A Menu of State Policy Good Practices for Unconventional Natural Gas Development

Contents

Introduction

Unconventional natural gas development has grown rapidly in the United States in recent years, driven largely by production from shale and tight sandstone formations. Although the pace of development will continue to ebb and flow with gas prices, production will almost certainly continue rising in the coming years.

The federal government regulates several aspects of oil and gas exploration and production through various statutory and regulatory schemes, but states have traditionally held primary regulatory responsibility for oil and gas development on private land. Many states are now modifying existing regulations or developing altogether new regulations in response to expanding unconventional oil and gas development. As they seek to do so, they often look to other states or organizations for policy insights.

This paper provides a menu of policy good practices that could be—and in some cases have been—adopted by state policymakers. The menu presents a range of options because conditions vary substantially by region in light of differences in climate, topography, and geology. Operators in dry areas of Texas, for example, might face a lower risk that surface waste pits will overflow due to a large precipitation event than operators in Pennsylvania.

The paper begins by defining policy good practices and the methodology used to identify them. It then describes the impacts that the practices are designed to address, and a range of available policy good practices that could further lessen upstream sector impacts.

Defining policy good practices

As used here, the term "policy good practice" describes a policy that allows for the safe, responsible and economically feasible development of unconventional gas resources. Several organizations have begun to explore "best practices," "good practices," and other policy and operating standards in the natural gas context. The definition of policy good practices used here generally tracks these organizations' approaches.

For example, the Center for Sustainable Shale Development (CSSD) created fifteen performance standards for the gas industry in the Appalachian Basin.[1] The State Review of Oil and Natural Gas Environmental Regulations (STRONGER) develops guidelines for managing exploration and production (E&P) wastes from oil and gas development generally and hydraulic fracturing specifically.[2] Similar to STRONGER, the American Petroleum Institute (API)—an industry association—provides detailed technical standards for oil and gas development, including hydraulic fracturing.[3] Governmental groups like the Secretary of Energy Advisory Board Shale Gas Production Committee have also suggested general guidelines for safer shale gas development.[4] Many operating companies, ranging from international and national oil companies to both large and small independent operators, have a set of good operating practices.

Finally, a growing number of environmental and investor groups are publishing suggested best practices or more general guidelines—organizations like the Worldwatch Institute[5] or the Intermountain Oil and Gas BMP Project at the Getches-Wilkinson Center for Natural Resources, Energy, and the Environment, University of Colorado.[6]

Table 1 compares definitions of best practices in unconventional gas development used by the groups described above.

Table 1. Examples of definitions of best practices and other guidelines for unconventional gas development

	Center for Sustainable Shale Development	State Review of Oil & Natural Gas Environmental Regulations	American Petroleum Institute	Secretary of Energy Advisory Board Shale Gas Production Subcommittee	Worldwatch Institute
Label for standard or guideline	Performance standards	Guidelines	Best practices	Recommendations	Best practices
Definition	"consensus on what is achievable and protective of human health and the environment"[7]	"protection of public health, safety, and the environment"[8]	"meet or exceed federal requirements"[9]	"if implemented will reduce the environmental impacts from shale gas production"[10] Describes the need for best practices, defined as practices that "improve operational and environmental outcomes."	"minimize the risks associated with shale gas development"[11]

Developing suggested policy good practices

In considering the policy good practices explored in this paper, we first conducted a landscape analysis of guidelines, standards, or regulations (generally described as standards here) created by state, local, regional, and federal governments; industry actors; and other organizations. We then identified some of the standards that have successfully balanced community, environmental, and economic concerns. It is important to note that the policy good practices identified here are representative and not comprehensive.

Categorization of impacts

Previous efforts to categorize best practices in this space have taken two general approaches: some authors have organized and described best practices by the stage of development at which they occur,[12] and others have grouped best practices by the environmental medium they affect, such as water or air,[13] or by the various aspects of communities they affect (roads and local economics, for example). This paper employs the latter approach because many of the potential impacts of unconventional resources development tend to overlap the various stages of the development process. Nevertheless, understanding the stages of development is still a useful backdrop for discussing impacts by medium.

At a basic level, exploring for, producing and transporting unconventional gas generally requires the following actions:

1. Identifying underground resources through geologic evaluation, including seismic testing and other techniques;
2. Obtaining the legal right to engage in exploration and production activities including necessary regulatory approvals;
3. Building the drill site, which may include preparing the land and constructing access roads, digging and lining pits for storing and disposing wastes, and obtaining an available source of surface or ground water to assist in drilling and completing the well;
4. Drilling the well, which includes moving a rig onto the location, drilling to specified depths, tripping out the drill string, and setting and cementing casing to protect freshwater drinking supplies and to isolate targeted formations;
5. Completing the well, which generally includes perforating the casing within the targeted formation and pumping volumes of primarily water and sand into the well at high rates to hydraulically fracture the rock;
6. Gathering, separating, processing, compressing, and transporting produced hydrocarbons, which may include a combination of oil, natural gas, and natural gas liquids; and
7. Properly disposing of nonmarketable produced fluids and materials.

Impacts addressed by policy good practices

The potential impacts of improperly conducted unconventional gas development are diverse. We explored some of the most important potential impacts identified by state environmental and oil and gas agencies and peer-reviewed scientific papers. These potential impacts can be broadly categorized as follows:

1. Water impacts
   a. Contamination of surface water, ground water, and soil
   b. High-volume use of certain surface and ground water sources
   c. Water disposal, which may implicate concerns regarding induced seismicity
2. Air impacts
   a. Emissions of air pollutants
3. Broad environmental impacts
   a. Soil compaction and erosion
   b. Landscapes and wildlife
4. Community impacts
   a. Physical infrastructure
   b. Local economy and public services
   c. Noise

Table 2 summarizes these potential impacts, as identified by selected jurisdictions.

Table 2. Select impacts of unconventional gas development

Environmental medium/community sector impacted	Specific impacts	Select sources identifying impacts	Categories of good practices by environmental medium
Water impacts			
Surface water	• Containment requirements • Contamination: spills or improper storage or disposal of diesel, drilling muds, fracturing fluids, drilling and fracturing wastes; leakage from centralized waste facilities • Quantity	• Delaware River Basin Commission[14] • Department of Interior, Fish & Wildlife Service[15] and U.S. Geological Survey[16] • Milheim et al.[17] • Rozell & Reaven[18]	• Pit and tank location, construction, lining, and maintenance • Casing, cementing, plugging, and fracturing practices • Maintain well control during drilling and fracturing • Monitoring and reporting water quality and chemicals used at the site • Limiting water quantity impacts • Implementing safe waste disposal practices • Reducing the risks of seismic events associated with underground disposal of waste
Ground water	• Contamination: spills, leaks, improper disposal described in row 1; leakage from drilled, producing, or abandoned wells; sedimentation caused during the drilling process; leaking underground injection control wells • Quantity	• Midland, Texas[19] • New Mexico Oil Conservation Division[20] • U.S. Geological Survey[21] • Warner et al.[22]	
Water disposal	• Underground injection control wells for disposing of drilling and fracturing wastes • Potentially induced seismicity	• Frohlich et al.[23] • Keranen et al.[24] • Zoback and Arent[25]	• Performance standards
Air impacts			
Air	• Fugitive methane and methane leakage from wells, pneumatic devices; liquids unloading; processing equipment, and transmission pipelines • CO_2, VOCs, and other pollutants from equipment at well sites and transportation of materials to and from well sites	• Allen at al.[26] • Alvarez et al.[27] • Environmental Protection Agency[28] • Pétron et al.[29] • UT/EDF study • White House methane white papers released in April 2014	• Monitoring, measuring, and mitigating air emissions
Broad environmental impacts			
Soil compaction and erosion	• Contamination: spills, leaks, improper disposal described in row 1 • Compaction and compression • Erosion	• Bureau of Land Management[30] • National Park Service[31]	• Reducing soil compaction and erosion
Landscapes and wildlife	• Wildlife habitat fragmentation, impacting endangered and threatened species	• Department of the Interior, Fish & Wildlife Service, U.S. Geological Survey[32]	• Reducing landscape habitat impacts; protecting wildlife

Table 2. (continued) Select impacts of unconventional gas development

Environmental medium/community sector impacted	Specific impacts	Select sources identifying impacts	Categories of good practices by environmental medium
Community impacts			
Physical infrastructure	• Roads • Housing	• Randall[33] • Fullenwider[34]	• Reducing local physical impacts such as road damage and congestion; noise, dust, and light pollution; and impacts to agricultural resources
Local economy and public services	• Impacts on existing community economy and culture • Fire, emergency, and police • Courts	• Christopherson & Rightor[35] • Jacquet[36] • Penn State Extension[37] • Williston, North Dakota impact statement[38]	• Soil compaction and erosion

The effects of unconventional gas development described here are not comprehensive, and many of them are not unique to unconventional development. A number of the impacts we identified are associated with both conventional and unconventional development. But the combination of horizontal drilling and hydraulic fracturing has led to unconventional resources development in locations where communities are less familiar with oil and gas exploration and production.

A menu of policy good practices

The regulatory framework governing unconventional resource development is comprised of federal, state, and local regulations. In addition, various organizations issue recommended good or best practices that supplement this framework and further support responsible development. For each of the impact areas identified above, this portion of the paper provides a menu of policy good practice options. These options draw from a variety of sources, including the CCSD's performance standards—a group of standards developed by a collaboration of energy companies and environmental groups;[39] recommendations made by the Department of Energy's Shale Gas Production Subcommittee[40] and other federal agencies; guidelines of STRONGER; standards suggested by the Ground Water Protection Council, a nonprofit group of state regulators; and state regulations and guidelines, among other sources.

Water impacts—policy good practice options

The following tables identify potential policy good practice options to mitigate water impacts.

First, we outline the importance of policy good practices around water pit and tank management. The next tables touch on good well construction, control, monitoring, and plugging practices to ensure the protection of ground water. Finally, we discuss options around water disposal impacts in the last two tables in the section.

Table 3. Water impacts—Pit and tank location, construction, lining, and maintenance to protect surface and ground waters and soil

Source	Policy good practice
Notification of potentially affected entities	
Colorado	Notify all public water systems "within fifteen ... stream miles downstream" of the operation before beginning any site construction activities near a public water supply.[41]
Pit and well site locations	
Colorado; Michigan; Marcellus Shale Advisory Commission	Establish buffer zones around public water supplies. Place well separators, storage tanks, and treatment equipment at least 2,000 feet from the water supply,[42] and place outermost disturbed edge of well site at least 1,000 feet from public water supply.[43] Within 2,000-2,640 feet of public water supplies, use pitless drilling systems.[44]
Pennsylvania	Ensure that the bottom of the pit is at least 20 feet above the seasonal high water table, unless operator shows that pit will only be used during a dry time of the year.[45]
Pit and tank design, lining, and operation	
Texas,[46] Oklahoma	Design pit so that no stormwater flows into it.[47]
Pennsylvania	Ensure that soil beneath all pit liners is "smooth and uniform" and able to support the weight of the substances that will be placed in it.[48]
Center for Sustainable Shale Gas Development	Use double liner and install leak detection system.[49]
Pennsylvania	Ensure that seams connecting portions of the plastic liner are sealed.[50]
Pennsylvania	Use liner material that is compatible with the waste substance and will not corrode.[51]
Pennsylvania; Nebraska	Prevent the placement of waste, debris, or other equipment in the pit that is likely to tear the liner.[52] Secure liner edge "to prevent wind damage."[53]
Texas	Inspect liner at least annually for tears or compromise.[54]
Containment	
Michigan, Pennsylvania	Place impervious containment beneath "oil heating and treating equipment,"[55] all tanks or containers that hold drilling mud, hydraulic oil, diesel fuel, drilling mud additives, hydraulic fracturing additives, hydraulic fracturing flowback,[56] and ensure that containment is at least 50% larger than the volume of the largest container.[57]
Michigan	Construct and seal "sidewalls and floor" of secondary containment and spill containment "to prevent the seepage of hydrocarbons or brine, or both, into the surrounding soils, surface waters, or groundwater."[58]
Marcellus Shale Advisory Commission	"Conduct an engineering analysis of spill containment systems at unconventional shale gas well sites, including wells, well pads, storage tanks/impoundments, and other equipment facilities."[59]
Marcellus Shale Advisory Commission	Use high-density polyethylene pipe to transport flowback water from well to pits and tanks.[60]
Bureau of Land Management, West Tavaputs Plateau	Place all drill cuttings on an impermeable barrier.[61]

Table 4. Water impacts—Casing, cementing, fracturing, and plugging practices to prevent underground water contamination

Source	Policy good practice
Secy. of Energy Advisory Board, Ground Water Protection Council, Erie-Encana and Erie-Anadarko MOU	Eliminate the use of diesel fuel and benzene[62] in hydraulic fracturing fluids.[63]
Chesapeake, Halliburton, Encana	Use green-certified fracturing fluids and develop broader certification system/"responsible products program" for safe fracturing chemicals."[64]
North Dakota,[65] Pennsylvania,[66] Texas[67]	Use new pipe for casing or test used pipe to the maximum pressure to which it will be subjected during fracturing.
BLM[68]	Conduct mechanical integrity test of each well prior to hydraulic fracturing to ensure that well can withstand the maximum pressure to which it will be subjected during fracturing.
Secy. of Energy Advisory Board	Pressure test casing to "confirm formation isolation"[69]
Arkansas	Monitor casing annuli that could show "potential loss of well bore integrity" during fracturing and "establish methods to timely relieve any excessive pressures."[70]
BLM,[71] other states[72]	Produce detailed cement bond log or cement evaluation log for each well that shows the adequacy of cementing.

Table 5. Water impacts—Well control

Source	Policy good practice
Montana,[73] Pennsylvania[74]	Use blowout equipment that is "in good working order" on all unconventional wells, typically with a blind ram. Test equipment before placing on well.
Montana,[75] North Dakota[76]	Ensure that blowout equipment has remote control capabilities.
Colorado,[77] Montana[78]	Ensure that blowout prevention and "pipe fittings, valves, and unions"[79] can handle the maximum anticipated pressure of the hydraulic fracturing regulation without being compromised.

Table 6. Water impacts—Monitoring and reporting water quality and chemicals used at site

Source	Policy good practice
Colorado	Test surface and groundwater sources within 2,000 feet of the wellhead and bottomhole location (the point at which the underground wellbore ends) prior to commencing well site development and within six months after completing the last hydraulic fracturing job.[80]
Michigan	Install "[a] minimum of 1 groundwater monitoring well downgradient which is in close proximity to all hydrocarbon or brine storage secondary containment areas" in order to continuously monitor water quality that is downgradient from surface pits during pit usage.[81]
Michigan	Require operator to provide a "determination of the direction of groundwater flow and depth to the groundwater in the uppermost aquifer."[82]
Texas	Require chemical disclosure, and if trade secret status is claimed, allow appeal by surface owner, neighboring property owners, state agencies. Require reporting of trade secret information to emergency responders, state agencies that will conduct clean-up.[83]

Table 7. Water impacts—Limiting water quantity impacts

Source	Policy good practice
Susquehanna River Basin Commission	Coordinate with state and, if relevant, groundwater district and regional water authority to determine points at which water withdrawals would have the fewest impacts; through these entities, coordinate with other operators to avoid simultaneous water withdrawals from the same water body.[84]
Pennsylvania, West Virginia	Produced water management plan that describes sources from which water will be withdrawn and anticipated quantity of withdrawal; keep records of actual quantities of water withdrawal, date on which they were withdrawn, and source with specific GPS location.[85]
Susquehanna River Basin Commission	Halt water withdrawals if passby flow within a stream drops below a point designated as safe for aquatic life.[86]
Center for Sustainable Shale Gas Development; Pennsylvania DEP	Reuse 90% of all flowback and produced water.[87]

Table 8. Water impacts—Implementing safe waste disposal practices

Source	Policy good practice
Waste transportation and tracking	
Ohio, Pennsylvania	Develop waste management plan that describes likely content of wastes and where and how each waste will be disposed of.[88]
Arkansas	Provide name, address, and emergency phone numbers for flowback waste transporters; track wastes and specify locations where the wastes may be delivered. Certify that tanks can hold wastes and will not leak."[89]
Centralized E&P Waste Disposal	
Colorado	Before constructing the facility, collect hydrological data on the "existing quality of shallow ground water" and "[a]n evaluation of the potential for impacts to nearby surface water and ground water." Sample all water wells within a one-mile radius of the site and conduct "baseline and periodic surface water monitoring."[90]
Colorado	At the facility construct "[s]urface water diversion structures, including, but not limited to, berms and ditches … to accommodate a one hundred (100) year, twenty four (24) hour event.[91]

Table 9. Water impacts—Reducing the risks of seismic events associated with underground disposal of wastes

Source	Policy good practice
Ohio	Establish "maximum allowable operating pressure" and test casing, tubing, and packer to this pressure.[92]
Ohio	"Monitor injection pressures and injection volumes for each saltwater injection well on a daily operational basis with average and maximum pressures and volumes compiled monthly and filed annually with the division on a form supplied by the division."[93]
Ohio	Install an automatic shut-off system for when "the permitted maximum allowable surface injection pressure on the injection pump is exceeded."[94]
Arkansas	Avoid certain geographic areas with seemingly unstable or numerous faults.[95]

Air impacts—policy good practice options

Table 10 identifies potential policy good practice options regarding air impacts, specifically around air monitoring and controlling emissions.

Table 10. Air impacts—Controlling air emissions and collecting data

Source	Policy good practice
Secy. of Energy Advisory Board	"Design and field a system to collect air emissions data;"[96] collect "comprehensive methane and other air emissions data from shale gas operations."[97]
Clean Air Act, Pennsylvania	"Within 60 days after the well is put into production, and annually thereafter ... perform a leak detection and repair (LDAR) program that includes either the use of an optical gas imaging camera ... or a gas leak detector capable of reading methane concentrations in the air of 0% to 5% with an accuracy of +/- 0.2%."[98]
Clean Air Act, Pennsylvania, West Virginia	Equip storage vessels and tanks "with VOC emission controls achieving emissions reduction of 95% or greater."[99]
Clean Air Act, West Virginia	Install pneumatic controllers with "low bleed or no bleed design.[100]

Broad environmental impacts—policy good practice options

Tables 11 and 12 outline potential policy good practice options for reducing soil impacts and lessening landscape habitat and wildlife impacts.

Table 11. Broad environmental impacts—Reducing soil compaction and erosion

Source, or similar guideline	Policy good practice
Louisiana, Ohio	During seismic testing, avoid using equipment in wet areas and areas with valuable topsoil that risks compaction or erosion.[101]
West Virginia	Have a "registered professional engineer" certify the plan for preventing and mitigating erosion and sediment control and the site construction plan at each site.[102]
Marcellus Shale Advisory Commission	Arrange for an inspection upon completion of "erosion and sedimentation control measures,"[103] and "allow for County Conservation Districts to engage in inspections of erosion and sedimentation controls at unconventional well sites..."[104]

Table 12. Broad environmental impacts—Reducing landscape habitat impacts; protecting wildlife

Source	Policy good practice
Marcellus Shale Advisory Commission; Ohio; Secy. of Energy Advisory Board	Locate "high conservation value forests, conservations of biological diversity, sensitive aquatic communities,"[105] sensitive habitats and wildlife and plant species; flag these areas prior to conducting seismic surveys. Avoid these areas during seismic testing, and avoid constructing well sites in these areas.[106]
North Dakota	Place netting over all pits and ensure that netting is fully secured and covers the entire pit.[107]
Colorado, Ohio	Wherever possible, use existing roads and already-disturbed land surfaces for access roads and well pads.[108]
Maryland	Measure the cumulative landscape impact of the operator's wells in a region and develop a strategic plan to cluster wells or otherwise reduce the overall regional footprint.[109]
Colorado	Disinfect water withdrawal hoses between uses to avoid invasive species transfers.[110]
Marcellus Shale Advisory Commission	Minimize the disturbance of soil at sites and revegetate sites soon after disturbance to avoid the germination of invasive species.[111]

Community impacts—policy good practice options

Beyond broad environmental impacts, policy good practices to mitigate community impacts should also be considered. Tables 13 and 14 outline potential policy good practices for managing a broad range of issues, including community engagement and local economy impacts; land use planning; road, noise, dust, light, and agricultural impact management; and site restoration.

Table 13. Community impacts—Reducing physical local impacts and nuisances such as road damage and congestion, noise, dust, and light pollution, and impacts to agricultural resources

Source, or guideline similar to policy good practice	Policy good practice
Process: Notifying and listening to the community	
Marcellus Shale Advisory Commission	Notify county or municipality prior to developing well site and allow opportunity for local government to comment.[112]
Marcellus Shale Advisory Commission	Notify all "landowners and water purveyors," or "adjacent municipalities within 2,500 feet" of the well site prior to development.[113]
Addressing road conditions	
Ohio	Prior to constructing well sites, enter road use agreement with municipality that addresses which roads will be used, likely average number of daily truck trips, allocation of responsibility for widening or otherwise upgrading roads, allocation of responsibility for repairing or paying for road damage; allocation of responsibility for any accidents or other liability.

Table 13. (continued) Community impacts—Reducing physical local impacts and nuisances such as road damage and congestion, noise, dust, and light pollution, and impacts to agricultural resources

Source, or guideline similar to policy good practice	Policy good practice
Preventing nuisances and physical impacts to homeowners, farmers, and other community members	
Colorado	Install fence around well site, including pits containing wastes.[114]
Farmington, New Mexico	Place landscaping features around sites within 300 feet of homes or paved streets.[115]
Fort Worth, Texas	Set back wells at least 600 feet from residences and public buildings.[116]
Fort Worth and Arlington, Texas; Farmington, New Mexico	Use mufflers on all equipment; limit decibel levels around sites.
Fort Worth, Texas	Conduct "open hole formation or drill stem testing" and hydraulic fracturing operations only "during daylight hours."[117]
Fort Worth and Arlington, Texas' Farmington, New Mexico; State of Illinois	Maintain a minimum of $5 million in environmental and personal liability insurance, or post bond.[118]
Site restoration	
Fort Worth, Texas	"Promptly clear drill and operation sites of all litter, trash, waste and other substances used ... and after [a]bandonment or completion grade, level and restore[such] property to the same surface conditions as nearly as possible as existed before operations."[119]

Table 14. Community impacts—Addressing changes to the local economy, enhanced demand for local services, and land use planning needs

Source	Policy good practice
Oklahoma,[120] West Virginia	Speak with surface owner where well will be located and owners and residents of all neighboring properties. Identify concerns of these individuals and address them where feasible, such as avoiding important agricultural lands and limiting the timing of operations. Agree on amount of money that will be paid to surface owner for damages to the surface.
Marcellus Shale Advisory Commission	Work with states to support job training and certification programs.[121]
United Kingdom	Negotiate community benefit or impacts benefit agreements through which operator pays a fixed amount to the community for parks, community services, conservation, or other improvements, or provides these amenities.[122]

Encouraging continuous improvement

In general, good policies balance environmental concerns and unconventional gas development in a reasonable and cost effective manner. Unconventional gas operators already must comply with a number of federal, state, and local regulations, but state governments can encourage continuous improvement in operational practices through a variety of policy incentives.

- First, state governments can promote greater public recognition of operators that implement good environmental and social practices. Broader public recognition could even help operators at the community level. To the extent that local officials are concerned about the impacts of development, a positive and public track record could potentially smooth the permitting process for operators entering new communities.
- Second, states can offer faster-track permitting to operators that commit to implementing good practices. This would create a direct incentive for operators to participate in a good practices program. Fast or "faster"-track permitting for necessary pre-drilling and drilling permits.
- Third, states can implement a centralized permitting process in areas where several agencies possess significant authority over the development process. States can designate one agency as a lead agency and require other agencies with equities to coordinate and participate in joint meetings.
- Finally, states can implement voluntary best practices and allow compliant operators to avoid certain other procedural and paperwork requirements.

Some states have begun to incentivize continuous improvement through good policy practices. Colorado, for example, rewards operators who voluntarily implement good practices as part of a comprehensive drilling plan approved by the state. These plans allow one or more operators to prepare a joint plan for the development of multiple wells in one area, working in conjunction with several state agencies to voluntarily reduce impacts on wildlife and the environment.[123] The state offers incentives for these plans in order to "facilitate and encourage" their use.

Conclusion

As the unconventional oil and gas sector continues to grow and mature, many states are looking to modify or develop new safeguards to accommodate that growth. Although these states vary in their climate, topography, and geology, they can still draw upon lessons learned in other states and by other organizations. The policy options outlined in this paper illustrate how states, outside organizations, and operators are finding ways to develop unconventional resources in safe, responsible, and economically feasible ways.

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44. Colorado would allow pitless drilling systems or containment practices that are required for all pits. 2 CO ADC 404-1:317B (Westlaw 2014).

45. 25 Pa. Code § 78.56(a)(4)(iii) (Westlaw 2014).

46. Tex. Admin. Code tit. 16, § 3.8 (Westlaw 2014). Note that the Texas regulations do not apply to flowback pits, specifically, but to other types of pits. The regulations show, however, that these types of requirements might be feasible for all pits.

47. Okla. Admin. Code § 165:10-29-1(g)(3) (Westlaw 2014) (for wells in certain areas, providing that "[n]o pit shall be constructed or maintained so as to receive outside runoff water").

48. 25 Pa. Code § 78.56(a)(4)(ii) (Westlaw 2014).

49. Center for Sustainable Shale Development, Performance Standards, August 19, 2013, https://www.sustainableshale.org/wp-content/uploads/2014/01/Performance-Standards-v.-1.1.pdf. at 2.

50. 25 Pa. Code § 78.56(a)(4)(i) (Westlaw 2014) ("Adjoining sections of liners shall be sealed together to prevent leakage in accordance with the manufacturer's directions.").

51. 25 Pa. Code § 78.56(a)(4)(i) (Westlaw 2014) ("The liner shall be designed, constructed and maintained so that the physical and chemical characteristics of the liner are not adversely affected by the waste and the liner is resistant to physical, chemical and other failure during transportation, handling, installation and use.").

52. 25 Pa. Code § 78.56(a)(4)(ii) (Westlaw 2014) (Liner subbase must be "free from debris, rock and other material that may puncture, tear, cut or otherwise cause the liner to fail").

53. 267 Neb. Admin. Code, Ch. 3, § 012.13.

54. Tex. Admin. Code tit. 16, § 3.8(d)(4)(G) (Westlaw 2014) ("f the operator does not propose to empty the pit and inspect the pit liner on at least an annual basis, the operator shall install a double liner and leak detection system").

55. Mich. Admin. Code r. 324.1002(3)(d) (Westlaw 2014).

56. 58 Pa. Cons. Stat.. § 3218.2(c) (Westlaw 2014).

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58. Mich. Admin. Code r. 324.1002(e)(Westlaw 2014).

59. Governor's Marcellus Shale Advisory Commission Report, July 22, 2011, at p. 107 (recommendation 9.2.11), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf. at 110 (recommendation 9.2.27).

60. Governor's Marcellus Shale Advisory Commission Report, July 22, 2011, at p. 107 (recommendation 9.2.11), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf. at 109 (recommendation 9.2.23).

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64. Chesapeake Energy, GreenFrac®, http://www.chk.com/Corporate-Responsibility/EHS/Environment/Green-Frac/Pages/Information.aspx; Halliburton, Clean Innovations, http://www.halliburton.com/public/projects/pubsdata/Hydraulic_Fracturing/CleanSuite_Technologies.html; Memorandum of Understanding, Town of Erie, Colorado, and Encana, http://www.erieco.gov/DocumentCenter/View/4736.

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66. 25 Pa. Code § 78.84(b), § 78.84(c) (Westlaw 2014) (requiring internal pressure rating of new casing to be "20% greater than anticipated maximum pressure," or allowing used casing if more stringent conditions are met).

67. Tex. Admin. Code tit. 16, § 3.13(4)(A) (Westlaw 2014).

68. Department of the Interior, Bureau of Land Management, 43 CFR Part 3160, Oil and Gas; Hydraulic Fracturing on Federal and Indian Lands at 75, May 16, 2013, http://www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate/public_affairs/hydraulicfracturing.Par.91723.File.tmp/HydFrac_SupProposal.pdf. (Some commenters on this requirement in the BLM's draft rules suggested that this requirement causes delay and thus increases the cost of rig time. Many states already require this test, however, and the BLM already requires a casing pressure test.)

69. Secretary of Energy Advisory Board, Shale Gas Production Committee 90-Day Report, Aug. 18, 2011, at 20-21, http://www.shalegas.energy.gov/resources/081811_90_day_report_final.pdf.

70. Code Ark. R. § B-19(g) (2011).

71. The BLM's most recent draft rules for hydraulic fracturing on federal lands require the use of a cement evaluation log rather than a bond log because of industry comments indicating that bond logs are not always the most accurate measure of the adequacy of cement. Department of the Interior, Bureau of Land Management, 43 CFR Part 3160, Oil and Gas; Hydraulic Fracturing on Federal and Indian Lands at 7, May 16, 2013, http://www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate/public_affairs/hydraulicfracturing.Par.91723.File.tmp/HydFrac_SupProposal.pdf.

72. 805 Ky. Admin. Regs. 1:120 §4(3)(b) (requiring "[entire casing and cementing record, any packers and other special down hole equipment, and cement bond logs, if run"); N.D. Admin. Code 43-02-03-31 (Westlaw 2014 (requiring a log "from which the presence and quality of bonding of cement can be determined in every well in which production or intermediate casing has been set"); Tex. Admin. Code tit. 16, § 3.13(F), § 3.13 (C) (Westlaw 2014) (requiring cement log with "complete data concerning the cementing of surface casing in the well as specified on a form furnished by the commission" and a temperature survey or cement bond log "If cement is not circulated to the ground surface or the bottom of the cellar").

73. Admin. R. Mont. 36.22.1014(1)(b) (Westlaw 2014) ("For development wells and in all areas of known formation pressures, blowout prevention and well control equipment must be installed.").

74. 25 Pa. Code § 78.72(b) (Westlaw 2014).

75. Admin. R. Mont. 36.22.1014(7)(b) (Westlaw 2014) (in areas where hydrogen sulfide might be encountered, requiring "a remote auxiliary choke control panel to operate the choke manifold set up at a safe distance upwind from the rig floor").

76. N.D. Admin. Code 43-02-03-28 (Westlaw 2014) ("The director may require remote operated or automatic shutdown equipment to be installed on, or shut in for no more than forty days, any well that is likely to cause a serious threat of pollution or injury to the public health or safety.")

77. 2 Code Colo. Regs. § 404-1:317(a) (Westlaw 2014).

78. Admin. R. Mont. 36.22.1014 (Westlaw 2014) ("The rated working pressure of all blowout preventers and well control equipment must equal or exceed the maximum anticipated pressure to be contained at the surface.").

79. 25 Pa. Code § 78.72(d) (Westlaw 2014).

80. 2 Code Colo. Regs § 404-1:609(d)(1), (d)(2) (requiring sampling of water wells "within 12 months prior to setting conductor pipe" for a well, subsequent monitoring within 6 and 12 months of the initial sample, and "a second subsequent sampling event" "between sixty (6) and seventy-two (72) months following completion of the Well").

81. Mich. Admin. Code r. 324.1002(3)(b)(i) (Westlaw 2014).

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83. Tex. Admin. Code tit. 16 § 3.29(c) (Westlaw 2014).

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86. 18 CFR §806. 23, see also Susquehanna River Basin Commission, 64 Water Withdrawals for Natural Gas Drilling and Other Uses Suspended to Protect Streams, July 16, 2012 http://www.srbc.net/newsroom/NewsReleasePrintFriendly.aspx?NewsReleaseID=90 ("Under SRBC's passby flow restrictions, when streams drop to predetermined protected low flow levels, operators who are required to meet the agency's passby requirement must stop taking water.").
87. The Center for Sustainable Shale Development provides that by September 24, 2014 or date of an operator's initial application to be certified under the center's standards, "Operators must recycle a minimum of 90% of the flowback and produced water, by volume from its wells …"
88. Ohio Admin. Code 1501:9-1-02(A)(3) (Westlaw 2014) (requiring a "plan for disposal of water and other waste substances resulting from, obtained, or produced in connection with exploration, drilling, or production of oil or gas"); 25 Pa. Code § 78.55(a) (Westlaw 2014) ("Prior to generation of waste, the well operator shall prepare and implement a plan under § 91.34 (relating to activities utilizing pollutants) for the control and disposal of fluids, residual waste and drill cuttings, including tophole water, brines, drilling fluids, additives, drilling muds, stimulation fluids, well servicing fluids, oil, production fluids and drill cuttings from the drilling, alteration, production, plugging or other activity associated with oil and gas wells.").
89. Code Ark. R. § Rule E-3(d), (h), (i) (2014).
90. 2 Code Colo. Regs. § 404-1:908(b)(7)(B)(vi), (b)(9)(A), (b)(10) (Westlaw 2014). Note that Colorado only requires baseline and periodic surface water monitoring in certain circumstances.
91. 2 Code Colo. Regs. § 404-1:908(b)(5)(E) (Westlaw 2014).
92. Ohio Admin. Code 1501:9-3-07(D) (Westlaw 2014).
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94. Ohio Admin. Code 1501:9-3-07(G) (Westlaw 2014).
95. Arkansas Oil & Gas Commission, Permanent Disposal Well Moratorium Area, http://www.aogc.state.ar.us/notices/Ex.%20 1B%20-Permanent%20Disposal%20Well%20Moratorium%20 Area.pdf.
96. Secretary of Energy Advisory Board, Shale Gas Production Subcommittee Second 90-Day Report, Nov. 18, 2011, at 4, http://www.shalegas.energy.gov/resources/111811_final_report.pdf.
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98. Pennsylvania Department of Environmental Protection, Air Quality, Doc. 275-2101-003, Air Quality Permit Exemptions, http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-96215/275-2101-003.pdf (providing requirements that must be followed if operators are to be exempt from certain state-implemented federal Clean Air Act permitting). The Clean Air Act rules for tanks at oil and gas sites are contained in 78 Fed. Reg. 58416 (2013).
99. Pennsylvania Department of Environmental Protection, Air Quality, Doc. 275-2101-003, Air Quality Permit Exemptions, at 10, http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-96215/275-2101-003.pdf ; Presentation by Robert Keatley, PE, Senior Engineer/Supervisor, West Virginia DEP – Division of Air Quality, New Air Quality Regulation "NSPS OOOO," Oil and Natural Gas Industry Workshop, Feb. 6, 2013 (describing how West Virginia will implement the federal Clean Air Act regulation).
100. Pennsylvania Department of Environmental Protection, Air Quality, Doc. 275-2101-003, Air Quality Permit Exemptions, at 14, http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-96215/275-2101-003.pdf.
101. Ohio Department of Natural Resources, BMP's and Recommendations for Oil and Gas Activities on State of Ohio Lands at 10, Jan. 30, 2012, http://oilandgas.ohiodnr.gov/portals/oilgas/pdf/leasingBMP.pdf ("Drill buggies used for dynamite surveys should avoid all sensitive and wet areas."); La. Admin. Code tit. 76, § 301(F) (Westlaw 2014) ("Boats, marsh buggies, airboats, or other types of marsh vehicles, when used, must be used so as to cause the minimum disturbance or damage to the lands, waterbottoms, and wildlife and fisheries resources thereon.").
102. West Virginia requires this "[f]or well sites that disturb three acres or more of surface." W. Va. Code R, § 22-6A-7(c)(15)(2) (Westlaw 2014).
103. Governor's Marcellus Shale Advisory Commission Report, July 22, 2011, at p. at 107 (recommendation 9.2.15)., http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf.
104. Governor's Marcellus Shale Advisory Commission Report, July 22, 2011, at p. at 105 (recommendation 9.1.17), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf.
105. Governor's Marcellus Shale Advisory Commission Report, July 22, 2011, at 110, (recommendation 9.2.26), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf; Secretary of Energy Advisory Board, Shale Gas Production Committee 90-Day Report, Aug. 18, 2011, at 17, http://www.shalegas.energy.gov/resources/081811_90_day_report_final.pdf (recommending "[p]reservation of unique and/or sensitive areas as off-limits to drilling" and "science-based characterization of important landscapes, habitats and corridors to inform planning, prevention, mitigation and reclamation of surface impacts").
106. Ohio Department of Natural Resources, BMP's and Recommendations for Oil and Gas Activities on State of Ohio Lands, at 11, Jan. 30, 2012, http://oilandgas.ohiodnr.gov/portals/oilgas/pdf/leasingBMP.pdf.
107. N.D. Admin. Code 43-02-03-19.1 (Westlaw 2014) ("All open pits and ponds which contain saltwater must be fenced. All pits and ponds which contain oil must be fenced, screened, and netted."). Note that North Dakota does not apply this rule to reserve pits for drilling and well completion and recompletion wastes if those pits are closed within ninety days after drilling operations are complete. Due to the threats to wildlife caused by all open pits, however, it seems advisable to place netting over all pits.

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109. Maryland Department of the Environment, Marcellus Shale Safe Drilling Initiative Study Part II, Best Practices (Draft for Public Comment), at 8, http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/Draft_for_Public_Comment_6.24.2013.pdf (proposing to require Comprehensive Gas Development Plans).
110. 2 Code of Colo. Regs. § 404-1:1204(a)(2) (Westlaw 2014) (required in cutthroat trout habitat).
111. Governor's Marcellus Shale Advisory Commission Report, July 22, 2011, at 111, (recommendation 9.2.30), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf.
112. Governor's Marcellus Shale Advisory Commission Report, July 22, 2011, at 105, (recommendation 9.1.17), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf.
113. Governor's Marcellus Shale Advisory Commission Report, July 22, 2011, at 106, (recommendation 9.2.5), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf.
114. 2 Code of Colo. Regs. § 404-1:1002 (requiring fencing of the reserve pit only when livestock are not already fenced in an area away from the pit, if the surface owner requests this).
115. Code of City of Farmington, New Mexico § 19-3-10(b) (requiring landscaping plan if principal uses occur within 300 feet of a well site or there is a paved street within 100 feet of the well site).
116. City of Fort Worth, Texas, Ordinance No. 18449-02-2009 § 15-36(A), (Feb. 3, 2009), available at http://fortworthtexas.gov/uploadedFiles/Gas_Wells/090120_gas_drilling_final.pd, at p. 17 (requiring this setback unless a waiver is granted).
117. City of Fort Worth, Texas, Ordinance No. 18449-02-2009 § 15-42(A)(7),(A)(16), (Feb. 3, 2009), available at http://fortworthtexas.gov/uploadedFiles/Gas_Wells/090120_gas_drilling_final.pdf, at p. 32.
118. See City of Arlington, Texas, Ordinance No. 07-074 § 6.01(C)(4), (Oct. 23, 2007), available at http://www.arlingtontx.gov/planning/pdf/Gas_Wells/Ordinance_with_signatures.pdf, at p. 25; City of Fort Worth, Texas Ordinance No. 18449-02-2009 § 15-41(C)(4)), (Feb. 3, 2009), available at http://fortworthtexas.gov/uploadedFiles/Gas_Wells/090120_gas_drilling_final.pd, at p. 29; Farmington, New Mexico Code of Ordinances § 19-2-101, http://library.municode.com/index.aspx?clientId=10760 (follow "Chapter 19 – Oil and Gas Wells" hyperlink, then "Article 2 -- Administration and Enforcement," then "Division 4 – Bond and Insurance) (all requiring operators to maintain environmental pollution liability insurance that will cover $5 million per incident); 225 Ill. Comp. Stat. § 732/1-35(a)(3) (Westlaw 2014).
119. City of Fort Worth, Texas, Ordinance No. 18449-02-2009 § 15-41 (Feb. 3, 2009), available at http://fortworthtexas.gov/uploadedFiles/Gas_Wells/090120_gas_drilling_final.pdf at p. 25,.
120. Okla. Stat. tit. 52. § 318.3 (Westlaw 2014), W. Va. Code R, § 22-6A-10(a) (Westlaw 2014).
121. Governor's Marcellus Shale Advisory Commission Report, July 22, 2011, at 117, (recommendation 9.4.17), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf 117.
122. On-shore Oil and Gas Development in Hampshire, Conventional (oil and gas) and Unconventional (shale gas), Frequently Asked Questions, Version 10, (April 2014) available at http://documents.hants.gov.uk/mineralsandwaste/onshoreoilandgas-faq.pdf, at p.14 ("£ 100,000 of community benefits will be provided per well site where fracking takes place").
123. 2 Code of Colo. Regs. § 404-1:216 (Westlaw 2014).

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