FRACTURED COMMUNITIES

Case Studies of the Environmental Impacts of Industrial Gas Drilling

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Riverkeeper is an environmental watchdog organization dedicated to protecting the Hudson River and the New York City drinking water supply. For more information about us please visit www.riverkeeper.org. We are a founding member of the Waterkeeper Alliance, an international organization that works with nearly 200 Waterkeepers to protect waterways around the globe. For more information please visit www.waterkeeper.org.

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EXECUTIVE SUMMARY

This report describes hundreds of case studies demonstrating that industrial gas drilling, including horizontal drilling using high-volume hydraulic fracturing, results in significant adverse environmental impacts. These impacts result from changes in land use, roadbuilding, water withdrawals, improper cementing and casing of wells, over-pressurized wells, gas migration from new and abandoned wells, the inability of wastewater treatment plants to treat flowback and produced water, underground injection of brine wastewater, improper erosion and sediment controls, truck traffic, compressor stations, as well as accidents and spills.

The studies in this report rely exclusively on investigations, findings, and statements of state and federal regulators in the Marcellus Shale region (Pennsylvania, Ohio, and West Virginia), the Barnett Shale (Texas), the Fayetteville Shale (Louisiana and Arkansas), as well as regulators in the western states of Wyoming and Colorado.

In the past two years in Pennsylvania, state regulators have found that gas drilling using high-volume hydraulic fracturing has contaminated drinking water, polluted surface waters, polluted air, and contaminated soils. In Ohio, state regulators found that inadequate well casing resulted in drinking water contamination and the explosion of a house. In Texas, state regulators found elevated levels of benzene and other toxics in neighborhoods with nearby gas compressors. In Wyoming, EPA has warned residents not to drink the water, and in Colorado, hundreds of spills have been reported as residents continue to investigate localized health impacts they feel are associated with nearby drilling operations.

At a time when the oil & gas industry should be on its best behavior, the industry continues to operate with impunity and lobby against federal regulatory oversight. Even as the impact of the Gulf disaster continues to shine a light on the true costs of deregulation, the industry continues to cut corners at the expense of workers and communities across America.

No one debates that the gas industry in the United States has long played a fundamental role in our economy and energy production systems. New York State was the first to embrace the industry in 1821 when the first well was drilled upstate – drilling down vertically into a pool of gas. But the lay of the land is quite different now than when traditional gas drilling first began. More and more shale deposits are now in development as a result of emerging technologies, and an increasing percentage of these developments are in nonconventional shales, areas that were traditionally too difficult or expensive to tap. Hydraulic fracturing, a technology first utilized over 50 years ago, is now employed at roughly 90% of oil and gas wells in the U.S.

But the gas industry has yet to live up to its promise of providing clean energy with minimal environmental impact. Instead of acknowledging risk and undeniable impacts, executives and spokespeople demonize the opposition. Rather than full disclosure, there is secrecy coupled with empty promises of cooperation.

This needs to change. In 2009, Riverkeeper submitted a Case Studies report to the New York State Department of Environmental Conservation in an attempt to dispel myths from state regulators and gas industry executives that drilling was always safe and that reports of contamination were inaccurate. This report is an update that highlights some of the environmental impacts that hard working Americans have had to deal with as we strive to work with government agencies and industries to take the lead in creating long-term energy solutions and sustainable economies of scale that do not require the sacrifice of clean air and water.

After analyzing reports from state and federal regulators, this report concludes with recommendations that, if fully realized, may help to alleviate some of the problems documented across the country. These recommendations include legislative and regulatory actions that would be necessary in order to prevent and control further environmental contamination.

INTRODUCTION

"Reason, science, logic and economic opportunity has lost out to a calculated campaign of misinformation and ignorance … It would be irresponsible to see lawmakers cave to the scare tactics of radical opponents…"
Brad Gill, Executive Director, New York Independent Oil & Gas Association, August 2010[1].

Despite industry rhetoric to the contrary, the environmental impacts of industrial gas drilling are real and indisputable. As this report demonstrates, state and federal regulators are documenting thousands of incidents across the country where industrial gas drilling operations are the known or suspected cause of significant environmental contamination. To be sure, the case studies highlighted here are just a sampling of problems that regulators, landowners, municipalities, and local communities continue to uncover nationwide and around the globe as regulators continue to play catch-up and reverse the lax regulatory oversight that accompanied these problems.

But in the absence of proper preventative measures, environmental assessments, strong regulations and enforcement mechanisms, the cumulative environmental impacts of the industrialization of rural landscapes remains unknown, and the impacts of gas drilling operations continue to result in environmental degradation.

THE MARCELLUS SHALE

The Marcellus shale is a rock formation located approximately 5,000 to 8,000 feet below much of Pennsylvania, and portions of southern New York, Ohio and West Virginia[2]. It is believed to contain trillions of cubic feet of natural gas[3]. Until recently, the gas trapped within the Marcellus shale formation was thought to be prohibitively expensive to access[4]. Rising natural gas prices and advances in drilling technology – namely, the combination of high-volume hydraulic fracturing and horizontal drilling – sparked new interest in tapping the gas within the Marcellus shale[5]. The Marcellus Shale is but one of many shale deposits in the region that include the Utica, Burket, Helderberg, Mandata, and Rhinestreet formations, among many others.[6]

Natural gas companies have used high-volume hydraulic fracturing and horizontal drilling in Pennsylvania, Ohio West Virginia, Louisiana and Arkansas. Numerous incidents that have occurred either before, during or after such drilling activities have resulted in air and water pollution in these states. Several incidents that have been investigated by state regulators are described below.

According to an August 2010 report based on Pennsylvania Department of Environmental Protection (PA DEP) records, 1,435 violations of Pennsylvania state oil and gas laws occurred during gas drilling operations in the Marcellus Shale within a two-and-a-half-year period[7]. This figure does not include the 669 traffic citations and 818 written warnings issued to trucks hauling drilling wastewater[8]. These violations included improper construction of wastewater impoundments, faulty pollution prevention practices, discharges of industrial waste, improper well-casing and construction, and improper blowout prevention.[9]

Furthermore, a six-month Scranton Times-Tribune investigation showed a lack of oversight and significant environmental problems as a result of industrial gas drilling.[10] The paper found: (i) hundreds of spills at gas wells over the past five years, most of which the Pennsylvania Department of Environmental Protection (PA DEP) did not publicize; (ii) industrialization of the shale has left a permanent scar on the landscape and communities; (iii) industry's disclosure of chemicals used in its processes is incomplete and insufficient; and (iv) a "growing chorus of scientists" is arguing that not enough is known of the impacts to justify the intense development pace. [11]

The following are descriptions of some of the cases documented by state regulators where gas drilling operations and practices related to gas development and production resulted in serious environmental impacts.

I. Well Blowouts, Explosions and Operator Errors

A. EOG Well Blowout, Clearfield County, PA.

A June 3, 2010 gas well blowout in Clearfield County, Pennsylvania, about 100 miles outside Pittsburgh, sent at least 35,000 gallons of wastewater and natural gas spewing into the air for 16 hours. Fortunately, there were no casualties.[12]

Both PA DEP and an independent investigator concluded that the cause of the incident was untrained personnel and the failure to use proper well control procedures. According to PA DEP, EOG Resources and its contractor, C.C. Forbes LLC, "lost control of the well while performing post-fracturing well cleanout activities."[13]

This blowout occurred at the Punxsutawney Hunting Club 36H well. About 35,000 gallons of polluted water was collected after two nearby creeks were polluted, leading investigators to believe that nearly 1 million gallons of wastewater had been released. This figure includes the uncontrolled discharge of flowback fluids and saltwater flowing on the ground and into a tributary of Little Laurel Run, a high quality cold water fishery.[14]

EOG Resources and C.C. Forbes LLC were collectively fined more than $400,000 dollars ($353,400 and $46,600 respectively) and ordered to take over a dozen corrective actions.[15] EOG Resources, formerly known as Enron Oil & Gas Co., is a Houston-based company that operates nearly 300 active wells in the state, 139 of which are in the Marcellus formation.[16]

An independent investigator found that the combination of equipment being used by EOG should never have been considered barriers by themselves or used in the application which they were being used.[17] According to the report,"[t]he primary cause was the failure of EOG to maintain an adequate number of pressure barriers between the producing formation (the shale) and the atmosphere as well as failing to protect the primary barrier that was in place."[18] Other factors that contributed to EOG's failure to prevent and control the release were a failure to properly test the Blow-Out Preventers (BOPs) prior to use and to conduct the BOP test in the proper manner.[19] Agency officials noted that there could have been a "catastrophic failure" of the BOP.[20]

In addition, the companies did not have any personnel on-site at the time of the incident with current industry-accepted Well Control Certification credentials.[21] Further, EOG personnel failed to follow proper spill notification procedure as outlined in the company emergency preparedness plan, which caused a delay in PA DEP response time as the company did not contact the agency's emergency hotline.[22]

PA DEP found that multiple violations constituted unlawful conduct as well as a statutory nuisance under the PA Oil & Gas Act. In all, the well blowout amounted to five (5) violations of the Oil & Gas Act, five (5) violations of the Clean Streams Law, two (2) violations of the state's Air Act, and four (4) violations of the Solid Waste Management Act.[23]

B. Chief Oil & Gas and AB Resources Gas Well Explosion, Marshall County, WV.

In June 2010, an explosion at a gas well in West Virginia sent seven injured workers to the hospital. Chief Oil & Gas owns the well, which is operated by AB Resources PA, LLC.[24]

The crew had finished drilling the well and was starting the hydraulic fracturing process when they hit a pocket of methane that caused the explosion. The explosion occurred in Marshall County, West Virginia, 55 miles southwest of Pittsburgh.[25]

Subsequent to the explosion, West Virginia DEP ordered AB Resources PA, LLC to stop all operations in the state and issued two notices of violations to the driller for improper casing of the well. WV DEP's preliminary investigation into the incident indicated that conditions that led to the explosion may have been caused by the operator's failure to follow the plan outlined in the permit. AB Resources was cited for failing to set casing at the permitted depth and for inaccurately reporting the coal seam depth in the permit application.[26]

The cease operations order required the company to review the reported coal seam and casing depths for all drilled and proposed wells; take all steps necessary to comply with West Virginia Code requirements for a person trained in blowout prevention to be present at all times during drilling rig operation; and demonstrate knowledge and an understanding of the events that led up to and the cause of the June 7 incident. WV DEP lifted the cease order on July 21, 2010, releasing the company to resume operations.[27]

C. Atlas Well Fire, Hopewell Township, PA.

On April 1, 2010 both a tank and open pit used to store hydraulic fracturing fluid caught fire at an Atlas well pad.[28] Washington County's hazardous materials team responded to the fire and a state police fire marshal ruled the blaze an accident and estimated it cost Atlas Energy $375,000 in damages.[29] Flames were at least 100 feet high and 50 feet wide, with the plume of black smoke visible for miles.[30]

Residents had been complaining of noxious odors at the site for days before the fire. One resident, George Zimmerman, has a pending lawsuit against Atlas which alleges that the company's operations near his 480-acre farm have caused soil and water contamination on his property. The lawsuit and PA DEP's investigation of the fire, is pending. PA DEP's preliminary investigation indicated that the fire may have been caused by gas on the surface of the wastewater impoundment, the rubber-lined pit used to collect wastewater from hydraulic fracturing.[31]

D. Home Explosion Caused by Drilling Operations, Bainbridge Township, OH.

On December 15, 2007 an explosion occurred inside a home in Bainbridge, Ohio.[32] Two residents in the home were not injured but the structure was damaged significantly.[33] After investigating, the Ohio Department of Natural Resources ("Ohio DNR") determined that nearby high-volume hydraulic fracturing operations, conducted by Ohio Valley Energy Systems Corp. ("OVESC") in the "Clinton" sandstone formation caused the explosion.[34] According to an April 16, 2009 Order from the Ohio DNR, OVESC began drilling the English No. 1 natural gas well in the area on October 18, 2007.[35] The investigation further revealed that:

> Accumulation and confinement of deep, high-pressure gas in the surface-production casing annulus of the English No. 1 well, between November 16 and December 15, 2007, resulted in over-pressurization of the annulus. This over-pressurized condition resulted in the invasion, or migration of natural gas from the annulus of the well into natural fractures in the bedrock below the base of the cemented surface casing. This gas migrated vertically through fractures into the overlying aquifers, discharged or exited the aquifers through local water wells, and entered some inhabited structures in the area in varying concentrations through groundwater.[36]

In addition to the explosion, the drilling operations led to significant water contamination in the area. According to the Ohio DNR, this specific event contaminated "22 domestic and one public water supply."[37] A letter from the Ohio Department of Health regarding well sampling in the area after the event stated that "of the 78 wells sampled, 45 had measurable levels of dissolved methane in the water. Many of the 78 wells sampled also had iron, manganese, and less commonly aluminum and total dissolved solids, at levels exceeding U.S. EPA Secondary Maximum Contaminant Levels."[38] In response to this incident, the Ohio DNR directed OVESC to: (i) remedy inadequate primary cementing of the production casing of English Well No. 1; (ii) isolate the deep high-pressure gas zones that were the source of the overpressurization of the aquifers; and (iii) eliminate the confinement of annular gas which caused the build-up of pressure.[39] The Ohio DNR's report on this event states that:

> [r]emedial cementing operations completed by OVESC in mid-December, 2007 have effectively isolated and sealed deep, high-pressure gas bearing zones. As a result, natural gas from deep formations can no longer migrate up the surface-production casing annulus of the English #1 well and migrate into local aquifers.[40]

The Ohio DNR reported that three primary contributing factors led to the gas invasion of the shallow aquifers and subsequent explosion in the residence: (i) inadequate cementing of the production casing; (ii) the decision to proceed with hydrofracturing the well without addressing the inadequate cementing of the casing; and (iii) most significantly, the 31-day period after the fracturing during which the annular space between the surface and production casings was "mostly shut in." According to the report, the last factor confined the deep, high-pressure gas from the "Newburg" and/or "Clinton" formations within this restricted space.[41]

II. Drinking Water Contamination and Illegal Discharges

A. Cabot Oil & Gas, Dimock, PA.

Cabot Oil & Gas owns and operates at least 62 wells within a nine-square mile tract in Dimock. In January 2009, there were several reports of methane gas migrating to the surface, and at least one report of a drinking water well exploding.[42] Upon preliminary testing, the PA DEP found that four wells in the area contained elevated levels of methane.[43] After further investigation, the agency discovered that nine wells contained methane, four at levels indicating a threat of explosion.[44] The gas migration occurred close to high-volume hydraulic fracturing sites of Cabot Oil & Gas Corporation. The PA DEP noted that the area had not experienced previous drilling and "recent gas drilling in the vicinity has targeted the Marcellus Shale."[45] It conducted isotopic analysis in an attempt to discern the source of the stray gas.[46] The PA DEP determined that the gas did indeed originate in the target drilling formation of Cabot, and ruled out the possibility that the gas was produced by bacteria or originated from a shallower gas-bearing formation.[47]

The PA DEP issued Cabot a notice of violation on February 27, 2009, citing the company's failure to comply with Pennsylvania's Oil and Gas Act.[48] The Notice stated: "[PA DEP's] investigation revealed that Cabot had caused or allowed gas from lower formations to enter fresh groundwater."[49] In November 2009, the PA DEP and Cabot signed a consent order resolving the violations, which required Cabot to obtain PA DEP approval for any future well casing or cementing plans.[50]

PA DEP stated that agency inspectors "discovered that the well casings on some of Cabot's natural gas wells were cemented improperly or insufficiently, allowing natural gas to migrate to groundwater."[51]

On September 16, 2009, additional incidents in Dimock were linked to Cabot when two liquid gel spills occurred at the company's Heitsman natural gas well pad.[52] The spills polluted a wetland and caused a fish kill in Stevens Creek.[53] The PA DEP issued a notice of violation to Cabot for the spills.[54] PA DEP cited Cabot for violations of the Pennsylvania Clean Streams Law, Pennsylvania Solid Waste Management Act, the Dam Safety and Encroachments Act, and the Oil and Gas Act, as a result of: an unpermitted discharge of polluting substances, an unpermitted discharge of residual waste, two unpermitted encroachments on Stevens Creek, not containing polluting substances at the well site, and an unpermitted discharge of industrial waste.[55]

The two spills involved a lubricant gel used in the high-volume hydraulic fracturing process and totaled over 8,000 gallons.[56] According to Cabot, the releases were caused by failed pipe connections.[57] In addition, a third spill occurred on September 22, 2009 at the same site.[58] This subsequent spill involved 420 gallons of the same lubricant gel.[59]

Following these three spills, on September 25, 2009, PA DEP fined Cabot $56,650 and ordered the company to cease all high-volume hydraulic fracturing activities until it completed a number of engineering and safety improvements.[60] On October 16, 2009, PA DEP allowed Cabot to resume high-volume hydraulic fracturing activities after it submitted the required documents.[61]

On November 4, 2009, PA DEP and Cabot entered into a Consent Order and Agreement in settlement of violations regarding: excessive pressure/improper or insufficient cementing (casings) on certain wells; pollution of private water supplies within Dimock and Springville Townships in Susquehanna County; discharge of natural gas into ground water; discharge of industrial waste and/or residual waste onto the ground and/or into state waters, failure to submit well records, and failure to maintain a Driller's log.[62] PA DEP also found elevated levels of methane gas in wells that provide drinking water to 13 area homes and identified combustible gas in the headspaces of seven of the wells.[63]

PA DEP found that Cabot's unpermitted discharges polluted groundwater and contravened the state's Clean Streams Law and Solid Waste Management Act,[64] and ordered the company to immediately implement a number of corrective actions, including providing potable water and/or gas mitigation devices to affected residences.[65] PA DEP assessed a penalty of $120,000 as well as stipulated penalties for any future violations.[66]

After failing to comply with all of its obligations under the original Consent Order, PA DEP and Cabot modified the original Consent Order on April 15, 2010.

Under this Modification, PA DEP suspended all of Cabot's permit applications and fined the company an additional $240,000 dollars and the company agreed to pay an additional $30,000 dollars per month until PA DEP determined that Cabot had complied with all of its obligations under both the original Consent Order and the Modification.[67]

PA DEP had also collected samples from another drinking water well in the affected area and found the company responsible for elevated levels of dissolved methane gas.[68] In addition, the agency noted gas bubbling was continuing in cellars of certain wells and noted bubbling in five additional wells, indicating possible problems with insufficient or improperly cemented casings.[69] As part of the April 2010 Modification, PA DEP ordered Cabot to plug within 40 days three gas wells thought to be responsible for drinking water contamination and ordered Cabot to install treatment systems in affected homes within 30 days.[70] PA DEP found that Cabot had failed to comply with a 2009 Consent Order and PA DEP's chief stated in no uncertain terms that "[g]as migration is a serious issue that can have dire consequences to affected communities."[71]

In late July 2010, PA DEP gave Cabot Oil & Gas an additional 60 days to permanently fix the contaminated water supplies in Dimock.[72]

B. Chesapeake Energy, Bradford County, PA

In August 2010, PA DEP stated that three drinking water wells in Bradford County had tested positive for methane, with a lid exploding off of one of the wells. The agency issued a Notice of Violation against Chesapeake Energy and ordered the company to supply affected families with potable drinking water while investigations continue.[73] PA DEP is also investigating the cause of a July 13, 2010 fire at a Chesapeake Energy-operated separator tank.[74]

C. Shreiner Oil & Gas Operations Impact Drinking Water, McKean County, PA.

In April 2009, drilling activities conducted by Schreiner Oil & Gas impacted at least seven drinking water supplies along Hedgehog Lane in Foster, PA.[75] Stray gas became evident in numerous wells and residents complained. Two of the affected water supplies contained methane and five had iron and manganese above established drinking water standards.[76] After investigating, the PA DEP found that "the stray gas occurrence is a result of 26 recently drilled wells, four of which had excessive pressure at the surface casing seat and others that had no cement returns."[77] PA DEP also issued Schreiner a notice of violation regarding this incident for failing to submit well records.[78]

Prior to the April 2009 notice, PA DEP had issued three notices of violation to Schreiner pertaining to drilling on Hedgehog Lane for over-pressurized wells, wastewater pit violations and failure to post a well permit.[79]

As of February 2010, almost a year after PA DEP identified the drilling practices of Schreiner Oil & Gas as responsible for affecting seven water supplies in Bradford Township, two homes still had unresolved water supply issues.[80] As a result, PA DEP ordered the company to create a permanent solution for the homes within ten days and implement the plan within 30 days of its approval.[81] From samples taken from the two water supplies, PA DEP identified contaminants including total dissolved solids, chlorides, manganese, iron, dissolved methane and ethane gas.[82] The order also required Schreiner to improve the cement casing at three of its wells.[83] A PA DEP Regional Director noted that "[t]he families in this neighborhood have had their lives disrupted for too long."[84]

III. Surface Water Spills

A. Fracturing Fluid Spill, Bradford County, PA

In August 2010, PA DEP fined Talisman Energy $15,506 in for a November 2009 spill that sent over 4,200 gallons of hydraulic fracturing flowback fluid into a wetland and a tributary of Webier Creek, which drains into the Tioga River, a coldwater fishery.[85] The spill resulted from a pump failure and sand collection in a valve at the company's well in Armenia Township.[86]

B. Atlas Resources Fined for Discharges in Three PA Counties

In January 2010, PA DEP fined Atlas Resources $85,000 for violating state environmental laws at 13 well sites in southwestern Pennsylvania.[87] PA DEP found that Atlas failed to implement proper erosion and sedimentation control measures, which led to turbid discharges, and that Atlas discharged diesel fuel and hydraulic fracturing production fluids into the ground.[88] PA DEP also found Atlas failed to restore two wells after completing drilling.[89] These actions violated the state's Oil & Gas Act, Clean Streams Law, and the Solid Waste Management Act.[90] The company holds more than 250 permits for Marcellus wells in three counties.[91]

C. Range Resources Spill, Hopewell Township, PA

PA DEP fined Range Resources over $140,000 for an October 6, 2009 spill of approximately 250 barrels of diluted hydraulic fracturing fluids.[92] A broken joint in a transmission line caused the fluids to leak and ultimately flow into an unnamed tributary of Brush Run, in Hopewell Township, PA. The spill killed at least 168 fish and other aquatic life.[93] Brush Run is a high-quality warmwater fishery receiving special protections for its rich biodiversity.[94]

D. Atlas Wastewater Pit Overflow, Hopewell Township, PA.

In August 2010, PA DEP fined Atlas Resources $97,350 for allowing hydraulic fracturing fluids to overflow from a wastewater pit and contaminating a high-quality watershed in Washington County.[95] The violations occurred in December 2009 at the Cowden 17 gas well when an unknown quantity of fluid run-off entered a tributary of Dunkle Run.[96] Although Atlas corrected the problem once it was discovered, the company failed to report it to PA DEP.[97]

The spill violated the state's Oil & Gas Act, Solid Waste Management Act, and Clean Streams Law. A regional director for PA DEP stated that it was "unacceptable for drilling companies in Pennsylvania to threaten public safety or harm the environment through careless acts, such as this," and that "companies must adopt operating standards that prevent these sorts of accidents and they must make protecting our water resources a top priority."[98]

E. Fortuna Energy Illegal Discharges, Troy, PA.

At a drilling pad with three gas wells in Troy, PA, Fortuna Energy illegally discharged flowback fluids into a drainage ditch and through a vegetated area, eventually reaching a tributary of Sugar Creek.[99] DEP fined the company $3,500 for this and other violations.[100]

F. Buckeye Creek, WV

In June 2010, the West Virginia DEP released a report concluding that in August 2009 Tapo Energy discharged an unknown quantity of a "petroleum-based material" associated with its drilling activities into a tributary of Buckeye Creek in Doddridge County. The spill contaminated a three-mile-long segment of the creek before it was contained. Although WV DEP determined that the spill was accidental, the agency issued Tapo Energy a notice of violation and assessed a penalty of $10,000 for discharging pollutants into waters of the state.[101]

IV. Improper Wastewater Treatment

A. Wastewater Treatment Plant Violations, Jersey Shore, PA

In February 2010 PA DEP fined the borough of Jersey Shore, PA $75,000 for violations associated with its treatment of industrial gas drilling wastewater during 2008 and 2009.[102] The borough's wastewater treatment plant illegally processed wastewater with excessive chloride and exceeded other limits. Previously, PA DEP had ordered the company to stop accepting gas well wastewater in June 2009. [103]

B. High Levels of Total Dissolved Solids, Monongahela River, PA

In October 2008, PA DEP first determined that levels of total dissolved solids ("TDS") in the Monongahela River exceeded federal and state water quality standards.[104] Later that month PA DEP announced that it would begin investigating the source of these "unusually high" levels of TDS.[105] In order to immediately address the problem, PA DEP directed all sewage treatment plants that accept gas drilling wastewater, and discharge to the Monongahela River or its tributaries to drastically reduce the volume of gas drilling wastewater they accept to one percent of their daily flow. Prior to PA DEP's order to reduce the volume, wastewater constituted up to 20 percent of those plants' daily flow.

PA DEP traced high TDS levels to "delivery of highly mineralized wastewater to municipal wastewater treatment plants from natural gas drilling operations."[106] A report by the New York City Department of Environmental Protection noted that "[w]ater samples analyzed downstream of several wastewater treatment plant discharges in the Monongahela indicated TDS levels nearly twice the allowable limit and nearly five times average levels."[107]

In August and October 2009, PA DEP announced that TDS levels in the Monongahela River again exceeded drinking water quality standards.[108] [109]

In a letter to EPA Region 3 dated September 18, 2009, the Army Corps of Engineers (ACOE) reported that TDS levels in the Monongahela River spiked in October 2008 to 860 mg/L, compared to average baseline levels of 120 to 400 mg/L. ACOE attributed the spike to several factors, including "increased gas drilling in the Marcellus shale." In response to a request from PA DEP, ACOE increased flows from its dam releases in the Monongahela Basin in an attempt to dilute the concentration of TDS; however, the increased flows "had very little impact in reducing elevated TDS levels."[110]

V. Stray Gas Migration

From 1992 to 2008, there were at least nine cases involving gas migrations at operating wells in Pennsylvania, resulting in two fatalities. Of these cases, seven involved explosions. In four cases, the gas migration resulted from problems with the casing, or the pressurization of the annulus (the space in a well bore between the pipe and the casing). In three other cases, there was a leak or failure of the casing; in one case, an old well accounted for the compromised casing.[111]

A. Three Fatalities, Jefferson County, PA.

One incident of gas migration caused a house to explode in March 2004 in Jefferson County resulting in three fatalities. Pressurization of the annulus on at least one operating gas well was the cause of the gas migration.[112]

B. East Resources, McNett Township, Lycoming County, PA.

In July 2009, PA DEP confirmed a natural gas leak from an East Resources well in the Oriskany formation (not the Marcellus shale). Methane impacted two tributaries of Lycoming Creek as well as numerous private drinking water wells in the area, forcing the evacuation of one resident. PA DEP suspected the cause of the leak was improper casing in the well; measures taken by East Resources (now partly owned by Shell Oil) to stop the leak at the well site improved conditions in the drinking water wells and streams.[113]

C. Toy Migration, Armstrong County, PA

In October 2007, an explosion at a water well enclosure destroyed the pump and damaged the enclosure, affecting the water well quality.[114] PA DEP identified a newly drilled gas well as the source. Pressurization of the annulus was the mechanism of the gas migration.[115]

D. Knox Township, Jefferson County, PA

On April 18, 2009, fugitive gas began escaping from a domestic drinking water well in Knox, PA.[116] An investigation ensued and the PA DEP also discovered combustible gas in an adjacent drinking water well.[117] PA DEP believes that the likely cause of the fugitive gas migration is a recently drilled neighboring gas well.[118] The PA DEP is also investigating three additional reports of water quality issues that could be associated with the recent high-volume hydraulic fracturing activities in the area.[119]

E. Millcreek Township, Erie County, PA

A gas migration episode in November and December 2007 caused residents of Walnut Creek in Millcreek, PA to be evacuated from their homes for over two months.[120] Fugitive gas was discovered in the soil and "natural gas levels in and around homes . . . were found to be at explosive levels."[121] PA DEP investigations and isotopic analysis of the gas revealed that recently drilled gas wells in the area caused the migration.[122] PA DEP assessed a $32,000 civil penalty against First Alliance Church for this gas migration, which kept five families out of their homes for 39 days. First Alliance Church had hired a contractor to drill for natural gas on its property.[123]

F. Liberty Township, McKean County, PA.

In January 2008, PA DEP responded to a complaint regarding fugitive gas in a domestic drinking water well in Liberty, PA.[124] Further investigation revealed that two nearby recently drilled gas wells were over-pressurized, "exceeding the amount of allowable pressure on the casing seat."[125] The operator of the wells "placed packers and additional production casing . . . thereby eliminating pressure on the casing seat. The water well was aggressively pumped and over time the amount of combustible gas in the well bore decreased significantly."[126] When the amount of gas decreased to an allowable amount, the wells were brought back into production.[127]

G. Alexander Investigation, Washington County, PA

In September 2006, a migration of natural gas impacted several private drinking water supplies and surface soils in Washington County, PA.[128] PA DEP determined that a well that had been recently drilled using high-volume hydraulic fracturing had "communicated with [an] abandoned gas well."[129] As a result, the natural gas migrated to shallow groundwater and surface soils in the area.[130] Investigation by PA DEP revealed that fracturing activity at the recently drilled well had "created [a] pathway to [the] abandoned well and [caused] further migration into the shallow groundwater system."[131]

H. Howe Township, Forest County, PA.

In June 2005, stray natural gas entered two springs that serve as domestic water supplies for residents of Howe, PA.[132] The area has a long history of oil and gas drilling activity.[133] PA DEP discovered that the gas migration began close to the same time when two gas wells, located more than 3,000 feet away, were being drilled using high-volume hydraulic fracturing.[134] According to PA DEP, the "new gas wells are in regulatory compliance and additional measures were taken to prevent a gas migration."[135]

I. Hamlin Township, McKean County, PA

In September 2007, a migration of natural gas caused "a change in water quality and a minor explosion in a community water well."[136] Additionally, combustible gas was discovered in several private water wells within Kushequa village.[137] PA DEP determined through an investigation that a specific over-pressurized gas well was the cause of the stray gas release.[138] Also, "additional production casing was placed in the suspect well to permanently resolve the problem."[139] The responsible party was issued a Consent Order and Civil Assessment and must plug 15 orphan wells adjacent to the affected water wells.[140] PA DEP has stated that "[a] small percentage of abandoned wells leak oil or acidic water from mines, which contaminates streams and drinking water supplies."[141]

J. Wilson Investigation, Armstrong County, PA.

In October 2007, pressurization of the surface casing in a newly drilled gas well caused an explosion inside a residence and impacted a private water well.[142]

K. Dayton Investigation, Armstrong County, PA

In March 2008, PA DEP began investigating area-wide stray gas migration which forced the evacuation of one residence.[143] The source of the migration was a newly drilled gas well that was over-pressured and communicated with other operating and abandoned gas wells.[144] Corrective action resolved the problem.

L. Cogan House Township and Mifflin Township, Lycoming County, PA.

In May 2008 PA DEP ordered Range Resources – Appalachia, LLC and Chief Oil and Gas, LLC, to cease their surface water withdrawals from local streams due to violations of Pennsylvania's Clean Streams Law.[145] PA DEP's Regional Office Director stated that "[high-volume hydraulic fracturing] can often times consume millions of gallons of water. In the course of their operations, neither Range Resources nor Chief Oil and Gas have taken the necessary precautions to protect nearby streams from pollution or impairment during the drilling process."[146] The companies were within the jurisdiction of the Susquehanna River Basin Commission, and were required to obtain water withdrawal permits, but failed to do so.[147] [148]

M. Athens Township, Bradford County, PA.

In January 2005, Columbia Natural Resources, LLC violated Pennsylvania environmental regulations when it failed to implement proper erosion and sedimentation control measures along a road it constructed in connection with its natural gas drilling activities.[149] This resulted in contamination of two waterways and a wetland in Athens, PA.[150] Columbia also violated regulations when it filled a portion of the wetland without obtaining a permit from PA DEP.[151] In June 2005, PA DEP fined the company $6,500 for its violations.[152]

N. McCalmont Township, Jefferson County, PA.

In April 2008 PA DEP was informed of "a large fugitive expression" in Little Sandy Creek in McCalmont, PA.[153] Investigators discovered amounts of combustible natural gas in the basement of a nearby residence.[154] PA DEP determined that the gas was entering the house "through an un-sealed sump opening in the concrete floor of the basement."[155] Additionally, the investigation revealed "two recently drilled gas wells were over-pressured and were producing from different geologic strata."[156] PA DEP conducted isotopic analysis of the wells that indicated one of the wells was the probable source.[157] Continued monitoring of the residence determined the amount of gas in the sump was decreasing.[158]

O. Thirty-Eight Investigations at Abandoned Wells in PA.

The impacts of gas drilling operations are not restricted to new or currently operating gas wells. Many abandoned, or legacy, wells date back to the early 1900s, and some were abandoned without casing or plugging the boreholes. The casings and well heads of others were removed to supply scrap steel during World War II. Failing or absent plugs and casings of many of these abandoned wells have caused stray gas to migrate to the surface and contaminate the environment.[159]

Since 1998, PA DEP has investigated 38 cases of stray gas migration, half of which have been reported since 2007. Many of these cases are ongoing because, although isotopic analysis has confirmed gas wells are the source of the stray gas, the locations of many older abandoned wells is unknown. PA DEP has detected stray gas from abandoned wells in homes and in soils in residential areas, commercial buildings and parking lots, in private water wells and groundwater aquifers, in a church, a campground, and in a senior care home that resulted in temporary evacuation. Remediation has included plugging or venting the wells that can be located and installing treatment systems on drinking water wells, but problems persist in the many cases where the gas wells cannot be located.[160]

VI. Illegal Operations and Permit Violations

A. Susquehanna River Basin Commission Cease Order, Tioga County, PA.

In January 2010, the Susquehanna River Basin Commission (SRBC) ordered Novus Operating, LLC to immediately stop "all water-related activities" at two wells in Brookfield Township, Tioga County, PA.[161] The company began drilling wells without SRBC approval, despite SRBC's notification of the need for prior approval.[162]

B. Synd Enterprises and Vertical Resources Cease & Desist Order, PA

On December 12, 2006, PA DEP issued a cease and desist order to the owners of Synd Enterprises, Inc. and Vertical Resources.[163] The companies had "continued and numerous violations" of Pennsylvania law and had "shown a lack of ability or intention to comply with the provisions of the commonwealth's environmental laws."[164] Additionally PA DEP sought civil penalties of $657,040 to perform cleanup activities and plug wells.[165] Among the violations cited in the order were "over-pressured wells that cause gas migration and contaminate groundwater; failure to implement erosion and sedimentation controls at well sites which has caused accelerated erosion; unpermitted discharges of brine onto the ground; and encroachments into floodways and streams without permits."[166] On June 15, 2007, the PA DEP and Synd entered into a consent agreement whereby the owners of Synd paid a $400,000 civil penalty and "must refrain from owning or operating any future oil and gas operations in the commonwealth and must dissolve their other active companies here."[167]

C. U.S. Energy Cease & Desist Order, PA

On July 10, 2009, PA DEP issued a cease and desist order against U.S. Energy Development Inc. "for persistent and repeated violations of environmental laws and regulations."[168] The order prohibits U.S. Energy "from conducting all earth disturbance, drilling and hydro-fracturing operations."[169] The basis of the order is the company's 302 violations since August 2007, 197 of which remain unresolved.[170] The violations included "failure to implement measures to prevent accelerated erosion, unpermitted discharges, failure to restore well sites, encroachments into streams and wetlands without obtaining required permits, and failure to plug abandoned wells."[171] The cease and desist order was later lifted when a consent agreement was signed in which PA DEP assessed U.S. Energy a $200,000 civil penalty and required it to work under an environmental management plan.[172]

D. Ultra Resources Inc. and Fortuna Energy Inc. Permit Revocations, PA.

On October 28, 2009, PA DEP revoked three erosion and sedimentation control permits issued to Ultra Resources Inc. and Fortuna Energy Inc. because of technical deficiencies.[173] The deficiencies, namely the failure to provide for best management practices and some inaccurate calculations, were discovered after the permits had been approved.[174] The Chesapeake Bay Foundation challenged the permits, causing PA DEP to re-examine and subsequently revoke them.[175]

THE BARNETT, FAYETTEVILLE and HAYNESVILLE SHALES

The Barnett Shale is substantially similar geologically to the Marcellus Shale formation. The Barnett Shale underlies the cities of Dallas and Fort Worth and surrounding counties, covering approximately 5,000 square miles.[176] Because the Barnett Shale underlies the city of Fort Worth, the impact of drilling and exploration is felt somewhat differently than the effects of Marcellus drilling, which occurs in more rural areas. There are approximately 12,000 gas wells and 1,300 natural gas compressors operating in the Barnett Shale.[177] Since large-scale horizontal drilling began in the Barnett in 2002, there have been reports of water pollution, air pollution, geological disturbances, and impacts on human health and wildlife linked to high-volume hydraulic fracturing drilling practices.

The Fayetteville Shale underlies northern Arkansas and neighboring states. Drilling operations in the state reach depths of a few hundred feet to 7000 feet below the surface. The Haynesville Shale underlies northern Louisiana and parts of Texas and Arkansas.

I. Water Impacts

A. Hexavalent Chromium Contamination, City of Midland, TX.

In April 2009, a private well in Midland, was confirmed to be contaminated with 50 times the acceptable level of hexavalent chromium.[178] The Texas Commission on Environmental Quality (TCEQ) has tested about 240 wells and added filters to 42, where hexavalent chromium levels were found to exceed safe levels.[179] The source of this chromium-6 contamination has not been determined, but the TCEQ is investigating a link to natural gas drilling in the area.[180] Specifically, TCEQ made a connection to Schlumberger gas facilities in the area. In a press statement, the company denied that a source had been determined, but stated that the source was likely an adjacent operation. The TCEQ held public meetings in May and July 2009 to provide information on remediation to residents, but still has not identified a source.[181] The TCEQ has referred the area to the EPA for inclusion on the National Priorities List.[182]

B. Dish, TX

In response to a homeowner's complaint of gray tap water following nearby hydraulic fracturing operations in 2009, the Railroad Commission of Texas and the Town of Dish tested the water and detected elevated levels of arsenic, lead, chromium, butanone, acetone, carbon disulfide, and strontium up to 21 times above allowable concentrations. Previous testing also detected trace concentrations of five other toxic hydrocarbons.[183]

C. Creek and Soil Contamination, Arkansas

A 2009 study by the Arkansas Department of Environmental Quality found that fluids used in industrial gas production had been improperly applied on landfarms operating in the state and that at each of the sites contaminated fluids had run off into nearby creeks or streams and chloride concentrations in surrounding soil were abnormally high.[184]

D. Chesapeake, Schlumberger Fined for Cattle Deaths

In 2010 The Louisiana Department of Environmental Quality (LA DEQ) announced a pending settlement with Chesapeake Energy and its contractor Schlumberger Technology that would require the companies to pay $22,000 each for the death of 17 heads of cattle near a gas drilling site in Louisiana. LA DEQ confirmed that high levels of potassium chloride were found in and adjacent to a cow pasture.[185] Findings indicated that a "milky white substance" flowed from the natural gas well and pooled into a low area in the pasture that was accessible to the cows. People who witnessed the deaths reported that the cows appeared to be suffering a slow, painful death, with many bellowing loudly, bleeding and foaming at the mouth.

The industry says its practices are safe and argues that companies have drilled tens of thousands of wells in recent years with only a handful of incidents. Problems in Caddo Parish began Sunday evening when a well being drilled by Exco Resources Inc., a Dallas-based gas producer, struck a pocket of gas much shallower than the company expected. Workers tried to control the well, but gas escaped into the air. Gas was also found in shallow freshwater aquifer that provides drinking water to many residents. Investigators will seek to confirm any link. Subsequent tests found high levels of gas in dozens of local water wells, in some cases at levels that could lead to an explosion. "We didn't want people to have [gas] build up in their house and all of a sudden they have an explosive situation," said Otis Randle, regional director for the state Department of Environmental Quality, which conducted the tests. The evacuation was voluntary, but residents who stay behind can't use their water. Exco is paying for evacuatedresidents' hotel rooms. Mr. Randle said the water contamination hasn't been definitively linked to Exco's drilling operations, although it appears to be centered around the well site.

II. Air Impacts

A. Town of DISH, TX.

Reports of human illness and animal deaths led the town of DISH to spend 15% of its $70,000 annual budget on an air quality study of the effects of gas wells and compressor stations within the town and just across town lines.[186] The study, conducted in August 2009 by an independent environmental consulting firm, found the "presence in high concentrations of carcinogenic and neurotoxin compounds in ambient air near and/or on residential properties."[187] The compounds found "were in excess of what would normally be anticipated in ambient air" in communities like these.[188] These compounds included benzene, xylene, carbon disulfide, napththalene, dimethyl disulphide, methyl ethyl disulphide, and pyridine metabolites.[189] Many of the compounds were found in levels that exceeded either short- or long- term Effects Screening Levels established by the TCEQ.[190] Investigations in the area remain ongoing.

B. Dallas-Fort Worth, TX.

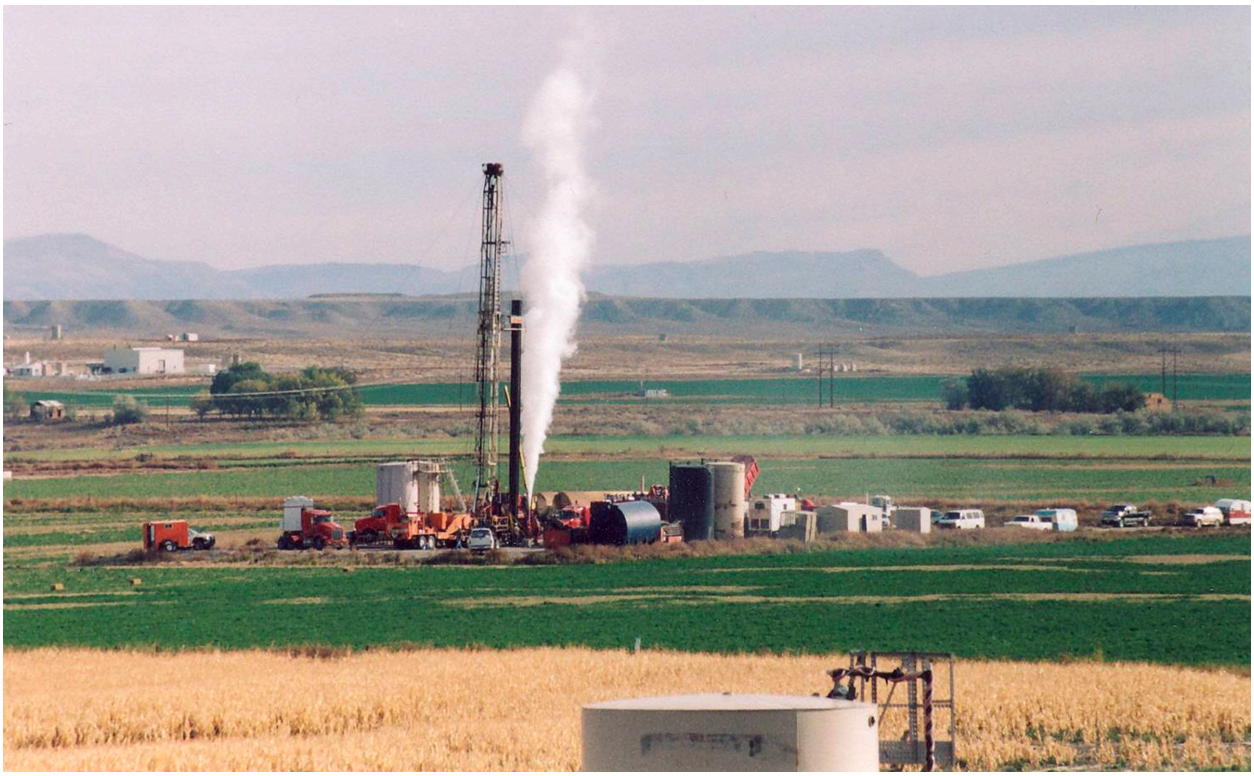
The Dallas-Fort Worth area has seen a dramatic impact on its air quality from natural gas drilling in the Barnett Shale. A report by Al Amendariz of Southern Methodist University, now EPA Region 6 Regional Administrator, found that the pollutant emissions from natural gas drilling activities per day surpassed those produced by all of the vehicle traffic in the Dallas-Fort Worth region.[191]

In addition to the independent study undertaken by Dish, the TCEQ is conducting a large-scale air monitoring program.[192] The initial results of that study found benzene levels in the air around Forth Worth to exceed short-term limits. Because benzene is a human carcinogen and the Barnett Shale gas is thought to be fairly "dry" the excessive levels are alarming to regulators. While the TCEQ is continuing its monitoring, officials have referred the findings to the EPA. The TCEQ met with the eight biggest operators in the Barnett Shale, and asked them to voluntarily reduce emissions from drilling operations after the TCEQ investigation found hydrocarbon vapors escaping from drilling machinery and storage tanks and significant levels of benzene in some locations.[193] The TCEQ is expected to release the results of the study in late 2009 or early 2010.[194] The TCEQ Toxicology Division issued a memorandum on October 27, 2009 reviewing the health effects documented in the DISH report that "strongly" recommended additional sampling in the area.[195] While the memorandum stated that the monitored concentrations of benzene in DISH did not exceed short-term limits, it also concluded that "the monitored concentrations of benzene at several of the sampling locations could pose a long-term health risk to residents if representative of normal and prolonged ambient conditions."[196]

III. Geologic Impacts

A. City of Cleburne, Johnson County, TX.

In addition to the effects on air quality and related health impacts, industrial gas drilling activity in the Barnett has been linked to minor earthquakes in the Fort Worth region.[197] Since the beginning of 2008, the Dallas-Fort Worth area has experienced at least 18 earthquakes. In the town of Cleburne, less than thirty miles from Fort Worth, at least seven earthquakes were documented in Cleburne alone between June and July 2009, with another possible earthquake reported on September 30, 2009. While a formal link has not been established, it is suspected that there is a link between disposing of gas drilling wastewater and the quakes.[198] The town of Cleburne had not registered an earthquake in its 142-year history prior to the June quakes.[199] A research team at Southern Methodist University is monitoring seismic activity around the Cleburne area. It is suspected that the quakes may be linked to the underground injection of wastewater from the hydraulic fracturing process. CITE. Chesapeake Energy closed two of its salt water disposal wells in the area after the quakes.[200]



WYOMING and COLORADO

Western states such as Colorado and Wyoming have experienced drilling booms over the past decade. Among the major geologic formations that spread under these states include sandstone, coalbed and shale are among the major geologic formations comprising these basins.[201] Hydraulic fracturing is common in all of these formations.

In 2004, EPA released a report stating that hydraulic fracturing in coal seams posed "little or no threat" to underground drinking water and that the practice required no further study.[202] This report has been criticized as unsupportable and politically motivated but is still widely cited by industry to support its claims that hydraulic fracturing is without risk. However, Weston Wilson, an EPA environmental engineer who invoked whistleblower status, wrote a letter to Congress stating that EPA conducted "limited research" in reaching its conclusions and that five of the seven members on the Peer Review Panel appeared to have conflicts of interest.[203] While the study focused on coal beds that are located within aquifers, common denominators between the processes, notably the vertical drilling through groundwater and the use of fracturing fluid under extremely high pressure, make this relevant for shale-producing states.

Violations committed by industrial gas drilling operators in Colorado alone included: failure to prevent unauthorized exploration and production (E&P) waste discharges; failure to prevent significant impacts to water resources; failure to properly remove and remediate oil wastes from open pits; failure to obtain pit permits; failure to remediate spills; failure to abide by permitted injection pressures; failure to properly construct drilling pits; failure to ensure proper management of E&P wastes to prevent significant adverse environmental impacts; failure to provide notice and consult with surface owner and local government prior to commencing drilling operations; failure to construct and operate an E&P pit to protect waters of the state; failure to install appropriate fencing to prevent significant adverse environmental impacts resulting from access to a pit by wildlife, migratory birds, domestic animals, or members of the general public; and failure to implement best management practices to minimize erosion and offsite sedimentation by controlling stormwater run-off.

I. Groundwater and Drinking Water Contamination

A. Pavillion, WY.

In response to complaints of foul odors and taste in residential wells, EPA Region 8 funded an investigation into the source and nature of the contamination.[204] Several rounds of reports, including one released in September 2010, considered data collected from residential and municipal wells in Pavillion, Wyoming in March and May 2009.[205]

On September 1, 2010, the U.S. Department of Health and Human Services' Agency for Toxic Substances and Disease Registry (ATSDR) recommended that affected well owners find alternate sources of water for drinking and cooking. For homes affected by methane migration, ATSDR recommended ventilating rooms while showering. While EPA has not yet identified the source of the chemical contamination "[s]ample results "indicate the presence of hydrocarbons and other chemical compounds found in groundwater and drinking water wells."[206] The agency committed to working with local communities "as long as necessary to ensure that Pavillion residents have safe water."[207]

One EPA official told area residents that "the groundwater associated with some inactive oil and gas production pits…is in fact highly contaminated."[208] EPA's investigation is ongoing and the agency made it clear that it has not yet pinpointed the source(s) of the contamination. However, EPA found heightened levels of hazardous contaminants in a number of drinking water wells, including the same chemicals used in nearby hydraulic fracturing operations.[209] EPA identified oil and gas activity in the region as a potential source of contamination, and the agency will be working with EnCana to mitigate the effects of drilling on the water supply.[210]

The most recent report stated:

> "EPA's sampling detected several petroleum hydrocarbons, including benzene and methane, in wells and in groundwater. EPA found low levels of petroleum compounds in 17 of 19 drinking water wells sampled. Sample results also confirm that nearby shallow groundwater is contaminated with high levels of petroleum compounds. There is uncertainty regarding the potential for this contaminated shallow groundwater to migrate to the drinking water aquifer. EPA also found a number of inorganic constituents such as sodium and sulfates in drinking and groundwater wells. Concentrations of these compounds and metals were generally within ranges identified in previous studies. EPA is working closely with various government partners and EnCana, the primary gas producer in the area, to ensure that affected residents receive water and to address potential sources. This includes securing access to alternate water sources, as well as the evaluation of potential long-term solutions such as water treatment systems and infrastructure."

The Pavillion area is currently being considered for addition to the National Priorities List.[211]

B. Windsor Energy Well Blowout, Clark, WY.

In August 2006 a Windsor Energy gas well blowout resulted from a breach in the surface casing approximately 255 feet below the surface. In a report issued in February 2007, the scientific consulting group Terracon concluded that the well blowout, and possibly previous gas drilling in the area, caused groundwater contamination with petroleum hydrocarbons such as BTEX (benzene, toluene, and total xylenes). In another study three months later, Terracon again detected the same contaminants in the groundwater.

C. Hundreds of Cases of Water Quality Violations, CO.

Colorado Oil and Gas Conservation Commission's (COGCC) 2008 and 2009 Water Quality Reports state that during those two years, COGCC assessed over $602,000 in penalties against 17 gas operators for violations impacting public health, safety, welfare and water resources. COGCC also reported that approximately 726 spills or releases of E&P waste were reported to the agency during 2008 and 2009.[212] Dating back to the mid-2007, COGCC reported that 182 spills contaminated groundwater, 82 contaminated surface water, and an additional 10 spills contaminated both surface and groundwater resources.[213] COGCC reports that during 2008, 430 spills (including E&P waste and fuel) were reported and 308 Notices of Alleged Violations (NOAVs) were issued to operators; In 2009, 371 total spills were reported and 260 NOAVs were issued to operators; Through May 1, 2010, 162 total spills were reported and 81 NOAVs were issued.[214] Pursuant to resident complaints and subsequent investigation, COGCC determined that 26 residential water wells were contaminated by gas drilling operations in 2009 and investigation at one other water well is ongoing.

D. Garfield County, CO.

In 2008, a report prepared for Garfield County, Colorado found a correlation between elevated levels of methane and chloride in groundwater wells and gas drilling activity.[215] The report stated, "[w]hile it is likely that some small amount of vertical migration of gas from the Wasatch Formation is naturally occurring, the low pre-drilling concentrations (<1ppm) and trend of increasing dissolved methane that is positively correlated to well numbers indicate that drilling and production activities are the cause."[216] The report elaborated that the positive correlation between drilling activity and increased levels of dissolved methane in the groundwater suggested "drilling and production activities are the cause."[217]

COGCC reported an ongoing problem with ground water contamination in Garfield County.[218] COGCC reported that methane and BTEX (benzene, toluene, ethylbenzene, and total xylenes) have been the principal forms of contamination and the agency has required EnCana, the gas producer in that region, to remediate this contamination and provide quarterly reports on the state of the groundwater.[219]

COGCC fined EnCana $266,000 in 2005 for natural gas migration into the Wasatch Formation that resulted from the company's "failure to protect water-bearing formations."[220]

E. Huerfano County, CO.

Pursuant to numerous citizen complaints alleging contaminated drinking water in Huerfano County, COGCC conducted an investigation and determined that high methane levels in 20 water wells were attributable to coalbed methane development in the area. As a result of the investigation, COGCC issued an order requiring the operator to shut-in all 52 of its gas wells and implement a mitigation and monitoring program during 2008.

F. Spring Contamination, CO.

COGCC reports that four (4) springs were contaminated from gas operations in 2009 and enforcement actions are ongoing. Additionally, COGCC investigations revealed that an additional seven springs and two residential water wells were contaminated by gas operations in the state during 2008. COGGC reports that an investigation at one other water well was ongoing.

G. North Fork Ranch, CO.

COGCC issued five NOAVs to an operator pursuant to ongoing well monitoring at the North Fork Ranch subdivision for drinking water contamination in 2009.[221]

II . Surface Water Impacts

From January through July 2010, COGCC reported that 57 spills or unauthorized releases of E&P waste contaminated groundwater resources, and 22 such releases contaminated surface waters of the state.[222] COGCC issued five (5) NOAVs in response to complaints concerning surface damage and leaking wells in 2009. Twenty-eight (28) spills or releases of E&P waste contaminated surface water resources of the state. One of these spills contaminated both groundwater and surface water resources; one spill contaminated a dry arroyo leading to surface water; and one additional NOAV was issued for improper erosion controls at a well construction site leading to excess sedimentation of a nearby stream in 2009. In 2008, COGCC reported that 24 spills or releases of E&P waste, contaminated surface waters of the state, and an additional five spills entered dry drainage features leading to surface waters.

A. Stream Depletion, Raton Basin, CO.

In 2006, COGCC, along with the Colorado Geologic Survey and the State Engineer's Office Division of Water Resources, hired a contractor to conduct a stream depletion study in the Raton Basin to assess the impacts on stream flow due to water removal by CBM wells. COGCC reported that stream depletion from all wells in the area is approximately 2,500 acre-feet per year, out of a total of 16,000 acre-feet annual flow.[223] COGCC issued an additional five NOAVs in 2008 for improper erosion and sediment controls impacting surface waters of the state.[224]

B. Marathon Oil Fracking Fluid Leak, Parachute Creek, CO.

On January 31, 2008 near Parachute, CO nearly 1.4 million gallons of fracking fluid owned by Marathon Oil leaked beneath a storage pit and discharged into Parachute Creek. Marathon, which had been storing the fluid for future drilling operations on the Roan Plateau, attributed the leak and contamination to a breach in the storage pit's liner.[225]

C. Benzene in Spring Water, Garfield County, CO.

Williams Production Co. is the largest natural gas producer in the Western Slope region of Colorado, which includes Garfield County.[226] According to one report, the company agreed in principle to pay a $423,000 fine to resolve a state investigation into a spring contamination case in which a Northwest CO resident drank benzene-tainted water in May 2008.[227]

A COGCC investigation indicated that the spring was contaminated from a leaking waste pit on a nearby well pad.[228] Findings from the investigation show that the pad was operating without a required state permit, and that the pit was not properly installed or maintained.[229] COGCC stated that proper permitting conditions at the well pad would have "greatly reduced" impacts to groundwater and the spring.[230] Williams Production Co. continues to dispute the COGCC determination that the leak from its well pad contaminated the spring.[231]

Williams has reported 74 spills or unauthorized releases of E&P waste since 2007, eight of which have contaminated surface or groundwater resources.[232] Williams Production Co. has also received 28 NOAVs from COGCC over the same time period.[233] COGGC's executive director admitted that the agency needs "to do a better job at bringing timely enforcement matters," noting that, because of the complex nature of the incidents and the fact that multiple operators operate in any given area, "simply investigating and developing the case is difficult and very time-consuming."

RECOMMENDATIONS

"The desire to maximize profits or cut costs never trumps compliance with regulatory requirements across the board…you cannot dump with impunity and essentially thumb your nose at the regulatory system."
United States District Court Judge McLaughlin, June 2010, sentencing two Swamp Angel Energy operators for illegally dumping brine wastewater from an oil drilling operation into Pennsylvania's Allegheny National Forest.[234]

"If you have a law and you don't enforce it, you don't have a law."
Former President Bill Clinton, June 2009, Waterkeeper Alliance annual conference.[235]

Riverkeeper recommends the following actions before increased industrial gas drilling operations are permitted:

I. Federal Legislative Action

(1) Congress must restore the original intent of the nation's environmental laws and close the loopholes that currently provide the oil and gas industry with a license to operate above of the law. These laws include: the Clean Water Act; the Safe Drinking Water Act, the Resource Conservation and Recovery Act (RCRA); and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, commonly known as Superfund). Continued acquiescence to special interests and inaction by elected officials is unconscionable and a betrayal of the public trust.

(2) Congress must pass the Fracturing Responsibility and Awareness of Chemicals (FRAC) Act. Introduced in 2009 by US Congressional Representatives Hinchey (D-NY) and DeGette (D-CO), this law would close current loopholes in the Safe Drinking Water Act and require the disclosure of chemicals used in hydraulic fracturing operations. Congressman Hinchey, who has for decades championed environmental protection in the upstate New York counties he represents, recently urged Speaker Pelosi to move the Act to the House floor for a vote.[236] Speaker Pelosi should heed Congressman Hinchey's call and expedite this process as soon as possible.[237]

(3) The House Energy and Commerce Committee, in conjunction with EPA, must continue its thorough investigation of Halliburton's and BJ Services' violation of a Memorandum of Agreement with EPA that the companies would not use diesel fuel in hydraulic fracturing operations. Evidence thus far, based in part on company statements, shows that the companies continued to use diesel fuel in at least 15 states from 2005 to 2007. The Agreement with EPA, while voluntary, was used by industry as leverage for securing exemptions from the Safe Drinking Water Act's underground injection rule that expressly regulates injections using diesel fuel.[238] Until recently BJ Services continued to expressly tell EPA that it was complying with the Agreement.

II. Federal Regulatory and Enforcement Action

(1) All EPA Regional Offices, as well as EPA Headquarters, should immediately bring all resources to bear to stem the growing tide of pollution resulting from resource extraction.[239] EPA Region III recently created a Resource Extraction Task Force that is exploring options to use targeted enforcement and other strategies to impose stricter environmental standards on fossil fuel extraction. According to Inside EPA, "the task force may be a precursor to broader EPA efforts to strengthen environmental protection requirements for the controversial practice of shale gas hydraulic fracturing, known as fracking, and clarify its authority to enforce environmental standards for the sector, despite efforts by Congress to limit the agency's regulatory authority."[240]

(2) The office of the EPA Inspector General should resume its investigation into the potential mishandling of information associated with the agency's 2004 study of fracturing and coalbed methane which has been widely criticized as politically motivated and scientifically flawed.[241]

(3) EPA must revisit its 1988 study of oil and gas industry exemptions from the Resource Conservation and Recovery Act (RCRA), which was used as the basis for exempting the industry from regulation under this critical law. According to an EPA official at the time, EPA exempted the industry from RCRA regulation "for solely political reasons, despite a scientific determination of the hazardousness of the waste."[242]

(4) EPA must ensure that its current study on hydraulic fracturing remains scientifically sound, unbiased and free of political pressure from any special interest. The agency should stand by its commitment to use a lifecycle analysis approach in order to measure the diverse range of impacts that result from gas drilling and the current study should lead the way for other long-term scientific assessments on this and other important environmental issues.

III. State Regulatory and Enforcement Action

(1) State agencies must expressly prioritize pollution prevention, regulation, monitoring, and enforcement in order to avoid the pitfalls of the past and prevent further degradation of air and water quality. All states must be equipped with the proper resources to monitor drilling operations; investigate pollution incidents; and enforce regulations designed to protect public health and the environment.

(2) State environmental regulatory agencies must not issue permits for more gas wells than the agencies can routinely expect.[243] In West Virginia regulators have acknowledged that the state is issuing gas drilling permits faster than its regulators can keep up with monitoring the industry.[244]

(3) States must undertake comprehensive environmental impact studies that include analysis of the potential cumulative impacts of industrial gas drilling operations. Despite the shortcomings of New York's 2009 environmental impact study, New York was to its credit the first state even to undertake such a study prior to permitting high-volume hydraulic fracturing and horizontal drilling. While other states, notably Pennsylvania, have stepped up enforcement efforts in recent years and, the purpose of environmental planning and review is to prevent degradation and contamination.

(4) States and local municipalities must require industry funding for increased enforcement and monitoring personnel.

(5) State agencies must properly identify and plug abandoned, or legacy, wells. Problems with these old wells highlight the need for remediation before increased drilling is permitted and underscore the need for tight regulation on current drilling operations.

(6) States must prohibit any discharge from gas drilling operations that may impact impaired waterways identified pursuant to section 303(d) of the Clean Water Act, and/or violate state water quality standards or Total Maximum Daily Loads (TMDLs). These regulations must consider topographical, geologic and hydrogeologic conditions that would increase the risk of surface or groundwater contamination.

(7) States should promulgate regulations and establish comprehensive monitoring programs that require all oil and gas wells to be equipped with monitoring devices installed to detect any contaminant movement from oil and gas facilities.

(8) States should not issue permits for water withdrawals unless the withdrawal will be implemented so as to ensure that the proposal will result in no significant individual or cumulative adverse impacts to the quantity or quality of the waters and water dependent natural resources; the withdrawal will implement environmentally sound and economically feasible water conservation measures; and the withdrawal is implemented so as to ensure that it is in compliance with all applicable municipal, state and federal laws as well as regional interstate and international agreements.

(9) States should officially classify all waste resulting from the exploration, development, extraction or production of crude oil or natural gas, including but not limited to drilling fluids and produced waters, shall be considered hazardous waste under the law of this state and subject to all pertinent generation, transportation, treatment, storage, and disposal laws and regulations.

IV. Permanent Protection of Public Lands and Water Supplies

(1) State and federal agencies should declare the following areas off-limits to oil and gas drilling operations: the area around and including any water system that has received a filtration avoidance determination from the United States Environmental Protection Agency; any area overlying a sole source aquifer; any other area identified as necessary for the protection of drinking water resources; any area identified as a critical habitat for a threatened or endangered species under section four of the federal Endangered Species Act as a bird conservation area or any other critical bird habitat for the protection of migratory or non-migratory birds; all floodplains; and, all areas within state parks, forest preserves, state forests, wildlife refuges, wildlife management areas, or wilderness areas. In addition, buffer areas, minimum setbacks and watershed resource protection measures should be outlined. And other exclusion areas should be considered to protect natural resource and public health and safety.

V. Investments in Infrastructure

(1) States must mandate and secure private sector investment in road maintenance and insurance coverage prior to permitting additional gas drilling operations. According to a senior official in the Pennsylvania State Police who recently testified before a State Senate panel, "local transportation infrastructure has begun to crumble under the weight and volume of [Marcellus] trucks." In just one three-day period in June 2010, targeted enforcement by PA DEP and State Police resulted in over 600 citations, resulting in 40 percent of waste haulers taken out of service because of safety concerns.[245] Another recent report shows that PA Department of Transportation is struggling to maintain roads and that pledges for repair funds by drilling companies have been outpaced by road damage, creating a public safety hazard.[246]

(2) States must mandate and secure private industry investment in wastewater treatment and insurance coverage prior to permitting additional gas drilling operations. In New York's 2009 DSGEIS, the state listed wastewater treatment plants around the state with the implication, but no assurance, that plants on the list were actually equipped to handle gas drilling wastewater.[247] In Pennsylvania, PA DEP has stated that Marcellus wastewater discharges have already harmed aquatic habitat and impaired drinking water supplies.[248] The industry's full and public disclosure of chemicals used at each gas drilling site, combined with federal, state, and local education and outreach to area residents, is the bare minimum needed to begin addressing these problems.

(3) States should require posting of liability bonds or require liability insurance coverage for each well owned or operated. Such bonds should be required in amounts that are sufficient to correct, repair or remedy any environmental damage or hazardous discharge resulting from oil or gas exploration or production.

VI. Best Management Practices and Corporate Responsibility

(1) Industry leaders need to continue working with independent experts, environmental organizations, and government regulators to establish comprehensive Best Management Practices (BMPs) that can be applied industry-wide.

(2) Industry leaders must commit to working with state and federal regulators to promulgate regulations that embody these BMPs. For companies that already utilize state-of-the-art technology, the cost of increased regulation should be next to nothing. Further, companies that cannot afford to implement BMPs and so-called "bad actors" will be unable to compete in the market.

(3) At a bare minimum, all gas drilling companies should publicly disclose all chemicals used in oil and gas well drilling and hydraulic fracturing. States should not issue permits for drilling operations until companies supply a complete list of chemical constituents of each additive that may be used in drilling or fracturing a specified well and ensure that such lists will be readily available for emergency workers and the public at large.

(4) Drilling, casing, operation, plugging and replugging of wells and reclamation of surrounding land should be done in such a manner as to prevent and/or remedy environmental damage, including but not limited to the escape of oil, gas, brine or water out of one stratum into another; the intrusion of water into oil or gas strata other than during enhanced recovery operations; the pollution of fresh water supplies by oil, gas, salt water, drilling fluids, hydraulic fracturing fluids or other contaminants; and blowouts, cavings, seepages and fires.

(5) BMPs should be established to ensure well integrity. Such regulations should include provisions for: maintaining a system of approved vendors; establishing and implementing best quality cementing and steel casing procedures; requiring the use of cement bond logs and other diagnostic procedures that provide the greatest accuracy for detecting potential problems.

(6) BMPs should include implementation of procedures to detect and repair water leaks; identification and installation of state-of-the-art water-conserving fixtures; employee training regarding appropriate water conservation techniques; public education regarding water conservation in connection with the use of water for which the applicant's permit is granted; and other water conservation measures and goals including pricing, conservation measures, drought protection measures, and limiting unaccounted-for water.

CONCLUSION

Federal and state regulators have documented significant environmental impacts resulting from industrial gas drilling operations nationwide.

These impacts include contamination to groundwater, drinking water, surface water, air and soil and result from changes in land use, roadbuilding, water withdrawals, improper cementing and casing of wells, over-pressurized wells, gas migration from new and abandoned wells, the inability of wastewater treatment plants to treat flowback and produced water, underground injection of brine wastewater, improper erosion and sediment controls, truck traffic, compressor stations, as well as accidents and spills.

The cumulative impacts of these environmental problems remain unknown.

Legislative, regulatory, and enforcement action is needed on the federal, state, and local level in order to curb the rising tide of pollution from industrial gas drilling operations.

PHOTO CREDITS

Cover	Deserted house with Hydraulic fracturing well in background in Dimock, PA
5	Well site during active Marcellus Shale drilling in Upshur County, WV in 2008. (An additional water storage pit is not in the photo.) Used by permission of West Virginia Surface Owners' Rights Organization: www.wvsoro.org. Copyright WVSORO, June 2008. EXECUTIVE SUMMARY
8	Pennsylvania resident Craig Sautner with samples of his family's tap water.
11	Hydraulic fracturing well in Dimock, PA.
12	Hydraulic fracturing well in Dimock, PA.
16	Warnings posted at a Cabot Oil & Gas drilling operation in Dimock, PA.
21	Photo taken from John Denton's front porch in Pavillion, WY. This hydraulic fracturing is into the tight sands formation, approximately 8,000 – 10,000 feet underground. Used by permission of Pavillion Area Concerned Citizens and Powder River BasinResource Council www.powderriverbasin.org.

All photographs by Giles Ashford unless otherwise noted

ENDNOTES

[1] IOGA Press Release, State Senate Has Let Down New Yorkers, August 4, 2010, available at: http://www.marcellusfacts.com/blog/
[2] PA DEP, Drilling for Natural Gas in the Marcellus Shale Formation, available at: http://www.dep.state.pa.us/dep/deputate/minres/oilgas/new_forms/marcellus/MarcellusFAQ.pdf.
[3] Id.
[4] Id.
[5] Id. See also Congressional Research Service, Unconventional Gas Shales: Development, Technology, and Policy Issues (October 30, 2009), available at: http://www.fas.org/sgp/crs/misc/R40894.pdf.
[6] See PA DEP, Marcellus Shale Examiner, Gas Drillers Eye Other Deep Formations (August 18, 2010), available at: http://www.dep.state.pa.us/dep/deputate/minres/oilgas/Marcellus_Examiner/Marcellus%20Shale%20Examiner%20-%20Wednesday,%20August%2018,%202010.htm.
[7] Pennsylvania Land Trust Association, Marcellus Shale Drillers in Pennsylvania Amass 1614 Violations since 2008
(September 1, 2010), available at: http://conserveland.org/uploaded_files/0000/0608/report_10sep01.pdf.
[8] Id.; See also PA DEP, State Enforcement Blitz Focuses on Trucks Hauling Drilling Waste Water (June 23, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=12375&typeid=1.
[9] Pennsylvania Land Trust Association, supra note 7.
[10] Laura Legere, Troubled Promise: Little Oversight, Looming Problems for PA Gas Industry, (June 20, 2010), available at: http://thetimes-tribune.com/news/troubled-promise-little-oversight-looming-problems-for-pa-gas-industry-1.855759.
[11] Id.
[12] See PA DEP Consent Order and Agreement with EOG Resources (July 12, 2010), available at: http://www.dep.state.pa.us/dep/deputate/minres/oilgas/PunxsutawneyHuntingClub36HWell%20Report/14.EOG%20COA.pdf; see also PA DEP Consent Order and Agreement with CC Forbes (July 12, 2010) , available at:
http://www.dep.state.pa.us/dep/deputate/minres/oilgas/PunxsutawneyHuntingClub36HWell%20Report/13.CC%20Forbes%20COA.pdf; PA DEP, Punxsutawney Hunting Club 36H Well Report (July 12, 2010), available at: http://www.dep.state.pa.us/dep/deputate/minres/oilgas/PunxsutawneyHuntingClub36H-Well%20Report/EOG.htm; PA DEP, Independent Report Faults Clearfield County Gas Well Operators for June 3 Blowout DEP Outlines Proper Procedures for all Marcellus Drilling Firms (July 13, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=12818&typeid=1.
[13] See id.
[14] See id.
[15] See id.
[16] See id.
[17] Vittitow, John G., Sr., Bedrock Engineering, Well Control Incident Analaysis, EOG Resources Punnxsutawney Hunting Club 36 H, July 2010.
[18] Id.
[19] Id.
[20] Id.
[21] Consent Order and Agreement, supra note 12 at E, F.
[22] Consent Order and Agreement, supra note 12 at H.
[23] See Consent Order and Agreement, supra note 12.

[24] See PA DEP, AB Resources – Marshall County Well Fire Incident (July 21, 2010), available at: http://www.dep.wv.gov/oil-and-gas/GI/Pages/ABRes.aspx.
[25] Id.
[26] Id.
[27] Id.
[28] Crompton, Janice, Residents Reported Gas Odors Before Explosion (April 01, 2010), available at: http://www.post-gazette.com/pg/10091/1047159-58.stm.
[29] Id.
[30] Id.
[31] Id.
[32] Report on the Investigation of the Natural Gas Invasion of Aquifers in Bainbridge Township of Geauga County, Ohio (September 1, 2008), available at: http://www.dnr.state.oh.us/Portals/11/bainbridge/report.pdf. See also Letter from John F. Husted, Chief of the Ohio Department of Natural Resources, Division of Mineral Resource Management (Aug. 28, 2008), available at: http://www.dnr.state.oh.us/Portals/11/bainbridge/cover_letter.pdf; Ohio Department of Natural Resources, Report on the Investigation of the Natural Gas Invasion in Bainbridge Township of Geauga County, Ohio (2008), available at: http://www.dnr.state.oh.us/Portals/11/bainbridge/report.pdf.
[33] Report on Bainbridge Investigation, supra note 32.
[34] See Ohio DNR, Order by the Chief to Ohio Valley Energy Systems Corp. (Apr.14, 2008), available at: http://ohiodnr.com/portals/11/bainbridge/2009-order-by-chief.pdf. See also Ohio DNR, Order by the Chief to Ohio Valley Energy Systems Corp. (Apr.16, 2008), available at: http://ohiodnr.com/portals/11/bainbridge/2009-order-by-chief-2.pdf; Report on Bainbridge Investigation, supra note 32.
[35] Ohio DNR, Order by the Chief to Ohio Valley Energy Systems Corp., Apr. 16, 2008, supra note 32.
[36] Id.
[37] Report on Bainbridge Investigation, supra note 32.
[38] Letter from Robert C. Frey, Ph.D., Chief of the Health Assessment Section of the Ohio Bureau of Environmental Health, Ohio Department of Health to Scott Kell, Deputy Chief of the Ohio Department of Natural Resources Division of Mineral Resource Management (Sept. 10, 2008), available at http://www.dnr.state.oh.us/bainbridge/tabid/20484/Default.aspx and http://www.dnr.state.oh.us/Portals/11/bainbridge/10-31-08_resident_mailing_odh_letter.pdf.
[39] Report on Bainbridge Investigation, supra note 32.
[40] Id.
[41] Id.
[42] See PA DEP, DEP Continues to Analyze Dimock Water Supplies (Mar. 27, 2009), available at: http://www.ahs2.dep.state.pa.us/newsreleases/default.asp?ID=5459, see also PA DEP, DEP Continuing Investigation Into High Methane Levels in Susquehanna County Wells (Jan. 23, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2116&typeid=1.
[43] Id.
[44] Id.
[45] Id.
[46] Id.
[47] New York City DEP, Rapid Impact Assessment Report (2009), available at: http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/rapid_impact_assessment_091609.pdf. See also Notice of Violation Letter from Craig Lobbins, PA DEP Regional Manager, to Thomas Liberatore, Cabot Oil & Gas Corporation , Vice President (Feb. 27, 2009) (on file with Riverkeeper).
[48] Id.
[49] Id.
[50] PA DEP, DEP Reaches Agreement with Cabot to Prevent Gas Migration, Restore Water Supplies in Dimock Township (Nov. 4, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2418&typeid=1.

[51] Id.
[52] See PA DEP, DEP Issues Violation Notice to Cabot Oil and Gas (September 23, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2373&typeid=1.
[53] Id.
[54] Id.
[55] Id.
[56] Id.
[57] Id.
[58] See PA DEP, DEP Orders Cabot Oil and Gas to Cease All Gas Well Fracking in Susquehanna County (September 25, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2375&typeid=1.
[59] Id.
[60] PA DEP, DEP Fines Cabot Oil and Gas Corp. $56,650 for Susquehanna County Spills (October 22, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2399&typeid=1.
[61] Id.
[62] See PA DEP Cabot Oil and Gas Consent Order and Agreement (November 4, 2009), available at: http://s3.amazonaws.com/propublica/assets/natural_gas/final_cabot_co-a.pdf.
[63] Id.
[64] Id. Cabot did not expressly agree to PA DEP findings reading state law violations.
[65] Id.
[66] Id.
[67] PA DEP, DEP Takes Aggressive Action Against Cabot Oil & Gas Corp to Enforce Environmental Laws Protect Public in Susquehanna County (April 15, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=10586&typeid=1
[68] Id. See also Modification to PA DEP Cabot Oil and Gas Consent Order Dated November 4, 2009 (April 15, 2010), on file with Riverkeeper.
[69] Id.
[70] Id.
[71] Id.
[72] PA DEP, DEP Gives Cabot Oil & Gas 60 Days to Implement Permanent Fix to Impacted Water Supplies in Susquehanna County Township (July 21, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=12985&typeid=1
[73] See Press and Sun-Bulletin, Methane found in northeastern Pennsylvania wells (August 13, 2010), available at: http://www.pressconnects.com/article/20100813/NEWS01/8130379/Methane-found-in-northeastern-Pennsylvania-wells.
[74] PA DEP, DEP Investigates Fire at Susquehanna County Natural Gas Well Pad (July 14, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=12844&typeid=1.
[75] PA DEP, DEP Identifies Responsibility for Bradford Township Gas Migration/Water Supply Problems (May 4, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2198&typeid=1.
[76] Id.
[77] Id.
[78] Id.
[79] Id.
[80] PA DEP, DEP Orders Schreiner Oil and Gas to Restore Water Supplies at Two Homes in McKean County (February 25, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=9348&typeid=1

[81] Id.
[82] Id.
[83] Id.
[84] Id.
[85] PA DEP, DEP Fines Talisman Energy USA for Bradford County Drilling Wastewater Spill, Polluting Nearby Water Resource (August 2, 1010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=13249&typeid=1.
[86] Id.
[87] PA DEP, DEP Fines Atlas $85,000 for Violations at 13 Well Sites (January 7, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2612&typeid=1.
[88] Id.
[89] Id.
[90] Id.
[91] Id.
[92] PA DEP, DEP Penalizes Range Resources $141,175 for Spill in High Quality Waterway (May 14, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=11412&typeid=1.
[93] Id.
[94] Id.
[95] PA DEP, DEP Fines Atlas Resources for Drilling Wastewater Spill in Washington County (August 17, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=13595&typeid=1.
[96] Id.
[97] Id.
[98] Id.
[99] PA DEP, DEP Fines Fortuna Energy Inc. $3,500 for Well Drilling Violations in Bradford County (February 1, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=3202&typeid=1.
[100] Id.
[101] WVDEP, WVDEP Concludes Investigation on Buckeye Creek (June 18, 2010), available at: http://www.dep.wv.gov/news/Pages/WVDEPconcludesinvestigationonBuckeyeCreek.aspx.
[102] PA DEP, DEP Fines Jersey Shore $75,000 for Sewage Treatment Plant Operation, Discharge Violations (February 19, 2010), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=9193&typeid=1.
[103] Id.
[104] PA DEP, DEP Investigates Source of Elevated Total Dissolved Solids in Monongahela River (Oct. 22, 2008), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2112&typeid=1.
[105] PA DEP, Total Dissolved Solids in Monongahela River Drop Significantly Below State, Federal Limits, PA DEP (Jan. 21, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2112&typeid=1.
[106] NYCDEP Rapid Impact Assessment, supra note 47.
[107] Id.
[108] PA DEP, DEP Detects Elevated Levels of Total Dissolved Solids in Monongahela River (Aug. 7, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2112&typeid=1.
[109] PA DEP, DEP Detects Total Dissolved Solids Over Standards in Monongahela River (Oct. 14, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2390&typeid=1.
[110] Army Corps of Engineers letter to US EPA Region 3 (September 19, 2009), on file with Riverkeeper.

[111] See PA DEP, Bureau of Oil and Gas Management, Stray Natural Gas Migration Associated with Oil and Gas Wells, Draft Report (December 28, 2009), available at: http://www.dep.state.pa.us/dep/subject/advcoun/oil_gas/2009/Stray%20Gas%20Migration%20Cases.pdf.
[112] Id.
[113] Id.
[114] Id. at 7.
[115] Id.
[116] PA DEP Stray Natural Gas Migration Report, supra note 111.
[117] Id.
[118] Id.
[119] Id.
[120] Id.
[121] PA DEP, DEP Assesses Penalty for 2007 Gas Migration That Forced Evacuation in Erie County (July 8, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2268&typeid=1.
[122] PA DEP Stray Natural Gas Migration Report, supra note 111.
[123] PA DEP Stray Natural Gas Migration Report, supra note 111.
[124] PA DEP Stray Natural Gas Migration Report, supra note 111.
[125] Id.
[126] Id.
[127] Id.
[128] Id.
[129] Id..
[130] Id.
[131] Id.
[132] Id. at 12.
[133] Id.
[134] Id.
[135] Id. at 12-13.
[136] Id.
[137] Id.
[138] Id.
[139] Id.
[140] Id.
[141] PA DEP, Governor Rendell Says PA Protecting Communities, Miners from Abandoned Oil, Gas Wells – Says $2.3 Million Will Plug 150 Abandoned Wells, Safeguard Public Health, Drinking Water (September 19, 2007), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=1488&typeid=1.
[142] Id.
[143] Id. at 6.
[144] Id.
[145] NYCDEP Rapid Impact Assessment, supra note 47.
[146] PA DEP, DEP Orders Partial Shutdown of Two Natural Gas Drilling Operations in Lycoming County (May 30, 2008), on file with Riverkeeper.
[147] Id; NYCDEP Rapid Impact Assessment, supra note 47 at 55.
[148] PA DEP, supra note 74.
[149] PA DEP, DEP Fines West Virginia Company $6,500 For Environmental Violations in Bradford County (June 24, 2005), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=308&typeid=1.
[150] Id.

[151] Id.
[152] Id.
[153] PA DEP Stray Natural Gas Migration Report, supra note 111 at 4.
[154] Id.
[155] Id.
[156] Id.
[157] Id.
[158] Id.
[159] PA DEP Stray Natural Gas Migration Report, supra note 111.
[160] Id.
[161] SRBC, SRBC Orders Natural Gas Driller to Stop All Water-Related Work at Drilling Site in Tioga, County, PA (January 13, 2010), available at: http://www.srbc.net/pubinfo/press/docs/Project%20ReviewNaturalGasNovusCeaseOrder11310.pdf.
[162] Id.
[163] PA DEP, DEP Seeks $657,040 Civil Penalty Against New York Company For Environmental Damage in Allegheny National Forest (January 11, 2007), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=1114&typeid=1.
[164] Id.
[165] Id.
[166] Id.
[167] PA DEP, DEP Fines Oil and Gas Operator $400,000 For Violations (June 15, 2007), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=1294&typeid=1.
[168] PA DEP, DEP Orders U.S. Energy to Cease Drilling Operations Throughout Pennsylvania (July 10, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2273&typeid=1.
[169] Id.
[170] Id.
[171] Id.
[172] PA DEP, DEP Reaches Agreement with U.S. Energy (Aug. 12, 2009), available at: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2322&typeid=1.
[173] PA DEP, DEP Revokes Erosion and Sedimentation Control Permits for Two Gas Companies (Oct. 28, 2009),
http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=2322&typeid=1.
[174] Id.
[175] Id.
[176] Texas Commission on Environmental Quality, Barnett Shale Geological Area. available at: http://www.tceq.state.tx.us/implementation/barnettshale.
[177] Health Issues Follow Natural Gas Drilling in Texas, NPR, Nov. 3, 2009, available at: http://www.npr.org/templates/story/story.php?storyId=120043996.
[178] EPA grants extension for further testing of chromium contaminated area, Midland Reporter-Telegram, Dec. 3, 2009, available at: http://www.mywesttexas.com/articles/2009/12/03/news/top_stories/epa_grants_extension_for_ testing_of_chromium.txt.
[179] Texas Commission on Environmental Quality, Cleanup in Midland Couty: West County Road 112, Midland, TX, http://www.tceq.state.tx.us/remediation/sites/cr112.html.
[180] Texas Commission on Environmental Quality, West County Road-112 Groundwater Plume Midland County, Texas, Site Update September 2009, http://www.tceq.state.tx.us/assets/public/remediation/variousremediationsites/westcr112/092409meeting.pdf.

[181] Texas Commission on Environmental Quality, TCEQ Holds Public Meeting on Water Well Contamination, http://www.tceq.state.tx.us/comm_exec/communication/media/05-09midlandmeeting.html; Texas Commission on Environmental Quality, TCEQ Holds Public Meeting on Water Well Contamination, http://www.tceq.state.tx.us/comm_exec/communication/media/06-09midlandchrome2.html.
[182] EPA, Search Superfund Site Information, West CR 112 Groundwater, http://cfpub.epa.gov/supercpad/cursites/csitinfo.cfm?id=0606992.
[183] See NRDC, SWITCHBOARD, "Incidents where hydraulic fracturing is a suspected cause of drinking water contamination," http://switchboard.nrdc.org/blogs/amall/incidents_where_hydraulic_frac.html.
[184] ADEQ, ADEQ Releases Landfarm Study Report (April 20, 2009), available at: www.adeq.state.ar.us/ftproot/Pub/pa/News_Releases/2009-04-20_ADEQ_releases_landfarm_report.mht.
[185] KLSA, We may now know what killed cows in Caddo Parish (May 2009), available at: http://www.ksla.com/Global/story.asp?S=10325772.
[186] State Tests Air Around Drilling And Pipeline Sites, KERA, Oct. 14, 2009, http://www.publicbroadcasting.net/kera/news.newsmain/article/0/1/1566121/North.Texas/State.Tests..Air.Around.Drilling.And.Pipeline.Sites.
[187] Wolf Eagle Environmental, DISH Air Study Results, Sept. 15, 2009 at 9, available at, http://www.townofdish.com/objects/DISH_Air_Study.pdf.
[188] Id.
[189] Id.
[190] See note 186.
[191] Al Armendariz, Emissions from Natural Gas Production in Barnett Shale Area and Opportunities for Cost-Effective Improvements, Jan. 26, 2009, http://www.edf.org/documents/9235_Barnett_Shale_Report.pdf.
[192] Cancer-causing toxin found in air near gas facilities, WFAA, Oct. 30, 2009. http://www.wfaa.com/sharedcontent/dws/wfaa/latestnews/stories/wfaa091029_mo_drilling.2669d39e4.html.
[193] State worried about air pollution near Barnett Shale wells, Fort Worth Star-Telegram, Nov. 22, 2009, http://www.star-telegram.com/804/story/1782464.html.
[194] Id.
[195] Texas Commission on Environmental Quality, Health Effects Review of Ambient Air Monitoring Data Collected by Wolf Eagle Environmental Engineers and Consultants for DISH, TX, October 27, 2009, http://www.tceq.state.tx.us/assets/public/implementation/barnett_shale/healthEffectsReview.pdf.
[196] Id.
[197] Is Drilling to Blame for Texas Quakes?, NPR, June 30, 2009, http://www.npr.org/templates/transcript/transcript.php?storyId=106059425.
[198] Cleburne quakes probably related to gas drilling, expert says, Dallas Morning News, June 8, 2009, http://www.dallasnews.com/sharedcontent/dws/dn/latestnews/stories/060909dnmetquakes.40620de.html.
[199] Temblors Rattle Texas Town, Wall Street Journal, June 12, 2009, http://online.wsj.com/article/SB124476331270108225.html.
[200] Chesapeake shuts two re-injection wells down as a precaution. Cleburne Times-Review. Aug. 14, 2009, http://www.cleburnetimesreview.com/local/local_story_226123755.html.
[201] Id.
[202] Study to Evaluate the Impacts to USDWs by Hydraulic Fracturing of Coalbed Methane Reservoirs available at http://www.epa.gov/safewater/uic/wells_coalbedmethanestudy.html.
[203] Wilson, Weston, Letter (October 8, 2004) available at http://latimes.image2.trb.com/lanews/media/acrobat/2004-10/14647025.pdf.
[204] URS Operating Services, Inc., Site Inspection – Analytical Results Report, Pavillion Area Groundwater Investigation Site. CERCLIS ID# WYN000802735. Aug. 2009, http://www.earthworksaction.org/pubs-others/EPA_2009_Pavillion_Groundwater_Report.pdf.

[205] http://yosemite1.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/1b6ae692cfeeab50852577920066afd4!OpenDocument.
[206] Id.
[207] Id. EPA's Analytical Results Report and additional information are available at the website below: http://www.epa.gov/region8/superfund/wy/pavillion/index.html.
[208] See http://www.commondreams.org/headline/2010/09/02-1.
[209] Id.
[210] EPA Region 8, Pavillion Groundwater Investigation, Pavillion Wyoming, Phase I Sampling Results (PowerPoint Presentation) Aug. 11, 2009, http://www.earthworksaction.org/pubs-others/EPA_2009_Pavillion_Groundwater.ppt.
[211] EPA, Search Superfund Site Information, Pavillion Area Ground Water Study, http://cfpub.epa.gov/supercpad/cursites/csitinfo.cfm?id=0802735.
[212] See COLORADO OIL & GAS CONSERVATION COMMISSION, DEPARTMENT OF NATURAL RESOURCES, ANNUAL REPORT TO THE WATER QUALITY CONTROL COMMISSION OF THE COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT, 3 (2008, 2009).
[213] See Brent Hubbard, Millions of Gallons Spilled in Colorado Over Two and a Half Year Period, Denver Post (June 28, 2010).
[214] See STATE OF COLORADO OIL & GAS CONSERVATION COMMISSION, DEPARTMENT OF NATURAL RESOURCES, STAFF REPORT (June 2010).
[215] Review of Phase II Hydrogeologic Study, Prepared for Garfield County. Geoffrey Tyne. Dec. 20, 2009. http://www.garfield-county.com/Index.aspx?page=1143.
[216] Thyne 21http://s3.amazonaws.com/propublica/assets/methane/thyne_review.pdf
[217] Id.
[218] Colorado Oil and Gas Conservation Commission, FY 2008-2009 Report to the Water Quality Control Commission and Watery Quality Control Division of the Colorado Department of Public Health and Environment, Nov. 2009, http://cogcc.state.co.us/Library/WQCC_WQCD_AnnualReports/WQCC08_09RPT.pdf.
[219] Id.
[220] Cadmus Group, Hydraulic Fracturing: Preliminary Analysis of Recently Reported Contamination, prepared for EPA (September 2009), on file with Riverkeeper.
[221] See COLORADO OIL & GAS CONSERVATION COMMISSION, DEPARTMENT OF NATURAL RESOURCES, ANNUAL REPORT TO THE WATER QUALITY CONTROL COMMISSION OF THE COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT, 3 (2008, 2009).
[222] COGIS database
[223] See S.S. PAPADOPULOS & ASSOC., COLORADO GEOLOGIC SURVEY, DRAFT COALBED METHANE STREAM DEPLETION ASSESSMENT STUDY – UATON BASIN, COLORADO, 44 (2007).
[224] See id.
[225] David O. Williams, "State Backlogged with Gas Contamination Cases Dating Back Years," The Colorado Independent, May 11, 2010. http://coloradoindependent.com.
[226] See David O. Williams, Critics Claim Colorado Gas Drillers Playing Both Sides of 'Fracking' Debate, The Colorado Independent (July 22, 2010).
[227] See Dennis Webb, Energy Giant Agrees to Pay Record Fine, The Daily Sentinel (July 23, 2010).
[228] See id.
[229] Id.
[230] Id.

[231] Id.
[232] COGGC COGIS Database search – spills: "willliams"
[233] Id.
[234] http://www.justice.gov/usao/paw/pr/2010_june/2010_06_24_04.html
[235] Pres. Bill Clinton at the 11th Annual Waterkeeper Conference, Bronx, NY, June 25, 2009.
[236] See http://www.eenews.net/assets/2010/06/04/document_gw_01.pdf
[237] See http://www.govtrack.us/congress/bill.xpd?bill=h111-2766
[238] See http://www.nytimes.com/gwire/2010/03/23/23greenwire-oilfield-company-failed-to-report-fracking-vio-34193.html. See also http://energycommerce.house.gov/Press_111/20100218/hydraulic_fracturing_memo.pdf and http://energycommerce.house.gov/Press_111/20100218/lesar_letter.pdf.
[239] Inside EPA - 08/20/2010
[240] Id.
[241] See NRDC, Drilling Down (October 2007), at: http://www.nrdc.org/land/use/down/contents.asp.
[242] Drilling Down at EN 143 – cite to original.
[243] http://www.pittsburghlive.com/x/pittsburghtrib/news/pittsburgh/s_696347.html
[244] http://www.businessweek.com/ap/financialnews/D9GFROA06.htm.
[245] http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=12375&typeid=1
[246] See http://www.oilandenergynews.com/2010/05/increased-gas-drilling-activities.html and http://www.timesleader.com/news/Lehman_Township_says_yes_to_gas_drilling_04-13-2010.html
[247] See NYSDEC DSGEIS Appendix 21.
[248] See http://www.post-gazette.com/pg/10107/1051146-358.stm.