

STATE STORMWATER POLICY OVERVIEW FOR THE OIL & GAS INDUSTRY

by

Anna Petryniak Ediger
Dr. Martin Doyle, Adviser
May 2014

Masters project submitted in partial fulfillment of the
requirements for the Master of Environmental Management degree in
the Nicholas School of the Environment of
Duke University

2014

Special thanks to the North Carolina League of Conservation Voters, and specifically Robin Smith, who provided mentorship on the regulatory aspect of this project as well as motivation for pursuing this research topic. Thank you to Dr. Martin Doyle for his guidance and direction throughout the research process. Additionally, special acknowledgement to Rubaina Anjum with whom the regulatory research was conducted and synthesized.

Table of Contents

List of Abbreviations.....	4
Executive Summary	5
Introduction	6
Stormwater	7
Phases of Natural Gas Production and Extraction.....	7
Data & Methods	9
Regulatory Review	9
Enforcement Review	10
Data of Interest	10
Pennsylvania	11
Colorado	12
Cross-State Comparison of Enforcement Data	13
Results & Discussion	15
Regulatory Results	15
Mechanisms for Stormwater Management.....	15
Regulations for Retention of Fluids	18
Regulatory Discussion.....	21
Mechanisms for Stormwater Management.....	21
Regulations for Retention of Fluids	24
Regulatory Synthesis	25
Limitations.....	26
Enforcement Results	27
Pennsylvania	27
Colorado	31
Enforcement Discussion.....	36
Pennsylvania	36
Comparison of Pennsylvania and Colorado Enforcement Programs	38
Enforcement Synthesis.....	41
Conclusion	41
Disparities in Rule-making and Enforcement	42
Case-specific factors	44

Recommendations.....	45
Literature Cited	47
APPENDIX.....	51

List of Abbreviations

BMPs	Best Management Practices
CDPHE	Colorado Department of Public Health and the Environment
CDPS	Colorado Discharge Permit System
COGCC	Colorado Oil and Gas Conservation Commission
DEP	(Pennsylvania) Department of Environmental Protection
E&SC	Erosion and Sediment Control
NORM	Naturally Occurring Radioactive Material
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
STRONGER	State Review of Oil & Natural Gas Environmental Regulations
SWMP	Stormwater Management Plan
TDS	Total Dissolved Solids
WQCD	Water Quality Control Division
USEPA	United States Environmental Protection Agency

Executive Summary

- Stormwater regulations applicable to the oil and gas industry were reviewed and synthesized in ten different states to determine if programs should be improved to better protect surface waters.
- Five primary mechanisms for stormwater management were identified. Their merits and limitations are discussed based on the scope of activities they cover throughout the oil and gas extraction and production process. Findings show that early phases of an oil and gas operation are regulated most frequently, raising concerns for surface water degradation during later activities.
- Six key regulatory provisions pertaining to open retention of pit fluids were identified. The paper interprets their potential ability to minimize environmental impacts. It's concluded that stormwater impacts could be mitigated by (1) initiating a pit permit system, and (2) including numeric standards based on local climate data in regulations.
- A review of the Pennsylvania and Colorado enforcement programs is conducted, with attention focused on the types of violations occurring in each state and associated penalty assessments. Results show that both states might face challenges in designing an enforcement program that effectively influences compliance.
- The regulatory and enforcement pieces are synthesized through a discussion of the differences in these policy tools and how that is specifically characterized in the case study of oil and gas stormwater regulations.
- The study concludes that states can best prioritize resources by focusing attention on designing effective regulations. Still, enforcement programs might be improved by implementing innovative methods of encouraging compliance in addition to traditional enforcement tools.

Introduction

In 2013, the energy sector marketed over 23 million cubic feet of natural gas, a greater than 15% increase over 2003 values (U.S. Energy Information Administration, 2014). In the same period, the number of producing wells increased by more than 22% (U.S. Energy Information Administration, 2014). As the natural gas sector has expanded, attention has been focused on the environmental impacts associated with its production. Due to the large quantity of land necessary for well pad construction, as well as the millions of gallons of fluids necessary for hydraulic fracturing, impact to surface waters is a significant environmental concern with respect to further expansion of the industry. This paper will focus on potential impacts to surface water associated with natural gas production through the pathway of stormwater.

Surface water degradation by industrial activities can be diminished through establishment of effective policies, which are demonstrated in part by strong regulation coupled with robust enforcement. Analysis of oil and gas policy is focused at the state level, as the industry is exempt from a suite of federal statutes dedicated to protection of water resources. These exemptions include provisions in the Clean Water Act, the Safe Drinking Water Act, the Resource Conservation and Recovery Act, and the Emergency Planning and Community Right-to-Know Act (The Bousson Advisory Group, 2014). As a result of these federal exemptions, primary regulatory and enforcement responsibility over the oil and gas sector rests at the state level. Consequently, wide variability exists in the policy frameworks governing oil and gas operators across the country. As states continue to modify and write new regulations applicable to the industry, the patchwork of existing policies begs to be investigated in order to inform future decision-making. This paper investigates how states have responded to this federal regulatory gap through regulation and enforcement activities. It uses this analysis to draw conclusions about how states may best prioritize government resources for better stormwater management.

The paper begins by describing the pathways through which stormwater interacts with activities on a well-pad, and how runoff has the potential to degrade surface water. It then investigates the approach of ten states to regulating the industry. It categorizes these approaches and provides a brief analysis of specific statutory and regulatory provisions that have the potential to prevent stormwater impacts. Based on data availability and findings in the regulatory review, Pennsylvania and Colorado are selected for enforcement analysis. A review of enforcement actions in these states was conducted and analyzed in light of various policy

and guidance documents available in each state. The paper concludes by comparing the regulatory and enforcement processes. It suggests that states should prioritize designing effective stormwater regulations and that creative enforcement tools may exist that can supplement traditional methods of encouraging compliance and deterring environmental impacts.

Stormwater

The EPA defines stormwater runoff as that which is “generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground ... it accumulates debris, chemicals, sediment or other pollutants that could adversely affect water quality if the runoff is discharged untreated.” (Office of Wastewater Management, United States Environmental Protection Agency, 2012a) The manner in which oil and gas activities may impact stormwater varies based on phase of operation. For purposes of this paper, four distinct phases of a natural gas operation were identified in order to better understand which activities were regulated for stormwater. Defining these phases is important because a comprehensive stormwater program should mitigate environmental impacts for any site activity, regardless of when it occurs. These phases do not represent an industry or governmental standard, but should accurately reflect the process of natural gas extraction, production, and closure, and are used as a frame of reference for this study.

Phases of Natural Gas Production and Extraction

Pre-Drilling

Oil and gas operators clear vegetation and cause earth disturbance to prepare a site for drilling. Potential pollutants during pre-drilling are those related to general construction activity, most frequently erosion and transport of sediment. Negative impacts associated with sediment transport include: reduction of habitat for aquatic life; degradation of water quality caused by pollutants bound to sediments; reduction of drinking water supplies due to sediment accumulation in reservoirs; costs imposed on residents, industry and the government for dredging waterways and reservoirs; and, costs imposed on utilities and their customers for water treatment (PA Department of Environmental Protection, 2012). Other threats to water quality associated with pre-drilling activity arise from vehicular traffic, which may change hydrologic properties of the land surface due to compaction (Adams et al., 2011; W.V.

Department of Environmental Protection, 2014). Construction activity may take from several days to weeks (Smith and Ozer, et al. 2012).

Drilling and Hydraulic Fracturing

Operators use millions of gallons of freshwater in the hydraulic fracturing process to efficiently extract the gas resource (FracFocus Chemical Disclosure Registry, 2014a). Due to the large amount of water required in a short period of time, certain states permit operators to temporarily store fresh water in open pits or tanks to mitigate impacts to water supply. States may also permit operators to store fluids used and produced in the hydraulic fracturing process. These fluids include but are not limited to oil-based drilling fluids, produced water, flowback, completion and workover fluids. Fluids stored in pits can interface with stormwater during precipitation events and inadequate construction standards may result in overflow and contamination of surface waters (Benefield, 2012).

A number of additives can be present in fracking fluid. The rules for disclosure of these additives and their concentrations vary across states, but commonly used chemicals include acids, corrosion inhibitors, friction reducers, biocides, clay stabilizers and gellants (FracFocus Chemical Disclosure Registry, 2014b). Under the direction of Congress, the United States Environmental Protection Agency (USEPA) is still assessing the potential health and environmental impacts of these additives, with a draft report expected at the end of 2014 (United States Environmental Protection Agency, 2014). However, a 2011 Congressional committee document reported that dozens of chemicals known to exist in hydraulic fracking fluids fall under the scope of the Safe Drinking Water Act and “are either known or possible human carcinogens.” (Office of Research and Development, USEPA, 2012)

Additionally, naturally occurring fluids found in underground shale formations may contain high concentrations of Total Dissolved Solids (otherwise known as TDS, an indicator of salinity) or Naturally Occurring Radioactive Materials (NORM), which are brought to the surface after hydraulic fracking. While the degree of salinity of formation water varies by location, studies have shown that TDS concentrations may far exceed those in seawater (Vengosh, Jackson, Warner, Darrah, & Kondash, 2014) If this fluid enters surface water bodies it has the potential to harm aquatic organisms. At the same time, it may impact water quality at treatment plants by creating unsafe chemical byproducts (Warren, 2010). Furthermore, surface water impacts during the drilling phase may result from equipment that is used to conduct natural gas extraction, where hydrocarbons and metals can be transferred to stormwater through contact

with on-site structures (Wachal, 2008). Drilling and hydraulic fracturing may take about four to six weeks (ExxonMobil and XTO Energy, 2014).

Production

During the production phase of natural gas extraction, on-site activity can significantly decrease. Sites are re-vegetated and open pits reclaimed. Generally, reclamation is indicated by the disposal of fluids or stabilization of pit contents. Subsequently, the pit may be filled with material which should be shaped to resemble its prior form and the surrounding landscape. The land surface should then be re-vegetated.

A well-head and processing facility remain on site while the well keeps producing gas (ExxonMobil and XTO Energy, 2014). These facilities may be limited in nature, conducting only preliminary processing of the natural gas prior to transporting it to a larger plant (Energy Information Administration, 2006). A site which has not been properly reclaimed may contribute to similar adverse stormwater impacts to those described in earlier phases. Additionally, operator error may cause an emergency situation, such as a spill or blowout. The production phase can last two to four decades (ExxonMobil and XTO Energy, 2014).

Post-Production

After an operator has terminated extracting natural gas, the well must be plugged and site reclaimed. On a properly managed and well-regulated site, plugging and reclamation should occur in a timeframe that does not expose surface water to potential pollution after activity on the site has ceased. Consequently, a robust regulatory program should place a clear deadline on permit renewals and expiration to ensure that state agencies have up-to-date information on the expected lifetime of a well in order to facilitate timely well closure and restoration.

Data & Methods

Regulatory Review

Ten states were selected for the first part of this study, which consisted of a review of state statutes, regulations, and stormwater program materials located through publicly available information online. The selection of states was influenced by quantity of natural gas production, potential expansion of the industry based on assessments of shale gas resources by the United

States Geological Survey¹, data availability, media profile, and was limited by time constraints (see Table 1). The ten states were: Alaska, Arkansas, Colorado, Louisiana, Michigan, Ohio, Pennsylvania, Texas, Virginia, and Wyoming.

When needed and feasible, employees at relevant state agencies were contacted to confirm how stormwater programs were implemented based on statutes and regulations. Agencies were contacted based on mission and purpose, which was most frequently devoted to environmental protection or the conservation of oil and gas. When possible, the contact was a stormwater permit engineer or individual most familiar with stormwater management regulations. In several states, regulatory responsibility over oil and gas activities is shared amongst two or more agencies and program information which was received was limited to the department's specific role in stormwater management.

Enforcement Review

Data of Interest

The regulatory review revealed that Pennsylvania and Colorado were suitable candidates for analysis of their stormwater enforcement programs. First, both states had easily accessible enforcement data and are among the top ten producers of natural gas in the nation ("U.S. Natural Gas Marketed Production," 2014). Additionally, these state programs were more rigorous than others, particularly in that they were designed to manage stormwater from pre-drilling through plugging and abandonment (i.e. the entire life of a natural gas project). However, program differences did exist with respect to the agencies which had oversight over oil and gas stormwater management, as well as the design of the state permit systems. Consequently, Pennsylvania and Colorado provide an interesting point of comparison between two programs that were shown to be broader in scope than those in other states.

The primary enforcement data of interest in each state included the (1) statutory, regulatory, or permit code which was violated and (2) the penalty in which the action resulted. The purpose of investigating the codes which were violated was to determine if any trends existed in the types of violations occurring in the industry, how they may relate to the regulatory review in the first part of this study, and if any specific threats to surface waters were prevalent. The value of penalty assessments was analyzed to posit whether or not monetary consequences might impact operator behavior and compliance. Lastly, the trends observed in

¹ (U.S. Geological Survey National Assessment of Oil and Gas Resources Team, 2013)

the data were interpreted based on technical guidance issued by state agencies, as well as materials from non-governmental organizations, in order to draw conclusions about what aspects of an enforcement program contribute to its effectiveness and how the Colorado and Pennsylvania programs can be improved.

Enforcement data were located on state government websites and were publicly available. In Pennsylvania, the Department of Environmental Protection (DEP) hosts a web service which publishes Oil and Gas Compliance Reports with details on issued violations and enforcement actions². In Colorado, the Department of Public Health and the Environment (CDPHE), Water Quality Control Division (WQD) posts similar information related to the Colorado Discharge Permit System (CDPS) for Construction Activities³.

Pennsylvania

Pennsylvania Oil and Gas Compliance Reports can be tailored by the user based on a number of specifications. Table 2 below lists criteria which were selected for purposes of this study. Where the criteria were not self-explanatory, the options provided from a pull-down menu in the database are listed in the second column. When possible, the criteria were selected broadly in order to obtain a comprehensive view of the state program. For example, all counties, municipalities, regions, operators, and inspection categories were included in the report.

In a few circumstances, the criteria selected were narrower in scope. For example, the 'dates of inspection' were limited to 2006 – 2013. Selecting this timeframe allows this study to focus on how enforcement actions may or may not have responded to the most recent policy modifications in Pennsylvania's Oil and Gas program. Legislative, regulatory, and oil & gas program changes have been more frequent in recent years in response to the rise of unconventional natural gas production in the Marcellus shale (Airey, Gormly, Keller, Russell, & Vorys, 2014; Governor's Marcellus Shale Advisory Commission, 2011; State Review of Oil & Natural Gas Environmental Regulations, 2013). Using this dataset will allow us to observe if violations and penalties have correspondingly evolved.

Among other data, the output generated in each annual report includes: the operator who was cited for a violation; the date and type of inspection; the region, county, and municipality in which the violation occurred; a code describing which statute or regulation was

² Available at: http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_compliance_report/20299

³ Available at: <http://www.colorado.gov/cs/Satellite/CDPHE-WQ/CBON/1251596875260>

violated; the type of violation (administrative, environmental health & safety); and any associated penalties. The Pennsylvania enforcement reports were produced to include only those inspections which resulted in resolved violations. This is because one of the main points of interest in comparing the state enforcement programs was the value of penalties which were issued. By selecting these criteria, there was increased confidence that the data would report an accurate penalty value. Additionally, due to the magnitude of violations issued and reported by the Pennsylvania DEP, as well as a primary interest in penalty assessments, any data that did not result in a monetary fine were removed from this analysis.

Table 2. Pennsylvania Oil and Gas Report Selected Criteria

Criteria	Options	Selection
Date of Inspection	-	Annual Report
County	-	All
Municipality	-	All
Region	Bureau of Oil and Gas Planning Program Management; DEP Division of Oil and Gas District Office: North Central; North West; South West	All
Operator	Database lists oil and gas operators in the state	All
Inspections with Violations Only	-	Yes
Resolved Violations Only	-	Yes
Inspection Category	Primary Facility; Client; Site	All
Unconventional Only ⁴ (PF Inspections)	-	Yes

Colorado

The CDPHE WQD has posted enforcement actions issued since 2009 related to the Colorado Discharge Permit System (CDPS). There are seven categories of permits issued through the CDPS for the protection of surface water. Out of these seven, only data associated with construction stormwater actions was used for this study, as all other categories were

⁴ Pennsylvania's unconventional gas resources are those associated with the recent expansion of the hydraulic fracking industry. Unconventional gas is more tightly held in its environment and is defined by the method through which it extracted as a result of this characteristic (Alberta Energy Regulator, 2014; Governor's Marcellus Shale Advisory Commission, 2011)

outside of the scope of this project. Information about stormwater enforcement actions was further divided into four categories: (1) Notices of Violation/Cease and Desist (Clean-Up) Orders (2) Compliance Orders on Consent (3) Expedited Settlement Agreements, and (4) Orders for Civil Penalty. A notice of violation is a document issued to an operator when they have not complied with statute, regulation, or a permit condition. An accompanying cease and desist or clean-up order identifies measures which the operator should take in order to mitigate the detrimental impacts of their actions. There is no penalty associated with these actions.

A Notice of Violation has the potential to result in either an expedited settlement agreement, or a compliance order on consent. These documents require that the operator pay a civil penalty for any wrongdoing and may be mutually established or simply reflect a mandate from the agency. An Order for Civil Penalty is a letter issued to the operator subsequent to a compliance order which signifies 30 days from which the penalty amount must be paid. Regardless of the method through which a penalty was established - expedited settlement agreement or compliance order - the value was documented along with the violations with which it corresponded (Colorado Department of Public Health and Environment, 2009).

In contrast to the Pennsylvania DEP Oil and Gas Compliance Reports which are generated in tabular form, the CDPHE enforcement actions mainly consist of letters of communication between the agency and operator. Consequently, each letter was reviewed and a table was created manually to resemble the output that was computer generated in Pennsylvania.

Cross-State Comparison of Enforcement Data

It is challenging to conduct a comparison of state oil and gas programs due to the variability which exists among them. States differ with respect to which agency has oversight of specific aspects of extraction and production. Additionally, available enforcement data differs in the manner in which it is reported and information it contains. More specifically, the Pennsylvania Compliance Reports list violations of *any* statute or regulation by an oil and gas operator; they are not limited to stormwater actions. However, the Pennsylvania data is limited to the oil and gas industry. In contrast, the Colorado CDPHE enforcement data is limited to *stormwater construction* violations, but lists any entity which violated the law, regardless of whether or not they are an oil or gas operator. Consequently, while the primary information extracted in each state is the same (the code for which a violation was issued and the

corresponding penalty value), the analysis of enforcement data differs in each state. Additionally, it is highly qualitative and limited in quantitative analysis.

In Pennsylvania, the DEP data is used to determine the compliance of oil and gas operators with stormwater regulations in comparison to other environmental protection statutes administered by the department. Examples of these other violations include those related to well construction, plugging and abandonment, failure to communicate information to the department, etc. The fraction of total violations that were stormwater or surface water related is compared to the frequency with which other laws were violated. As a result, we are able to better understand where the greatest compliance challenges exist and whether or not surface water degradation is a threat. The value of oil and gas program penalty assessments over time is illustrated in order to understand if fines are an important enforcement tool and if they may have an effect on compliance.

In Colorado, the enforcement review provides slightly different information. We can still use penalty assessments to observe if fines might be a significant part of influencing operator compliance. However, because we also have data for any permitted entity, we can compare penalty assessments issued to oil & gas operators versus other industries and determine if any disparities exist. There are also differences in the analysis of the types of violations which were issued in each state. In Pennsylvania, the particular statute or code which was violated was of primary interest. However, in Colorado the focus is on specific permit conditions. As a result, the Colorado analysis is focused on whether the frequency of permit conditions which were violated might cause immediate water quality impacts. For example, an immediate water quality impact could result when the permit condition violated was related to discharge of sediment-laden waters. In contrast, a non-immediate impact would be represented by the failure of the operator to update a site map.

While we cannot make a direct comparison between the findings in each state due to data differences, the enforcement analysis is useful in demonstrating the state of compliance for the industry, potential challenges, the use of penalties as an enforcement tool and their ability to influence operator behavior.

Results & Discussion

Regulatory Results

Mechanisms for Stormwater Management

A review of stormwater programs in ten states revealed five primary methods through which governmental agencies regulate oil and gas operators. The mechanisms include: an erosion and sediment control (E&SC) plan; a stormwater management plan (SWMP); a National Pollutant Discharge Elimination System (NPDES) stormwater construction permit; a NPDES Industrial Permit; and, a permit-by-rule. Results are summarized in Table 3 in the Appendix.

The results show that two out of ten states have chosen to not implement any formal stormwater management protocols for the oil and gas industry. These include Texas and Louisiana, which are the first and third largest producers of marketed natural gas in the nation.⁵ Where stormwater programs have been implemented, regulation appears to be concentrated on earlier phases of an oil and gas project, although phases are often not clearly defined. The most common regulated phase is “pre-drilling,” which is generally associated with construction activity. States that only cover the construction phase (pre-drilling) include Ohio, Virginia, and Wyoming. Michigan and Arkansas may cover pre-drilling and drilling, while Alaska only covers drilling. The Pennsylvania and Colorado programs cover construction through post-construction, which may extend through all phases of an oil and gas operation.

States which regulate stormwater may require an E&SC plan, a SWMP, a permit, or a combination thereof. E&SC plans and SWMP’s may be required through regulation or as part of a permit application. Where a permit is required, it may be issued through a state-specific oil and gas permit program or through a state-authorized program of the National Pollutant Discharge Elimination System. The NPDES is the primary permit program designed to protect surface waters from contamination by stormwater runoff, and is authorized by the Clean Water Act and administered by the U.S. Environmental Protection Agency at the federal level (United States Environmental Protection Agency, 2014). NPDES permits can be issued for point sources associated with construction or industrial activity. While the NPDES permit program covers a wide range of business activity, oil and gas operators have been exempt from attaining the industrial stormwater permit since 1987 and the construction stormwater permit since 2005

⁵ Based on the last full year of natural gas production data (2012), available through the Energy Information Administration. This assumption does not include any Federal production (“U.S. Natural Gas Marketed Production,” 2014)

(United States Environmental Protection Agency, 2012b).⁶ States which continue to implement the program for the oil and gas industry are unique.

There is variation in the scope of E&SC and SWMP's among states. Some states require only a SWMP, but embed aspects of an E&SC plan into it. Alternatively, other states require only an E&SC plan but may make references to stormwater management. These two types of plans may differ based on the stormwater impacts which they intend to mitigate. Importantly, to effectively protect surface water quality, stormwater should be managed for sediment and any other pollutants which are harmful in excessive quantities. At the same time, the manner in which stormwater drains a landscape should be controlled, as managing the volume of water entering receiving water bodies helps preserve their physical structure. Thus, E&SC is focused on the prevention of sediment accumulation; stormwater management is geared towards water quantity issues, as well as preserving water quality from impact of a broader set of pollutants (Wisconsin Department of Natural Resources, 2012). Ultimately, a comprehensive program should encompass all the aforementioned characteristics.

Ohio is the sole state that requires only an E&SC plan. Virginia regulations explicitly address E&SC and stormwater management as two separate topics. Section 260 of the Virginia Gas and Oil Regulation covers *Erosion, Sediment Control, and Reclamation* (and the development of an E&SC plan) and Section 270 applies to *Stormwater management*. Section 270 automatically regulates operators which are subject to Section 260, and requires the consideration of all pollution sources:

Stormwater runoff which has been contaminated by or come into contact with overburden, raw material, intermediate products, finished products, byproducts or wastes from gas, oil or geophysical operations located on the permitted site shall be managed in accordance with a plan approved by the director.

4VAC25-150-270.C

Arkansas requires only one plan, a “stormwater erosion & sediment control plan,” which may or may not take into full consideration all on-site pollutants. Arkansas also implements a permit-by-rule, pertaining to fluids retained in open pits on oil and gas sites. This applies to the drilling phase described in the introduction. The permit-by-rule replaced a former permit for the *Authorization to Construct, Operate and Close the Pits Associated with Oil and Gas Well*

⁶ An exception to the federal exemption exists in any state for operators that have failed to meet water quality and quantity standards under specific provisions of the Clean Water Act (Office of Wastewater Management, United States Environmental Protection Agency, 2012b).

Exploration and Production, which was required by the Arkansas Department of Environmental Quality from August 2008 – October 2011. Subsequently, the Arkansas Oil and Gas Commission and Arkansas Pollution Control and Ecology Commission published a joint rule – AOGC Rule B-17 or APCEC Regulation No. 34 – which addressed potential water quality impacts of pits located on oil and gas sites and replaced the general permit (personal communication, July 19, 2013).

Michigan operates a Soil Erosion and Sedimentation Control Program, which exempts oil and gas operators under the condition that an E&SC plan is filed with an application for permit-to-drill with the Office of Oil, Gas and Minerals (MCL 324.9115(3)). The E&SC plan covers the construction phase and might extend into the operational phase, as oil and gas operators must also submit an environmental impact statement form which references the E&SC plan (Michigan Department of Environmental Quality, 2014). At the same time, operators are regulated under separate provision that establishes a permit-by-rule associated with a NPDES stormwater construction program. This section of the law instructs that entities submit notice of coverage, an oil and gas permit, and an E&SC plan to the Department of Environmental Quality, which has the authority to require an individual permit for a site without adequate coverage (Mich. Admin. Code R. 323.2190).

Wyoming is one of two states that implements a state-authorized NPDES stormwater construction program (the Wyoming Pollutant Discharge Elimination System). The permit program was in place prior to the passage of the federal exemption and Wyoming has continued to implement it (personal communication, August 2, 2013). Colorado also regulates oil and gas construction activity through the Colorado Discharge Permit System (CDPS). The oil and gas CDPS has been justified in Regulation No. 61 by the Water Quality Control Commission due to potential environmental impacts of oil and gas operations in the absence of regulation, as well as the economic reasonableness of the permit program (5 CCR 1002-61.58). Once a construction site has been stabilized, oil and gas operators must submit notice to the CDPHE in order to transition coverage of stormwater activity to the Oil & Gas Conservation Commission, which necessitates a post-construction stormwater management plan (2 CCR 404-1:1002(f)(3)).

Like Colorado, Pennsylvania requires separate construction and post-construction stormwater management plans. During the construction and drilling phases, all operators must prepare an E&SC plan and those with sites greater than five acres must obtain a permit. Subsequent to drilling, operators must develop a post-construction stormwater management

plan that should be complementary yet distinct from the E&SC plan (Pa. Code § 102.8). Both plans fall under the jurisdiction of the Pennsylvania Department of Environmental Protection (DEP) Office of Oil and Gas Management, and the agency must inspect and approve E&SC measures on the well pad prior to drilling (State Review of Oil & Natural Gas Environmental Regulations, 2013).

Regulations for Retention of Fluids

In addition to stormwater management plans and permits, states have adopted regulations pertaining to containment and disposal of fluids and waste which can help mitigate stormwater impacts. For storage in open pits or tanks, six key provisions were found in state rules that were determined to be important for preventing environmental impacts from stormwater runoff and are summarized in Table 4. The first condition is that operators obtain approval or notify a government agency prior to pit construction. Second, certain states choose to limit the types of fluids or wastes stored in pits, with a major distinction being permissibility to hold fluids containing hydrocarbons. Additionally, state rules may specify requirements for locating pits in floodplains. Or, regulations may include construction standards that reference a given size storm event within which pit fluids should be retained. A majority of states necessitate a freeboard standard to ensure that fluids do not overtop and run off-site. Lastly, state regulations reference the timing and conditions for pit closure and reclamation.

Three states – Colorado, Texas, and Wyoming – require operators to obtain permits to retain fluids in open pits. All pits in Wyoming must undergo permitting, whereas Colorado and Texas exempt storage for water-based drilling fluids (16 Tex. Admin. Code § 3.8(d)(2), 2 CCR 404-1:903). However, Wyoming regulations streamline the permitting process by allowing operators to obtain authorization for permits in a particular area through “fieldwide” approval. Another layer of notification exists in Wyoming, where the Wyoming Oil and Gas Conservation Commission must be alerted 24 hours prior to pit construction or closure so that an inspector may be sent to the site (Wyoming Oil and Gas Conservation Commission, Environmental Rules, Including Underground Injection Control Program Rules for Enhanced Recovery and Disposal Projects, Ch. IV § 1).

Most states allow the storage of water-based drilling fluids. States which prohibit or limit the time period during which oily or briny waste may be stored include Alaska, Arkansas, Michigan, Texas, Ohio, and Virginia. Pennsylvania is the only state that allows storage of a large range of fluids where a time limitation or permit requirement was not identified.

Regulations tend to set broad mandates that prohibit pollution discharge of fluids and wastes retained in pits, but few set prescriptive standards guiding where pits may be located and to what standard they should be constructed. Three out of ten states make reference to pits constructed in floodplains. Arkansas directs oil and gas operators to comply with local ordinances under circumstances where pits are established in the 100-year floodplain (178.00.10-001 Ark. Code R. § B-17(f)). Texas rule prohibits operators from constructing pits in the 100 year floodplain unless a variance is obtained from the agency (16 Tex. Admin. Code § 3.8(d)(4)(H)(I)). Pennsylvania does not permit pits that contain potentially hazardous substances in the floodplain (Klapkowski, 2012).

The most common pit maintenance standard is a freeboard requirement, which restricts the amount of fluid that can be stored so that the likelihood of overtopping is reduced. Six out of ten states specify a two foot minimum of freeboard, including Arkansas, Colorado, Louisiana, Pennsylvania, Texas, and Virginia (178.00.10-001 Ark. Code R. § B-17(f), 2 CCR 404-1:902, La. Admin. Code 43.XIX.307(B)(2), 25 Pa. Code § 78.56(a)(2), 16 Tex. Admin. Code § 3.8(d)(4)(G)(iv), 4 VAC 25-150-300). The Wyoming Oil & Gas Conservation Commission provides operators with freedom to determine pit freeboard but spells out that extreme precipitation events should be considered in maintaining fluid levels (Wyoming Oil and Gas Conservation Commission, Environmental Rules, Including Underground Injection Control Program Rules for Enhanced Recovery and Disposal Projects, Ch. IV § 1(w)(viii)).

Three states use a recurrence interval for storm events (i.e. “frequency analysis,” see pgs. 345-349 in A.D. Ward and S.W. Trimble, 2004, Environmental Hydrology, CRC Press) to indicate that fluids must be maintained in pits below a certain threshold. In Arkansas, mud, circulation, and reserve pits should withstand a 10-year, 24 hour storm (178.00.10-001 Ark. Code R. § B-17(f)(2),(3)). In Colorado, centralized non-commercial waste management facilities on natural gas sites may use a variety of methods to treat and dispose of waste including land application, recycling, or the use of open impoundments (2 CCR 404-1:908(a)). Waste disposal at these facilities may not contribute to pollution unless a precipitation event is greater than the 100-year, 24 hour storm. Additionally, the facilities must have adequate run-on and run-off control systems to manage stormwater from a 25-year, 24 hour storm (2 CCR 404-1: 908.b(5)(E)). In Louisiana, certain pits must have levees constructed to a minimum height that ensures fluids do not overtop from a 100-year flood (La. Admin. Code 43:XIX.303J).

Reclamation standards for pit closure vary widely among states. Some states have prescriptive regulations, while others require the development of a site-specific plan that is submitted to a regulatory body. Most states outline reclamation standards in regulation. However, Colorado requires a site specific plan for interim and final reclamation (2 CCR 404-1:903, 2 CCR 404-1:905(b)). Ohio also requires an approved restoration plan for disturbed land, which should cover pit closure, and must be filed with an application for a permit-to drill (Ohio Rev. Code § 1509.06(A)(10) (2013)).

One aspect of reclamation is the length of time that a pit may be open prior to final restoration. It was found that the time for pit closure is primarily based on the type of fluid retained, and secondarily on climate and land use. In two states - Alaska and Virginia - the duration within which an operator must close a pit was not found. In other states, closure requirements were found to vary from a minimum of 30 days to a maximum of one year.

Arkansas, Louisiana, and Michigan all have a reclamation timeline of six months and allow a variety of fluids to be contained in pits (178.00.10-001 Ark. Code R. § B-17(h)(6), Mich. Admin. Code R. 324.407(9)(c), La. Admin. Code 43.XIX.307(B)(4)). Ohio requires quicker closure for pits storing waste fluids and saltwater, providing operators two weeks to two months based on location in an urbanized area (Ohio Rev. Code § 1509.072(A) (2013)). In Wyoming, pits are to be reclaimed as soon as possible if weather permits, but with a one year maximum. However, the commission has the ability to extend the closure timeline when it deems appropriate (Wyoming Oil and Gas Conservation Commission, Environmental Rules, Including Underground Injection Control Program Rules for Enhanced Recovery and Disposal Projects, Ch. IV § 1(qq)).

Colorado (3 – 12 months), Pennsylvania (90 days – 9 months), and Texas (1 – 12 months) have a wide timespan within which pits must be reclaimed (2 CCR 404-1:1000, 25 Pa. Code § 78.56(d), 16 Tex. Admin. Code § 3.8(d)(4)(H)). Variation in Colorado is based on land use, where crop lands are to be restored sooner than non-croplands. The timeline for pit closure further varies based on interim and final reclamation requirements. Interim reclamation provisions pertain to areas “no longer in use,” and final reclamation is achieved after plugging and abandonment. For both interim and final reclamation, sites classified as “crop-lands” are to be reclaimed within three months. Non-crop lands are to be reclaimed within six months in the interim, and within twelve months for final restoration (2 CCR 404-1:1003(b), 2 CCR 404-1:1004(a)). In Pennsylvania, all pits except those used for service, plugging and recompletion

have a nine month requirement for fluid removal (25 Pa. Code § 78.56(d)). Texas regulation has dewatering and backfill requirements based on content of pit fluid, ranging from thirty to 120 days (16 Tex. Admin. Code § 3.8 (d)(4)(H)).

Lastly, states differed in how final reclamation was defined, if at all. The most explicit and stringent definition in Colorado stated that final reclamation occurred in conditions with no unrestored subsidence for two growing seasons and when 80% of pre-disturbance vegetation is established (2 CCR 404-1:1004). In Arkansas, the operator must establish vegetative cover the lesser of 75%, or equivalent to surroundings, within six months of pit closure (178.00.10-001 Ark. Code R. § B-17(h)(6)). Alaska only specifies that reserve pits do not pose a threat to water quality or freshwater after a well has been completed, suspended, or abandoned (20 AAC 25.047).

Regulatory Discussion

Evaluating the suite of regulations pertaining to stormwater management on oil and gas sites necessitates making a value judgment in circumstances where each program contains merits and limitations. If a particularly narrow standard were selected for comparison across states (e.g. construction standards in the 100-year floodplain), it may be possible to develop a ranking system. However, due to the numerous pathways through which stormwater moves on oil and gas sites in time and space, and the variety of regulations and agencies with oversight of the industry, it is challenging to provide an overall ranking for each state. Nevertheless, this discussion attempts to synthesize the findings in each state to determine which program is most comprehensive in scope and which specific regulatory provisions should be further explored and considered for future application in other states.

Mechanisms for Stormwater Management

I suggest that the primary criterion in evaluating state stormwater management programs is that institutions and regulations cover all phases of an oil and gas operation. As discussed earlier, pollutants may vary based on stages of site activity, but a robust program should mitigate all potential contaminants. In many states, the oil and gas industry is regulated by both a Commission with oversight over natural resource extraction, as well as an agency dedicated to environmental protection. Consequently, programs should be designed to ensure regulatory gaps amongst agencies do not exist. This review concludes that Pennsylvania and

Colorado best match this criterion. Both programs enforce stormwater management standards during construction and post-construction phases, which require two separate plans that cover each stage of an oil and gas operation.

The Pennsylvania and Colorado programs are designed to preclude any gaps in oversight. Pennsylvania has one agency overseeing all aspects of operations, the Department of Environmental Protection (DEP), Office of Oil & Gas Management. The regulations also specify that the stormwater management plans covering different phases of operation must be designed to complement each other (Pa. Code § 102.8). In Colorado, the Department of Public Health and the Environment (CDPHE) administers the construction stormwater program and the Oil and Gas Conservation Commission (COGCC) is responsible for post-construction stormwater management. The transition is managed such that operators must submit a form to request termination of coverage under the CDPHE once they meet two requirements:

- (1) the area is not under the operational control of the permittee, and*
- (2) the site has been finally stabilized, such that all ground surface disturbing activities at the site have been completed, and all disturbed areas have been either built on, paved or equivalently hard-armored, or a uniform vegetative cover has been established with an individual plant density of at least 70 percent of pre-disturbance levels.*

(Colorado Department of Public Health and Environment, 2014)

After the CDPHE approves termination of CDPS permit coverage, COGCC Reclamation Regulations dictate the development of a post-construction stormwater management plan, which must be developed prior to final termination of coverage by the CDPHE (2 CCR 404-1:1002(f)(3)). Best Management Practices (BMPs) must then be implemented to manage stormwater quantity and quality until final reclamation is achieved (2 CCR 404-1:1002(f)(2)). Final reclamation at a well site is complete when on site activity has ceased and 80% of pre-disturbance vegetation is established or methods have been implemented to prevent further erosion (2 CCR 404-1:1004(d)).

No other states in this review were found to make the explicit distinction between construction and post-construction, while ensuring that both E&SC measures and broader stormwater management goals were addressed. In several states, the phases to which a stormwater management plan should be applied were not clearly defined. In such cases, it is possible that industry may have the flexibility to work with state agencies to tailor BMPs for

optimal stormwater management based on local conditions and practices. In these instances, the result would be a positive outcome for both parties. On the other hand, vague regulatory language could also encourage bad actors to take short cuts and avoid implementing adequate measures to prevent environmental impacts. In this review, we were not able to locate specific language that explicated the phases to which stormwater management should take place in Arkansas, Ohio, Michigan and Virginia. Another detrimental outcome to limited or vague language is that disagreements between government and industry have the potential to lead to battles in court in enforcement situations, which may be costly for both entities.

Further research from a strict legal perspective could fill in some of the holes in understanding about the phases of operation which stormwater plans and permits intend to cover. This type of legal analysis could prove that some of the states in this study do intend for stormwater management to take place over the life of a project. Nevertheless, even if the scope of state programs was intended to be broader, several rules provide stormwater management alternatives or variances that might diminish the degree to which surface waters are protected. One alternative exists in Arkansas where compliance with a guidance document approved by the Arkansas Department of Environmental Quality can replace the development of a site-specific erosion and sediment control plan (178.00.10-001 Ark. Code R. § B-17(l)(2)). In Virginia, variances can be implemented for any provisions of Section 260 (erosion and sediment control) or Section 270 (stormwater management) of the oil and gas regulations:

The director may waive or modify any of the requirements of this section that are deemed inappropriate or too restrictive for site conditions... The director [of the Department of Mines, Minerals, and Energy] shall consider variance requests judiciously, keeping in mind both the need of the applicant to maximize cost effectiveness and the need to protect off-site properties and resources from damage.
4VAC25-150-270.D

In Virginia, the Director is a politically appointed position (Code of Virginia § 45.1-161.2). It is possible then that permitting decisions may be more or less favorable for industry based on the agenda of the sitting Governor. However, variances may also provide a good alternative option for stormwater management for unique circumstances which regulations did not anticipate. Ultimately, they must be offered to operators under appropriate conditions.

Another finding of the review of stormwater management mechanisms was that some states have chosen not to implement a traditional permit system. For example, Arkansas regulations require that operators develop a stormwater erosion and sediment control plan but

do not specify that the plan be approved by the agency. Instead, the regulation simply specifies that operators should furnish the plan to the department when asked (178.00.10-001 Ark. Code R. § B-17(l)(1)). Another example of a non-traditional permit system is in Michigan, which implements its state NPDES program through a permit-by-rule. That is, once a site-specific soil erosion and sediment control plan has been approved by the state agency, a separate NPDES permitting process does not take place between the operator and department. Instead, the operator may notify the agency that they are in compliance with the requirements of the Michigan NPDES rules (Mich. Admin. Code R. 323.2190). One potential concern in these states is that stormwater management measures implemented by a natural gas operator may not be appropriate or optimally designed for site-specific conditions. This could result if regulatory guidelines are designed broadly in order to be suitable for any entity subject to the rule.

Regulations for Retention of Fluids

Secondary criteria for comparing stormwater management programs is based on rules which regulate the open retention of fluids used and produced during natural gas extraction. Initial observations of pit rules indicate a potential surface water threat may exist in states where it is permissible to openly store oil-based drilling fluids. From an environmental health perspective, it would appear that states which entirely prohibit use and storage of oil-based drilling fluids take the most protective regulatory approach. However, it was found that states which allow open retention of a variety of fluids may be more likely to implement a permitting or government notification system.

If the permission to store a greater variety of fluids in a state generates a permit system, such a program could be more protective than one that limits fluids. For example, Wyoming allows open storage of oil-based muds and high density brines. However, the program also requires that any type of pit is permitted on an annual basis, discharges are prohibited without an NPDES permit, and the Oil and Gas Conservation Commission is alerted 24 hours prior to pit construction and closure (Wyoming Oil and Gas Conservation Commission, Environmental Rules, Including Underground Injection Control Program Rules for Enhanced Recovery and Disposal Projects, Ch. IV § 1(w)). However, examples like Colorado and Texas limit permit requirements to pits that may pose environmental harm, while water-based drilling fluids are exempt. The effectiveness of these permitting systems may thus be limited. Unless permits are required for any type of fluid, the program may not increase overall environmental protection.

Additional insight was gained in reviewing pit regulations. That is, a persistent problem in state rules is the shortage of numeric standards based on local precipitation data that could facilitate construction and location of open pits. States should consider the effects of increasing the specificity of regulations and modeling language such as that used in Colorado or Arkansas. For example, the COGCC exploration and waste management rules define the recurrence interval of a precipitation event which run-on and run-off structures on non-commercial waste management facilities should withstand:

Surface water diversion structures shall be constructed to accommodate a one hundred year, twenty four hour event. The facility shall be designed and constructed with a run-on control system to prevent flow onto the facility during peak discharge and a run-off control system to contain the water volume from a twenty-five year, twenty four hour storm.

2 CCR 404-1: 908(b)(5)(E)

It is possible that the likelihood of overtopping of fluids is higher in states with vague regulatory language because operators have more flexibility in pit design. At the same time, even if pits are constructed to a high standard without regulatory mandates, rare and large storm events undoubtedly occur. In these circumstances, fluids could be discharged even under the best design standards and vague regulatory language could influence enforcement negotiations. Government agencies could be incentivized to issue reduced fines for pollution discharge violations because a numeric standard was not in place with which the operator had to comply; in other words, the large precipitation event might be treated as an ‘act of God.’ However, numeric standards eliminate these gray areas by defining a threshold above which a precipitation event is considered too large to accommodate, and below which operators must prevent discharge of fluids.

Regulatory Synthesis

In summary, stormwater regulations may be lacking in certain states. Some failed to implement any stormwater management programs, while many appeared to focus plans and permits on construction activity. Indeed, earlier phases of natural gas extraction are characterized by intense site activity and pollution potential, yet it is important for state governments to consider how water quality can be affected throughout the life of a producing well. Due to the differences in site activity over time, a two-phase permit system may be an optimal approach to regulating the industry.

At the same time, the ability to use pits is common practice. Every state in the scope of this study had some regulation that referenced the use of pits. The discussion section and Table 4 illustrated the landscape of state regulations, and offer specific provisions which should be considered for inclusion across jurisdictions. While a quantitative program evaluation is necessary to reveal if these provisions are truly effective, it appears that a handful of states have crafted unique language that may be more protective and deserves further investigation. Such examples are found where (1) pit permits are required, and (2) where pit construction and siting standards are specifically defined and based on local climatology.

Limitations

A limitation of this study is that it assumes a comprehensive review of state rules. However, this assumption could fall short due to the disparity amongst states in organizing regulations. Each state has the option to locate specific provisions in a different rule set. Consequently, stormwater, open containment, or numerous other resource extraction provisions may be clustered together or scattered throughout various statutes and regulations. Further research into this subject would be useful and could prove that additional rules exist so that the scope of certain stormwater programs was not fully characterized.

Additionally, this study is not a legal review, scientific analysis, nor quantitative program evaluation. Rather, this paper analyzes stormwater programs from a point of view that balances environmental law, policy, science and management. A strict legal or scientific interpretation could yield alternate conclusions about the costs and benefits of state oil and gas stormwater programs and rules. Nevertheless, the perspective of this paper is useful, as the intersection of these fields of study and the coordination of specialized practitioners are at the heart of applied environmental management problems. In the formation of new regulations, or the amendment of existing policies, it is these considerations which may be applied by decision-makers.

Enforcement Results

Pennsylvania

Pennsylvania DEP Enforcement Activity

Figure 1 reports PA DEP enforcement activity over time. It shows the annual number of inspections, inspections resulting in violations, violations, and enforcement actions.⁷ There is a pattern of rapid increase in oil & gas enforcement by the Pennsylvania DEP beginning in 2007, followed by a decline in recent years; enforcement activity was minimal prior to 2008. In 2006 through 2007, less than twenty wells were inspected per year. During the same time period, less than thirty violations and enforcement actions were each issued annually. Violations and enforcements reached a peak in 2010, when 1142 violations and 335 enforcements were issued. The number of wells inspected continued to increase until 2011. However, since 2010-2011 the number of violations issued has dropped precipitously, with just over 300 issued in the last year. Inspections, including those resulting in violations, showed a more than 50% reduction in 2013 values from their peak in 2010. Enforcements in 2013 were below 2008 levels, but still five times greater than 2007 values.

Pennsylvania DEP Oil and Gas Penalty Assessments

Figure 2 shows oil and gas penalty assessments reported each year. The graph displays statistics from 2008 – 2013. Earlier values are excluded because only three penalty assessments total were issued in 2006 and 2007. The value of penalty assessments reported ranges from \$0 to \$353,000. The trend in the number of penalty assessments issued, as well as the mean penalty value has followed the enforcement trend displayed in Figure 1. However, this trend is significantly right-skewed by outliers for operators hit with large fines. The median value of fines issued is more consistent. In 2008, this value was \$6,300. It then hovered around \$11,500 for the following three years and then dropped to around \$3,500.

⁷ As explained in the methods section, any enforcement action that did not result in a penalty was eliminated in the quantitative analysis of penalty assessments. However, for general analysis of the enforcement program as described in this paragraph, all observations are included, regardless of their association with a monetary fine (Figure 1). All other figures in the enforcement section are based on the limited dataset associated with penalties.

Figure 1. Pennsylvania DEP Oil and Gas Compliance Report Summary

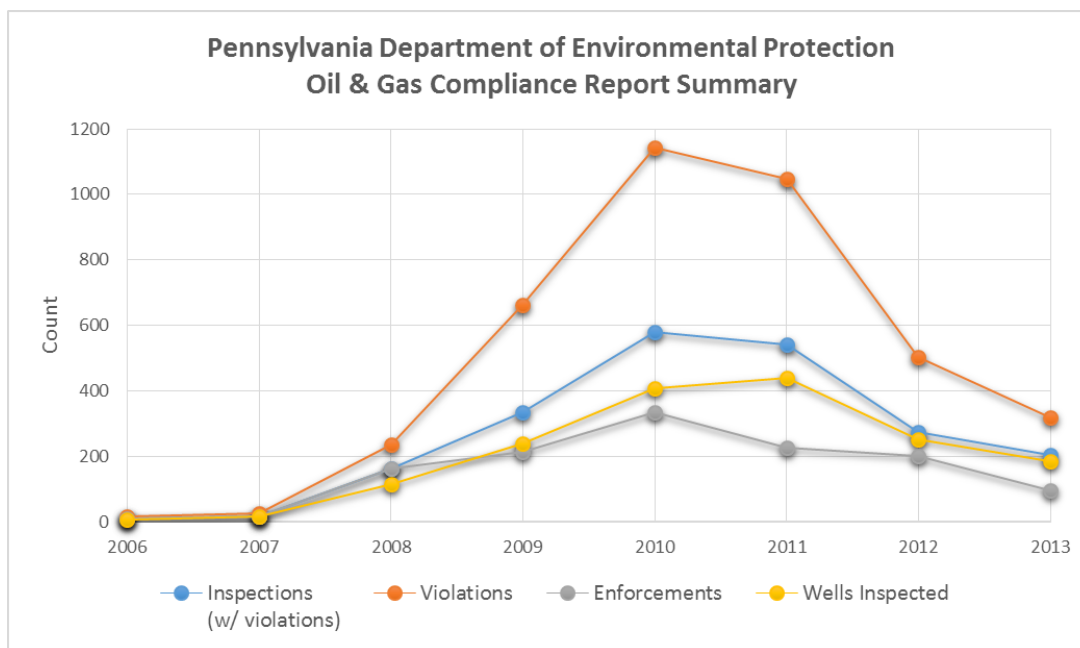
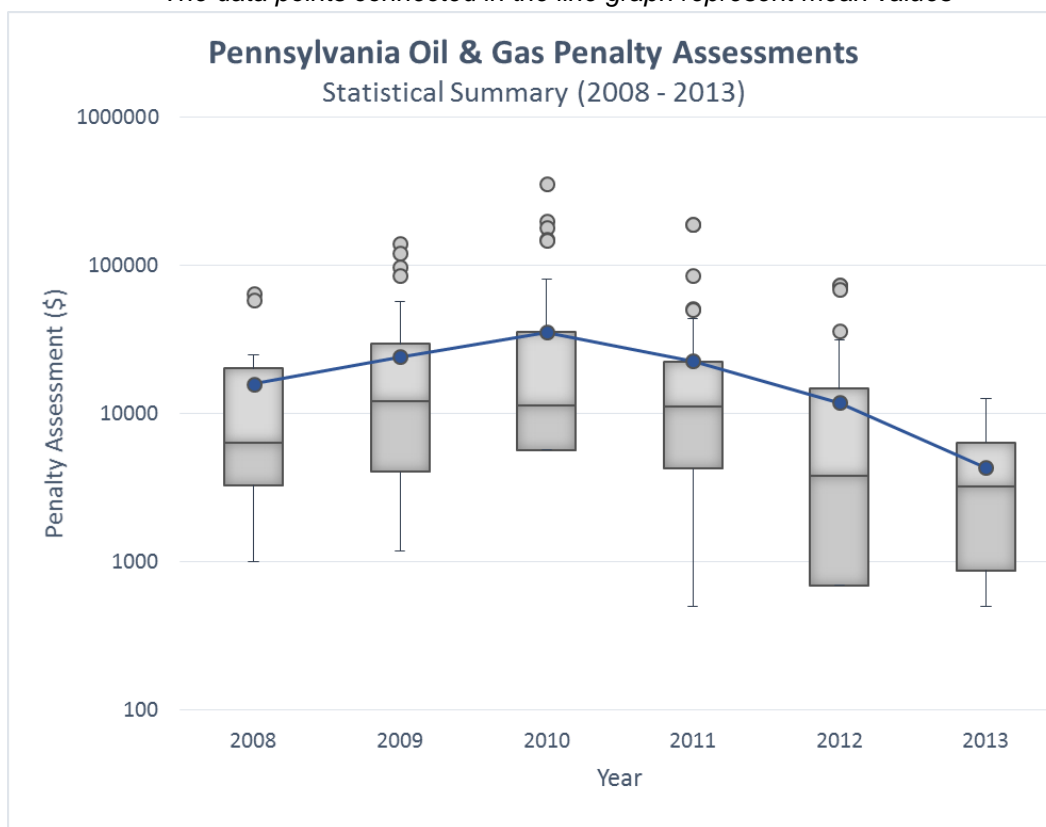


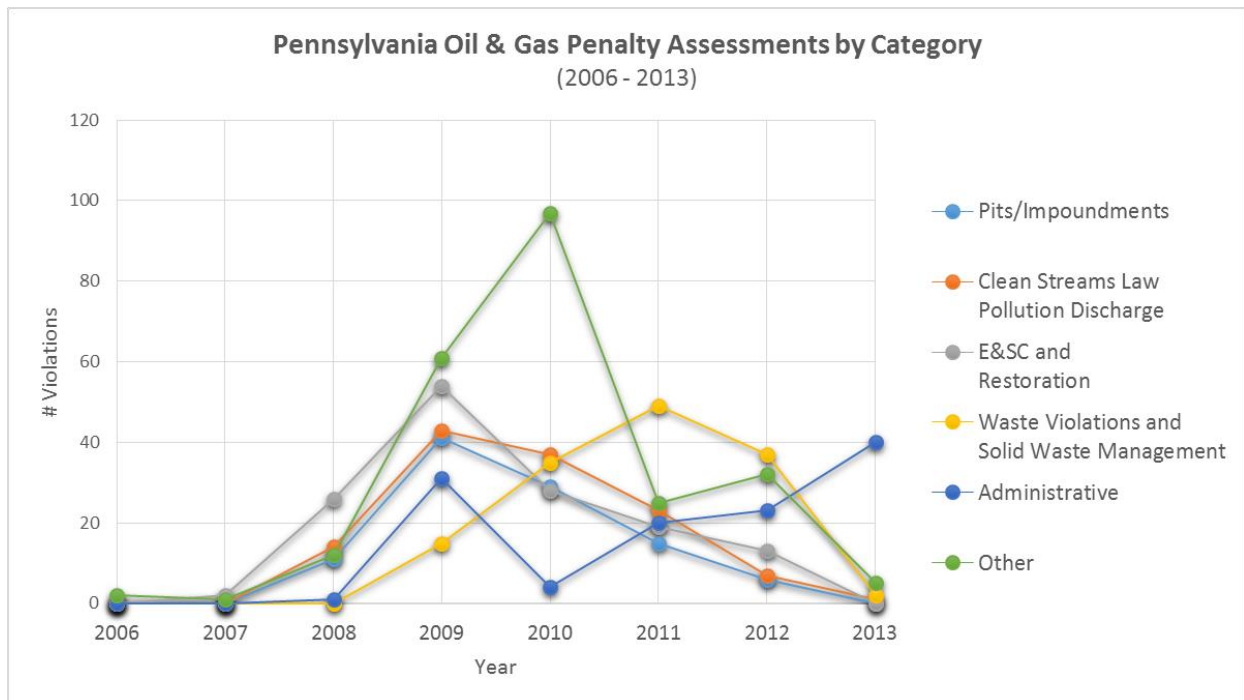
Figure 2. Pennsylvania Oil and Gas Penalty Assessments and Statistical Summary by Year
 Corresponding numerical values may be found in Table 5 in the appendix;
 The data points connected in the line graph represent mean values



Analysis of Oil and Gas Violations by Category

Figures 3 and 4 display the number of violations issued to oil and gas operators that were associated with a penalty assessment. The figure breaks down the violations by type, where categories were created based on stormwater management issues associated with oil and gas extraction as discussed in the regulatory section. The categories include: pits/impoundments; Clean Streams Law (pollution discharge); erosion & sediment control and restoration; waste and solid waste; administrative; other.

Figure 3. Pennsylvania Oil & Gas Penalty Assessments by Category and Year



Operators that failed to comply with 24 Pa. Code § 78.56, pertaining to pits and tanks for temporary containment, are included in the pits/impoundments category. This section of regulation mandates that pits be structurally sound, impermeable, with minimum freeboard and sufficient holding capacity. Another category was generated for violations that resulted in pollution discharges and were cited under the Pennsylvania Clean Streams Law 35 P.S. § 691. These violations may include industrial wastes (35 P.S. § 691.301) or other pollutants (35 P.S. § 691.401). Erosion & sediment control and restoration violations were grouped into one category. Penalties issued for E&SC cite 25 P.S. § 102.4, which requires that operators implement controls that reduce erosion and sedimentation and restore a site until it is stabilized under Section 206 (reclamation requirements) of the Oil and Gas Act. Waste and solid waste

was categorized together because inspection comments in the solid waste category frequently noted spills of fluids and industrial waste, such as drilling muds and cuttings. Waste violations cite non-compliance with 35 P.S. 6018.301, the Solid Waste Management Act (SWMA), which requires that operators, “properly store, transport, process or dispose of a residual waste,” and/or 25 Pa. Code § 78.54, with similar requirements.

The administrative category was created to report paperwork violations that did not create an immediate hazard to the environment. Lastly, the ‘other’ category was created to demonstrate the frequency with which violations were issued for regulatory provisions that are not associated with stormwater management on oil and gas sites. Examples of citations in the ‘other’ category include, but are not limited to well construction, non-administrative reporting requirements, plugging and abandonment, encroachment, and operating without a permit. The ‘other’ category also includes general citations. In the oil and gas compliance reports, Pennsylvania DEP staff cited a general violation of the Oil & Gas Act when multiple violations were detected on a well pad. As a result, the ‘other’ category may in fact capture stormwater related violations.

The trends in Figures 3 and 5 reveal which regulations have the greatest amount of non-compliance on a year-by-year basis. Erosion and sediment control violations represented the largest category in 2008 at 41% of annual citations. This category then reduced in importance over time at 22% of violations in 2009, around 12% for the next three years, and did not represent any violations in 2013. The frequency of pit violations was highly variable from year to year, ranging from 1% in 2008 to 20% in 2012, with fluctuations in between. Citations for pollution discharges have steadily decreased on a year-to-year basis. In 2008, over one-fifth of violations were related to water pollution, which diminished to two percent of total penalty assessments in 2013. In contrast, waste violations have shown an increasing trend, except for the most recent year. There were no waste citations in 2008, while they represented over a third of penalty assessments in 2012. Administrative violations have generally increased, comprising one percent of 2008 penalty assessments and 83% of those issued in 2013⁸. Other violations have fluctuated within a range of 11 – 42% of penalty assessments, with the maximum percentage issued in 2010. The ‘other’ and ‘administrative’ categories represent non-

⁸ The large percentage of violations in the administrative category in 2013 may not accurately reflect industry or enforcement activity. Data analysis was conducted in early 2014 and as a result, it is feasible that the 2013 oil and gas compliance data was not fully updated. Nevertheless, 2013 data is included in Figure 5 to display the possible increasing trend in administrative violations over time.

stormwater related violations and except for 2012, these two categories never comprised over half of violations issued.

Colorado

Colorado Department of Public Health and the Environment, WQCD Enforcement Activity

The quantity of enforcement actions issued through the Colorado Discharge Permit System for stormwater construction permits is in a significantly lower range than that of the Pennsylvania Oil & Gas program. While the Colorado enforcement actions include only construction stormwater violations, they include permitted entities in any industry. Of the total enforcement actions, 22% were issued to oil and gas operators over the five year period. Consequently, the enforcement program may be significantly smaller than that in Pennsylvania, or it may operate in a more informal manner by issuing less orders and penalty assessments. The largest number of formal violations was issued in 2009 and 2011 (7). The greatest number of expedited settlement agreements took place in 2009 (12). The largest number of compliance orders was issued in 2010 (13), after which they began to decline on an annual basis (Figure 4).

Figure 4. CDPHE WQCD Enforcement Program Summary for Stormwater Construction Permitting

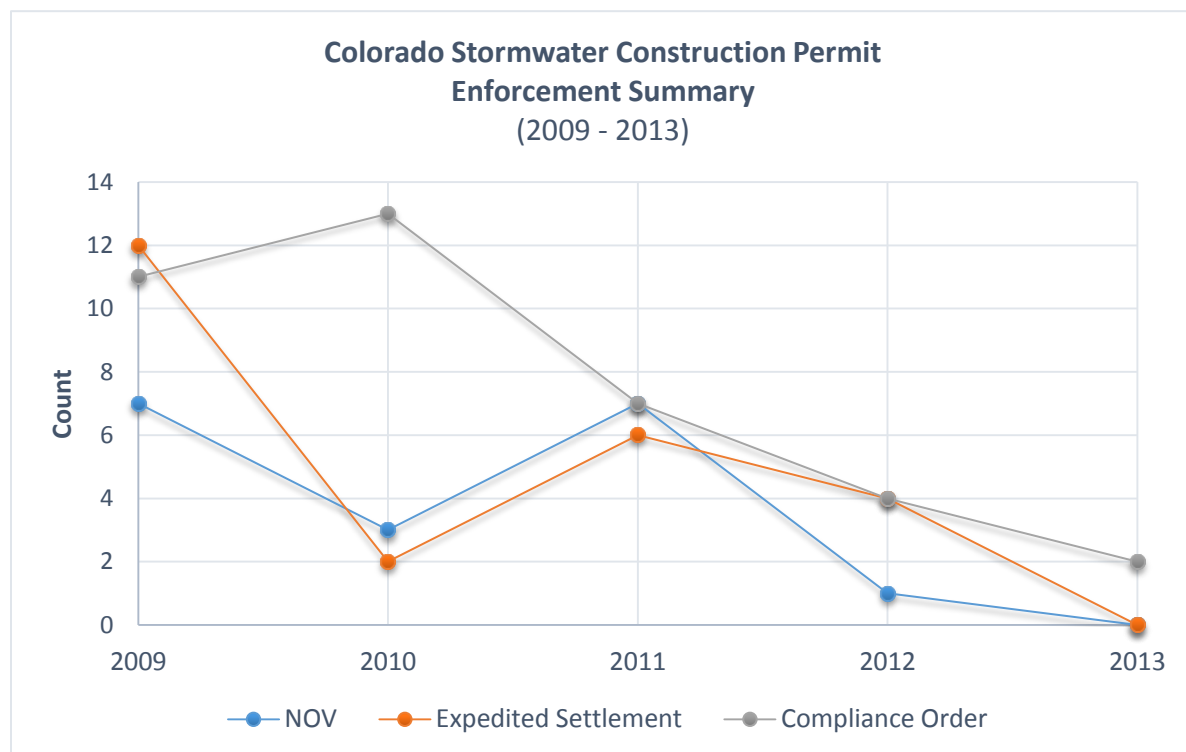
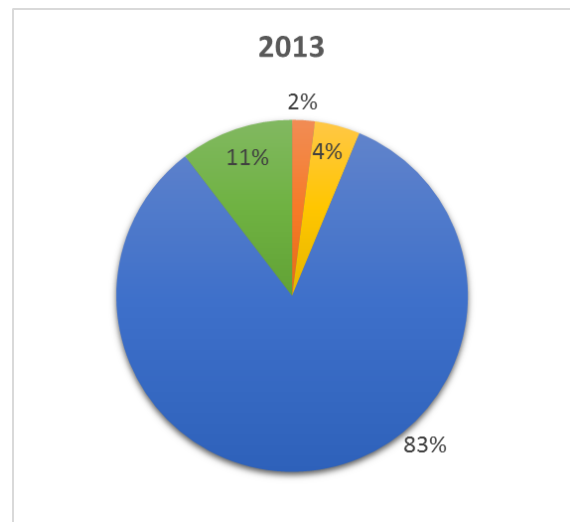
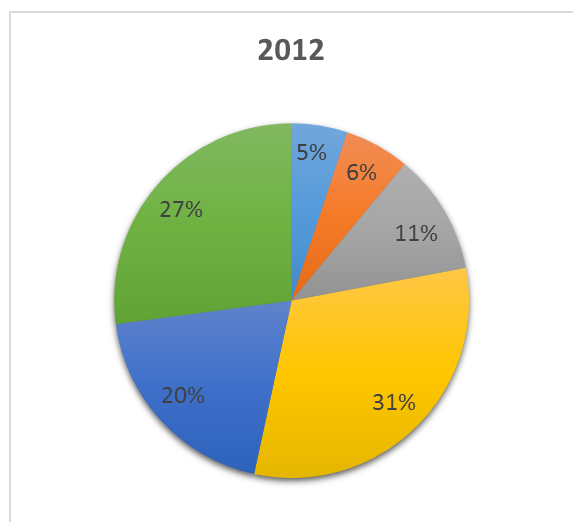
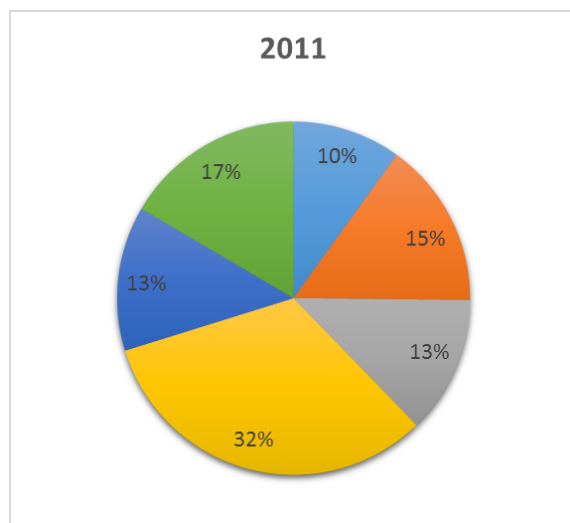
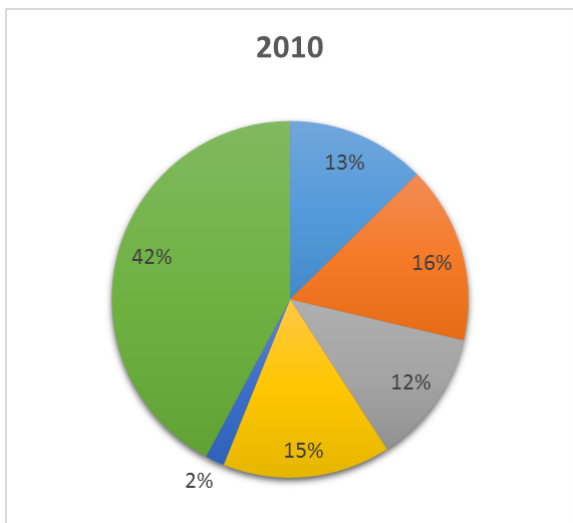
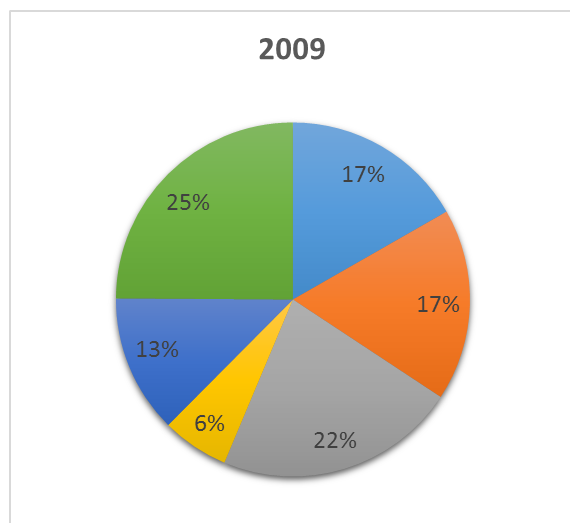
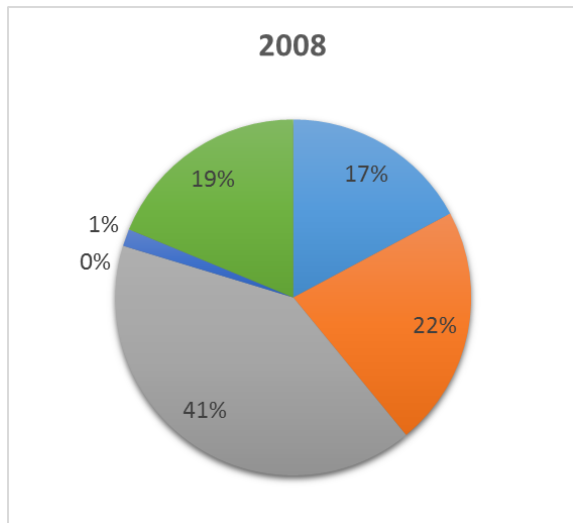


Figure 5. Pennsylvania Oil & Gas Penalty Assessments by Category

■ Pit Violations
 ■ Clean Streams Law Pollution Discharge
 ■ E&SC and Restoration
 ■ Waste Violations and Solid Waste Management
 ■ Administrative
 ■ Other



Analysis of Stormwater Construction Permit Violations

Permit violations for the CDPS stormwater construction permit were not highly concentrated in any one category. The majority of violations were issued for Part I.B. (General Requirements), Part I.C. (SWMP Content), and Part I.D. (Terms and Conditions) of the permit, whose frequency is portrayed in Figure 6. Within each category, another pie chart displays the frequency with which specific sections under each part of the permit were cited. Many enforcement actions listed multiple violations within each case. Sections of the permit which were violated only one or two times were eliminated from the dataset⁹.

Thirty-nine percent of violations were listed for Part I.B., which outlines the five general requirements of a stormwater management plan. Together, these requirements state that all sources of stormwater pollution must be properly detected and mitigated according to appropriate engineering and hydrologic standards throughout the life of the project, and that the plan may include specific actions to be taken to diminish the occurrence of spills. Almost half of Part I.B. violations issued by the CDPHE WQCD were not specific to any of the five requirements listed; instead, a violation was broadly cited against the entire section of the permit. The next largest category cited, with 41% frequency, was Part I.B.3 “Implementation.” Generally, this citation was issued when operators did not implement a SWMP, or did not use it in accordance with the law. Part I.B.2 “Sources and Practices” consisted of 10% of Part I.B. violations, and was issued to operators that failed to include all potential causes of pollution in a SWMP as well as the appropriate practices to mitigate the potential harm they might cause. Only 1 violation in the entire dataset was issued against Part I.B.4 “Spill Prevention Control and Countermeasure.” This section allows operators to expand the scope of their stormwater construction permit to simultaneously comply with *Spill Prevention Control and Countermeasure* requirements in the Clean Water Act.

Forty-two percent of total violations were cataloged for Part I.C. of the stormwater construction permit, which outlines in detail the minimum information a permit must contain. Within Part I.C., the sections of the permit which were violated were distributed fairly evenly. Part I.C.1 requires that operators prepare a description of site activities, their geographic distribution over time and how natural conditions will be changed. In Part I.C. 2, a site map is

⁹ A copy of the CDPS General Permit for Stormwater Discharges Associated with Construction Activity may be retrieved from: <http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheadername1=Content-Disposition&blobheadername2=Content-Type&blobheadervalue1=inline%3B+filename%3D%22Permit.pdf%22&blobheadervalue2=application%2Fpdf&blobkey=id&blohtable=MungoBlobs&blobwhere=1251808459293&ssbinary=true>

required, which shows areas of disturbance, natural bodies of water, and where structural and non-structural BMPs will be implemented. The BMPs must be used appropriately for each stage of construction activity in order to effectively mitigate potential pollution. Part I.C.3 lists thirteen potential sources of pollution that may threaten surface waters and operators must assess their applicability to the project associated with the permit. It is necessary for the SWMP to have an individual charged with responsibility over its accuracy and maintenance. Part I.C.4 requires operators to describe practices that will be implemented to attain final stabilization of the site and in Part I.C.5. operators ensure that BMPs will be inspected and maintained over the life of the project.

Part I.D. of the permit states the terms and conditions with which a permitted entity must comply, and this part represents 19% of total violations. Part I.D.1 made up 18% of total Part I.D violations. It prohibits operators from violating water quality standards or maintaining poor site conditions. Thirty-six percent of Part I.D. violations were issued for Part I.D.2 due to poor construction and inadequate maintenance of BMPs. Part I.D.5, SWMP requirements, consisted of 14% of total Part D violations. This section requires that operators prepare and implement a stormwater management plan in advance of earth disturbing activities. It also requires that the plan and stormwater controls be routinely updated to reflect practices on the ground. Part I.D.6 provides conditions for inspecting stormwater controls installed on the construction site. The inspection schedule should reflect the season (climate conditions), the occurrence of precipitation events, and maturity of the site. The five remaining sections under Part I.D. were not cited in any of the enforcement reports.

CDPHE WQCD, CDPS Stormwater Construction Permit Penalty Assessments

Most enforcement actions cited violations of multiple permit sections. Consequently, penalties may reflect the sum of a number of instances of non-compliance. Figure 7 displays summary statistics for penalty values, which were assessed when a Notice of Violation led to more formal enforcement proceedings, such as an Expedited Settlement Agreement or a Compliance Order. Over the five year period, 2009 – 2013, 74 penalties were assessed, 17 of which were issued to oil and gas operators, and 57 to permitted entities in other industries. The median, mean, and maximum penalty values issued to oil and gas operators were more than two times those for other permitted entities, while the minimum was almost double for oil and gas operators.

Figure 6. Violations by section of the CDPS Stormwater Construction Permit Colorado (2009 – 2013)

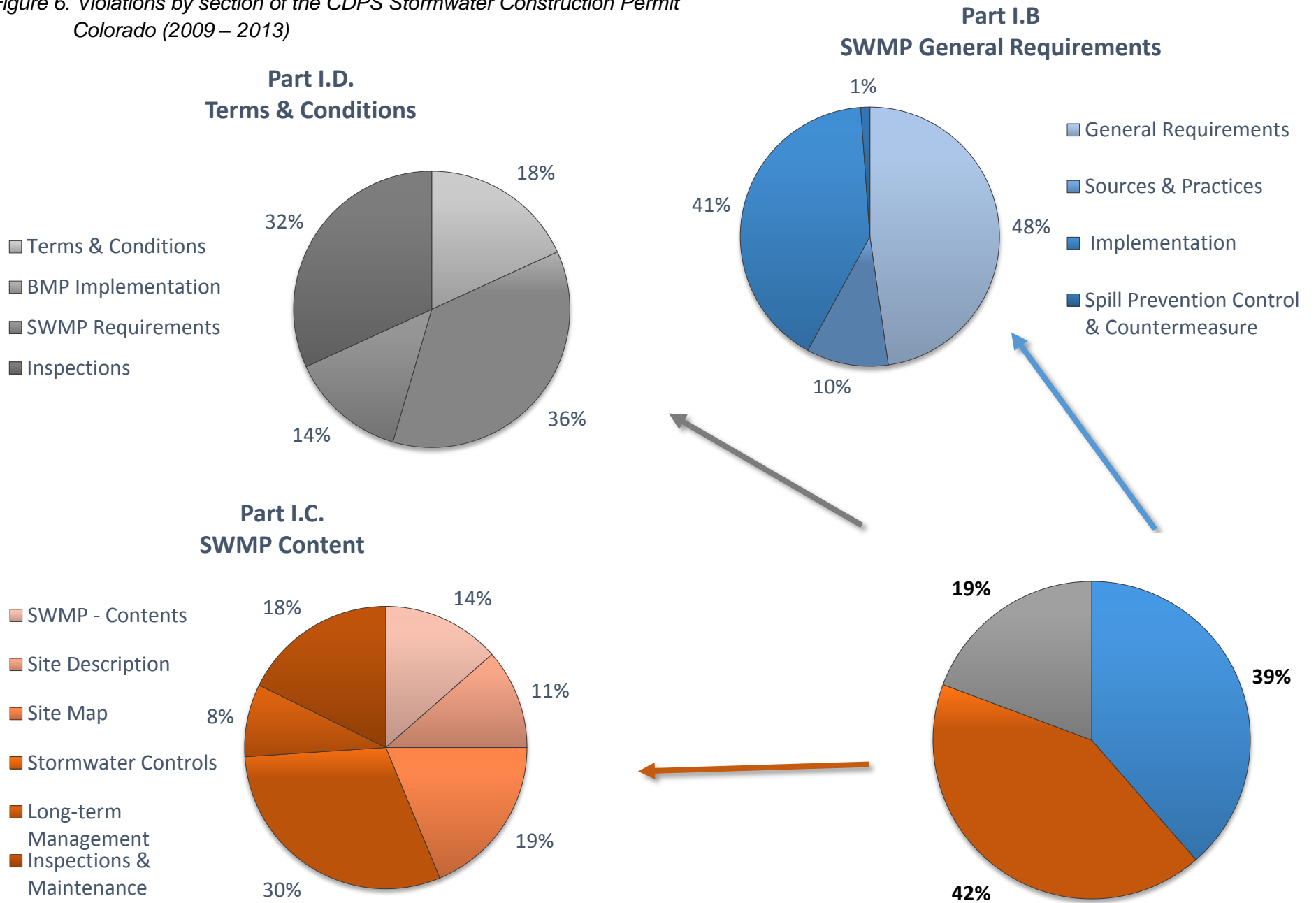
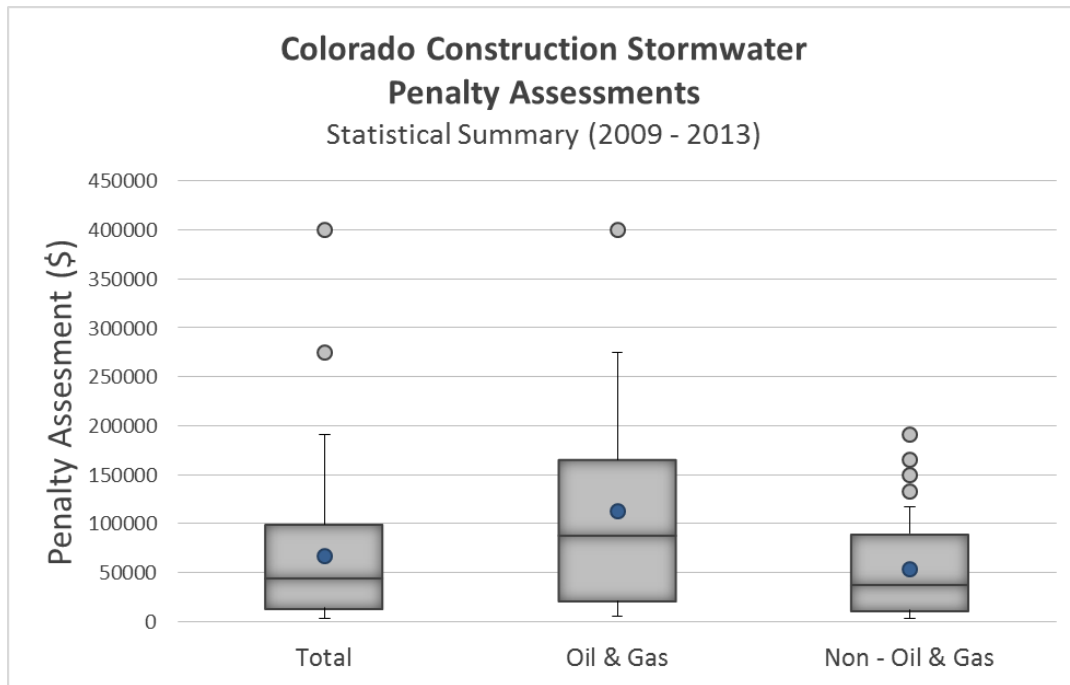


Figure 7. Colorado CDPS Construction Stormwater Penalty Assessments (2009 – 2013)
 Corresponding numerical values may be found in Table 6 in the appendix;
 The data points within the inter-quartile range represent the mean value



Enforcement Discussion

Pennsylvania

Pennsylvania data shows an increasing trend in enforcement from 2006 – 2011. The fastest growth in enforcement activity, beginning in 2008, coincides with the expansion of natural gas extraction in the Marcellus Shale (Governor’s Marcellus Shale Advisory Commission, 2011). A decreasing trend in enforcement after 2011 follows. These trends may be influenced by several initiatives that have been undertaken by the Commonwealth of Pennsylvania in response to expansion of the industry. In 2011, Governor Corbett of Pennsylvania signed an executive order that established the Marcellus Shale Advisory Commission, a multi-stakeholder group charged with forming policy recommendations to encourage responsible development of the natural gas industry (Governor’s Marcellus Shale Advisory Commission, 2011). Subsequently, major policy amendments to Pennsylvania’s oil and gas laws were passed in 2012 (Act 13). Additionally, the Pennsylvania oil and gas program

completed its fifth review by STRONGER¹⁰ in 2013. Together, this activity shows that Pennsylvania's oil and gas program has undergone rapid change through new regulatory requirements and internal program policy changes, which may influence the trends observed in Figures 1, 2, 3, and 5.

Figure 3, which displays violations by category and year, shows that E&SC and restoration violations have generally decreased over time and waste violations have increased. One possible explanation for these trends is that the number of new permits and wells drilled peaked in 2011 so that the types of violations occurring each year are appropriately associated with phases of natural gas extraction and production (Figure 8; Kelso, 2012). More specifically, since most earth-disturbing activity and pollution potential is concentrated in a tight timeframe prior to natural gas production (during pre-drilling and drilling phases), one might expect the largest number of violations associated with surface water pollution to occur when the largest number of permits is issued. The number of permits issued in 2013 would break this trend, since it was greater than 2012, but data may not have been fully input into the reporting system by the time of this report.

An alternative explanation for the types of violations occurring on well pads may be in part explained by the activities of the Marcellus Shale Advisory Commission and the Oil and Gas Act of 2012. The Advisory Commission made several recommendations related to stormwater protection in its final report, and the Pennsylvania DEP states that all suggestions related to preserving environmental health were incorporated into the Oil and Gas Act of 2012 (Klapkowski, 2012). These recommendations required that the DEP inspect all erosion and sediment controls installed on a well pad prior to the commencement of drilling activity and that the DEP study and implement optimal engineering standards for pits to limit fluid discharge (Recommendation 9.2.27) (Governor's Marcellus Shale Advisory Commission, 2011). Additionally, they empowered the DEP to withhold a permit if a pit is located in a floodplain or to rescind a permit when an operator has consistently failed to comply with the Oil and Gas Act, Clean Streams Law, or the Solid Waste Management Act. The Oil and Gas Act also increased the maximum penalty value which DEP staff could assess (Klapkowski, 2012). Consequently, a potential explanation for the decline in erosion & sediment control and pit violations, as well as

¹⁰ STRONGER, or the State Review of Oil & Natural Gas Environmental Regulations, is a non-partisan, multi-stakeholder organization comprised of members which represent industry, environmental, and government interests. States may elect to have STRONGER conduct a review of their oil and gas regulations. STRONGER compares them to baseline standards developed by the organization, and provides recommendations for improvement (State Review of Oil & Natural Gas Environmental Regulations, 2013).

Clean Streams Law pollution discharges, may be newer stricter regulations and increased potential for fines. However, neither passage of the Oil & Gas Act, nor the trend in permits issued, explain the increase in waste violations.

Enforcement activity and penalty assessments by the DEP Oil and Gas program show a peak in 2010, after which a declining trend is present. This trend is in part supported and contradicted by staffing levels. In response to increased activity in the Marcellus Shale, the DEP increased well fees to augment the amount of staff dedicated towards the oil and gas program. There were 202 oil and gas program staff members in 2013, a more than threefold increase from 2009 levels. The majority of these employees (80%) were technical staff dedicated to permitting, analysis, and enforcement (State Review of Oil & Natural Gas Environmental Regulations, 2013). A sharp increase in enforcement activity after 2008 may thus be explained by more staff. The trend in decreased enforcement activity is more difficult to explain. One possible reason is an internal agency effort undertaken in the first half of 2011 to increase consistency in inspections and reporting by DEP personnel. A report was issued by the department summarizing this effort, which stated that differences amongst DEP regional branches were evident and to counteract the disparities, a uniform inspection report was created and training was implemented to increase consistencies in reporting. Moreover, the report directed DEP staff to report violations so that “[when] multiple violations are identified under one incident, only one violation should be entered into eFACTS.” (Pennsylvania Department of Environmental Protection, 2011)

Nevertheless, the declining trend in inspections and enforcement is troubling. The agency report recommended that DEP personnel focus environmental protection efforts on inspections, rather than enforcement. However, since the data shows decreases in both inspections and enforcement, the regulated community may not be properly incentivized to operate to the highest standards. Moreover, the 2013 STRONGER review recommends that the DEP hire even more staff to successfully implement the Oil & Gas Act of 2012. Based on the continued decline in inspections portrayed in Figure 1, it appears that the DEP has not capitalized on new inspection opportunities offered in the recent statutory amendments.

Comparison of Pennsylvania and Colorado Enforcement Programs

In Colorado, the number of reported enforcement actions is significantly smaller than in Pennsylvania, but the mean and median value of penalty assessments are higher for all permitted entities, including oil and gas operators. Enforcement activity in Colorado has shown

a decreasing trend, while data reported by the COGCC shows that the number of applications for permits to drill have consistently increased over the period of this review, from 171 applications in 2009, to 2261 applications in 2013 (Colorado Oil and Gas Conservation Commission, 2014). Comparison of natural gas gross withdrawals (MMcf) and the number of producing gas wells in both states show they are on the same order of magnitude (Figure 9, Appendix). Consequently, we are able to conclude that true discrepancies exist in the enforcement programs of these two states.

Among other reasons, possible explanations for the disparities in penalty values may be enforcement staff levels, the frequency with which inspections are conducted and differences in penalty policies. The imbalance in penalty values is even more interesting in light of the fact that the Colorado Water Quality Division Stormwater Penalty Policy authorizes issuance of a penalty of \$10,000 per day, while Pennsylvania has authorized a penalty that can be as high as \$25,000 to \$75,000 per day since passage of Act 13 (Water Quality Control Division, Colorado Department of Public Health and Environment, 2007; Klappkowski, 2012). Yet, the civil penalty policies in both states are similar, and calculated as follows:

Pennsylvania (Department of Environmental Protection, 2002):

Impact + Willfulness + Commonwealth Cost + Violator Savings + Violation History - Cooperation

Colorado (Water Quality Control Division, Colorado Department of Public Health and Environment, 2007):

Base Gravity + Aggravating/Mitigating Factors + Economic Benefit, where Base Gravity = Potential Damage + Fault + History

One difference in the penalty calculations is that Pennsylvania accounts for costs to the Commonwealth. Additionally, the oil and gas civil penalty policy in Pennsylvania seems to have a more narrow interpretation of term, 'continuing violation' than the CDPHE WQD. That is, PA DEP staff are directed to only assess a larger penalty for a continuing violation where

discharges, damage, or conditions observed to be continuous over time; for example, a monitored effluent discharge... singular incidents or conditions that are not yet corrected, but not continually causing pollution or damage (e.g. erosion and sediment controls), should be considered single events, or possibly multiple events, but should not have a daily penalty assessed. (Department of Environmental Protection, 2002)

On the other hand, because the stormwater civil penalty policy in Colorado applies only to construction stormwater, it is possible that continuing violations are interpreted more broadly to include erosion and sediment controls.

Colorado penalty calculations are also more prescriptive with regards to continuing violations. The Colorado stormwater civil penalty policy gives regulators a daily dollar amount which permitted entities should be fined based on the permit section which was violated and the number of days for which the misconduct continued. The policy also includes daily dollar amounts that staff should fine operators based on the degree of fault and compliance history. Additionally, a percentage of the base gravity penalty is added based on the designated use of the stream, where the penalty value can double if there is major potential damage to aquatic life in a Class 1 stream. Considerations that may increase or reduce the penalty value include, “voluntary and complete disclosure of violations” (resulting in a 10% to 50% reduction in value), “full and prompt cooperation” (5%-25% reduction), “instituting a regularized and comprehensive environmental compliance program” (5%-25% reduction), or “committing a violation with intention, recklessness, or negligence” (5%-100% increase) (Colorado Department of Public Health and Environment, 2007).

In Pennsylvania, prescriptive daily penalty values are not provided. Rather, staff are provided with a wide range of potential values for the base penalty based on potential harm to human health and safety (severe \$5,000 - \$25,000; significant \$1,000 - \$5,000; moderate to low up to \$1,000). Another range of penalty values is provided to account for the willfulness of the violator in non-compliance with the law. However, specific penalty values are established for violations of the Clean Streams Law and their magnitude is based on the designated use of the receiving water body. In Pennsylvania, cooperation with the DEP can reduce penalties by up to 20%, while a history of violations can increase the fee by 10% (Department of Environmental Protection, 2002). The prescriptive calculations in Colorado’s stormwater civil penalty policy are another potential explanation for the significant difference in penalty values assessed by enforcement staff in both states. However, based on written department policies, Pennsylvania appears to have more flexibility in issuing an appropriate penalty value, as well as a larger daily maximum, whose lack of use is telling.

Another difference between Pennsylvania and Colorado is the manner in which inspections versus formal enforcement actions are approached. In Pennsylvania, a 2011 internal review listed recommendations for the department’s enforcement program. One of the suggestions in this report was that the program evolve over the long term to prioritize inspections over formal enforcement actions while effectively meeting its goals (Pennsylvania Department of Environmental Protection, 2011). This could be interpreted to mean a decrease in the issuance of penalty assessments.

In contrast, limited staffing numbers in Colorado influence the manner in which the enforcement program operates. A 2012 CDPHE WQCD document which was generated by statutory obligation reported on “Efforts to develop a more streamline process for preventing violations and enforcing regulations and permits for stormwater discharges associated with construction activities.” (Water Quality Control Division, Colorado Department of Public Health and Environment, 2012) The division reported that they were severely understaffed, where 4 full-time employees were dedicated to enforcement of three to five thousand construction sites. Only 19 inspections were conducted from October 2011 to 2012. Consequently, a top priority for the department was responding to complaints rather than routine inspections. At the same time, when enforcement staff were capable of visiting a site, penalties were one of the only mechanisms they had to influence operator behavior due limited ability to inspect in the future (Water Quality Control Division, Colorado Department of Public Health and Environment, 2012).

Enforcement Synthesis

A review of enforcement data in two states which were considered to have strong regulatory programs revealed very different levels of enforcement activity and approaches to encouraging industry compliance. In Pennsylvania, a low threshold for obtaining a violation and penalty assessment was found, yet monetary fines associated with these enforcement actions were relatively small. Additionally, the types of violations occurring on oil and gas sites show that surface waters could be significantly impacted by the industry, but these threats might be mitigated by policy changes that have taken place in response to expansion of the industry in recent years. In Colorado, enforcement activity is significantly limited by the number of personnel dedicated to compliance. However, when enforcement actions do occur, penalty assessments are significantly higher than those in Pennsylvania. The permit sections which are violated are not concentrated on any specific type of violation so that conclusions about threats to stormwater cannot be drawn.

Conclusion

The motivation for this research was to determine how to best craft regulatory and enforcement programs to protect the environment, specifically with respect to stormwater impacts, for the emerging natural gas industry. Indeed, regulation and enforcement are two separate policy instruments, which at times are appropriately examined independent of one

another. Nevertheless, developing a comprehensive environmental protection program consists of both policy tools which may influence one another and outcomes may appear contradictory. For example, where stringent regulations may be perceived to be environmentally protective, by increasing costs to the operator, they may in fact decrease the probability of compliance and require more enforcement (Heyes, 2000).

Thus, the ultimate goal of these two policy tools acting in combination is to minimize impacts to the environment. Under ideal circumstances, regulations would be crafted so that no enforcement action would be necessary and any inspection would reveal full compliance. The benefit derived by complying with regulation would be greater than the cost of non-compliance in addition to penalties and enforcement-related costs (Heyes, 2000). Consequently, I propose that dedicating state resources towards drafting regulations so they “get it right” the first time should be a priority over enforcement program design. Once an enforcement action is necessary, the environment has already been harmed or had the potential to be impacted. The subsequent discussion further emphasizes the priority of rule-making over enforcement, which is supported by the characteristics of these policy tools, external factors which drive their efficacy, and supporting information identified in the regulatory and enforcement case studies described above.

Disparities in Rule-making and Enforcement

Rule-making is a slow process by design. It is open to the public and heavily influenced by a wide variety of stakeholders and advocacy groups. The process is defined in statute and seeks input through public comment, which may influence the outcome of how regulations are drafted. When considering one regulation in isolation, it is also an infrequent occurrence. Although finalizing a new rule may take years, once it is complete it may not be amended for decades. This is because rule-making is driven by statutory changes, which are also uncommon due to influence by advocacy groups and constituents. Building consensus among a large number of stakeholders is difficult and timely.

Regulatory provisions are also driven by the economic and political climate during which they are drafted. That is, the political party which is in the majority will drive the regulatory agenda and the economic climate may shape stakeholder and constituent mindsets as to whether or not regulatory compliance costs are reasonable. Additionally, any champion of a rule change may be balancing a broader agenda and deciding how to allocate their political

capital. That is, in order to drive an extensive policy agenda forward, advocating for stringent regulations in one set of rules may require increasing flexibility elsewhere. Since rule-making is an infrequent process that can be easily undermined, these challenges together imply that when it occurs, it is imperative that it is done well in order to protect the environment in the long term.

In contrast, enforcement is a more nimble process that can change on a continuous basis, and is limited to a smaller group of stakeholders. In part, this is because enforcement changes may be driven by internal agency dynamics in addition to statutory changes. An example of a state enforcement program change due to statute may be permissibility to assess a new daily maximum penalty, as was the case in Pennsylvania due to the Oil & Gas Act of 2012. Alternatively, a rapid change can take place if agency leadership instructs staff to focus on inspections rather than penalty assessments. Indeed, a similar example was found in Pennsylvania where an internal department review recommended that enforcement staff prioritize inspections over formal enforcement actions.

The primary parties interested in the details of an enforcement program will be the regulated community. This is because they undergo inspections and have the potential for economic loss through penalty assessments. Enforcement programs may evolve based on dialogue between the regulator and regulated community. As inspectors have repeat interaction with specific operators or industry as a whole, they may use feedback to redesign flexibility within the penalty process.

Economic climate may also influence compliance and enforcement activity, albeit differently than it does rule-making. In an economic recession, the regulated community may be incentivized to take short-cuts and avoid compliance costs. However, regulators may seek to fill budget shortfalls by collecting compliance fees through penalty assessments and issue more violations than normal. The capability of enforcement staff to assess the penalties may be dependent upon appropriations and agency funding, which may be reduced in an economic downturn. These scenarios additionally reflect the changing nature of enforcement programs and the necessity to create rules that encourage compliance as well as environmental protection in the absence of adequate enforcement.

The Pennsylvania and Colorado enforcement reviews support these conclusions. It is not possible to infer from the data the degree of operator compliance. This is because we do not have confirmation that inspections were conducted randomly nor if the reported data is representative of the compliance of the entire industry. However, where both programs

contained strong regulatory provisions, enforcement data and analysis revealed deficiencies in both states. In Pennsylvania, the enforcement program is well-funded and well-staffed. However, the mean (5-year average: \$19,015) and median (5-year average: \$7,972) value of the penalty assessments is not likely to be sufficient to alter operator behavior. Where operator behavior is motivated by economics, these values indicate an operator could experience financial gain by avoiding compliance.

In Colorado, the value of penalty assessments is more likely to deter operators from non-compliance. However, the blatant lack of inspections has the potential to significantly counteract this. In both circumstances, the significant political and economic influences on the enforcement programs are also evident. In Colorado, this is marked by lack of funding to hire more enforcement staff and in Pennsylvania, this is apparent through the myriad of activity taking place in the state in response to extraction of the Marcellus Shale. More insight can be gained from factors which are specific to this particular case study.

Case-specific factors

Designing regulation and enforcement will also depend on the nature of the industry as well as the pollution which should be prevented. With respect to the industry, the financial size of natural gas production companies may determine the ability to comply, pay fines, and contest enforcement actions. Large companies with higher profit margins may have the capacity to install compliance measures and may be more influenced by external market drivers like public reputation. Additionally, publicly-traded companies are held accountable by their shareholders and poor compliance can impact stock price values (Heyes, 2000). A study by Badrinath and Bolster:

shows that a firm's stock market valuation declines 0.43% in the week of settlement – which for anything but the smallest firm translates into a dollar amount far in excess of the nominal penalty.

These values are derived from data spanning the 1970s – 1990s (Heyes, 2000) Today, it is possible these values could prove to be higher.

In the United States, the oil and gas industry is comprised of more than 14,000 companies, but less than one percent of these operators are producing more than fifty percent of the natural gas (Kusnetz, 2011) Thus, the industry is characterized by large players and it is

possible that there may be external motivating factors to induce compliance outside of traditional enforcement activity. Especially so because when enforcement actions do occur, large operators are more likely to have sufficient funds to contest penalties and litigate matters in court.

In addition to critically thinking about the industry which is regulated, it is important to consider characteristics of the pollutant. In the case of stormwater, environmental impacts are not always generated from a particular point on the landscape. Consequently, it can be difficult to trace the source of pollution. However, a permit system mitigates this effect, by treating stormwater runoff as a point source. This means that outfalls which drain stormwater are designated on a site, which allows regulators to better identify the sources of pollution when impacts are discovered downstream. Erosion & Sediment Control Plans and Stormwater Management Plans likewise designate outfalls on a site. Designing a program that treats stormwater runoff as a point source, and which generates sites for outfalls that are approved by a governmental agency is critical because it holds industry accountable when pollution does occur.

Recommendations

Together, these considerations indicate that focusing attention on crafting optimally designed regulations may be more effective than increasing enforcement activity. The regulatory discussion and synthesis provide a starting point for research on state rules which can be improved. However, a well-designed enforcement program continues to be important, although government agencies should focus attention on non-traditional strategies. First, agencies should consider issuing penalties less frequently but at much higher values. Where operators may set enforcement expectations based on the historical behavior of a state agency, it is important to set appropriate precedent. Agencies should also consider what a *large* penalty value means to a given operator based on the true economic gain that may have been achieved from non-compliance.

Additionally, well fees or other long-term funding mechanisms should be implemented that are sufficiently large to sustain adequate enforcement staff. Moreover, enforcement programs should encourage greater public involvement. For an emerging industry receiving significant national attention, it may be beneficial to increase availability of enforcement data and disseminate synthesized information. As a result, market-drivers and public reputation could be significant motivators to induce compliance, and in certain situations, could even be

more effective than penalties which have historically been issued. Public outreach campaigns may allow citizens to recognize poor stormwater practices and notify enforcement staff when violations occur.

Natural gas production may play a significant role in the future economy of the United States. Growth of the industry has already shaped the economies in certain states. When responsibly conducted, natural gas production can replace alternative methods of energy extraction and reduce environmental impacts. However, a challenge exists in that federal legislation has left states with the primary role for environmental management on a number of issues. In the case of stormwater, states have responded with varying degrees of stringency. In all states, room exists for improvement. This study has touched the surface on challenges and possibilities in improving stormwater management programs. Certainly, it highlights opportunities for amending programs to increase environmental protection.

Literature Cited

- Adams, M. B., Edwards, P. J., Ford, W. M., Johnson, J. B., Schuler, T. M., Gundy, M. T., & Wood, F. (2011). Effects of Development of a Natural Gas Well and Associated Pipeline on the Natural and Scientific Resources of the Fernow Experimental Forest. *United States Department of Agriculture, Forest Service, Northern Research Station*, (General Technical Report NRS-76), 1–22.
- Airey, J. W., Gormly, K. M., Keller, J. K., Russell, G. D., & Vorys, W. I. (2014, February 20). 2013 Pennsylvania oil and gas law review. *Lexology*. USA. Retrieved from <http://www.lexology.com/library/detail.aspx?g=e57da5b1-2ee4-41ef-b75e-81d4c46228a7>
- Alaska Department of Environmental Conservation, Division of Water (2011). Storm Water Exemption for Oil and Gas Activities. Retrieved April 24, 2014, from <http://dec.alaska.gov/water/wnpssc/stormwater/oilandgas.htm>
- Alberta Energy Regulator. (2014). What is Unconventional Oil and Gas? Retrieved April 19, 2014, from <http://www.aer.ca/about-aer/spotlight-on/unconventional-regulatory-framework/what-is-unconventional-oil-and-gas>
- Benefield, Ryan, Arkansas Department of Environmental Quality (2012). Natural Gas Drilling Activities - A State Perspective. Arkansas.
- Colorado Department of Public Health and Environment, Air Pollution Control Division (2009). Enforcement Guide: Stationary Sources Program. Retrieved April 24, 2014, from <http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheadername1=Content-Disposition&blobheadername2=Content-Type&blobheadervalue1=inline%3B+filename%3D%22Enforcement+Guide.pdf%22&blobheadervalue2=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1251818038649&ssbinary=true>
- Colorado Department of Public Health and Environment, Water Quality Control Division (2007). *Stormwater Civil Penalty Policy* (pp. 1–20). Colorado.
- Colorado Department of Public Health and Environment, Water Quality Control Division (2012). *Report to the General Assembly of the State of Colorado in accordance with Colorado House Bill 12 - 1119. Efforts to develop a more streamlined process for preventing violations and enforcing regulations and permits for stormwater discharges association with construction activities*. Colorado.
- Colorado Department of Public Health and Environment, Water Quality Control Division (2014). *Notice of Amendment of Permit Coverage*. State of Colorado. Retrieved from <http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheadername1=Content-Disposition&blobheadername2=Content-Type&blobheadervalue1=inline;+filename=%22Request.pdf%22&blobheadervalue2=application/pdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1251807328249&ssbinary=true>

- Colorado Oil and Gas Conservation Commission. (2014). *COLORADO WEEKLY & MONTHLY OIL & GAS STATISTICS*. Colorado. Retrieved from www.colorado.gov/cogcc
- Department of Environmental Protection, Bureau of Oil and Gas Management (2002). *Civil Penalty Assessments in the Oil and Gas Management Program*. Pennsylvania. Retrieved from <http://www.elibrary.dep.state.pa.us/dsweb/Get/Version-48287/550-4180-001.pdf>
- Energy Information Administration, Office of Oil and Gas (2006). *Natural Gas Processing: The Crucial Link Between Natural Gas Production and Its Transportation to Market* (pp. 1–11). Retrieved from http://www.eia.gov/pub/oil_gas/natural_gas/feature_articles/2006/ngprocess/ngprocess.pdf
- ExxonMobil and XTO Energy. (2014). About Natural Gas: Phases of Natural Gas Production. Retrieved August 07, 2013, from <http://aboutnaturalgas.com/content/technology-and-process/phases-of-natural-gas-production/>
- FracFocus Chemical Disclosure Registry. (2014a). Hydraulic Fracturing Water Usage. Retrieved April 13, 2014, from <http://fracfocus.org/water-protection/hydraulic-fracturing-usage>
- FracFocus Chemical Disclosure Registry. (2014b). What Chemicals Are Used. Retrieved April 13, 2014, from <http://fracfocus.org/chemical-use/what-chemicals-are-used>
- Governor's Marcellus Shale Advisory Commission. (2011). *Governor's Marcellus Shale Advisory Commission Report*. Pennsylvania.
- Heyes, A. (2000). Implementing Environmental Regulation : Enforcement and Compliance. *Journal of Regulatory Economics*, 17(2), 107–129. doi:10.1023/A:1008157410380
- Kelso, M. (2012). Drilled Wells by Operator Over Time in PA's Marcellus. *FracTracker*. Retrieved April 20, 2014, from <http://www.fractracker.org/2012/05/drilled-wells-by-operator-over-time-in-pas-marcellus/>
- Klapkowski, K. (Pennsylvania Department of Environmental Protection (2012). *Pennsylvania's Act 13 of 2012, Susquehanna River Basin Commission Water Quality Advisory Committee Meeting*. Harrisburg, PA. Retrieved from <http://www.srbc.net/programs/docs/wqac052212Act13.PDF>
- Kusnetz, N. (2011, September 1). Who Are America's Top 10 Gas Drillers? *ProPublica*. Retrieved from <http://www.propublica.org/article/who-are-americas-top-10-gas-drillers>
- Michigan Department of Environmental Quality. (2014). Office of Oil, Gas, and Minerals - Forms Page. *Soil Erosion & Sedimentation Control Plan; Environmental Impact Assessment*. Retrieved April 17, 2014, from http://www.michigan.gov/deq/0,4561,7-135-3311_4111_4231-9207--,00.html
- Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management (2011). *Internal Review of Inspection and Enforcement of Natural Gas Operations* (pp. 1–10).

Pennsylvania Department of Environmental Protection, Bureau of Waterways Engineering and Wetlands, Division of Wetlands, E. and T. (2012). Erosion and Sediment Pollution Control Program Manual. Retrieved February 24, 2014, from <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8300>

State Review of Oil & Natural Gas Environmental Regulations. (2013). *Pennsylvania Follow-Up State Review*. Retrieved from [http://strongerinc.org/sites/all/themes/stronger02/downloads/Final Report of Pennsylvania State Review Approved for Publication.pdf](http://strongerinc.org/sites/all/themes/stronger02/downloads/Final%20Report%20of%20Pennsylvania%20State%20Review%20Approved%20for%20Publication.pdf)

The Bousson Advisory Group, Allegheny College (2014). Laws and Regulations. Retrieved April 18, 2014, from <http://sites.allegheny.edu/boussonadvisorygroup/laws-and-regulations/>

U.S. Energy Information Administration. (2014). Natural Gas Gross Withdrawals and Production. *Data: Production*. Retrieved April 19, 2014, from http://www.eia.gov/dnav/ng/ng_prod_sum_a_epg0_fgw_mmcf_a.htm

U.S. Geological Survey National Assessment of Oil and Gas Resources Team, and L. R. H. B. (2013). *National Assessment of Oil and Gas Project, Map of Assessed Shale Gas in the United States, 2012* (p. 5). Reston, Virginia. Retrieved from http://pubs.usgs.gov/dds/dds-069/dds-069-z/DDS-69-Z_pamphlet.pdf

U.S. Natural Gas Marketed Production. (2014). *United States Energy Information Administration*. Retrieved April 13, 2014, from <http://www.eia.gov/dnav/ng/hist/n9050us2m.htm>

U.S. Natural Gas Number of Gas and Gas Condensate Wells. (2014). Retrieved April 13, 2014, from http://www.eia.gov/dnav/ng/hist/na1170_nus_8a.htm

United States Environmental Protection Agency. (2014). EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources. Retrieved from <http://www2.epa.gov/hfstudy>

United States Environmental Protection Agency, Office of Research and Development (2012). Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources Progress Report, (EPA/601/R-12/011), 122. Retrieved from <http://www2.epa.gov/sites/production/files/documents/hf-report20121214.pdf#page=209>

United States Environmental Protection Agency, Office of Wastewater Management (2012a). EPA Stormwater Program. Retrieved April 13, 2014, from http://cfpub.epa.gov/npdes/home.cfm?program_id=6

United States Environmental Protection Agency, Office of Wastewater Management (2012b). Regulation of Oil and Gas Construction Activities. Retrieved April 16, 2014, from <http://cfpub.epa.gov/npdes/stormwater/oilgas.cfm>

United States Environmental Protection Agency, Office of Wastewater Management (2014). Stormwater Basic Information. Retrieved April 16, 2014, from <http://cfpub.epa.gov/npdes/stormwater/swbasicinfo.cfm>

- Vengosh, A., Jackson, R. B., Warner, N., Darrah, T. H., & Kondash, A. (2014). A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States. *Environmental Science & Technology*. doi:10.1021/es405118y
- Wachal, D. J. (2008). Characterizing Storm Water Runoff from Natural Gas Well Sites in Denton County, Texas. *Dissertation Prepared for the Degree of Doctor of Philosophy, University of North Texas*. Retrieved April 18, 2014, from http://marcellus-wv.com/online-courses/construction/marcellus-issues-in-west-virginia-an-introduction/wachal_dissertation.pdf
- Warren, K. J. (2010). Pennsylvania's Regulation of Total Dissolved Solids. *The Legal Intelligencer*, 242(54), 2–5.
- West Virginia Department of Environmental Protection. (2014). Construction Stormwater General Permits. Retrieved August 22, 2013, from <http://www.dep.wv.gov/WWE/Programs/stormwater/csw/Pages/home.aspx>
- Wisconsin Department of Natural Resources. (2012). Erosion control and storm water management plans. Retrieved April 20, 2014, from http://dnr.wi.gov/topic/stormwater/construction/erosion_control.html#4

APPENDIX

Table 1. Natural Gas Gross Withdrawals and Production by State (MMcf) – 2012
States highlighted in gray were selected for the regulatory review

State	Natural Gas Gross Withdrawals (MMcf)	State	Natural Gas Gross Withdrawals (MMcf)
Texas	8,143,510	Michigan	129,333
Alaska	3,164,791	Kentucky	106,122
Louisiana	2,955,437	Ohio	84,482
Pennsylvania	2,256,696	Montana	66,954
Wyoming	2,225,622	New York	26,424
Oklahoma	2,023,461	Florida	18,681
Colorado	1,709,376	South Dakota	15,085
New Mexico	1,276,296	Indiana	8,814
Arkansas	1,146,168	Tennessee	5,825
West Virginia	539,860	Illinois	2,125
Utah	490,393	Nebraska	1,328
Mississippi	452,915	Oregon	770
Kansas	296,299	Arizona	117
North Dakota	258,568	Maryland	44
California	246,822	Nevada	4
Alabama	215,710	Missouri	0
Virginia	146,405		

Source: (U.S. Energy Information Administration, 2014)

Table 3. Summary table of mechanisms for regulating stormwater on oil and gas sites¹¹.
 Color of box indicates phase of operation covered by the regulatory mechanism.
 Reference cited in footnote indicates either the regulation which implements the mechanism or source of information.

Regulatory Mechanisms	Erosion & Sediment Control Plan	Stormwater Management Plan	NPDES: Stormwater Construction Permit	NPDES: Stormwater Industrial Permit	Permit-by Rule	Phase of Operation Covered
Alaska ¹²						Construction/ Pre-Drilling
Arkansas ¹³						
Colorado ¹⁴						Drilling
Louisiana ¹⁵						
Michigan ¹⁶						Construction & Drilling
Ohio ¹⁷						
Pennsylvania ¹⁸						Post- Construction
Texas ¹⁹						
Virginia ²⁰						
Wyoming ²¹						

¹¹ Information captured in table researched and synthesized in coordination with Rubaina Anjum.

¹² Oil and gas activities in the North Slope Borough uniquely require an industrial stormwater permit (AKG 33-1000) due to geographical conditions that could contribute to the violation of a water quality standard (Alaska Department of Environmental Conservation, 2011).

¹³ 178.00.10-01 Ark. Code R. § B-17(l), "The Discharge from a Pit or any activity associated with the drilling or completion of a well to any surface or ground waters or in a location where it is likely to cause pollution to any surface or groundwaters is prohibited." 178.00.10-01 Ark. Code R. § B-17(e)

¹⁴ 2 CCR 404-1:1002; 5 CCR 1002-61

¹⁵ La. Admin. Code 33.IX.2511(A)(2)(b); La. Admin. Code 33.IX.2511(C)(1)(c)(iii)

¹⁶ MCL 324.9115(3), Mich. Admin. Code R. 323.2190

¹⁷ Ohio Admin. Code § 1501:15-1-03, Ohio Admin. Code § 3745-39-04(A)(2)(b)

¹⁸ Pa. Code § 102.5(c), Pa. Code § 102.8(a)

¹⁹ "Under § 3.8 of this title, the RRC prohibits operators from causing or allowing pollution of surface or subsurface water. Operators are encouraged to implement and maintain BMPs to minimize discharge of pollutants, including sediment in storm water..." 16 Tex. Admin. Code § 3.30(b)(2)(B)(ii)

²⁰ 4 VAC 25-150-260, 4 VAC 25-150-270

²¹ Wyoming Department of Environmental Quality, Water Quality Rules and Regulations, Ch. 2 § 6 (a), Ch. 2 § 6 (g)

Table 4. Selected provisions related to stormwater impacts from regulations for open containment²²

State	Prior Approval for Pit Construction	Types of Fluids Permitted in Pits	Floodplain Regulations	Standards for Storm Event	Freeboard Requirement	Reclamation Standards
<p>Alaska</p> <p>20 AAC 25.528 20 AAC 25.047</p>	No reference	<p>NO: crude oil 20 AAC 25.528</p> <p>YES: drilling fluids; cutting 20 AAC 25.047</p>	No reference	No reference	No reference	<p><i>Upon completion, suspension, or abandonment of the well, the operator shall ... leave the reserve pit in a condition that does not constitute a hazard to freshwater.</i></p> <p>20 AAC 25.047</p>
<p>Arkansas</p> <p>178.00.10-001 Ark. Code R. § B-17</p>	<p><i>The Operator shall notify the appropriate AOGC Regional Office ... at least forty-eight hours prior to the commencement of Pit construction operations.</i></p> <p><i>AOGC and ADEQ staff may conduct site inspections as deemed necessary.</i></p> <p>§ B-17 (d)</p>	<p><i>No waste oil, hydraulic fluids, transmission fluids, trash or any other miscellaneous rig waste may be disposed into a Mud, Circulation, or Reserve Pit.</i></p> <p>Post-drilling Produced Water and Frac Flow-back must meet special conditions to be stored. Requirements based on closure timeline, construction standards, and use in a recycling program.</p> <p>YES: Water-Based Drilling Fluid & Encountered Water § B-17 (g)</p>	<p>Mud, Circulation and Reserve Pits: <i>constructed within the 100 year flood plain must be in accordance with any county or other local ordinance or requirement...</i> § B-17(f)(1)(A)</p> <p><i>location...shall be chosen with reasonable consideration to maximizing the distance from surface waters.</i> § B-17(f)(1)(B)</p>	<p>Mud, Circulation, Reserve Pits: Withstand 10-year, 24 hour storm during operation</p> <p>§ B-17(f)(2-3)</p>	<p>2 feet min</p> <p>§ B-17(f)(2-3)</p>	<p>Remove pit fluids and liner. <i>The closed Pit shall be filled with native materials and covered with topsoil...The area shall be returned to grade, reclaimed and seeded ... Operator shall submit the Notice of Pit closure to AOGC signed by the Operator within 30 days after Pit closure..</i> § B-17(i)(4)-(6)</p> <p><i>Vegetative coverage of 75%, or equivalent to the surrounding landscape, whichever is less, shall be obtained within six months of Pit closure.</i> § B-17(h)(6)</p>
<p>Colorado</p> <p>2 CCR 404-1:900 2 CCR 404-1: 1000</p>	<p>Prior approval needed for pits with pollution potential. No permit for water-based drilling fluid. Submit pit form w/ Application for Permit to Drill. 30 day turnaround. (903)</p>	<p>Treated produced water (902(h))</p> <p>Drilling or Completion Fluids ; Water-based drilling fluids (903(a), 903(c))</p> <p>Exploraton & Production waste disposal and Fresh Water (902(e))</p>	No reference	<p>Non-commercial, E&P waste management facilities: <i>Surface water diversion structures...shall be constructed to accommodate a 100 year, 24 hour event.</i> Run-on & Run-off control system should manage a 25 year, 24 hour storm. (908(b)(5)(E))</p>	<p>2 feet min</p> <p>(902)</p>	<p><i>...pits shall be closed in accordance with approved Site Investigation and Remediation Workplan (905(b))</i> Interim and Final Reclamation requirements. Closure based on land use and floodplain. Timeline varies (3-12 months). Cropland final reclamation: <i>over two growing seasons has indicated no significant unrestored subsidence (1000 Series)</i></p>

²² Information captured in table researched and synthesized in coordination with Rubaina Anjum. Exact regulatory language specified through use of italics.

<p>Louisiana</p> <p>La. Admin Code 43.XIX.Chapter 3</p>	<p><i>Except for reserve pits, operators must notify the Office of Conservation of the intent to construct new pits at least 10 days prior to start of construction.</i></p> <p>§305(B)</p>	<p>YES: burn pits, compressor station pits, natural gas processing pits, produced water pits, washout pits, well test pits, emergency pits, onshore terminal pits, salt dome cavern pits, reserve pits</p> <p>§307</p>	<p>No reference</p>	<p><i>Production pits may not be constructed in a "V" or A zone as determined by flood hazard boundary or rate maps... unless such pits have levees which have been built at least 1 foot above the 100-year flood level and able to withstand the predicted velocity of the 100-yr flood.</i></p> <p>§303(J)</p>	<p>2 feet</p> <p>§307(B)(2)</p>	<p><i>Pits shall be emptied of fluids in a manner compatible with all applicable regulations, and closed in accordance with §311 and §313 within six month of completion of drilling or work over operations.</i></p> <p>§307(B)(4)</p>
<p>Michigan</p> <p>MCL 324.614</p>	<p>Not explicit.</p> <p><i>Drilling mud pits shall be located and plotted as instructed by the supervisor.</i></p> <p>Mich. Admin. Code R. 324.407(4)</p>	<p><i>Except as provided in R 324.407(2), a permittee of a well shall not dispose of oil or gas field waste, or both, in earthen pits.</i></p> <p>Mich. Admin. Code R. 324.702</p> <p>YES: Drill cuttings, muds, and fluids, water-based drilling muds, cuttings, native soils, cementing & solidification material.</p> <p>There is reference to the formation from which materials come from.</p> <p>Mich. Admin. Code R 324.407(2), Mich. Admin. Code R 324.407(7)(b)</p>	<p>No reference</p>	<p>No reference</p>	<p>No reference</p>	<p><i>All free liquids above the solids in the pit shall be removed to the maximum extent practical... (a) All drilling mud pits shall be stiffened before encapsulation... (b) The drilling mud pit shall be carefully encapsulated and buried as soon as practical after drilling completion, but not more than 6 months after drilling completion. (c) The drilling mud pit shall be buried not less than 4 feet below the original ground grade level. (f) R 324.407(9)(a-f)</i></p>
<p>Ohio</p> <p>Ohio Admin. Code § 1501:9-3-08</p> <p>Ohio Rev. Code § 1509.072 § 1509.22 § 1509.06</p>	<p><i>Temporary storage of saltwater and oil field wastes. 1501:9-3-08(A)</i></p> <p><i>Pits may be used for temporary storage of frac-water and other liquid substances produced from the fracturing process. 1501:9-3-08(C)</i></p>	<p>Spill prevention and control 1509.22(4)</p>	<p>See Standards for Storm Event</p>	<p>[Saltwater and oil field waste pits] shall have a continuous embankment surrounding them sufficiently above the level of the surface to prevent surface water from entering. Such pits shall not be used in an area which is subject to flooding... unless so constructed that the pits would not normally be affected by flooding. 1501:9-3-08(A)</p>	<p><i>The level of saltwater in excavated pits shall at no time be permitted to rise above the lowest point of the ground surface level.</i></p> <p>1501:9-3-08(A)</p>	<p>Restoration plan should be filed w/ application for permit to drill 1509.06(A)(10)</p> <p>Pits containing brine and other waste resulting, obtained, or produced in connection with exploration or drilling must be filled (w/in 14 days in urbanized area and w/in 2 months elsewhere) 1509.072(A)</p>

<p>Pennsylvania</p> <p>25 Pa. Code § 78.56</p>	<p>No reference</p>	<p>YES: Brines, drill cuttings, drilling muds, oils, stimulation fluids, well treatment and servicing fluids, plugging and drilling fluids other than gases</p> <p>25 Pa. Code § 78.56 (a)</p>	<p>No reference</p>	<p>No reference</p>	<p>2 feet min</p> <p>25 Pa. Code § 78.56 (a)(2)</p>	<p><i>Unless a permit under The Clean Streams Law or approval under § 78.57 or § 78.58... has been obtained for the pit, the owner or operator shall remove or fill the pit within 9 months after completion of drilling, or in accordance with the extension granted by the Department... 25 Pa. Code § 78.56 (d)</i></p>
<p>Texas</p> <p>16 Tex. Admin. Code § 3.8</p>	<p><i>The pits required...to be permitted include... saltwater disposal pits; emergency saltwater storage pits; collecting pits; skimming pits; brine pits; brine mining pits; drilling fluid storage pits (other than mud circulation pits); drilling fluid disposal pits (other than reserve pits or slush pits); washout pits; and gas plant evaporation/retention pits. §3.8(d)(2)</i></p>	<p><i>A person may, without a permit, maintain or use reserve pits, mud circulation pits, completion/ workover pits, basic sediment pits, flare pits, fresh makeup water pits, fresh mining water pits, non-commercial fluid recycling pits, and water condensate pits...</i></p> <p>§3.8 (d)(4) NO: oil or oil products §3.8(d)(2)</p>	<p><i>Unless otherwise approved by the district director after a showing that the fluids will be confined in the pit at all times, all authorized pits shall be constructed, used, operated, and maintained at all times outside of a 100-year flood plain...</i></p> <p>§3.8(d)(4)(H)(iv)(l)</p>	<p><i>All pits shall be designed to prevent stormwater runoff from entering the pit. If a pit is constructed with a dike or berm, the height, slope, and construction material of such dike or berm shall be such that it is structurally sound and does not allow seepage.</i></p> <p>§3.8(d)(4)(G)(iii)</p>	<p>2 feet min §3.8(d)(4)(G)(iv) <i>All pits shall be sufficiently large to ensure adequate storage capacity and freeboard taking into account anticipated precipitation.</i> §3.8(d)(4)(G)(ii)</p>	<p>Pits should be backfilled. Depending on the type of pit, dewatering, compaction and backfilling vary from 30-120 days, to one year.</p> <p>§3.8(d)(4)(H)</p>
<p>Virginia</p> <p>4VAC25-150-300 4VAC25-150-420</p>	<p>Not explicit. See regulatory language for types of pit fluids permitted.</p>	<p><i>All fluids from a well, pipeline or corehole shall be handled in a properly constructed pit, tank or other type of container approved by the director.</i></p> <p>4VAC25-150-420(A)</p>	<p>No reference</p>	<p>No reference</p>	<p>2 feet min</p> <p>4VAC 25-150-300(B)(1)</p>	<p><i>Pits are to be temporary in nature and are to be reclaimed when the operations using the pit are complete. All pits shall be reclaimed within 180 days... 4VAC25-150-300(A)(1) At the conclusion of drilling and completion operations... the pit shall be drained in a controlled manner and the fluids disposed of... 4VAC25-150-300(B)(3)</i></p>
<p>Wyoming</p> <p>Wyoming OGCC Environmental Rules, Including Underground Injection Control Program Rules for Enhanced Recovery and Disposal Projects, Ch. IV § 1</p>	<p>Permit required. Option to obtain fieldwide approval. Permit is valid for one year. Staff must be notified of construction and closure within 24 hours of event to provide ability to inspect. CH. IV §1(d)-(g), (k), (w)</p>	<p>YES: Reserve, produced water, skim, emergency drilling fluid, workover/ completion fluid, heavy sludges, basic sediment & water, centralized pits. Ch. IV §1(b), (h) – (j)</p> <p>Oil-based drilling muds and high density brines. Ch. IV §1(w)</p>	<p><i>Form 14A must be submitted and approved prior to use of a produced water pit... The information required for submitted includes a standard water analysis to include oil and grease, maximum and average estimated inflow, size of pit, freeboard capacity... maximum fluid level above average ground level, distance to closest surface water... A plan view map and topographic map of sufficient size and detail to determine surface drainage system and all natural waterways and irrigation systems...</i></p> <p>Ch. IV § 1(r)(i)</p>	<p><i>Liquids must be kept at a level that takes into account extreme precipitation events and prevents overtopping and unpermitted discharges.</i> Ch. IV § 1(w)(viii)</p>		<p>Reclaim as soon as weather conditions permit, but within 1 year. Exemption for pits with water produced in association with recovery of coalbed methane gas in Powder River Basin. § 1(qq) <i>Site rehabilitation... in accordance with reasonable landowner's wishes, and/or resemble original vegetation and contour of adjoining lands. §1(rr)</i></p>

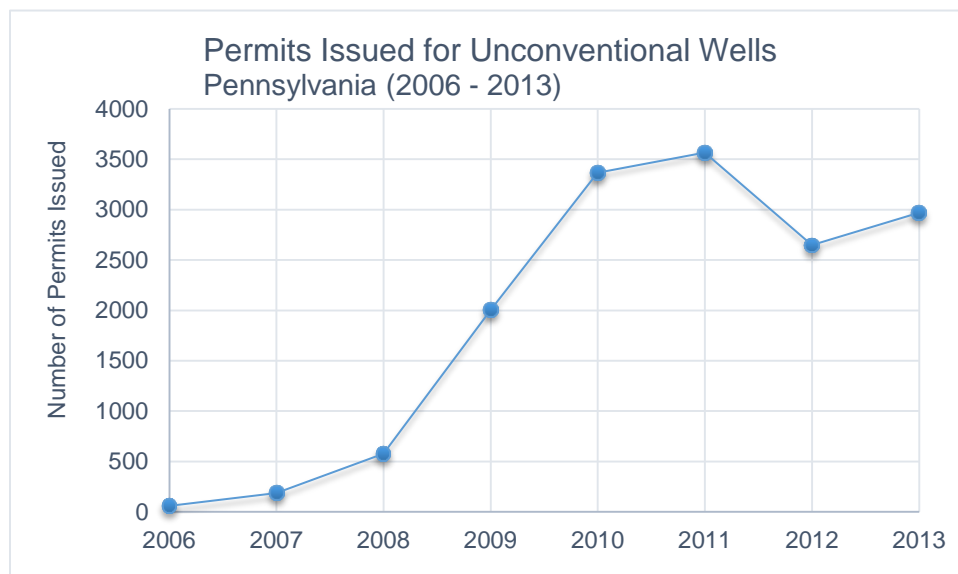
Table 5. Pennsylvania Oil and Gas Penalty Assessments (\$) Statistical Summary by Year
Numerical values correspond to Figure 2, page 28

	2006	2007	2008	2009	2010	2011	2012	2013
Count	2	1	15	47	56	49	46	8
Mean	\$9,567	\$2,500	\$15,844	\$24,091	\$35,325	\$22,695	\$11,821	\$4,314
Median	\$9,567	\$2,500	\$6,300	\$12,150	\$11,250	\$11,128	\$3,775	\$3,229
Min	\$8,105	\$2,500	\$1,000	\$1,182	\$0	\$500	\$0	\$500
Max	\$11,028	\$2,500	\$64,000	\$141,175	\$353,419	\$190,000	\$73,271	\$12,550

Table 6. Colorado CDPS Construction Stormwater Penalty Assessments (2009 – 2013) Statistical Summary by Permitted Entity
Numerical values correspond to Figure 7, page 36

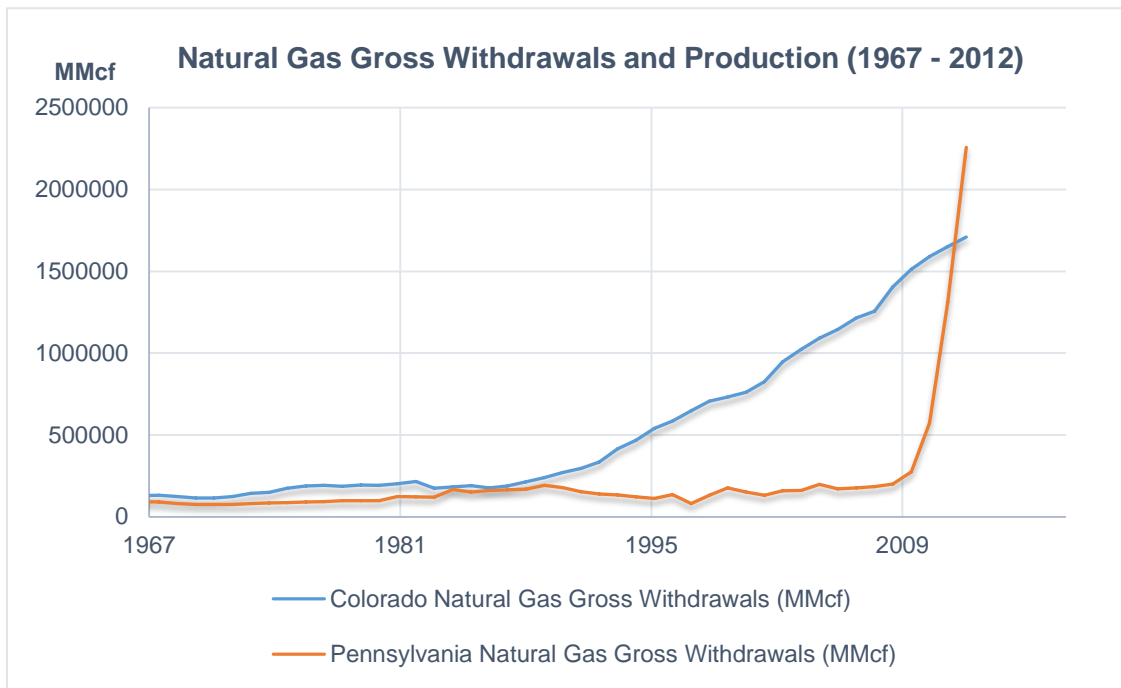
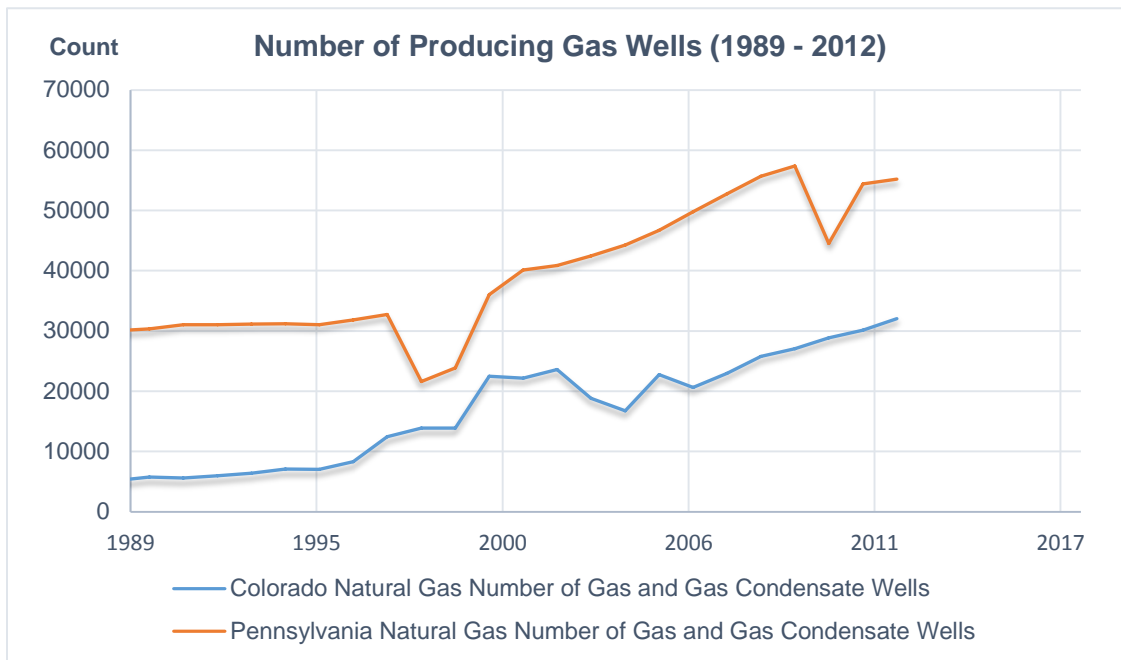
	Total	Oil and Gas	Non – Oil and Gas
Count	74	17	57
Mean	\$66,466	\$111,958	\$52,899
Median	\$45,000	\$98,000	\$38,857
Min	\$2,875	\$5,437	\$2,875
Max	\$400,000	\$400,000	\$190,396

Figure 8. Number of Permits Issued in Pennsylvania by Year (2006 – 2013)
(All Counties, All Municipalities, All Regions, All Operators, Only Unconventional Wells, All Well Types)



Source: Pennsylvania Oil and Gas Reports, “Permits Issued Detail Report” 2014
Retrieved from: http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297

Figure 9. Overview of the Natural Gas Industry in Pennsylvania and Colorado:
 Number of Producing Gas Wells (1989 – 2012) and
 Natural Gas Gross Withdrawals and Production (1967 – 2012)



Source: Energy Information Administration, "Natural Gas Data, Production" 2014
 Retrieved from: <http://www.eia.gov/naturalgas/data.cfm>