to identify common themes with respect to BMP categories, authors, and the timing of their publication. Second, the essay begins to synthesize and organize the BMPs that address the risk to water resources from spills at or near oil and gas production sites.

The "best practice" concept likely hails from the field of business management, and suggests there is "always one method . . . which is . . . better than any of the rest" to achieve a goal.[17] In the U.S. environmental context, the term "best management practice" grew out of the federal Clean Water Act. There it is used to describe permit conditions for industrial "point source" permits,[18] and voluntary actions that sources not directly regulated by the statute—including most agricultural operations—can take to reduce nutrient

15. RISKS AND RISK GOVERNANCE, *supra* note 8, at 76–77 (citing Professor Barry Rabe from the University of Michigan, who notes that the shale governance literature is "very limited"); *see also* Michael P. Vandenbergh, *The Implications of Private Environmental Governance*, 99 CORNELL L. REV. ONLINE 117, 133, 138–39 (2014) (identifying topics in private environmental governance that need further research). *But see id.* at 137 n.82 (identifying some oil and gas private governance scholarship); Hari Osofsky & Hannah Wiseman, *Hybrid Energy Governance*, 2014 U. ILL. L. REV. 1 (2014) (describing governance of the energy sector by public and private actors).

16. *But see* Amanda Leiter, *Fracking, Federalism, and Private Governance*, 39 HARV. ENVTL. L. REV. 107 (2015) (providing an important initial analysis of voluntary measures within the oil and natural gas industry).

17. Gretchen Rumohr-Voskuil, *Best Practice: Past, Present, and Personal*, 25 LANGUAGE ARTS J. MICH. 26, 27 (2010) (quoting Frederick Winslow Turner, THE PRINCIPLES OF SCIENTIFIC MANAGEMENT (1911)).

18. *See, e.g.*, 33 U.S.C. § 1314(e) (2012); 40 C.F.R. § 122.44(k) (2012); *see generally* U.S. ENVTL. PROT. AGENCY, EPA 833-B-93-004, GUIDANCE MANUAL FOR DEVELOPING BEST MANAGEMENT PRACTICES (BMP) (1993), https://www3.epa.gov/npdes/pubs/owm0274.pdf.

pollution in America's waterways.[19] Today, BMPs are present in numerous industries and come in a wide variety of forms. In the oil and gas sector, the American Petroleum Institute (API)—an association of oil and gas producers—has long published detailed guidelines for improving the industry's safety and environmental performance known as "Recommended Practices."[20] The federal government has incorporated some of API's practices into regulation,[21] as have a number of states.[22] The federal government curates a separate set of oil and gas BMPs that it incorporates into permits for oil and gas development on public lands.[23]

As unconventional development took off, private actors seized upon the development of best practices or standards to promote private governance of these activities and their impacts,[24] and to suggest these practices could inform or supplant the need for public regulation. Government panels, third party certification programs, and even environmental investors and advocacy groups jumped on the BMP bandwagon, referencing private sector standards whether they were supporting or opposing them.[25]

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19. *See* 33 U.S.C. § 1319 (2012).

20. *See, e.g.*, AM. PETROL. INST., RECOMMENDED PRACTICE FOR OCCUPATIONAL SAFETY FOR OIL AND GAS WELL DRILLING AND SERVICING OPERATIONS, API RECOMMENDED PRACTICE 54 (3d ed. 1999, reaff'd. 2007), https://4cornerssafety.com/uploads/clywISBb31iOYendtRsK5JdIbQ5lytDa.pdf [hereinafter API, RECOMMENDED PRACTICE]. The API has set standards for the industry since 1924. *See supra* note 10, and accompanying text.

21. *See, e.g.*, 30 C.F.R. § 250.1629(b)(3) (2018) (incorporating by reference API RP 14G, Recommended Practice for Fire Prevention and Control on Open Type Offshore Production Platforms); 30 C.F.R. § 250.855 (2018) (incorporation of API RP 14C on emergency shutdown systems).

22. *See, e.g.*, MICH. ADMIN. CODE r. 299-2362 (2017), Cementing (incorporating by reference API specification 5CT); OKLA. ADMIN. CODE § 165-10-3(h)(5) (2017) (requiring flare tips to be placed in accordance with API Standard 2000).

23. *See* U.S. DEP'T OF THE INTERIOR & U.S. DEP'T OF AGRIC., BLM/WO/ST-06/021+3071/REV 07, SURFACE OPERATING STANDARDS AND GUIDELINES FOR OIL AND GAS EXPLORATION AND DEVELOPMENT: THE GOLD BOOK (4th ed., rev'd. 2007), https://www.blm.gov/sites/blm.gov/files/Gold%20Book%202007%20Revised.pdf [hereinafter THE GOLD BOOK].

24. *See, e.g.*, MARCELLUS SHALE COALITION, RECOMMENDED PRACTICES: DRILLING AND COMPLETION (2013) [hereinafter MARCELLUS SHALE COALITION, DRILLING AND COMPLETION]; CANADIAN ASS'N OF PETROL. PRODUCERS, CAPP HYDRAULIC FRACTURING OPERATING PRACTICE: FLUID TRANSPORT, HANDLING, STORAGE AND DISPOSAL (2012) [hereinafter CAPP OPERATING PRACTICE].

25. SEC'Y OF ENERGY ADVISORY BD., U.S. DEP'T OF ENERGY, SHALE GAS PRODUCTION SUBCOMMITTEE NINETY-DAY REPORT 4 (Aug. 11, 2011), https://www.edf.org/sites/default/files/11903_Embargoed_Final_90_day_Report%20.pdf [hereinafter NINETY-DAY REPORT] (recommending the creation of a shale gas industry organization to identify best practices); *cf*. Letter from Civil Soc'y Inst. et al. to Mr. Fred Krupp, President, Envtl. Defense Fund

BMPs are generally defined as methods found to be the most effective and practical means of achieving an objective.[26] This is a highly subjective concept. Moreover, in the dynamic, diverse space of unconventional oil and gas development, there may not be a "single best engineering practice" to develop or adopt.[27] The key, then, is whether private governance through the establishment and up-take of BMPs contributes to "a culture of continuous improvement."[28]

How do private and public sector management systems interact with one another? Do BMPs create a glide path to regulation, or delay public policy? Or do they obviate the need for regulatory intervention altogether? Taken alone or in combination with public action, do they improve safety and environmental performance? And perhaps more fundamentally, what makes a practice "best"? This essay will not answer all of these questions, but provides a framework for considering them in future scholarship.

To explore the role of BMPs in unconventional oil and natural gas production, this essay focuses on surface spills of hydrocarbons, drilling wastes, fracturing fluid, and wastewater at production sites. These releases can contaminate soil, surface water, and groundwater supplies; their impact depends on the volume and location of the release, the toxicity and persistence of spilled chemicals, the presence of barriers to the environment, and the response. The essay builds on earlier papers identifying the top pathways and causes of surface spills, based on an analysis of spill records associated with unconventional wells in four producing states: Colorado; New Mexico; North Dakota; and

(May 22, 2013), http://www.civilsocietyinstitute.org/media/pdfs/Final%20EDF%20letter-1-3-2ver3.pdf (criticizing the Environmental Defense Fund's participation in the creation of the Center for Sustainable Shale Development, an industry-environmental partnership to set environmental standards for unconventional oil and gas development).

26. *See, e.g.*, 40 C.F.R. § 130.2(m) (2018) (defining BMP as "[m]ethods, measures or practices selected by an agency to meet its nonpoint source control needs."); *see also* 2 N.C. ADMIN. CODE 60C.0102(4) (2018) (defining BMP as "a practice, or combination of practices, that is determined to be an effective and practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals").

27. *See, e.g.*, NINETY-DAY REPORT, *supra* note 25, at 10.

28. *Id.*

Pennsylvania.[29] While much of the academic literature has focused on subsurface releases and the potential for well bores to create a conduit to aquifers,[30] this essay focuses on a more prosaic threat. There is no debate over whether surface spills occur,[31] and these spills can pose risk to surface and underground water sources.[32]

The analysis draws from a survey of fifty-four BMP publications and an extensive review of the most relevant subset, to describe a suite of "leading management practices" (LMPs) that target surface spills. The essay uses the term "LMP" to capture the need for "continuous improvement,"[33] as "best" suggests each practice is as effective as it ever needs to be, and can be universally applied.[34] Instead, LMPs are those practices that appear *given current evidence* and *in a particular time and place* to be the most effective in terms of reducing surface releases and their impacts. For the remainder of the article, the term LMP is used instead of BMP.

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29. Kelly O. Maloney et al., *Unconventional Oil and Gas Spills: Materials, Volumes, and Risks to Surface Waters in Four States of the U.S.*, 581-582 SCI. TOTAL ENV'T 369 (2017); Lauren A. Patterson et al., *Unconventional Oil and Gas Spills: Risks, Mitigation Priorities, and State Reporting Requirements*, 51 ENVTL. SCI. & TECH. 2563 (2017).

30. *See, e.g.*, Robert B. Jackson et al., *The Environmental Costs and Benefits of Fracking*, 39 ANNU. REV. ENV'T & RESOURCES 237 (2014); Dominic C. DiGiulio & Robert B. Jackson, *Impact to Underground Sources of Drinking Water and Domestic Wells from Production Well Stimulation and Completion Practices in the Pavillion, Wyoming, Field*, 50 ENVTL. SCI. & TECH. 4524 (2016); Anthony R. Ingraffea et al., *Assessment and Risk Analysis of Casing and Cement Impairment in Oil and Gas Wells in Pennsylvania, 2000-2012*, 111 PNAS 10955 (2014); *see also* Wiseman, *supra* note 1, at 736 (commenting on the focus on subsurface risks).

31. *See* ALAN KRUPNICK ET AL., PATHWAYS TO DIALOGUE: WHAT THE EXPERTS SAY ABOUT THE ENVIRONMENTAL RISKS OF SHALE GAS DEVELOPMENT 28 (2013) (noting general agreement among experts regarding impacts on surface water); RISKS AND RISK GOVERNANCE, *supra* note 8, at 58 (noting that of the twelve risks that surveyed government, industry, NGO, and academic experts agreed upon, seven had to do with risks posed to surface waters).

32. *See* Amanda Shores et al., *Produced Water Surface Spills and the Risk for BTEX and Naphthalene Groundwater Contamination*, 228 WATER AIR & SOIL POLLUTION 435 (2017); Sheila M. Olmstead et al., *Shale Gas Development Impacts on Surface Water Quality in Pennsylvania*, 110 PNAS 4962 (2013); Maloney et al., *supra* note 29.

33. NAT'L PETROL. COUNCIL, *Chapter Two: Operations and Environment*, *in* PRUDENT DEVELOPMENT: REALIZING THE POTENTIAL OF NORTH AMERICA'S ABUNDANT NATURAL GAS AND OIL RESERVES 167, 171 (2011), http://www.npc.org/reports/NARD/NARD_Ops-Environment.pdf (defining "continuous improvement" as "adherence to standards and adoption of improved practices based on advances in science, technology, methods for improved risk management, and lessons learned").

34. *Cf. id.* at 179 (noting that a "one-size-fits-all approach . . . would be impossible").

This effort addresses only a small part of the growing field of private governance in oil and gas, but it is published with the hope that it will inspire further analysis. Developing a better understanding of this field and its role in oil and gas governance is critical. For instance, work could be done to further categorize and compare practices for relative cost, technical feasibility, and compatibility with different geologies; track their evolution; and prioritize those that address the most prevalent risks at a well site. As hydraulic fracturing and horizontal drilling expand across the United States and internationally, governments around the world could benefit from an improved understanding of the practices to encourage or require.

This essay begins the project of synthesizing and analyzing oil and gas private governance. Part I enumerates the factors that make unconventional oil and natural gas production particularly challenging to regulate. Part I then reviews oil and gas LMPs addressing surface spills to provide a descriptive framework for better understanding this governance area. This essay proposes grouping oil and gas LMPs into three categories: measures addressing specific pathways or causes; cross-cutting measures; and information-based measures.

Part II identifies LMPs gleaned from common themes that were identified in the twenty sets of standards most focused on spill risks and analyzes the stringency of these measures—to reduce surface releases of substances at and near oil and gas production sites. Part III looks beyond industry adoption to describe ways in which these measures are—and can be—used by other private and public actors. Much work remains to be done in the area of oil and gas private governance, but this descriptive framework and initial analysis could guide ongoing scholarly and practical discussions.

I. Drivers and General Descriptions of LMPs

A. The Rise of Unconventional Production and the Diffuse Nature of the Industry

In the mid-2000s, conventional oil and natural gas reservoirs in the United States were declining in production,[35] and natural gas prices were high.[36] But unconventional oil and natural gas production, brought on by breakthroughs in hydraulic fracturing and horizontal drilling techniques, was quietly transforming the national energy picture. In 2005, the U.S. Department of Energy began tracking unconventional production.[37] By 2015, at the height of the unconventional boom, domestic oil production had increased 55% and domestic natural gas production had increased 66%.[38]

Not only did the boom increase production, it also grew the geographic footprint of oil and natural gas production. By 2015, the U.S. Department of Energy identified thirty-four oil and natural gas producing states.[39] Production is taking place across the United States in communities that are unfamiliar with energy extraction activities[40] and the effects these activities have on traffic, air quality, water, and a town's housing stock and health services.

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35. Cynthia B. Foreso & André Barbé, *Production Increases from Shale Deposits Drive Changes in U.S. Energy Trade* 7, Fig. 3 (U.S. Int'l Trade Comm., Off. of Industries Working Paper No. ID-040, 2015), https://www.usitc.gov/publications/332/energy_initiative_working_paper_final.pdf.

36. *See* FERC STAFF REPORT, HIGH NATURAL GAS PRICES: THE BASICS (2d ed. 2006), https://www.ferc.gov/legal/staff-reports/high-gas-prices.pdf.

37. *See* U.S. DEP'T OF ENERGY, ENERGY INFO. ADMIN., DOE/EIA–0216(2007), U.S. CRUDE OIL, NATURAL GAS, AND NATURAL GAS LIQUIDS RESERVES: 2007 ANNUAL REPORT 7 (2009), http://www.eia.gov/naturalgas/crudeoilreserves/archive/2007/full.pdf [hereinafter EPA, 2007 ANNUAL REPORT].

38. *See* ENERGY INFO. ADMIN., U.S. CRUDE OIL AND NATURAL GAS PROVED RESERVES, YEAR-END 2015, at 26 tbl.5, 36 tbl.10 (2015), https://www.eia.gov/naturalgas/crudeoilreserves/index.php (publishing historic production data); *cf.* EPA, 2007 ANNUAL REPORT, *supra* note 37, app. A, at A-3 tbl.A1.

39. *See, e.g.*, Michael Lewis, *EIA Expands Geographic Coverage of Natural Gas Production with New Data for Ten States*, U.S. ENERGY INFO. ADMIN. (Jul. 1, 2015), https://www.eia.gov/todayinenergy/detail.php?id=21892.

40. *See, e.g.*, NAT'L ENERGY TECH. LAB., MODERN SHALE GAS DEVELOPMENT IN THE UNITED STATES: AN UPDATE (2013), https://www.netl.doe.gov/File%20Library/Research/Oil-Gas/shale-gas-primer-update-2013.pdf.

Unconventional oil and natural gas production differs from conventional production in intensity and scale.[41] This means that traditional materials and waste management practices may not adequately address risk. In 2010, West Virginia's Department of Environmental Protection noted that horizontal wells "are likely to result in considerably larger well sites than historically have been constructed[,]" and that the "pits associated with these operations will be containing significantly larger volumes of fluid than conventional operations."[42] As volumes grow and the chemical makeup of wastewater changes, new storage and disposal techniques may be necessary.[43]

As the shale boom in Arkansas took off in 2009, the Department of Environmental Quality inspected eleven "landfarming" facilities, and determined that every facility had overflowed and discharged wastewater into waters of the state.[44] This discovery prompted Arkansas to revoke facility permits[45] and increase testing at remaining facilities.[46] Similarly, Pennsylvania asked operators to stop sending wastewater to municipal wastewater treatment facilities, after chemical detections in the Susquehanna suggested the wastewater could not be treated adequately at those facilities.[47] State and federal agencies have adapted some regulatory requirements to meet the new realities of oil and natural gas production.

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41. *See, e.g.*, *Technology Drives Natural Gas Production Growth from Shale Gas Formations*, U.S. ENERGY INFO. ADMIN. (July 12, 2011), http://www.eia.gov/todayinenergy/detail.cfm?id=2170.

42. WEST VIRGINIA, INDUSTRY GUIDANCE, *supra* note 7, at 3.

43. *See, e.g.*, NAT'L PETROL. COUNCIL, *supra* note 33, at 193 (observing that unconventional production requires larger amounts of water and chemicals).

44. ARK. DEP'T OF ENVTL. QUALITY, ARKANSAS LAND FARM STUDY (2009), https://www.adeq.state.ar.us/water/planning/pdfs/2009_all_landfarms_combined-final.pdf.

45. *See, e.g.,* Fayetteville Shale Land Farm, LLC, AFIN 43-00527 (Ark. Dep't of Envtl. Quality, Mar. 13, 2009) (notice of violation and permit revocation), http://www.adeq.state.ar.us/downloads/webdatabases/legal/cao/lis_files/09-038.pdf.

46. *See, e.g.,* Authorization for a No-Discharge Water Permit Under the Arkansas Water and Air Pollution Control Act, Permit No. 5040-WR-1, AFIN 73-01055 (last modified Apr. 1, 210), https://www.adeq.state.ar.us/downloads/WebDatabases/PermitsOnline/NPDES/Permits/5040-WR-1.pdf (demonstrating the increased monitoring/testing requirements mandated by the Arkansas Department of Environmental Quality under a permit modified after the 2009 inspection).

47. *See* Letter from Michael Krancer, Sec'y, Pa. Dep't of Envtl. Prot., to Shawn Garvin, Regional Adm'r, Region III, U.S. Envtl. Prot. Agency (July 26, 2011), https://www.epa.gov/sites/production/files/2015-06/documents/letter_padep_natural_gas.pdf.

However, the nature of this industry makes it a regulatory challenge.[48] First, and perhaps most fundamentally, the oil and gas value chain includes millions of potential sources of air and water pollution. Estimates of active wells in the United States vary, but one industry source puts the number at 900,000.[49] Each well or well site hosts flow lines carrying chemicals, wastewater, freshwater, and product; gathering lines taking product to processing; tank batteries holding chemicals and wastewater; diesel generators; and other equipment. A study of just five gas processing facilities, twelve well sites, and seven gathering stations—a small fraction of America's oil and gas infrastructure—identified 75,000 potentially emitting components.[50] Regulators do not have a good handle on the universe of sources that could leak, explode, split, or fail, thereby releasing fracturing chemicals, drilling muds, wastewater, or product—let alone the means to confirm these components are being inspected, maintained, and replaced when necessary. State inspectors are stretched thin—in some cases asked to determine the compliance status of hundreds of wells each year.[51]

Second, the industry has changed rapidly, upending regulator expectations. Agencies struggle to catch up to changes in technology, and to understand the risks they pose and the ways to manage those risks.[52]

Third, the unconventional production industry features diverse actors of different sizes. In contrast to the off-shore oil and gas industry, independent producers[53] or stand-alone subsidiaries of the multi-national giants have dominated

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48. *See* Kate Konschnik & Mark Boling, *Shale Gas Development: A Smart Regulation Framework*, 48 ENVTL. SCI. & TECH. 8404, 8405 (2014).

49. Tim Meko & Laris Karklis, *The United States of Oil and Gas*, WASH. POST, Feb. 14, 2017, https://www.washingtonpost.com/graphics/national/united-states-of-oil/ (citing DrillingInfo.com).

50. NAT'L GAS MACHINERY LAB. ET AL., EPA PHASE II AGGREGATE SITE REPORT: COST-EFFECTIVE DIRECTED INSPECTION AND MAINTENANCE CONTROL OPPORTUNITIES AT FIVE GAS PROCESSING PLANTS AND UPSTREAM GATHERING COMPRESSOR STATIONS AND WELL SITES (2006).

51. RISKS AND RISK GOVERNANCE, *supra* note 8, at 79 (comments of Mark Zoback, Professor at Stanford University).

52. *See* Konschnik & Boling, *supra* note 48, at 8404–05.

53. Major oil and natural gas companies are integrated companies, in that they have ownership stakes upstream (in production) and downstream, to retail outlets. Independent producers own production and gathering facilities only.

market share in the U.S. shale plays.[54] These companies range considerably in size and savvy, from mom-and-pop operations to companies like Devon Energy with 2016 revenues of $12.2 billion.[55] A 2013 study counted seventy-nine companies operating 9,458 wells in Pennsylvania. Of those companies, five owned nearly half of the wells, while twenty-one owned just one or two wells.[56]

Applying uniform regulatory standards to these different firms may result in uneven compliance. Smaller companies may not have environmental compliance officers on staff, or the technical knowledge needed to meet a particular standard. In addition, some of the literature suggests smaller companies are "out of the public eye and are therefore not under the same pressures" to report on their environmental performance.[57] Smaller firms also may not hold the long view on compliance and relationship-building with regulators; instead, they may sell to larger companies when prices drop,[58] or abandon wells entirely rather than shoulder plugging and cleanup costs.[59]

Moreover, well owners rely heavily on contractors for much of the drilling and completion activities. Not only does this expand the universe of firms potentially responsible for a surface spill of chemicals, wastewater, or product, but contractors may be differently positioned in their assumption of legal risk. For instance, most state and federal requirements apply to well operators, even though

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54. *See* Jody Chudley, *The Best Little Oil Companies in Canada*, ALBERTA OIL (Oct. 21, 2106), https://www.albertaoilmagazine.com/2016/10/best-little-oil-companies-canada/; *see also* ZHONGMIN WANG & ALAN KRUPNICK, US SHALE GAS DEVELOPMENT: WHAT LED TO THE BOOM 10 (Resources for the Future Issue Brief 13-04, 2013) (noting that the major producers were more interested in conventional oil and gas development).

55. Devon Energy Corp., Annual Report (Form 10-K) 58 (Feb. 15, 2017).

56. RISKS AND RISK GOVERNANCE, *supra* note 8, at 107–08 (describing a presentation and study by Jennifer Nash, Executive Director of the Mossavar-Rahman Center for Business and Government at the John F. Kennedy School at Harvard University).

57. Wawryk, *supra* note 8, at 425 n.100 (citing SUSTAINABILITY LTD. & UNEP, THE OIL SECTOR REPORT: A REVIEW OF ENVIRONMENTAL DISCLOSURE IN THE OIL INDUSTRY 10 (1999)).

58. *See* Andy Vuong, *Economy Unearths Stripper Well Risks*, DENVER POST, Nov. 14, 2008, https://www.denverpost.com/2008/11/14/economy-unearths-stripper-well-risks/.

59. Joshua Zeffos, *'Orphaned' Oil and Gas Wells are on the Rise*, HIGH COUNTRY NEWS (Jan. 16, 2018), http://www.hcn.org/issues/50.3/energy-industry-orphaned-oil-and-gas-wells-are-on-the-rise.

service companies such as Halliburton, Baker Hughes, and Schlumberger perform many of the higher-risk activities that take place at a well site.[60]

In addition, while some independent producers belong to the American Petroleum Institute, many of them belong to a different trade association—the Independent Producers Association of America (IPAA)—or to no trade group at all. The different trade groups and companies often reflect sharply different views on regulation. The fractured association membership also inhibits universal uptake of voluntary standards,[61] as differently placed companies "gain exposure to and adopt new technologies and operating practices in different ways and at different rates."[62]

Layered over the industry's complexity is a de-centralized regulatory landscape.[63] In the United States, private contract law and state regulation are the primary drivers of legal constraints on oil and gas exploration and development. This can lead to a proliferation of different legal standards in different parts of the country, and siloed data sets that make interstate analysis of the environmental risks of oil and gas activities challenging. On the other hand, "a constrained federal role may create interesting opportunities for states, localities, and industry organizations to develop new roles in governance."[64]

The industry is remarkably innovative, but absent strong and consistent regulatory mandates or market signals,[65] this

60. RISKS AND RISK GOVERNANCE, *supra* note 8, at 108.

61. *See also* Magali Delmas & Michael W. Toffel, *Stakeholders and Environmental Management Practices: An Institutional Framework*, 13 BUS. STRATEGY & ENV'T 209, 214 (2004) (noting that greater market concentration leads to faster diffusion of environmental management practices "than if the industry were more fragmented").

62. NAT'L PETROL. COUNCIL, *supra* note 33, at 172–73; *see also* RISKS AND RISK GOVERNANCE, *supra* note 8, at 108 (noting that a diverse set of players in the industry may inhibit self-regulation).

63. *See* Osofsky & Wiseman, *supra* note 15, at 17 ("Much of the law applicable to hydraulic fracturing is state-based—a confusing mix of common law property and statutory environmental and energy regulation.").

64. RISKS AND RISK GOVERNANCE, *supra* note 8, at 77.

65. Market signals might include consumer/community demand, insurance premiums and the ability to acquire insurance, see Peter Behr, *Insurance Issues Loom Over Shale Gas Development*, E&E NEWS (Aug. 1, 2013), https://www.eenews.net/stories/1059985449, and investor and shareholder concerns, see David Hasemyer, *3 Dozen Shareholder Climate Resolutions Target Oil, Gas and Power Companies*, INSIDECLIMATE NEWS (Mar. 8, 2018), https://insideclimatenews.org/news/07032018/shareholder-resolutions-climate-change-2-degrees-methane-lobbying-trump-administration.

innovation is focused on production efficiency and cutting costs—not environmental performance.

B. Concerns about the Risk to Water Resources

Attendant with the rapid increase in the geographic distribution of oil and gas production, and a sharp rise in the scale of production, was a growing concern about the risks of drilling and completion activities to water resources.[66] Some of this concern was based on actual incidents of water contamination and lost aquatic diversity near oil and natural gas production and wastewater treatment facilities.[67]

In particular, much of the public fear[68] and the academic literature[69] since 2005 focused on the risk posed by subsurface incidents. However, lack of access to subsurface locations has made this risk relatively difficult to document and characterize. Surface spills at production sites are more readily detected and more widely reported.

For this reason, researchers convened by The Nature Conservancy and the National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California,

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66. *See, e.g.*, Wiseman, *supra* note 1.

67. *See, e.g.*, Maloney et al., *supra* note 29, at 370; *see also* Diana M. Papoulias & Anthony L. Velasco, *Histopathological Analysis of Fish from Acorn Fork Creek, Kentucky, Exposed to Hydraulic Fracturing Fluid Releases*, 12 SE. NATURALIST 92 (2013); Kathleen A. Patnode et al., *Effects of High Salinity Wastewater Discharges on Unionid Mussels in the Allegheny River, Pennsylvania*, 6 J. FISH & WILDLIFE MGMT. 55 (2015); Denise M. Akob et al., *Wastewater Disposal from Unconventional Oil and Gas Development Degrades Stream Quality at a West Virginia Injection Facility*, 50 ENVTL. SCI. TECH. 5517 (2016); Christopher D. Kassotis et al., *Endocrine Disrupting Activities of Surface Water Associated with a West Virginia Oil and Gas Industry Wastewater Disposal Site*, 557-558 SCI. TOTAL ENV'T 901 (2016); Patterson et al., *supra* note 29, at 2563 (citing Yusuke Kuwayama et al., *Water Quality and Quantity Impacts of Hydraulic Fracturing*, 2 CURRENT SUSTAINABLE RENEWABLE ENERGY REP. 17 (2015)); Dan Packel, *Pa. Families Win $4.2M Verdict in Cabot Fracking Trial*, LAW360 (Mar. 10, 2016), https://www.law360.com/articles/770036; *but see* Memorandum Opinion, Ely et al. v. Cabot Oil & Gas Corp., et al., Case No. 3:09-CV-2284, (D.P.A Mar. 31, 2017) (vacating jury award and ordering a new trial).

68. *See, e.g.,* Stephen O'Day & Jessica Lee Reece, *Top Environmental Concerns in Fracking*, OIL & GAS MONITOR (Mar. 19, 2012), http://www.oilgasmonitor.com/top-environmental-concerns-fracking/; Neela Banerjee, *Has Fracking Tainted Your Water? Scientists Say EPA Safety Study Was Censored*, INSIDECLIMATE NEWS (Dec. 5, 2017), https://www.dallasnews.com/news/environment/2017/12/05/water-tainted-fracking-scientists-said-safe-now-say-censored.

69. *See* sources cited *supra* note 30. *See also* Wenjiang Sang et al., *Effect of Hydrofracking Fluid on Colloid Transport in the Unsaturated Zone*, 48 ENVTL SCI. & TECH. 8266 (2014).

Santa Barbara[70] compiled and reviewed spill data associated with unconventional oil and natural gas wells in four states—Colorado, New Mexico, North Dakota, and Pennsylvania. This research culminated in the publication of two papers.[71] The analysis identified 21,300 unconventional wells drilled between 2005 and 2014 in these states, and 6,622 spills attributed to or associated with those wells.[72] When spill reports identified the materials released, the materials most often spilled in Colorado were crude oil, drilling waste, wastewater, and fracturing solution; in New Mexico, wastewater, crude oil, natural gas, and drilling waste; in North Dakota, crude oil, wastewater, drilling waste, and fracturing solution; and in Pennsylvania, drilling waste, wastewater, and natural gas.[73] Fifty-seven of the spills were of fresh water; these spills tended to be much larger in volume than other types of spills.[74]

Most of the spilled materials did not reach surface waters, although 7% of the spills reached water or came within 100 feet of a water body.[75] Moreover, it was not possible with available data to determine whether spills percolated into the ground to affect groundwater. Despite the absence of evidence to suggest significant environmental harm from these spills, spill data is important to study in order to characterize the mechanics and sources of spills, and thus, suggest LMPs for better managing fluids.

70. *SNAPP: Impacts of Hydraulic Fracturing on Water Quantity and Quality Working Group*, NAT'L CTR. FOR ECOLOGICAL ANALYSIS & SYNTHESIS, https://www.nceas.ucsb.edu/featured/baruch-mordo (last visited Mar. 23, 2018).

71. *See* Patterson et al., *supra* note 29; Maloney et al., *supra* note 29.

72. *See* Maloney et al., *supra* note 29, at 372 tbl.1. The Patterson paper used state well data rather than a proprietary data set, and counted all Colorado wells through 2014, resulting in a higher well count. *See* Patterson et al., *supra* note 29, at 2567 & SI Table S4 (recording 30,848 unconventional wells from 2005-2014, and 6,648 spills).

73. *See* Maloney et al., *supra* note 29, at 372 (citing tbl. S3, Fig. 2B) (calculating top spilled material rates per 100 spudded wells: crude oil (2.7% of wells), drilling waste (2.5%), wastewater (1.7%) and HF solution (0.5%) in CO; wastewater (6.3%), crude oil (5.5%), natural gas (1.3%) and drilling waste (0.5%) in NM; crude oil (24.1%), wastewater (14.1%), drilling waste (3.2%) and HF solution (1.4%) in ND; and unknown (6.4%), drilling waste (3.6%), wastewater (3.3%) and natural gas (1.9%) in PA).

74. *Id.* at 372–73.

75. *Id.* at 373–74 (citing tbl. 2). Spills were mapped in relation to flowing as well as ephemeral and intermittent streams, because all three can serve as conduits to other bodies of water. The available data did not reveal whether water was flowing in streams at the time of a spill.

The analysis identified common pathways and causes of spills on well sites. "Pathways" described the location where the spill began.[76] Between 93% (in Pennsylvania) and 98% (in North Dakota) of all spills came from the following pathways: drilling equipment; completion equipment; tanks; pits; flowlines; heater treaters (cylindrical containers that heat oil to ease transport in cold weather); pumps; transportation; wellhead leaks; blowouts;[77] and "unknown" (signifying that the spill report did not reveal where the spill originated).[78] Spills from tanks, pits, and flowlines accounted for 50% of the spills where the patheway was reported, with tanks and flowlines each accounting for at least one in five spills.[79] Another 7.8% of well site spills related to transportation, with 87% of those spills occurring during loading and unloading of liquids for fueling, mixing, and disposing of materials offsite.[80]

Spill causes fell into four general categories: equipment failure (including leaks, corrosion, and broken components); environmental conditions (i.e., freezing, high winds, and animals); human error (from accidental mishaps such as overflows and incorrect valve positions, to intentional bad acts such as vandalism and illegal dumping); and "unknown".[81] In the time period represented by the dataset, only Colorado and New Mexico asked operators to report the likely cause of a spill; therefore, cause was not reported for most of the spills in North Dakota and Pennsylvania.[82] When cause was made known to regulators in all four states, equipment failure was the most common, followed by human error.[83]

Within these categories, some spill reports were much more specific, recounting stories of rusted, burst, frozen,

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76. Patterson et al., *supra* note 29, at 2566.

77. *Id.* The dataset suggested that only about 1 well in 1,000 will experience a blowout. This is consistent with other estimates in the literature. *See* discussion *infra* Section II.B.6.

78. Patterson et al., *supra* note 29, at 2566.

79. *See id.* at 2569.

80. *Id.*

81. *Id.* at 2566.

82. *See id.* In addition, almost half of the New Mexico spills in the dataset likewise fail to identify cause. *See also id.* at 2570 fig.8.

83. *See id.*

corroded, or worn drain lines, thief hatches, equalizers, welds and seams, filters, gaskets, hoses, Murphy switches, fittings, hammer unions, nipples, and valves.[84]

With the risks better identified and characterized—while also recognizing the factors that make this industry a particularly fertile ground for private environmental governance—this essay now turns to a review of the LMPs that seek to prevent, mitigate, or reduce the impact of surface spills.

C. General Characteristics of Surface Spill LMPs

As noted in the Introduction, LMPs are voluntary measures designed to effectively achieve an outcome; here, the reduction of surface spills and mitigation of their impact on surface and groundwater resources. In recent years, the number and type of oil and gas LMPs has exploded. We reviewed fifty-four sets of standards, and focused on twenty that targeted risks from surface spills. This part makes general observations about oil and gas LMPs to provide a framework for evaluating the nature and role of LMPs in improving practices in unconventional oil and gas development. Specifically, it describes the types of LMPs that have been proposed, the groups that have proposed them, the timing of their emergence, and other notable LMP trends and patterns.

1. Types of LMPs

There are many types of LMPs. For ease of exploration, this essay proposes categorizing practices into three broad types: source-specific, cross-cutting, and informational.

"Best practices" most commonly conjures up source-specific measures—those tailored toward particular types of equipment or activities at well sites, or specific causes of spills such as corrosion, flooding, fire, or human error. Many

84. *See generally SNAPP—Hydraulic Fracturing—Unconventional Oil and Gas Spills: Risks, Mitigation Priorities, and State Reporting Requirements*, KNOWLEDGE NETWORK FOR BIOCOMPLEXITY, https://knb.ecoinformatics.org/#view/doi:10.5063/F1KD1VVS (last visited Mar. 23, 2018).

source-specific LMPs have been published; to make sense of them, it is exceedingly important to subcategorize practices and prioritize them based on the most prevalent risks at well sites. Within those priority areas, one could then start to evaluate which LMPs might be most effective or helpful. For example, some LMPs suggest lining fluid storage pits, so that if fluid escapes the pit, it does not enter the soil. Potentially more effective LMPs identify the necessary material and thickness of the liner to be used and suggest methods for maintaining its integrity. These provide helpful guidance, so long as they don't "lock-in" standards and inhibit uptake of comparably effective or superior products as they come to market. Still another group of LMPs discourage pits entirely, instead promoting "closed-loop" systems that store fluids in enclosed storage units. This essay does not suggest which source-specific LMPs are superior, but in the context of surface releases, it attempts to identify the range of measures promoted by LMPs.

Our second proposed category of LMPs encompasses measures that tend to reduce the impacts of any mishap, no matter the equipment or technology involved. Although many LMPs identify specific practices or technologies that can reduce individual risks, such as the risk of chemicals spilling from a tank and entering surface water, there is an large and important category of practices that we view as "cross-cutting"—they reduce a variety of risks at a well-site regardless of the specific practice or technology producing the risk. For example, the use of lower- or zero-toxicity chemicals for fracturing means that no matter how much of the chemical spills, or where it spills, these fluids will pose lower risk to environmental receptors (a stream, a field of wheat, a child) than fluids containing higher-toxicity chemicals. Similarly, the recommended use of "setbacks"—rules ensuring minimum distances between well sites and homes, water supplies, and sensitive natural resources—means that any type of spill is less likely to reach the environment than if the site were closer to the affected resource.

Cross-cutting LMPs, which have not previously been identified in a category of their own, are important and deserve more attention in future work. They are efficient, in that changing one practice or technology, such as the type of chemical used at a well site, can reduce numerous risks. They are also universally applicable, and could be particularly important as governments and industries worldwide grapple with the best means of reducing the risks posed by oil and gas development. Whether a well site is in a desert or the middle of the ocean, using lower-toxicity chemicals or locating the site away from sensitive resources can have important benefits. Uptake of cross-cutting LMPs will still vary, of course, depending on the landscape, climate, and species existing in a particular location.

Our third proposed LMP category focuses on information-based measures that ensure the reporting and public disclosure of data that will inform risk reduction strategies. A large private governance literature has suggested that disclosure itself can reduce certain risks.[85] There are, of course, limitations to information-based strategies. For example, a homeowner who learns that certain chemicals are stored at a nearby well site might not have the scientific knowledge required to understand the magnitude of the risk associated with those chemicals. She may also lack the means to avoid the risk—for instance, she might not be able to move away or to purchase technology that could reduce her exposure to releases. Meanwhile, consumers of electricity or heating powered by natural gas may not be able to connect the product that they consume with the chemicals used at some well site hundreds or thousands of miles away.[86]

Yet, information disclosure can still be effective. More robust and uniform information about the chemicals, actors, and technologies present at well sites can provide useful data for scientists, regulators, insurers, and other experts with the knowledge and resources to assess risks and methods for risk reduction. Meanwhile, information about incidents and

85. *See, e.g.,* Bernard S. Black, *Dislosure, Not Censorship: The Case for Proxy Reform*, 17 J. CORP. L. 49 (1991); Michael D. Guttentag, *An Argument for Imposing Disclosure Requirements on Public Companies*, 32 FLA. ST. U. L. REV. 123 (2004); David W. Case, *The Law and Economics of Environmental Information as Regulation*, 31 ENVTL. L. REP. 10,773 (2001); David W. Case, *Corporate Environmental Reporting as Informational Regulation: A Law and Economics Perspective*, 76 U. COLO. L. Rev. 379, 385–86 (2005); *but see* Steven M. Davidoff & Claire A. Hill, *Limits of Disclosure*, 36 SEATTLE U. L. REV. 599 (2012-2013).

86. Kate Konschnik, *Goal-Oriented Disclosure Design*, 54 NAT. RESOURCES J. 319, 347 (2014).

their causes improves understanding of the most prevalent impacts, and thus the private or public measures needed to address them.[87]

2. Actors Generating LMPs

As public attention to oil and gas development grew, more groups proposed improved regulations, LMPs, or both. Many of the LMP compilations researched for this essay were published by national environmental non-government organizations (NGOs), or industry associations such as the American Petroleum Institute. The Investor Environmental Health Network (IEHN), an organization using shareholder power to reduce the use of toxic chemicals in publically traded companies, also has developed oil and gas LMPs.[88] Still other practices have been proposed by private groups convened specifically to create a voluntary regime for on-shore oil and gas production. The most prominent example of this type of group is the Center for Responsible Shale Development (CRSD), where oil and gas companies partner with environmental NGOs to craft voluntary LMPs, and then certify compliance with these LMPs.[89]

Governments are also important contributors to the creation and dissemination of LMPs. Although federal and state agencies play a large regulatory role in this space, that is not their exclusive role. The U.S. Department of Energy, for instance, leads technical workshops,[90] and funds

87. *See* COLO. OIL AND GAS CONSERVATION COMM'N, OGCC-2014-PROJECT #7948.2014, RISK-BASED INSPECTIONS: STRATEGIES TO ADDRESS ENVIRONMENTAL RISK ASSOCIATED WITH OIL AND GAS OPERATIONS 24–25 (determining in a review of spill reports that pipelines and flowlines accounted for half of all spills); COLO. OIL AND GAS CONSERVATION COMM'N, RULES 1101 AND 1102: FLOWLINE GUIDANCE (2015), http://cogcc.state.co.us/documents/reg/OpGuidance/Rule%201101%20and%201102%20Flowline%20Guidance%20-%20515-15.pdf (writing rules in response to the analytical findings).

88. *See* INVESTOR ENVTL. HEALTH NETWORK, EXTRACTING THE FACTS: AN INVESTOR GUIDE TO DISCLOSING RISKS FROM HYDRAULIC FRACTURING OPERATIONS (2015), http://www.iehn.org/documents/frackguidance.pdf

89. *See* CTR. FOR RESPONSIBLE SHALE DEV., http://www.responsibleshaledevelopment.org/ (last visited Apr. 3, 2018); *see also* ROBERT LACOUNT ET AL., NAT'L GAS SUPPLY COLLABORATIVE, ENVIRONMENTAL AND SOCIAL PERFORMANCE INDICATORS FOR NATURAL GAS PRODUCTION (2017), https://www.mjbradley.com/sites/default/files/NGSCIndicatorsFinal.pdf (set of standards published by a consulting firm with several natural gas companies).

90. *See, e.g.*, U.S. Dep't of Energy, Natural Gas Infrastructure R&D and Methane Emissions Mitigation Workshop, Nov. 12-13, 2014, Sheraton Pittsburgh Airport Hotel, Final

innovative energy and environmental performance research.[91] Even those agencies that identify largely as regulators employ non-regulatory strategies to enhance environmental performance and regulatory compliance. These agencies may employ a combination of legal requirements and LMPs into their work. For example, LMPs may inform permit conditions.[92] Agencies may also alert the oil and gas community to LMPs, encouraging their use and suggesting compliance even in the absence of a direct order.[93] In addition, LMPs may be a glide path to regulation. For instance, the U.S. Environmental Protection Agency (EPA) has developed LMPs with the natural gas industry through its voluntary program Natural Gas STAR, and then incorporated some of these practices into regulation.[94]

Sometimes, federal agencies and state governments have convened or directed advisory panels to craft unconventional oil and natural gas LMPs. The Department of Energy under the Obama Administration tasked the Secretary of Energy Advisory Board Shale Gas Subcommittee with research into improved oil and gas practices.[95] Pennsylvania's Governor Corbett ordered a group of experts "from within the

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Agenda, https://energy.gov/sites/prod/files/2014/11/f19/NG-Infrastructure-Workshop_Agenda .pdf.

91. *See, e.g.,* Press Release, U.S. Dept. of Energy, Office of the Under Secretary for Sci. & Energy, DOE Announces $13 million to Quantify and Mitigate Methane Emissions from Natural Gas Infrastructure (Sept. 8, 2016), https://www.energy.gov/under-secretary-science-and-energy/articles/doe-announces-13-million-quantify-and-mitigate-methane; SHALE RESEARCH & DEVELOPMENT, U.S. DEPT. OF ENERGY, https://www.energy.gov/fe/science-innovation/oil-gas-research/shale-gas-rd (last visited Apr. 25, 2018) (describing funding efforts of the DOE's Office of Fossil Energy to contribute to "a safe and environmentally sustainable supply of natural gas").

92. *See* WEST VIRGINIA, INDUSTRY GUIDANCE, *supra* note 7, at 1 (noting that the document is intended to "facilitate compliance with applicable statutory and regulatory requirements … by promoting the use of necessary best management practices" and advising that the state will require new information in the permit application, which will be appended to the source permit).

93. *See e.g.*, OHIO ENVTL. PROT. AGENCY, OHIO'S REGULATIONS: A GUIDE FOR OPERATORS DRILLING IN THE MARCELLUS AND UTICA SHALES (2012) [hereinafter OHIO EPA, GUIDEBOOK]; WEST VIRGINIA, INDUSTRY GUIDANCE, *supra* note 7.

94. *See, e.g.*, *EPA's Voluntary Methane Programs for the Oil and Natural Gas Industry*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/natural-gas-star-program (last updated Jan. 31, 2018); *see also* Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews, 77 Fed. Reg. 49,490 (Aug. 16, 2012) (to be codified at 40 C.F.R. pts. 60 & 63) (incorporating the voluntary "green completion" standard used in Natural Gas STAR); *see also infra* at 298-99.

95. *See generally* NINETY-DAY REPORT, *supra* note 25; SECOND NINETY-DAY REPORT, *supra* note 6.

environmental, conservation, state and local government, academic, and natural gas industry communities" to form the Marcellus Shale Advisory Commission and write recommendations for mitigating environmental impacts.[96] Governor O'Malley similarly directed the Maryland Department of the Environment and Department of Natural Resources "to assemble and consult with an Advisory Commission" to identify practices that would reduce the environmental risks posed by hydraulic fracturing in that state.[97]

Government-appointed advisory panels are not always intended to suggest new regulatory requirements. The Shale Gas Subcommittee of the Secretary of Energy's Advisory Board, for instance, recommended the creation of a "shale gas industry production organization" to identify "best" practices for four aspects of unconventional natural gas production.[98] Commenters noted that the brief recommendation left open many questions about the representation, accountability, and technical capacity of such an organization;[99] to date, no such private-sector LMP organization has been created.

3. Timing Trends of LMPs

The following chart (Chart 1) maps out the timeline of LMPs reviewed for this essay. While some of the standards predate the shale gas boom, the chart reflects a marked increase in the publication of industry standards as unconventional oil and gas expanded, from 2005–2013. The proliferation in standards likely flowed from multiple factors, including the change in production techniques and their likely impact on the environment, as well as greater public awareness and concern about oil and natural gas production.

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96. GOVERNOR'S MARCELLUS SHALE ADVISORY COMM'N, REPORT (2011), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf [hereinafter MARCELLUS SHALE REPORT].

97. MARYLAND BEST PRACTICES, *supra* note 7, at 4.

98. NINETY-DAY REPORT, *supra* note 25, at 4.

99. *See, e.g.*, Ben W. Heineman, Jr., *Can the Fracking Industry Self-Regulate?*, THE ATLANTIC (Aug. 19, 2011), https://www.theatlantic.com/technology/archive/2011/08/can-the-fracking-industry-self-regulate/243831/.

Alongside lower oil[100] and gas prices[101] and flagging wells in 2015–2016,[102] the pace of new LMPs slowed. The chart reveals another, more modest uptick in 2017. This is a trend worth watching. Because production levels remain relatively low, new LMPs and industry-driven risk management systems could be rising up to take the place of regulatory rollbacks by the federal government.

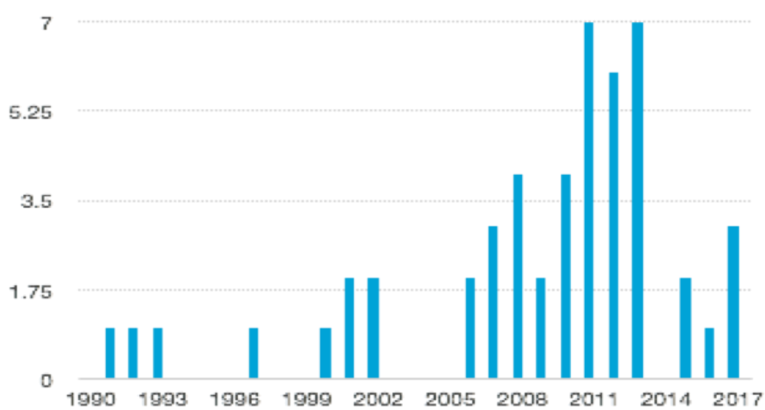

Chart 1. LMPs Timeline

4. Other LMP Characteristics

A few other characteristics common across oil and natural gas LMPs are notable. First, none of the LMP compilations sought to prioritize practices that might mitigate the biggest or most likely risks. Instead, they swept across all aspects of well development and production, treating each practice as important as the last. For instance, despite surface spills being readily documented, only twenty of the fifty-four sets of LMPs really addressed this risk to water resources. In turn,

100. DELOITTE, OIL AND GAS REALITY CHECK 2015: A LOOK AT THE TOP ISSUES FACING THE OIL AND GAS SECTOR 1 (2015), https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-oil-and-gas-reality-check-2015.pdf (noting how oil prices dropped in December 2014 from $100 to below $60 per barrel, and sliding below $45 in 2015).

101. Kristen Tsai & Jason Upchurch, *Natural Gas Prices in 2016 Were the Lowest in Nearly 20 Years*, U.S. ENERGY INFO. ADMIN. (Jan. 13, 2017), https://www.eia.gov/todayinenergy/detail.php?id=29552.

102. Laura Legere, *U.S. Shale Gas Production Hits New Record with Fewer* Wells, GLOBAL WARMING POL'Y F. (June 9, 2016), https://www.thegwpf.com/u-s-shale-gas-production-hits-new-record-with-fewer-wells/.

those standards that did address surface spills failed to target some of the higher-risk pathways and causes of spills, such as completion equipment, heater treater failures, and wellhead leaks. Going forward, it may be more effective to correlate and calibrate practices to the risks that data suggest might be either the highest impact or most likely events. For that reason, Part II focuses on LMPs that correlate to the most common surface spills detected in earlier analyses of state spill data.

Second, the published LMPs do not mention cost or implementation detail. This makes it difficult to assess on their face whether these practices are practical for all firms, or possible to implement in different shale plays and geographic contexts. On the other hand, the third general observation is that there appears to be strong agreement across LMPs on ways to reduce the risk and impact of surface spills. There may be more deviation for risks that are more speculative, or dominated by low probability, high impact events.

Fourth, the LMPs for unconventional oil and gas production, much like regulation in this area, focus almost exclusively on well owners and operators. Given how much of the well construction, completion, and production process relies on contractors, this may reveal a gap in governance. Fifth, for some of the types of LMPs reviewed, there has been a notable uptake of these practices into regulatory requirements. Part II makes selective notation where this has occurred but does not attempt to be comprehensive.

II. LEADING MANAGEMENT PRACTICES FOR SURFACE-BASED IMPACTS

Having identified and categorized the possible universe of relevant LMPs, this part focuses on the subset of standards that seek to prevent or mitigate impacts associated with surface spills and releases at well sites or from pipelines leading to and from these sites. As noted in the introduction, Part II focuses on surface spill LMPs, placing them in the substantive categories introduced in Part I: cross-cutting measures, source- or impact-specific measures, and informational measures. The source-specific category focuses on LMPs that address the most common surface impacts and their causes, as identified in previous analyses. This effort helps to demonstrate how the industry, regulators, and scholars can begin to navigate the vast universe of LMPs and identify those standards that might be the most effective, practical, or efficient for specific circumstances.

There are two critical limitations to this effort. First, it is difficult to comprehensively identify the full universe of LMPs, given the many sources for these standards. Most of the sets of practices described in this article were identified in a U.S. EPA compilation from April 2014, or through references cited in that publication.[103] Further research was done to search for updates of earlier standards and new standards published since April 2014. This review revealed twenty sources that contained LMPs most relevant to surface impacts. This method may not have identified all of the applicable LMPs; however, what is described in this essay should be a relatively robust and reasonably representative set of practices that exist in this area.

Second, in suggesting which practices might be "leading practices" most relevant to surface spills, this essay does not attempt to identify which leading practices were the "best" from the perspective of most effective at preventing or mitigating spills. One could compare similar practices and select the most apparently stringent as the "best." However, in some cases more stringent measures may not be adopted, if they are likely to cause higher costs for the operator or are otherwise considered infeasible. Furthermore, a simple recommendation that operators should contain potential spills from tanks might be preferable to more prescriptive standards, to the extent it can induce operators to develop creative spill prevention methods not yet imagined by LMP drafters. In addition, when determining which standard to apply, geography may matter; setback distances, for instance, may vary widely from a relatively "wet" landscape

103. *See generally* U.S. ENVTL. PROT. AGENCY, COMPILATION OF PUBLICLY AVAILABLE SOURCES OF VOLUNTARY MANAGEMENT PRACTICES FOR OIL AND GAS EXPLORATION & PRODUCTION (E&P) WASTES AS THEY ADDRESS PITS, TANKS, AND LAND APPLICATION (2014), https://www.epa.gov/sites/production/files/2016-04/documents/og_ep_vol_wste_mgt_prctcs_compilation_040114.pdf.

to an arid environment containing few if any permanent surface water features. Therefore, instead, the essay identifies a menu of potential leading practices that might be effective in addressing the most prevalent spill risks.

This Part begins with a survey of cross-cutting measures that would reduce the potential impact of spills from any source or cause. Next, the essay identifies the LMPs that have emerged to address the most prevalent pathways (tanks, flow lines, transfers for transport, and pits) and causes (equipment failure and human error) of surface spills, as identified in analyzing spill records from four states. Finally, this Part explores informational practices that, if adopted, would enable companies and regulators to collect and analyze more robust data, to better characterize risk and trigger the development of LMPs that are calibrated to the root causes of surface spills.

A. Cross-Cutting Measures

While most oil and gas LMPs appear to focus on discrete sources and causes of spills, some standards and regulatory guidance recognize certain practices will reduce the risk of water contamination across the board. A publication from the State of New Mexico suggests that source reduction and material substitution are highly effective generic pollution prevention strategies.[104] These are examples of "cross-cutting" measures.

Source reduction refers to the practice of decreasing a production site's use of water and production of wastewater. Some LMPs suggest pooling leaseholds or drilling multiple wells on a single pad, as a means of maximizing production over a smaller footprint and time period.[105] Others focus on recycling wastewater for reuse in drilling and hydraulic

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104. N.M. OIL CONSERVATION DIV., POLLUTION PREVENTION BEST MANAGEMENT PRACTICES FOR THE NEW MEXICO OIL AND GAS INDUSTRY 41 (2000), http://www.emnrd.state.nm.us/ocd/documents/2000PollutionPreventionBMPs.pdf [hereinafter NEW MEXICO BMPS]; *see also* OIL & GAS DIV., RAILROAD COMM'N OF TEX., WASTE MINIMIZATION (2001), http://www.rrc.state.tx.us/media/5707/wastemin.pdf [hereinafter RAILROAD COMM'N OF TEX., WASTE MINIMIZATION].

105. *See, e.g.*, APPALACHIAN SHALE RECOMMENDED PRACTICES GROUP, RECOMMENDED STANDARDS AND PRACTICES 3 (2012) [hereinafter APPALACHIAN SHALE RECOMMENDED PRACTICES].

fracturing operations,[106] or wastewater treatment to "provide more options for ultimate disposal."[107] Still others focus on drilling[108] and completion[109] techniques that reduce water use.

Material substitution calls on operators and service companies to use less toxic alternatives to drilling muds, fracturing chemicals, and solvents.[110] Some LMPs recommend phasing out diesel compounds altogether from fracturing fluids.[111] IEHN proposes standards to facilitate disclosure of corporate efforts to find less toxic alternatives to drilling and completion chemicals.[112] In 2011, IEHN demonstrated that material substitution was a practical approach that some in industry were pursuing. IEHN reported to investors that one company had eliminated 25% of the additives used in its fracturing fluid in most shale

106. *Id*. at 2 (suggesting the use of "acid mine drainage, saline ground water, industrial effluent, [and] municipal effluent"); MARYLAND BEST PRACTICES, *supra* note 7, at 37 (promoting goal of 100% recycling); 16 TEX. ADMIN. CODE § 3.8 (2018); *see also* INVESTOR ENVTL. HEALTH NETWORK & INTERFAITH CTR. ON CORP. RESPONSIBILITY, EXTRACTING THE FACTS: AN INVESTOR GUIDE TO DISCLOSING RISKS FROM HYDRAULIC FRACTURING OPERATIONS 10 (2011) [hereinafter IEHN, INVESTOR GUIDE] (Goal 7: Prevent Contamination from Waste Water); CTR. FOR RESPONSIBLE SHALE DEV., PERFORMANCE STANDARDS VERSION 1.5, at 4, 17 (adopted Aug. 19, 2013, amended Dec. 18, 2017), http://www.responsibleshaledevelopment.org/wp-content/uploads/2018/01/Performance-Standards-v.1.5.pdf [hereinafter CRSD, PERFORMANCE STANDARDS] (requiring a 90% recycling rate by March 20, 2014, under originally-adopted Performance Standard 2).

107. *See* WEST VIRGINIA, INDUSTRY GUIDANCE, *supra* note 7, at 4.

108. *See, e.g.*, NEW MEXICO BMPS, *supra* note 104, at 76; PA. DEP'T. OF ENVTL. PROT., OIL AND GAS OPERATORS MANUAL 4-5 (2001) [hereinafter PA. DEP, OIL & GAS OPERATORS MANUAL] (suggesting the use of cable tool drilling; intermediate casing strings to shut off "specific geologic horizons"; and cessation of drilling when "water is encountered in an excessive amount" until the water zone is plugged).

109. PA. DEP, OIL & GAS OPERATORS MANUAL, *supra* note 108, at 4-5 (encouraging rapid completion "to minimize the time water is being blown back to the surface").

110. *See, e.g.*, COTTONWOOD RES. COUNCIL, A COMMUNITY APPROACH TO OIL AND GAS DEVELOPMENT: CREATING A PARTNERSHIP FOR THE FUTURE 41–43 (2013); UTAH DEPT. OF ENVTL. QUALITY, BEST MANAGEMENT PRACTICES FOR OIL AND GAS INDUSTRY OPERATORS [hereinafter UTAH DEQ BMPS]; APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 4–5; MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2; MARYLAND BEST PRACTICES, *supra* note 7, at 30–31; IEHN, INVESTOR GUIDE, *supra* note 106, at 8 (Goal 4: Reduce and Disclose all Toxic Chemicals).

111. *See, e.g.*, MARYLAND BEST PRACTICES, *supra* note 7, at 34; NINETY-DAY REPORT, *supra* note 25, at 25; CRSD, PERFORMANCE STANDARDS, *supra* note 106, at 7 (Performance Standard 7).

112. IEHN, INVESTOR GUIDE, *supra* note 106, at 8 (Goal 4: Reduce and Disclose all Toxic Chemicals) (recommending "[q]ualitative or quantitative goals and/or timetables . . . for lowering toxicity of chemicals using available toxicity scoring models" and pointing to existing systems employed by Baker Hughes and Halliburton); *Id.* at 16, n.13 (describing a proposed New York regulation to require a showing by operators that they conducted an evaluation of "available alternative chemical additive products").

plays;[113] another had used a Halliburton process called CleanStream to kill bacteria in the well, thereby using ultraviolent light rather than 2,400 gallons of a "toxic biocide."[114] But substitutions can be more expensive and may not enjoy broad uptake without clear market or regulatory signals.[115] To date, very few agencies have prohibited the use of any chemical for fracturing,[116] even after EPA suggested state permitters restrict the use of several diesel compounds.[117]

Some LMPs address both source reduction and material substitution, for instance those suggesting types of drilling muds to use. Drilling muds are the fluids used to drill a well.[118] They lubricate and cool the drill bit and bring the cut-away earth back to the surface.[119] Often, the earth contains clay, which can expand when exposed to water and clog up a drilling operation. Dispersed muds contain chemicals used to break up the clay; nondispersed muds use physical methods like dilution to keep the clay from clumping.[120] One LMP suggests using nondispersed muds to reduce chemical use in the drilling stage.[121] Similar LMPs encourage clay or "solids" control to "minimize [the] need to dilute mud," thereby using less water and generating less waste.[122]

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113. IEHN, INVESTOR GUIDE, *supra* note 106, at 8 n.12 (Chesapeake Energy example).

114. *Id.* (El Paso example).

115. Lustgarten, *supra* note 8 (describing that material substitution happens more readily when required, as is the case for offshore oil and gas production, because that justifies the higher cost to shareholders).

116. *See, e.g.,* WYO. CODE R. CH. 3 § 45(g) (2018) (prohibiting the injection of certain chemicals into groundwater, and otherwise requiring pre-approval for their use).

117. U.S. ENVTL. PROT. AGENCY, EPA 816-R-14-001, PERMITTING GUIDANCE FOR OIL AND GAS HYDRAULIC FRACTURING ACTIVITIES USING DIESEL FUELS: UNDERGROUND INJECTION CONTROL PROGRAM GUIDANCE #84 (Feb. 2014). *See also* ENVTL INTEGRITY PROJECT, FRACKING BEYOND THE LAW: DESPITE INDUSTRY DENIALS, INVESTIGATION REVEALS CONTINUED USE OF DIESEL FUELS IN HYDRAULIC FRACTURING (Aug. 2014).

118. *Drilling Fluid*, SCHLUMBERGER OILFIELD GLOSSARY, http://www.glossary.oilfield.slb.com/Terms/d/drilling_fluid.aspx (last visited Apr. 26, 2018) (noting the term is synonymous with "drilling mud").

119. *Drilling Fluid*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/drilling%20fluid (last visited Apr. 26, 2018).

120. *Drilling Fluid Types*, PETROWIKI, http://petrowiki.org/Drilling_fluid_types#Nondispersed_sytems (last updated June 2, 2015).

121. NEW MEXICO BMPS, *supra* note 104, at 57, 76; *see also* RAILROAD COMM'N OF TEX., *supra* note 104, at 5-4 (suggesting low toxicity glycols, synthetic hydrocarbons, polymers and esters instead of oil-based drill fluids).

122. NEW MEXICO BMPS, *supra* note 104, at 76*; see also* RAILROAD COMM'N OF TEX., WASTE MINIMIZATION, *supra* note 104, at 5-5.

Siting decisions can dial up or down the risk of a spill polluting nearby surface or groundwater resources. Therefore, some LMPs suggest avoiding floodplains when siting a well[123] or implementing additional controls when a well pad is at risk of inundation.[124] LMPs also encourage siting that considers subsurface hydrogeology,[125] for instance, to avoid placing a well over (and therefore, drilling through) a major drinking water source. Several practices discouraged well pad development on slopes;[126] one described the additional design elements necessary to support an impoundment built into a hillside.[127] Texas suggests considering stormwater flow in site selection, to ensure flow will be captured before it contaminates surface waters.[128]

Other LMPs suggest siting wells or impoundments a minimum number of feet from surface waters and drinking water sources.[129] Less frequently, LMPs suggest not building oil and natural gas infrastructure in sensitive areas.[130] A

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123. *See* COTTONWOOD RES. COUNCIL, *supra* note 110, at 38; Scott Bearer et al., *Evaluating the Scientific Support of Conservation BMPs for Shale Gas Extraction in the Appalachian Basin*, 14 ENVTL. PRAC. 308, 314 tbl.4 (2012).

124. *See, e.g.*, MARCELLUS SHALE REPORT, *supra* note 96, §§ 9.2.12–.13, at 107.

125. *See, e.g.*, APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 2; *see also* BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS FOR HYDRAULIC FRACTURING GUIDELINE VERSION 1.1, at 12 (2016) [hereinafter BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS] (discouraging well siting "[o]n top of an aquifer or recharge area identified" by the regulator).

126. *See, e.g.*, COTTONWOOD RES. COUNCIL, *supra* note 110, at 38; MARYLAND BEST PRACTICES, *supra* note 7, at 17 (discouraging siting on slopes > 15% grade); Bearer et al., *supra* note 123, at 314 tbl.4; THE GOLD BOOK, *supra* note 23, at 15 (noting that well pads constructed on slopes are more costly "and result in greater resource impacts").

127. THE GOLD BOOK, *supra* note 23, at 17 (warning that pits constructed improperly on slopes may leak).

128. RAILROAD COMM'N OF TEX., WASTE MINIMIZATION, *supra* note 104, at 5-3.

129. *See* COTTONWOOD RES. COUNCIL, *supra* note 110, at 38 (encouraging well siting at least 1,000 feet from surface waters); MARCELLUS SHALE REPORT, *supra* note 96, § 9.2.11, at 107 (recommending a minimum setback distance from a public water supply of 1,000 feet unless waived in writing, and expansion of the minimum setback distance from a private water well from 200 feet to 500 feet); BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 12 (discouraging storage facility siting within 200 meters of a water supply well or groundwater capture zones); MARYLAND BEST PRACTICES, *supra* note 7, at 12 (identifying water features that warrant setbacks), 15 (suggesting 1that the edge of a well pad should sit at least 300 feet from wetland habitat), 18 (suggesting a 2,000 foot setback from drinking water sources); *see also* EXPLORATION & PRODUCTION WASTE MANAGEMENT FACILITIES GUIDELINES WORKGROUP, AM. PETROL. INST., API ORDER NO. G0004, GUIDELINES FOR COMMERCIAL EXPLORATION AND PRODUCTION WASTE MANAGEMENT FACILITIES 13 (2001) [hereinafter E&P GUIDELINES] (suggesting impoundments should be "appropriately spaced" from surface water bodies used for drinking water, and wetlands).

130. *See* MARYLAND BEST PRACTICES, *supra* note 7, at 14 (noting "[c]ertain ecologically important areas, recreational areas and sources of drinking water may only be fully protected if certain activities are precluded there").

number of states have incorporated setbacks in well permitting requirements.[131]

While most setback LMPs target wells and well pads, British Columbia also notes in its collection of requirements and recommendations that above-ground storage systems and containment ponds must be at least 100 meters away from the natural boundary of a water body, unless they are built on a permitted well location.[132] Another LMP discourages siting of a reserve pit in "areas with shallow groundwater."[133]

Wherever a well pad or pit is located, LMPs also suggest ways to reduce the chances that a spill from that source will reach the environment. For instance, some LMPs encourage implementation of stormwater management practices.[134] Well pad design elements can also blunt the potential impact of a release; LMPs suggest spill diversion features,[135] secondary containment,[136] impermeable berms,[137] or well pad surfaces[138] that block a spill's entry into soil or water. Finally, some LMPs advocate for more stringent site security

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131. *See id.* at 14 (noting "[c]ertain ecologically important areas, recreational areas and sources of drinking water may only be fully protected if certain activities are precluded there").

132. *See* BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 13, 16.

133. COTTONWOOD RES. COUNCIL, *supra* note 110, at 42.

134. *See, e.g.*, Bearer et al., *supra* note 123, at 314 tbl.4 (suggesting stormwater controls should be based on a 10-year/24-hour storm and also suggesting buffer strips of vegetation); OHIO EPA, GUIDEBOOK, *supra* note 93, at 6 (suggesting perimeter controls, sediment basins/traps, methods for isolating drainage, and regular inspections); APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 3 (suggesting the use of Professional Engineers to design pads and their erosion and sediment controls); *See Generally* MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2; UTAH DEQ BMPS, *supra* note 110.

135. *See* MARYLAND BEST PRACTICES, *supra* note 7, at 22 (stating well pad "design must allow for the transfer of stormwater and other liquids that collect on the pad to storage tanks . . . or . . . to trucks"); COTTONWOOD RES. COUNCIL, *supra* note 110, at 41 (suggesting sloping to reserve pit and secondary containment).

136. *See* STATE REV. OF OIL & NAT. GAS ENVTL. REG., INC., 2015 GUIDELINES § 4.2.1.4.2, at 26 [hereinafter STRONGER GUIDELINES]; COTTONWOOD RES. COUNCIL, *supra* note 110, at 41.

137. *See, e.g.*, MARYLAND BEST PRACTICES, *supra* note 7, at 22.

138. *See, e.g.*, *id.* at 22 (suggesting drill pads should be of a "'zero-discharge' design" and be "underlain with a synthetic liner with a maximum permeability of 10^{-7} centimeters per second"); MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2 (encouraging the use of temporary impermeable materials under "critical" well pad areas); STRONGER GUIDELINES, *supra* note 136, § 4.2.1.4.2, at 26 (Prevention Measures) (noting that in high-risk areas, regulators should consider requiring tertiary containment and/or monitoring systems).

measures, to prevent vandalism or unintentional damage or displacement of oil and natural gas infrastructure by persons or animals.[139]

Several cross-cutting practices target general site operations. Some recommend monitoring operating parameters[140] and testing equipment,[141] to make it more likely personnel will detect abnormal conditions and other brewing emergencies. Others advise training employees,[142] and empowering them to stop work when they observe operations "that are potentially unsafe or that may pose a significant environmental threat."[143] One LMP suggests that operators might establish "common, basin-wide minimum safety training programs and competency expectations for contractors."[144] Another recommends that the operator should have a representative onsite during critical operations undertaken by a contractor.[145]

Spill response LMPs[146] are also critical for reducing the impact of a release once it occurs. Some appear to echo existing federal requirements for spill prevention, control, and countermeasure plans,[147] including that operators

139. *See* APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 4; MARYLAND BEST PRACTICES, *supra* note 7, at 42; STRONGER GUIDELINES, *supra* note 136, § 4.2.1.4.2 at 26; *see also* BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY OPERATIONS MANUAL VERSION 1.15 § 9.1.6, at 85 (2018) [hereinafter BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY] (suggesting fencing around completed wells located within 800 meters of a populated area); CAPP OPERATING PRACTICE, *supra* note 24 (suggesting actions to restrict wildlife access to impoundments); E&P GUIDELINES, *supra* note 129, at 18.

140. APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 6, 7.

141. *See id.* at 6; BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY, *supra* note 139, § 9.6.10, at 103–04 (encouraging blowout preventer pressure tests, starting at 1,400 kPa, with no more than a 10% drop in pressure over 10 minutes), § 9.6.14, at 105–06 (advising response drills).

142. *See* BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY, *supra* note 139, at 105 (advising training in blowout prevention for "a sufficient number" of employees, including the driller, rig manager, and a permit holder representative); MARYLAND BEST PRACTICES, *supra* note 7, at 41; APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 4; MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 3 (including, suggesting having staff receive well control certification from the International Association of Drilling Contractors or the International Well Control Forum); E&P GUIDELINES, *supra* note 129, at 17.

143. APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 1.

144. *Id.* at 4.

145. *Id.* at 6; MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 3.

146. *See, e.g.*, MARYLAND BEST PRACTICES, *supra* note 7, at 22, 41.

147. Oil and Hazardous Substance Liability, 33 U.S.C. § 1321 (2012); Oil Pollution Prevention, 40 C.F.R. § 112 (2018).

prepare an emergency response plan[148] and coordinate with response agencies.[149] Others suggest having spill kits onsite at all times.[150]

B. Source-Specific or Impact-Specific Measures

Analysis of spill reporting in four states indicated that at least for the first ten years of a well's life, spills are most likely to take place during the "active phase" of drilling and completion.[151] This subpart focuses on LMPs that would be relevant during the drilling and completion phases of well development.

As noted in Part I, the most prevalent pathways for surface spills in the four-state dataset were: tanks; flow-lines; transportation (and within this category, mostly loading/unloading activities); and where they are still used, pits or surface impoundments. The most common spill causes fell into two categories: equipment failure; and human error or purposeful action (such as vandalism). This part focuses on the available LMPs that would address these pathways and causes, and reduce the occurrence and impact of high-risk releases. However, as noted, these LMPs do not address all high-risk pathways—for instance, heater treaters or equipment used in hydraulic fracturing and well completion—or causes, such as preventing vandalism and illegal dumping.

1. Drilling LMPs

At the beginning of a well's development, the oil and gas operator drills the well and lines it with steel casing and cement. To do this, the operator (or a drilling contractor) cuts through rock formations and soil thousands of feet

148. *See, e.g.*, APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 3.
149. *Id.* at 2.
150. MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2.
151. Patterson et al., *supra* note 29, at 2567.

underground. Drilling fluids and muds keep the drill bit cool and pull "drill cuttings" (debris) out of the well bore as the well deepens.[152]

During this process, spills or releases might occur from the fueling of diesel-powered equipment; the mixing and storage of drilling muds; the release of drilling muds from the rig; the storage of waste fluids and contaminated drill cuttings on site; and transfer of this waste to trucks for disposal.

Several LMPs recommended a closed-loop mud system.[153] In such a system, separation of the drill cuttings from the returned drilling fluid takes place in tanks, which are set inside of secondary containment.[154] As the Pennsylvania Department of Environmental Management explains, "When a closed loop system is used, the drilling fluid is continuously recycled down the hole to remove cuttings to the surface."[155]

One LMP recommends treating and monitoring drilling wastewater and cuttings prior to placement in a pit.[156]

2. Tank LMPs

Tanks are used onsite to store produced hydrocarbons, fresh water, chemicals, blended fracturing fluids, and when a closed-loop system is used, returned drilling fluids. Tanks often release fluids because of equipment failure; for instance, if automatic switches fail to shut down the tank when fluids in it reach a high level.[157] Tank spills also occur when valves on the tanks fail or are left open,[158] rupture,[159]

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152. RAILROAD COMM'N OF TEX., WASTE MINIMIZATION, *supra* note 104, at 4-2.

153. *See, e.g.*, NEW MEXICO BMPS, *supra* note 104, at 57; APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 4; COTTONWOOD RES. COUNCIL, *supra* note 110, at 43; IEHN, INVESTOR GUIDE, *supra* note 106, at 12 (Goal 9) (noting that all of Exxon's drilling rigs in the Marcellus region at the time used closed loop drilling fluid systems); THE GOLD BOOK, *supra* note 23, at 17.

154. MARYLAND BEST PRACTICES, *supra* note 7, at 31.

155. PA. DEP, OIL & GAS OPERATORS MANUAL, *supra* note 109, at 4-6.

156. COTTONWOOD RES. COUNCIL, *supra* note 110, at 43.

157. *See, e.g.*, Incident No. nJK1217338654, Well API No. 30-039-24591, N.M. Oil Conservation Div. (May 2, 2000).

158. *See, e.g.*, Incident No. I_1849555_V_577702, Well API No. 37-035-21162, Pa. Dep't of Envtl. Prot. (2009).

159. *See, e.g.*, Incident No. I_2236813_V_686799, Well API No. 37-115-21349, Pa. Dep't of Envtl. Prot. (2014) (employee using cell phone light to check level of fluid in tank caused vapors to ignite in the tank, rupturing the tank).

or corrode.[160] Colorado's data revealed that 72% of tank leaks were due to equipment failure (corrosion), while more than half of overflow spills were caused by human error.[161]

Many LMPs relate to tank design and use, which could address these prevalent pathways and causes. One requires that the tanks be "above ground, constructed of metal, and lined if necessary to protect the metal from corrosion from the contents."[162] Other LMPs warn that tanks should be designed for corrosion protection when necessary.[163] Another LMP recommends the use of steel tanks "at drilling sites in close proximity to drinking water resources, floodplain areas, or where shallow ground water is susceptible to contamination."[164]

One set of LMPs suggests that new tanks and ancillary equipment "should be tested and inspected before use."[165] BLM suggests checking and cleaning tank drip pans on a regular basis as well.[166]

One LMP expresses a preference for closed tanks and recommends netting open tanks to prevent migratory birds or other wildlife from accessing the contents.[167]

In addition, many LMPs encourage the use of secondary containment, to catch any release that may occur from a tank.[168] Only one LMP seemed somewhat dismissive of secondary containment, except for "extended, unmanned flowback operations."[169]

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160. *See, e.g.*, Incident No. I_2188766_V_674276, Well API No. 37-005-29498, Pa. Dep't of Envtl. Prot. (2013).

161. Patterson et al., *supra* note 29, at 2570.

162. MARYLAND BEST PRACTICES, *supra* note 7, at 23.

163. STRONGER GUIDELINES, *supra* note 136, § 5.9.3, at 55 (Tank Construction and Operation Standards); COTTONWOOD RES. COUNCIL, *supra* note 110, at 41; E&P GUIDELINES, *supra* note 129, at 15.

164. OHIO EPA, GUIDEBOOK, *supra* note 93, at 7.

165. E&P GUIDELINES, *supra* note 129, at 15.

166. THE GOLD BOOK, *supra* note 23, at 39.

167. STRONGER GUIDELINES, *supra* note 136, § 5.9.3, at 55 (Tank Construction and Operation Standards).

168. *See, e.g.*, NEW MEXICO BMPS, *supra* note 104, at 49–50 (requiring, for instance, drums and saddle tanks containing product to be stored on an impermeable pad, and mandating above-ground tanks containing fluids, other than fresh water, to be stored in an impermeable berm); APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 3, 6-7; MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2; MARYLAND BEST PRACTICES, *supra* note 7, at 22; COTTONWOOD RES. COUNCIL, *supra* note 110, at 41; E&P GUIDELINES, *supra* note 129, at 37.

169. BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY, *supra* note 139, § 9.7.9, at 122.

An API guideline noted that "loading or filling of tanks may create the potential for spills."[170] It suggests the use of valve systems that automatically close when overfill is likely and alarms that sound when the waste level in a tank exceeds a certain point.[171] (As noted, these systems need to be inspected regularly and replaced before possible failure.) Another LMP suggests tanks should have monitoring systems to track tank levels.[172]

One measure suggested labeling chemicals and storing them in a way that avoids "constant direct exposure to the sun or moisture."[173] Finally, one LMP recommends emptying tanks prior to their retirement, and removing tanks from the site once a well ceases production and is shut in.[174]

3. Pit/Impoundment LMPs

Pits or impoundments are dug into the ground at or near the well site and used to store freshwater; drill cuttings and used drilling fluids and muds; flowback; and produced water. They can be—but are not always—lined with clay, plastic, or other materials to prevent seepage into the ground. Spills from these facilities occur under a number of circumstances involving apparent liner leaks;[175] overflow;[176] and damage to pit walls from animals or weather conditions.[177]

LMPs targeting the design and operation of pits are the most detailed and technical of all the LMPs reviewed for

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170. E&P GUIDELINES, *supra* note 129, at 15.

171. *Id.*; *see also* BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY, *supra* note 139, at 39 (describing leak detection monitoring tools).

172. *See, e.g.*, APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 6, 7.

173. *See* COTTONWOOD RES. COUNCIL, *supra* note 110, at 41.

174. *See* STRONGER GUIDELINES, *supra* note 136, § 5.9.4, at 55 (Tank Removal and Closure).

175. *See, e.g.*, Incident No. 20090616151752, Well API No. 33-025-00782, North Dakota (Jun. 12, 2009) (describing an apparent leak through the liner of a pit).

176. *See, e.g.*, Doc. No. 1417895, Well API No. 05-071-0794, Colorado (Mar. 31, 2004) (describing a pit that overflowed because roads were temporarily inaccessible and a team could not reach the facility).

177. *See, e.g.*, Doc. No. 12300068, API Well No. 05-071-07081, Colorado (June 24, 2004) (noting that a badger or rodent seems to have chewed through the impoundment's wall, causing it to leak).

this essay. Perhaps not surprisingly, then, a Professional Engineer may be required to design a pit and supervise its installation.[178]

British Columbia states that pits that will contain fluids other than fresh water must not be bigger than 6600 cubic meters, and should be sited away from drilling and fracturing operations, in a location that ensures the contained fluids will remain within the leasehold in the event of a failure.[179] Texas suggests building V-shaped pits, to save money, construction time, and material costs while protecting the environment.[180] Other pit design LMPs are less specific, merely calling for sizing that "ensure[s] adequate storage" and to consider the types of waste the pit will store when setting construction standards.[181] API suggests "enhanced protective design elements" when an impoundment will be located in a 100-year floodplain or directly over an aquifer's recharge zone.[182]

Several pit LMPs encourage operators to install an impermeable liner—or two—underneath, to capture any fluids that might escape the pit.[183] Some practices specify that the liner should collect and contain spills from hoses or fittings used to load or unload fluids at the pit.[184] British Columbia, the U.S. Bureau of Land Management, and the Northern Plains Council specify recommended line thickness and permeability.[185] In addition, some measures encourage

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178. BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 9.

179. *Id.* at 13–14.

180. RAILROAD COMM'N OF TEX., WASTE MINIMIZATION, *supra* note 104, at 5-3.

181. STRONGER GUIDELINES, *supra* note 136, § 5.5.3, at 47 (Technical Criteria for Constructing Pits).

182. E&P GUIDELINES, *supra* note 129, at 13. These design elements might include dikes; berms; clay or synthetic liners; and leak detection systems. *Id.*

183. *See, e.g.*, BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 13–14. (but also describing pits that may not need liners, such as blowdown, flare and emergency pits); *see also* E&P GUIDELINES, *supra* note 129, at 36–37 (noting that multiple liners may be necessary "based on the facility's potential to contaminate water resources"); *Alternatives to Pits*, EARTHWORKS, https://earthworksaction.org/issues/alternatives_to_pits/ (last visited Apr. 21, 2018) (recommending two layers of liners in all circumstances, when pits must be used).

184. BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 13; *see also* E&P GUIDELINES, *supra* note 129, at 37 (noting that impoundments need a piping system for both liners "only in cases of substantial leachate volume and a very high groundwater contamination risk"); *cf* CRSD, PERFORMANCE STANDARDS, *supra* note 106, at 5 (Performance Standard 3) (requiring double liners, each equipped with leak detection).

185. BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 13 (recommending that the synthetic liner should be at least thirty millimeters thick and a

the use of a secondary containment system.[186] British Columbia appears to require tougher liner standards in some circumstances, for instance, when an above-ground walled storage system will be used for more than one year.[187] If an operator has not lined a pit, the organization State Review of Oil and Natural Gas Environmental Regulations, Inc. (STRONGER) encourages the operators to periodically skim and remove the hydrocarbons that accumulate on the surface;[188] another LMP suggests the removal of oil from any impoundment, lined or not.[189] Some standards require fencing for impoundments.[190] West Virginia also requires lifelines to rescue workers who may have fallen into an impoundment.[191]

Several LMPs address pit operations. Some suggest or require operators to maintain a freeboard ranging from fifty centi-meters[192] to two feet.[193] Others call for frequent inspection of the pit and liner.[194] A few LMPs call for measures to prevent birds from landing on the fluids.[195]

Some LMPs recommend doing away with pits altogether, and as an alternative, recommend using tanks and closed-loop drilling systems to store drilling waste.[196] Others are

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permeability of 10^{-7} cm/s or less); COTTONWOOD RES. COUNCIL, *supra* note 110, at 42 (recommending liners of twelve millimeters thick and a permeability of 10^{-7} cm/s or less); THE GOLD BOOK, *supra* note 23, at 17 (recommending permeability of 10^{-7} cm/s or less).

186. *See* BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 14–15 (noting the secondary containment system should hold 110% of the maximum fluid stored).

187. *See id.* (requiring a synthetically lined secondary containment structure and natural or engineered barrier between the pit and the aquifer).

188. STRONGER GUIDELINES, *supra* note 136, § 5.5.4, at 49.

189. COTTONWOOD RES. COUNCIL, *supra* note 110, at 42.

190. *See* WEST VIRGINIA, INDUSTRY GUIDANCE, *supra* note 7, at 3; THE GOLD BOOK, *supra* note 23, at 17.

191. *See* WEST VIRGINIA, INDUSTRY GUIDANCE, *supra* note 7, at 3.

192. *See* BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 14; *see also id.* at 18 (requiring one meter of freeboard for containment ponds).

193. COTTONWOOD RES. COUNCIL, *supra* note 110, at 42; THE GOLD BOOK, *supra* note 23, at 17.

194. *See, e.g.*, COTTONWOOD RES. COUNCIL, *supra* note 110, at 42 (daily leak inspections); *see also* WEST VIRGINIA, INDUSTRY GUIDANCE, *supra* note 7, at 3 (requiring "regular" inspections).

195. *See, e.g.*, COTTONWOOD RES. COUNCIL, *supra* note 110, at 42; *Alternatives to Pits*, *supra* note 183.

196. OHIO EPA, GUIDEBOOK, *supra* note 93, at 7; MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2; MARYLAND BEST PRACTICES, *supra* note 7, at 23 (recommending use of pits only for fresh water storage and collection); COTTONWOOD RES. COUNCIL, *supra* note 110, at 42; IEHN, INVESTOR GUIDE, *supra* note 106, at 10 (Goal 7); CRSD, PERFORMANCE STANDARDS, *supra* note 106, at 5 (Performance Standard 3)

less direct but note that the use of pits "is declining nationally" and that the "use of alternatives is generally encouraged."[197]

4. Flowline LMPs

Flowlines are used in many ways on a well site—to carry fresh water to the drilling rig, chemicals to mixing tanks, wastewater away from the well, and hydrocarbons produced from the well. They vary in length and thickness, are made of polyvinyl, steel, and poly-coated metal, and may be installed above or below ground for temporary or long-term use. Spills can occur from flowlines when: someone disconnects the hose;[198] the line corrodes and begins to leak;[199] a valve fails;[200] or a flowline freezes and cracks.[201]

Flowline LMPs suggest regular testing of flowlines for leaks.[202] New Mexico recommends "preventative maintenance" on flowlines without more detail.[203] This presumably refers to ensuring that flowlines are properly connected to the well or containers and that they are not cracked or otherwise compromised.

In addition, several LMPs address the risk of spills or releases when a truck backs over a flowline or excavation activities sever a line that runs underground. One urges operators to know where subsurface flowlines are located

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(requiring phase-out of pits by March 20, 2015); RAILROAD COMM'N OF TEX., WASTE MINIMIZATION, *supra* note 104; *Alternatives to Pits*, *supra* note 183.

197. STRONGER GUIDELINES, *supra* note 136, at 47–48. *See also* E&P GUIDELINES, *supra* note 129, at 36 (noting that tanks "can be used to replace surface impoundments").

198. *See, e.g.*, Incident No. 400608672, Well API No. 05-123-38563, COGIS (May 14, 2014).

199. *See, e.g.*, Incident No. 2146742, Well API No. 05-045-13637, COGIS (Oct. 25, 2013).

200. *See, e.g.*, Incident No. 20060323181101, Well API No. 33-007-01489, North Dakota (Mar. 23, 2006).

201. *See, e.g.*, Incident No. nT01434429856, Well API No. 30-025-40517, N.M. Oil Conservation Div. (Dec. 10, 2014).

202. *See, e.g.*, APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 5; MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2–3; *see also* STRONGER GUIDELINES, *supra* note 136, § 11.4.1, at 95 (Reused and Recycled Fluids: Pipelines) (urging use of a leak detection system, calibrated to the age of the line and the fluids being transported).

203. NEW MEXICO BMPS, *supra* note 104, at 47.

before digging.[204] Another encourages burying flowlines at least three feet beneath the surface[205] (at least four feet below a body of water).[206] Texas suggests an automatic pump shut-off valve at a well when flowlines are at risk of freezing and rupturing.[207]

Several flowline LMPs focus on the design standards of the lines. Some recommend using flowlines "designed for at least the greatest anticipated operating pressure or the maximum regulated relief pressure."[208] They suggest using materials that will not be degraded by the fluid transferred through them.[209]

In the event a flowline does crack or rupture, LMPs recommend having "fluid recovery systems" that capture the released fluid and direct it into a tank or reserve pit.[210] Another LMP recommends using secondary containment around flowlines that must cross water courses.[211]

When the wells on a well pad are shut in, one LMP encourages disconnecting or isolating flowlines that run from the wellhead.[212] An inactive well may still collect hydrocarbons and, if a flowline should fill with methane gas, for instance, a danger is created. This is the apparent cause of the explosion in Firestone, Colorado, in 2017, when a home located near a wellfield exploded and killed two people.[213]

A limited number of states have adopted standards for flowlines. Most notably, Colorado has implemented fairly

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204. *See* MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2; *see also* MARYLAND BEST PRACTICES, *supra* note 7, at 24 (recommending non-federal pipelines report the location of their lines to the state).

205. *See* COTTONWOOD RES. COUNCIL, *supra* note 110, at 40.

206. *See id.* at 38; *see also* THE GOLD BOOK, *supra* note 23, at 36 (suggesting pipelines should be buried "below the scouring depth" of a stream).

207. RAILROAD COMM'N OF TEX., WASTE MINIMIZATION, *supra* note 104, at 6-5.

208. *See* MARYLAND BEST PRACTICES, *supra* note 7, at 24.

209. *See, e.g.*, STRONGER GUIDELINES, *supra* note 136, § 11.4.1, at 95 (Reused and Recycled Fluids: Pipelines).

210. *See, e.g.*, APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 5.

211. *See* COTTONWOOD RES. COUNCIL, *supra* note 110, at 38.

212. *See, e.g.*, BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY, *supra* note 139, at 90 tbl.9A (General Requirements for All Inactive Wells).

213. *See* David Kelly, *Deadly House Explosion in Colorado Traced to Uncapped Pipe from Gas Well*, L.A. TIMES, May 2, 2017, 7:50 PM, http://www.latimes.com/nation/nationnow/la-na-colorado-explosion-20170502-story.html.

comprehensive standards, following a study implicating these lines in many surface spills[214] and the Firestone tragedy.[215]

5. Transportation LMPs

As noted in Part I, transportation was a common pathway of spills on well sites in the four-state dataset. Within this category, most of the spills or releases occurred during the loading of waste or unloading of product at the site or during refueling events. In Colorado and New Mexico, 88% of the transportation spills were due to human error.[216] Because the dataset focused on spills at wells sites or nearby and attributed to a site, it likely underestimates the total number of spills related to transportation and potentially overestimates the share of spills that occur during loading and unloading. Nevertheless, this section focuses on LMPs related to loading and unloading at the well site, rather than safety measures on the open road.

Some LMPs recommend that drivers perform "preventative maintenance programs and safety checks" on vehicles carrying oil and gas production fluids.[217] Others suggest a safety screening process and drug testing for drivers,[218] as well as driver training.[219] LMPs also recommend ensuring that drivers are well rested and alert.[220]

LMPs recommend safety practices for backing up a truck, including use of a spotter.[221] When refueling onsite, LMPs

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214. *See* sources cited *supra* note 87. *See also* Patterson et al., *supra* note 29.

215. Nick Snow, *Colorado Commission Approves Oil, Gas Flowline Requirements*, OIL & GAS J. (Feb. 14, 2018), https://www.ogj.com/articles/2018/02/colorado-commission-approves-oil-gas-flowline-requirements.html.

216. Patterson et al., *supra* note 29, at 2570 & SI Section E, at S18.

217. *See, e.g.*, CAPP OPERATING PRACTICE, *supra* note 24; *see also* MARCELLUS SHALE COALITION, MSC RP 2012-5, RECOMMENDED PRACTICES: MOTOR VEHICLES SAFETY 2 (2012) [hereinafter MARCELLUS SHALE COALITION, MOTOR VEHICLES SAFETY] (suggesting companies draft written, detailed maintenance programs and implement pre- and post-trip inspections of vehicles).

218. *See* MARCELLUS SHALE COALITION, MOTOR VEHICLES SAFETY, *supra* note 217, at 2; STRONGER GUIDELINES, *supra* note 136, § 4.2.5, at 35 (Waste Hauler Certification).

219. STRONGER GUIDELINES, *supra* note 136, § 4.2.5, at 35 (detailing contents of such training).

220. *See, e.g.*, MARCELLUS SHALE COALITION, MOTOR VEHICLES SAFETY, *supra* note 217, at 3.

221. *See id.*

recommended using portable containment equipment, and closely monitoring fuel transfers.[222]

Other LMPs encourage the use of alternatives to truck transport, such as pipelines, centralized storage, and treatment facilities.[223]

6. Blowout LMPs

The four-state dataset contained 83 instances of blowouts, fires, or explosions at a well site, resulting in an approximate blowout rate of 0.1% (or, one blowout for every 1,000 wells drilled). Other analyses calculated similar blowout rates both onshore and offshore.[224] However, these low probability events can have devastating effects, killing workers, destroying wells and well equipment, and releasing large volumes of chemicals and wastewater.[225] Moreover, given that more than 130,000 wells have been drilled onshore in the United States since 2010,[226] a rate of 0.1% still suggests 130 wells drilled in that time period were at risk of catastrophic failure. Therefore, this section describes LMPs addressing these events.

Some LMPs seek to prevent blowouts, for instance by recommending using at least three layers of steel pipe for well casing,[227] and installing "blow-out preventers,"[228] stabbing valves,[229] and a well pressure gauge.[230]

Other LMPs focus on minimizing the impact of a blowout or fire, should one occur. British Columbia directs operators to site flares and incinerators at least eighty meters from

222. *See* MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2; APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 5.

223. *See, e.g.*, MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 2; APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 2.

224. *See* BOB ORR & IRFAN BIDIWALA, MITIGATING THE ENVIRONMENTAL RISKS OF THE SHALE BOOM 59–65 (2013); INTERNAT'L ASS. OF OIL AND GAS PRODUCERS, RISK ASSESSMENT DATA DIRECTORY, REPORT NO. 434–2, BLOWOUT FREQUENCIES 3–9 (2010).

225. *See, e.g.*, Konschnik, *supra* note 86, at 351 n.187 (citing evidence of three blowouts at onshore wells in the United States in 2013).

226. Meko & Karklis, *supra* note 49.

227. *See* COTTONWOOD RES. COUNCIL, *supra* note 110, at 38.

228. *See* MARYLAND BEST PRACTICES, *supra* note 7, at 33–34 (and recommending weekly testing); MARCELLUS SHALE COALITION, DRILLING AND COMPLETION, *supra* note 24, at 3; BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY, *supra* note 139, § 9.6.1, at 98–99.

229. *See* BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY, *supra* note 139, § 9.6.8, at 103.

230. *See id.* § 9.6.9, at 104 (Blowout Prevention Manifold).

facilities such as public roads, buildings, or utilities,[231] and to clear vegetation below flare stacks.[232]

C. Informational Measures

Informational measures may not seem immediately relevant to reducing the risk and impact of surface spills. However, measures for understanding baseline conditions before drilling begins, characterizing the volume and relative toxicity of materials and waste found on site, and learning from past spills are critical to the risk reduction effort.[233]

"Companies across all industry sectors, including the international oil and gas industry, are facing increasing pressure to disclose information regarding their environmental and social performance to government and the public."[234] Where disclosure regulations do not yet exist, industry may initiate voluntary reporting.

This is precisely what happened with disclosure of hydraulic fracturing chemicals. In the face of inaction by state agencies and a Congressional exclusion of hydraulic fracturing from a federal disclosure law, companies began disclosing their chemicals on a voluntary basis, first individually[235] and then collectively on the FracFocus website.[236] Today, some LMPs focus on enhanced disclosure of the chemicals used in oil and natural gas production.[237]

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231. *See id.* § 9.6.15, at 107 (Fire Precautions and Equipment Spacing).

232. *Id.* at 108.

233. *See, e.g.*, RISKS AND RISK GOVERNANCE,, *supra* note 8, at 81 (citing Hannah Wiseman, Professor at Florida State University College of Law, noting that "[b]etter understanding of the risks requires better production of data").

234. Wawryk, *supra* note 8, at 423.

235. *Hydraulic Fracturing Fluid Selection and Disclosure*, RANGE RESOURCES, http://www.rangeresources.com/corp-responsibility/environment-health-and-safety/hydraulic-fracturing-fluid-selection-and-disclosure (last visited Apr. 24, 2018) (noting that it was "the first company to voluntarily disclose the fracturing fluid for each completed shale gas well on [its] website").

236. *See* Hannah J. Wiseman, *The Private Role in Public Fracturing Disclosure and Regulation*, 3 HARV. BUS. L. REV. ONLINE 49, 65–66 (2013); *see also* FRACFOCUS CHEMICAL DISCLOSURE REGISTRY, http://fracfocus.org/ (last visited Apr. 25, 2018).

237. MARCELLUS SHALE REPORT, *supra* note 96, § 9.2.14, at 107 (suggesting reporting include pump rate, pressure, and total volume; a list of all hazardous chemicals; water sources; and depth of potable aquifers encountered during drilling); *see also* BC OIL & GAS COMM'N, OIL AND GAS ACTIVITY, *supra* note 139, § 9.7.1, at 110 (Hydraulic Fracturing Fluid Report); STRONGER GUIDELINES, *supra* note 136, § 9.2.2, at 78 (Reporting); MARYLAND BEST PRACTICES, *supra* note 7, at 28–29 (suggesting regulators receive information about all fracturing chemicals, including those claimed to be trade secret, and enabling them to share

However, they may contain significant qualifications to the stated goal of chemical transparency,[238] and virtually none suggest reporting chemicals before they are used at a well.[239] Similarly, most state disclosure requirements allow non-disclosure for trade secrets or confidential business information,[240] and delay disclosure until after well completion.[241] Still, over two dozen states have followed the example set by industry standards to issue disclosure requirements.

Baseline water quality testing[242] has become another broadly accepted practice; several states now require or strongly encourage this testing.[243] In part, baseline testing emerged as a reaction to operators claiming that private water wells were contaminated before drilling commenced. This argument was particularly salient in Pennsylvania, which has more private wells than almost any other state,[244] and virtually no regulation of drinking water quality in those wells.[245]

IEHN encourages baseline sampling and noted that Chesapeake Energy found methane in 11% of the 1,312 water wells it tested before development in four West Virginia

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such protected information with health professionals); COTTONWOOD RES. COUNCIL, *supra* note 110, at 42 (similarly suggesting regulators should receive all chemical information).

238. *See* APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 5 (committing to transparency "to the extent permitted by suppliers, while respecting related intellectual property rights, and proprietary and confidential business information").

239. *But see* IEHN, INVESTOR GUIDE, *supra* note 106, at 8 (Goal 4: Reduce and Disclose all Toxic Chemicals) (calling for chemical disclosure "prior to fracturing operations").

240. *See, e.g.,* OKLA. ADMIN. CODE § 165:10-3-10(c)(4)(2017); OHIO REV. CODE § 1509.10(A)(9)(a)(2017); 58 PA. CONS. STAT. § 3222(b)(2) (2012).

241. *See, e.g.,* 58 PA. CONS. STAT. § 3222(b)(3) (2012); N.DAK. ADMIN. CODE §§ 43-02-03-27.1(1)(g), (2)(i) (2013); 2 COLO. CODE REGS. § 404-1:205A(b)(2)(A) (2017).

242. STRONGER GUIDELINES, *supra* note 136, § 9.2.1, at 77–78 (Hydraulic Fracturing Standards); COTTONWOOD RES. COUNCIL, *supra* note 110, at 29; IEHN, INVESTOR GUIDE, *supra* note 106, at 9 (Goal 5: Protect Water Quality by Vigorous Monitoring).

243. *See, e.g.*, 58 PA. CONS. STAT. § 3218 (2017); 2 COLO. CODE REGS. § 404-1:609 (2017); WYO. CODE R. CH. 3 § 46 (2017).

244. *A Quick Guide to Groundwater in Pennsylvania*, PENN. STATE EXTENSION, https://extension.psu.edu/a-quick-guide-to-groundwater-in-pennsylvania (last visited Apr. 24, 2018) (indicating that only Michigan has more private water wells than Pennsylvania).

245. BRYAN R. SWISTOCK ET AL., DRINKING WATER QUALITY IN RURAL PENNSYLVANIA AND THE EFFECT OF MANAGEMENT PRACTICES 5 (Jan. 2009), http://www.rural.palegislature.us/drinking_water_quality.pdf ("Pennsylvania remains one of the few states where well location, construction, testing and treatment are the voluntary responsibility of the homeowner.").

counties.[246] Having this information meant the company could later rebut the suggestion that methane in those water wells came from its drilling operations. Other companies undertook baseline water quality sampling after facing regulatory penalties and lawsuits for alleged contamination of residential drinking water wells.[247]

Baseline testing LMPs address how far from a proposed well or well pad to test surface and groundwater resources (ranging up to 2,500 feet[248]); how far in advance before development to conduct testing;[249] and what chemicals to look for in the water samples.[250] At least one practice recommends that companies hire qualified third parties to conduct the sampling, and share results with the landowners.[251]

Most of the baseline measures assume the company or its agent will conduct the baseline testing. One LMP recommends that state and local governments craft baseline testing requirements.[252] In fact, some state agencies have taken this work on themselves.[253] Canada's Yukon

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246. *See* IEHN, INVESTOR GUIDE, *supra* note 106, at 9 n.17, 17.

247. *See id.* (noting that Cabot Oil & Gas monitors water supplies within 2,500 of a well and Range Resources within 1,000 feet).

248. *See* APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 3; CRSD, PERFORMANCE STANDARDS, *supra* note 106, at 6. Sometimes individual companies go beyond any jurisdiction's requirements and LMPs, perhaps to distinguish themselves from the competition. In Pennsylvania, Hess conducted baseline testing of water wells and privately-owned springs and ponds out to 5,000 feet. *See* HESS CORP., 2010 CORPORATE SUSTAINABILITY REPORT 61 (2011), http://www.hess.com/docs/sustainability/2010.pdf?sfvrsn=2.

249. *See, e.g.*, MARYLAND BEST PRACTICES, *supra* note 7, at 44 (emphasizing that two years of pre-development baseline data is needed for robust comparisons to conditions after drilling begins, to capture seasonal and year-to-year variability).

250. *See, e.g.*, COTTONWOOD RES. COUNCIL, *supra* note 110, at 41 (listing ten chemicals commonly used in hydraulic fracturing that should be tested for—benzene, toluene, ethylbenzene, xylene, naphthalene, polynuclear aromatic hydrocarbons, hydrochloric acid, formaldehyde, ethylene glycol and sodium hydroxide—and forty-two others including arsenic, barium, thallium, selenium, and strontium).

251. *See* APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 3.

252. *See* NINETY-DAY REPORT, *supra* note 25, at 23.

253. *See* Janae Wallace, *Establishing Baseline Water Quality in the Southeastern Uinta Basin*, *in* 45 SURVEY NOTES 6–7 (2013), https://ugspub.nr.utah.gov/publications/survey_notes/snt45-1.pdf (describing the Survey's efforts to establish a comprehensive baseline dataset); *Collecting Baseline Data*, GOV'T OF YUKON, http://www.emr.gov.yk.ca/oilandgas/collecting-baseline-data.html (last updated June 6, 2016) (describing efforts to "enhanc[e] ongoing data collection to ensure we fill any gaps in our data").

Territory publishes an interactive map,[254] enabling the public to monitor progress in the government's baseline testing.

Once development has begun, informational practices can also help to characterize the chemicals, mixtures, and wastewater streams on a well pad—which, in turn, could suggest how these fluids should be handled and stored onsite, as well as transported offsite for appropriate disposal. Information about these fluids may also be useful in determining the appropriate response to a release.

Some informational practices seek to generate better data on the fate and transport of wastewater from oil and natural gas production sites,[255] as well as the chemical makeup of that wastewater.[256] Some states register all haulers of oil and gas wastewater,[257] which can define the universe of actors and more readily identify the source of highway spills or illegal dumping. API recommends waste tracking even where not required by a state.[258]

One LMP recommends consulting the Federal Department of Transportation's Safety and Fitness Electronic Records (SAFER) to track the safety performance of trucking companies before hiring them.[259] Similarly, at least one LMP seeks to enhance transparency around the compliance history of well operators.[260]

More generally, one practice suggested adoption of a uniform corporate reporting standard for key environmental metrics.[261] British Columbia directs operators to record

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254. *See Yukon's Oil and Gas Resources*, GOV'T OF YUKON, http://yukon4.maps.arcgis.com/apps/MapJournal/index.html?appid=2bf16a5b6f5840f590130d8643fd73cf (last visited Apr. 25, 2018).

255. *See* MARCELLUS SHALE REPORT, *supra* note 96, § 9.2.7, at 106; CAPP OPERATING PRACTICE, *supra* note 24; MARYLAND BEST PRACTICES, *supra* note 7, at 36–38; IEHN, INVESTOR GUIDE, *supra* note 106, at 10 (Goal 7: Prevent Contamination from Waste Water).

256. STRONGER GUIDELINES, *supra* note 136, § 5.2.2, at 41 (Waste Characterization) ("[W]aste management practices and regulatory requirements would be improved by obtaining a more complete knowledge, through sampling and analysis, of the range of hazardous and toxic constituents in E&P wastes.").

257. OHIO EPA, GUIDEBOOK, *supra* note 93, at 10; *see also* 16 TEX. ADMIN. CODE § 3.8(f) (2017).

258. E&P GUIDELINES, *supra* note 129, at 20.

259. *See* MARCELLUS SHALE COALITION, MOTOR VEHICLES SAFETY, *supra* note 217, at 2.

260. *See, e.g.*, MARCELLUS SHALE REPORT, *supra* note 96, § 9.2.16, at 108; *see also* MARYLAND BEST PRACTICES, *supra* note 7, at 29.

261. APPALACHIAN SHALE RECOMMENDED PRACTICES, *supra* note 105, at 7 (suggesting operators should task personnel to develop reporting criteria, beginning with water use and worker safety statistics, and then moving on to waste management and spill reporting).

results from ground-water monitoring near containment ponds.[262] STRONGER suggests regulators should collect data about the "locations, use, capacity, age and construction materials" of tanks.[263]

Several LMPs focus more squarely on spills. Some of these practices, if adopted, could elicit more accurate spill estimates. If the liner of an impoundment fails, for instance, leaks may not be detected right away. British Columbia suggests that operators calculate an "action leakage rate" for each containment pond holding different amounts of water, to help estimate the volume of wastewater that might have escaped through liner tears before detection.[264] Other informational LMPs could facilitate a spill response; for instance, requiring all trucks to be fitted with GPS tracking systems, to "help adjust transportation plans and identify responsible parties in the case of accidents/spills."[265]

In addition, LMPs or rules to improve spill reporting and data analysis can help companies and regulators identify spill trends and improve environmental performance.[266] As noted, previous spill analyses had to contend with data gaps and unknown causes for many spills. In Pennsylvania, for instance, the leading pathway and cause of spills in the analysis described in Part I was "unknown."[267] A few LMPs focus on what states should require in a regulatory reporting regime.[268] STRONGER suggests that if managed and analyzed effectively, regulators could use the information to "document significant trends," identify and prioritize

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262. *See* BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 19.

263. STRONGER GUIDELINES, *supra* note 136, § 5.9.2, at 54–55 (Technical Criteria for Tanks: General Requirements).

264. BC OIL & GAS COMM'N, MANAGEMENT OF SALINE FLUIDS, *supra* note 125, at 19–20 (defining "action leakage rate" as "the amount of leakage that would occur through the primary liner of a dual lined system, based on two (2) holes per hectare each with a diameter of two [millimeters]").

265. MARYLAND BEST PRACTICES, *supra* note 7, at 26.

266. *See* Patterson et al., *supra* note 29, at 2570–71.

267. *See id.* at 2569–71.

268. *See, e.g.*, STRONGER GUIDELINES, *supra* note 136, § 4.2.1.4.3, at 26–27 (Response Measures) (recommending states require spill reporting that results in the collection of the following information: name of the operator and the representative reporting the incident; the date and time of the incident and its discovery; the type and volume of material released; location of the incident; apparent extent of the release; damage or threat to groundwater, surface water, land, and/or air; and weather conditions).

environmental threats, and evaluate regulatory programs.[269] STRONGER also recommends that states require a "periodic review of spill histories" to note trends and opportunities for risk reduction going forward.[270]

Across all of these information-gathering standards, greater harmonization of data may be necessary, to enable broader analyses across plays, companies, and states.[271] STRONGER also encourages electronic reporting,[272] and data sharing between agencies,[273] which would facilitate research.

III. INCORPORATING LMPS INTO PRIVATE AND PUBLIC GOVERNANCE REGIMES

Leading management practices in oil and gas development will only be effective if they are used. However, LMPs are important beyond the short-term voluntary adoption of these measures. They might also inform or become incorporated into law; serve as the basis for shareholder resolutions or the setting of insurance premiums; pave the way for third party environmental performance certifications; or influence the environmental reputation of a firm. This part explores how LMPs have been—and might be—incorporated into broader governance regimes.

Some of the literature focuses on the role LMPs can play in the absence, and unlikely future establishment, of comprehensive public law. Much of this literature is describing emerging economies,[274] but the observations may apply to situations in the United States where the federal government is constrained or unwilling to regulate the sector for a particular environmental risk.

Industry crafts and follows LMPs for a number of reasons, reflecting the many pressures that companies feel

269. *Id.* at 30.

270. *Id.* § 4.2.1.4.2, at 26 (Prevention Measures).

271. NAT'L PETROL. COUNCIL, *supra* note 33, at 178 (noting that "[a]dditional efforts are needed in the area of standardization of data and its communication between entities").

272. STRONGER GUIDELINES, *supra* note 136, § 4.2.7.2, at 35–36 (Electronic Data Management).

273. *Id.* § 10.2.7, at 87 (Administrative: Data Management).

274. *See, e.g.*, Wawryk, *supra* note 8.

from "governments, regulators, customers, competitors, community, and environmental interest groups" to improve environmental performance.[275] First, industry actors may write and subscribe to LMPs in an effort to ward off or displace regulation. Once standards are in place, industry can argue that regulation is unnecessary or duplicative.[276]

Second, however, LMPs may suggest future regulation. After it is published, an industry standard can facilitate technology transfer between companies, deploying new ideas through peer-to-peer learning.[277] Organizations are more likely to mimic the behavior of firms "tied to them through networks."[278] Once the standard is proven to be feasible and becomes more widely accepted by industry, it may be easier for an agency to regulate by incorporating the LMP. In this way, industry action can steer regulators away from "prescriptive and costly command and control mechanisms" to manage environmental risk.[279] According to the API, about 100 of its 600 standards (15%) are referenced in more than 270 federal regulations.[280] When industry standards are incorporated into law, API argues that companies are more likely to recognize the terminology and understand what is being asked of them.[281]

One example of an industry standard creating a glide path to regulation is the "green completion" technique at oil

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275. Delmas & Toffel, *supra* note 61, at 209.

276. *See, e.g.,* John Siciliano, *14 States Sue EPA Over 'Job-Killing' Oil and Gas Rules,* WASHINGTON EXAMINER (Aug. 2, 2016) (quoting the West Virginia Attorney General's argument that methane regulations "ignore the industry's success in voluntarily reducing methane emissions"); Oil and Gas; Hydraulic Fracturing on Federal and Indian Lands; Rescission of a 2015 Final Rule, 82 Fed. Reg. 61,924, 61,942 (Dec. 29, 2017) (to be codified at 43 C.F.R. pt. 3160) ("In light of the protections available under other Federal regulations, the increased prevalence of state and tribal laws and regulations to address hydraulic fracturing, and new industry practices, the BLM believes that [a Federal rule is] unnecessar[y].")

277. *See* API, MOST VALUABLE RESOURCE, *supra* note 10, at 12.

278. Delmas & Toffel, *supra* note 61, at 214 (citing Isin Guler et al., *Global Competition, Institutions, and the Diffusion of Organizational Practices: The International Spread of the ISO 9000 Quality Certificates*, 47 ADMIN. SCI. Q. 507 (2002)).

279. Wawryk, *supra* note 8, at 404.

280. API, MOST VALUABLE RESOURCE, *supra* note 10, at 10; *see also* Derek Swick et al., *Gasoline Risk Management: A Compendium of Regulations, Standards, and Industry Practices*, 70 REG. TOXICOLOGY & PHARMACOLOGY S80, S81 (2014) (noting that many industry standards regarding gasoline quality have been incorporated into state law).

281. API, MOST VALUABLE RESOURCE, *supra* note 10, at 7; *see also* NAT'L PETROL. COUNCIL, *supra* note 33, at 173 (suggesting that regulators should evolve regulations to incorporate best practices).

and natural gas wells. After a well has been hydraulically fractured, a "green completion" or "reduced emission completion" captures the gas released from the well at the start of production, and uses it onsite or sends it to market.[282] Traditionally, that gas would be separated from the water coming up out of the formation and released to the atmosphere.[283] Industry came up with the process and in partnership with EPA under the Natural Gas STAR program, shared it with other companies.[284] However, when broader uptake stalled,[285] EPA stepped in to require green completions at gas wells,[286] and then oil wells.[287] Although the Trump Administration has been aggressive in seeking to delay or roll back other aspects of EPA's 2016 methane rule,[288] they have left the green completion requirements intact.[289]

An LMP may become binding on companies even if a legislature or agency does not directly impose these standards. For instance, a legislature may require regulators

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282. OHIO ENVTL. PROT. AGENCY, FACT SHEET: UNDERSTANDING THE BASICS OF GAS FLARING 2 n.1 (2014), http://www.epa.state.oh.us/portals/27/oil%20and%20gas/basics%20of%20gas%20flaring.pdf.

283. *Id.*

284. U.S. ENVTL. PROT. AGENCY, LESSONS LEARNED FROM NATURAL GAS STAR PARTNERS: REDUCED EMISSIONS COMPLETIONS FOR HYDRAULICALLY FRACTURED NATURAL GAS WELLS (2011).

285. While the captured gas paid for the incremental cost of the "green completion," it could not compensate firms for the lost opportunity cost of moving the drilling rig more quickly to another site. *See* Konschnik & Boling, *supra* note 48, at 8407–08.

286. Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews, 77 Fed. Reg. 49,490, 49,497 (Aug. 16, 2012) (to be codified at 40 C.F.R. pts. 60 & 63).

287. Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources, 81 Fed. Reg. 35,824, 35,845 (June 3, 2016) (to be codified at 40 C.F.R. pt. 60).

288. *See e.g.,* Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources; Grant of Reconsideration and Partial Stay, 82 Fed. Reg. 25,730 (June 5, 2017) (codified at 40 C.F.R. pt. 60) (detailing EPA's decision to reconsider four provisions of the 2016 methane rule); Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources: Stay of Certain Requirements, 82 Fed. Reg. 27,645 (June 16, 2017) (codified at 40 C.F.R. pt. 60) (detailing EPA's proposal to delay key provisions of the methane rule for two years); Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources; Amendments, 83 Fed. Reg. 10,628 (Mar. 12, 2018) (codified at 40 C.F.R. pt. 60) (detailing a final amendment to the methane rule, which allows leaks to go unrepaired during unscheduled or emergency shutdowns).

289. *Oil and Gas 111b Methane Rule*, ENVTL. LAW AT HARV., http://environment.law.harvard.edu/2017/09/oil-gas-111b-methane-rule/ (last visited Apr. 28, 2018) (describing the history and current status of the methane rule, as well as detailing the Trump Administration's actions to rollback and delay certain aspects of the rule).

to consider LMPs when permitting wells.[290] In other instances, courts may use the measures to determine whether a company has behaved negligently.[291] While custom and industry practices are not controlling,[292] they are highly relevant to whether the actor should have understood "the risks of the situation and the precautions required to meet them."[293] Courts may also rely on industry standards to fashion a remedy. When BP was found to have dumped waste on the North Slope in Alaska,[294] a federal court required the company to implement an environmental management system, because this practice was becoming an industry norm. Courts may also require disclosure of internal industry standards, if that information is not already public.[295]

Third, industry actors may use LMPs in order to be good "corporate citizens"—an effort that can arise simply from the positive culture of a particular company or from the desire to increase profits by attracting concerned consumers. Adherence to standards can help a company "develop[ ] greater public trust" and earn its social "license to operate."[296] By contrast, inferior practices could "undermine public trust" and block "access to the resource."[297]

Some firms may be more sensitive to environmental issues after a pollution disaster.[298] In addition, several studies have found that companies are motivated "by the desire to improve or maintain relations with their

290. *See, e.g.*, 72 PA. STAT. ANN. § 1601.1-E(9)(iii) (West 2018) (noting "it is in the best interest of the Commonwealth to lease oil and gas rights in State forests and parks" *when* the state uses strong lease protections, incorporates BMPs, and monitors the impact of gas operations).

291. RESTATEMENT (SECOND) OF TORTS § 295A (AM. LAW INST. 1965) ("In determining whether conduct is negligent, the customs of the community . . . are factors to be taken into account . . . .").

292. *Id.* (indicating that customs "are not controlling where a reasonable man would not follow them").

293. *Id.* at cmt. b. *See also id.* at cmt. c. (noting that "no industry or trade can be permitted . . . to set its own uncontrolled standards at the expense of the rest of the community"). This suggests that proactive standards are more likely to be embraced by the judiciary.

294. *BP Amoco Admits Environmental Lapse*, 97 OIL & GAS J. 34, 34–35 (1999).

295. *See, e.g.*, Paintcare v. Mortensen, 183 Cal. Rptr. 3d 451, 467–68, 472 (Cal. Ct. App. 2015) (approving state regulation directing companies to disclose paint recycling best practices, over opposition by industry).

296. API, MOST VALUABLE RESOURCE, *supra* note 10, at 6.

297. NAT'L PETROL. COUNCIL, *supra* note 33, at 171.

298. Delmas & Toffel, *supra* note 61, at 216 (citing Aseem Prakash, *Responsible Care: An Assessment*, 39 BUS. & SOC'Y 183 (2000)).

communities."[299] Since 1990, API has required all members to accept a set of ten environmental principles.[300] While the principles are vague—for instance, one pledges to make "safety, health and environmental considerations a priority in our planning and our development of new products and processes"[301]—the trade group and its members can point to them as a sign of their commitment to these issues.

A company's "organizational structure, strategic positioning and performance will affect how [it perceives] institutional pressures" and responds.[302] Larger companies may be more likely to feel widespread public pressure and have greater capacity to craft or adopt LMPs. Larger companies may also welcome tougher industry standards or even greater regulation in the shale plays, if it pressures smaller competitors out of the market.[303] That said, while the major companies have taken the lead on voluntary methane pollution reduction standards,[304] the independent oil and natural gas companies jumped first to voluntarily disclose hydraulic fracturing chemicals.[305] And all larger companies do not necessarily embrace a culture of safety,[306] suggesting other factors influence behavior as well.

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299. *Id.* at 213 (citing Irene Henriques & Perry Sadorsky, *The Determinants of an Environmentally Responsive Firm: An Empirical Approach,* 30 J. ENVTL. ECON. & MGMT. 381 (1996) (based on surveys by 700 firms)).

300. *See, e.g.*, Wawryk, *supra* note 8, at 402–03.

301. *Environmental Principles*, AM. PETROL. INST., http://www.api.org/oil-and-natural-gas/environment/environmental-principles (last visited Apr. 24, 2018).

302. Delmas & Toffel, *supra* note 61, at 212.

303. *See, e.g.,* Richard Valdmanis, *As Trump Targets Energy Rules, Oil Companies Downplay their Impact,* REUTERS (Mar. 23, 2017) (noting that 13 of the 15 biggest oil and gas producers in the United States reported in SEC filings that compliance with regulations "is not impacting their operations or their financial condition"); *see also* John A. Welsh & Jerry F. White, *A Small Business is Not a Little Big Business*, HARV. BUS. REV. (1981), https://hbr.org/1981/07/a-small-business-is-not-a-little-big-business ("Changes in government regulation … usually affect a greater percentage of expenses for small businesses than they do for large corporations.").

304. *See* Press Release, Am. Petrol. Inst., *supra* note 14; s*ee also* Josh Siegel, *Exxon, Shell, BP Pledge to Reduce Methane Emissions from Natural Gas*, WASH. EXAMINER (Nov. 22, 2017, 2:29 PM) (characterizing the partnership as "part of an effort by the industry to show it is committed to combating climate change even as the Trump administration rolls back regulations").

305. *See supra* note 235, and accompanying text.

306. RISKS AND RISK GOVERNANCE, *supra* note 8, at 61 (citing Charles Perrow, Professor Emeritus of Sociology at Yale University, describing two large industrial accidents at BP facilities—a massive leak in Prudhoe Bay, Alaska and the explosion at a production facility in Texas City, Texas—that occurred even after the company had been warned of safety shortfalls).

Fourth, industry may self-impose LMPs to standardize industry operations, making them more efficient and assuring consistent outcomes. In a publication dedicated entirely to the value of standards, API argued that industry would be much less effective and cost-effective if, for instance, "every nut and bolt in the world were made in a different way."[307]

As noted in Part I, other actors beyond industry may create or promote LMPs. They also act out of several motivations. Environmental advocates or community groups who believe that regulation is inadequate may push for more stringent LMPs in hopes that voluntary measures will further reduce impacts.[308] Interest groups can work with industry to adopt the standards, or wage negative public relations campaigns to pressure firms to act.[309] However, LMPs might also compete with regulation, "diverting scarce advocacy or other resources, or reducing the perceived demand for government action."[310]

Other private actors might craft LMPs or reference them when comparing firms or characterizing and pricing risk. For instance, insurance companies could incentivize better performance by oil and gas operators by identifying a suite of LMPs and charging lower premiums for companies that conform to these LMPs. Indeed, insurance companies have some of the strongest, most direct incentives to reduce risk in order to avoid paying damages associated with negative environmental impacts.[311] These companies likely benefit from identifying the most effective LMPs for reducing risk. However, much of their analyses are not transparent and therefore not readily available for broader learning.

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307. API, MOST VALUABLE RESOURCE, *supra* note 10, at 3.

308. *See, e.g.,* COTTONWOOD RES. COUNCIL, *supra* note 110, at 28 (noting that state and federal laws "may not be specific enough to address oil and gas development at the local level" and that "[f]or this reason BMPs are extremely important to ensure responsible gas development").

309. Delmas & Toffel, *supra* note 61, at 214 (describing Rainforest Action Network's campaign to force Mitsubishi to stop using products made from old-growth forests).

310. Vandenbergh, *supra* note 15, at 133.

311. *See* David A. Dana & Hannah J. Wiseman, *A Market Approach to Regulating the Energy Revolution: Assurance Bonds, Insurance, and the Certain and Uncertain Risks of Hydraulic Fracturing*, 99 IOWA L. REV. 1523, 1568 (2014).

Some private organizations have launched certification programs, to acknowledge companies that have committed to meeting LMPs.[312] Firms might be able to charge "green premiums" for their willingness to meet stricter environmental standards.[313] In addition, companies may sign up for compliance-plus programs to enhance their environmental reputation,[314] creating or competing in "a market for environmental virtue."[315] Some government programs can offer these reputational rewards as well,[316] for instance the Natural Gas STAR[317] and Design for the Environment[318] programs at EPA. Companies can use membership in voluntary certification programs or partnerships with government to signal a "proactive environmental stance" and improve relations with regulators.[319]

Governments compile LMPs, or appoint task forces or panels to perform this function, for a number of reasons. Agencies may believe that they lack the political capital to write sufficiently stringent regulations. By identifying LMPs, the agency may encourage behaviors that improve environmental performance without having to change the law. Alternatively, the agency may detect widespread support for a practice labeled as an LMP and use that information to draft future regulations. Several recommendations issued by Governor Corbett's advisory board were ultimately incorporated into Pennsylvania law.[320] At the federal level, the EPA regulated methane emissions from fractured oil and gas wells after the Secretary of

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312. *See, e.g.*, CTR. FOR RESPONSIBLE SHALE DEV., ACCREDITATION PROCESS VERSION 1.0 (Aug. 19, 2013), http://www.responsibleshaledevelopment.org/wp-content/uploads/2016/09/CRSD-Accreditation-Process-V.1.pdf; *see also* ROBERT LACOUNT ET AL., *supra* note 89.

313. *See, e.g.*, Joshua Belcher & Ram Sunkara, *Green Tariffs: Attracting New Loads with Sustainable Options*, RENEWABLE ENERGY WORLD (June 14, 2017), (describing premiums some customers are willing to pay to purchase clean energy).

314. *See* David B. Spence, *Corporate Social Responsibility in the Oil and Gas Industry: The Importance of Reputational Risk*, 86 CHI-KENT L. REV. 59, 77–78 (2011).

315. RISKS AND RISK GOVERNANCE, *supra* note 8, at 106 (citing Aseem Prakash, Professor of Political Science at the University of Washington, describing the reputational use of voluntary environmental programs).

316. Delmas & Toffel, *supra* note 61, at 213.

317. *Natural Gas STAR Program*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/natural-gas-star-program/natural-gas-star-program (last updated Sept. 29, 2017).

318. NAT'L PETROL. COUNCIL, *supra* note 33, at 232.

319. Delmas & Toffel, *supra* note 61, at 215.

320. *See, e.g.*, H.B. 1950, Gen. Assemb., 2011–2012 Reg. Sess. (Pa. 2012) (enacted).

Energy's Advisory Board recommended that the EPA expand its regulatory efforts to "explicitly include methane, a greenhouse gas."[321]

Sometimes, LMPs can socialize a standard before regulations are in place. For example, Pennsylvania law requires legislative approval of regulation as well as approval by the Independent Regulatory Review Commission,[322] lengthening the process for promulgation. As a result, the Pennsylvania Department of Environmental Protection took nearly five years to finalize shale gas regulations directed by the legislature.[323] In the meantime, however, well operators in the Commonwealth could adopt the API practices, or LMPs identified by the Marcellus Shale Advisory Commission. To the extent they did, which again is not clear, these standards could have served an important transition function.

Limited research suggests that the oil and gas industry can react quickly to signals by government. Following Colorado's announcement that it would begin assessing penalties for late reporting of hydraulic fracturing chemical use, late submissions to that state dropped 6-fold, from 36.1% to 5.2%.[324] Almost immediately after the Wyoming Supreme Court decided to review trade secret protection requests by companies reporting hydraulic fracturing chemical use, trade secret assertions in Wyoming plummeted.[325] However, research is needed to determine the extent of this response, and its possible use to drive adoption of more protective practices.

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321. SECOND NINETY-DAY REPORT, *supra* note 6, at 4.

322. *See* INDEP. REGULATORY REVIEW COMM'N, THE REGULATORY REVIEW PROCESS IN PENNSYLVANIA (2011), http://www.senate.state.tx.us/cmtes/82/c510/0410BI-PIRRC-Process.pdf.

323. *See* Pa. H.B. 1950; *cf.* 46 Pa. Bull. 6431–522 (Oct. 2016).

324. *See* Kate Konschnik & Archana Dayalu, *Hydraulic Fracturing Chemicals Reporting: Analysis of Available Data and Recommendations for Policymaking*, 88 ENERGY POL'Y 504, 512 (2016).

325. KATE KONSCHNIK & ARCHANA DAYALU, REPLICATION DATA FOR: HYDRAULIC FRACTURING CHEMICALS REPORTING: ANALYSIS OF AVAILABLE DATA AND RECOMMENDATIONS FOR POLICYMAKERS V.3, HARV. DATAVERSE (2015) https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/EFNV5J (utilizing the data from this report Kate Konschnik and Archana Dayalu created a chart of the frequencies of the trade secret assertions in Wyoming before and after the state Supreme Court signaled it might tighten disclosure oversight (chart on file with the author)).

Meanwhile, agencies could do more to encourage adoption of LMPs. For instance, many state and local governments require oil and gas operators to post a bond or provide other financial assurance before drilling a well.[326] The bond is designed to ensure that if the operator causes damages and fails to address those damages, taxpayers will not shoulder the costs of reclamation. In some cases, agencies set the required assurance based on the depth of a well, as a proxy for the relative cost to close the site.[327] In other contexts, states have set fees based on relative risk.[328] Similarly, governments could reduce bond amounts for operators who demonstrate compliance with certain LMPs. This could be a beneficial alternative to what is sometimes viewed as intrusive "command and control" regulation. [329]

Some stakeholders support the development of "[s]trong company practices and policies" to work alongside regulation.[330] The API requires members to "obey[] all laws *and* best practice."[331] As one researcher suggested, having "a strong safety culture is more effective than just having companies follow regulations."[332] Examples of cooperative governance—where private standards complement public law—exist in a number of areas, from risk management of gasoline[333] to climate change.[334] Within the unconventional

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326. *See, e.g.*, OHIO REV. CODE §1509:9-1-03 (2017) (requiring a bond of $5,000 for one well, or $15,000 for all the wells drilled in Ohio); OKLA. ADMIN. CODE § 165:10-1-10 (2017) (requiring evidence of financial assurance for $50,000, or a surety of $25,000, to cover well plugging and site restoration for wells in the state).

327. *See, e.g.*, CAL. PUB. RES. CODE § 3202, 3204, 3207 (2017) (requiring assurance of $25,000 for wells less than 10,000 feet deep, and $40,000 for deeper wells); ALA. CODE 9-17-6(c)(5) (2017) and ALA. ADMIN. R. 400-1-2-.03 (2017) (requiring assurance of $5,000-$30,000 per well depending on depth).

328. *See, e.g.* 415 ILL. COMP. STAT. ANN. § 135/65(a) (2017) (imposing a tax on drycleaners tied to the risk posed by different types of solvents used at a facility).

329. *Cf.* Dana & Wiseman, *supra* note 311, at 1547–52 (discussing insurance as a potential command-and-control alternative).

330. RISKS AND RISK GOVERNANCE, *supra* note 8, at 12 (describing remarks by Kris J. Nygaard, ExxonMobil Production Company); *see also* NAT'L PETROL. COUNCIL, *supra* note 33, at 199 ("Together, voluntary actions and regulatory oversight had led to a more harmonious concert between the natural gas and oil industry and the environment.").

331. Wawryk, *supra* note 8, at 403 (emphasis added) (quoting *API Environmental Stewardship Pledge for CAREFUL Operations*, AM. PETROL. INST., http:// www.api.org, (accessed Feb. 27, 2002)).

332. RISKS AND RISK GOVERNANCE, *supra* note 8, at 17 (citing Mark Zoback, Professor at Stanford University).

333. *See, e.g.*, Derek Swick et al., *supra* note 280 (describing the industry standards that have arisen alongside federal regulation, including those to address the design and construction of storage tanks and reducing static electricity during loading and unloading).

oil and gas context, private disclosure standards drove states to require reporting of hydraulic fracturing chemicals.[335] Importantly, views about whether industry or government should act first may depend on the nature of the risk; one survey revealed more support for industry to act when a risk was well known, but more support for government action in the face of uncertainty, when additional research about a possible risk is needed.[336] In other words, "government is trusted more when less information is available."[337]

"Governmental bodies may promote or discourage the formation of . . . private standards, but they do not exercise direct control over the content of the private standards or the activities of the organizations that implement them."[338] Given this, agencies may still need to regulate to set a floor for environmental performance. Then, private standards may "fill gaps by acting more quickly than government or by acting when government is unable to do so."[339]

Industry may also craft standards to clarify government regulations,[340] rather than substitute for or complement them.

The rationale for an LMP, and the worldview of its authors, may drive the LMP's stringency and specificity. For instance, some industry standards reviewed in Part III lacked numerical precision, or suggested that LMPs were only necessary in extreme circumstances, such as when a project posted "a very high groundwater contamination risk."[341] These standards may represent a very generic commitment to environmental protection—perhaps to gain social license in a community and enable discretion by more savvy companies, while bringing along substandard participants in the industry. By contrast, the standards crafted by industry and environmental advocates for a third-party certification program were more stringent than others,

334. Vandenbergh, *supra* note 15, at 136–37.
335. *See* Wiseman, *supra* note 236, at 53–54.
336. ALAN KRUPNICK ET AL, *supra* note 31, at 31–35.
337. *Id.* at 33.
338. Vandenbergh, *supra* note 15, at 120.
339. *Id.* at 133.
340. API, MOST VALUABLE RESOURCE, *supra* note 10, at 7.
341. E&P GUIDELINES, *supra* note 129, at 37.

likely in an effort to build the certification brand and be seen as the gold standard in the industry.

For instance, while API Order No. G0004 noted that multiple pit liners might be needed "based on the facility's potential to contaminate water resources,"[342] the Center for Responsible Shale Development requires double liners and leak detection systems in all circumstances. Moreover, the Center required the elimination of pits by March 20, 2015, in favor of closed-loop drilling systems.[343]

CONCLUSION

Has private and public governance been effective at reducing spills and other incidents at well sites? Some data suggests yes. One study tracked an 80% decrease in blowouts in California (dropping to 0.2%) following improvements in production practices.[344] More generally, in 2017, an annual spill report by E&E News reporters noted a decline in spills over previous years.[345]

That said, other research suggests standards take on a life of their own, perpetuated even when they are not shown to be effective in practice.[346] However, LMPs that express clear, quantifiable outcomes, and are implemented in a transparent way (perhaps because of NGO participation or monitoring) hold the promise of real results.[347]

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342. E&P GUIDELINES, *supra* note 129, at 36–37.

343. CRSD, PERFORMANCE STANDARDS, *supra* note 106, at 5 (Performance Standard 3).

344. Preston D. Jordan & Sally M. Benson, *Well Blowout Rates in California Oil and Gas District 4 – Update and Trends*, 7 EXPLORATION & PRODUCTION 59 (2010).

345. *See* Mike Soraghan & Pamela King, *Oil Field Spills Down 17% Last Year*, E&E NEWS (July 27, 2017), https://www.eenews.net/stories/1060057966 (describing that in a 2016 spill record review of fourteen states, spills dropped 17%, while oil production dropped 7% and gas, less than 1%, with an average of twenty-three spills a day across the United States); *see also* Mike Soraghan & Pamela King, *Drilling Mishaps Damage Water in Hundreds of Cases*, E&E NEWS (Aug. 8, 2016), https://www.eenews.net/stories/1060041279.

346. Vandenbergh, *supra* note 15, at 128 & n.38 (citing STEERING COMM. OF THE STATE-OF-KNOWLEDGE ASSESSMENT OF STANDARDS & CERTIFICATION, TOWARD SUSTAINABILITY: THE ROLES AND LIMITATIONS OF CERTIFICATION 4 (2012), http://www.resolv.org/site-assessment/files/2012/06/Report-Only.pdf)). However, it has also been challenging to demonstrate that legal environmental requirements cause environmental improvements. *See id.* at 131.

347. *Id.* at 132–33 (describing a partnership by Walmart and the Environmental Defense Fund to reduce Walmart's global supply chain emissions by 20 million metric tons which, if successful, would be "equivalent to a regulation requiring a forty percent reduction in CO_2 emissions from the U.S. iron and steel industry")(citations omitted).

A great deal more research is needed, to explore further the role of LMPs in the overall governance of oil and gas and their effectiveness in achieving positive environmental outcomes. Additional work is also needed to reach consensus on a more tailored suite of practices that will address the greatest risks posed by unconventional oil and gas production. The practices should change over time, as should the risks they seek to minimize, based on the latest information. To ensure that this will happen, all stakeholders need to work to optimize LMPs and ensure technology transfer and evolution to the *next* leading practices. This requires open lines of communication between public and private actors to learn from one another.