Permitted to Pollute:

How oil and gas operators and regulators exploit clean air protections and put the public at risk

February 2017

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Acknowledgements

This report examines regulatory and policy questions—the real-life effects of which people surrounded by gas and oil development are forced to confront every day. We are grateful to the Pennsylvania residents who shared the time, personal experiences, and information that inspires our research and the hope that it will make a difference.

Many thanks to the Claneil Foundation for its generous support and commitment to expanding understanding of air pollution and health in Pennsylvania and beyond.

We appreciate the opportunity to collaborate with colleagues at partner organizations. As with other Earthworks' research projects, Wilma Subra of Subra Company generously analyzed our air sampling data.

Special thanks to Aaron Jacobs-Smith of the Clean Air Council for his expertise and assistance with regulatory analysis and writing.

Many thanks to Ryan Grode, Jill Kriesky, and Celia Lewis at the Southwest Pennsylvania Environmental Health Project (EHP) for their collaboration on gathering and interpreting air quality data, and to EHP fellow Eric Wahlstrom for his community outreach assistance.

Thanks also to Cynthia McCormick Richburg of Indiana University of Pennsylvania for her noise monitoring work and help in understanding this complex topic.

Much appreciation goes to Marcellus Outreach Butler and to Fayette Marcellus Watch for their work and help in the locations where our research took place.

Finally, thanks to staff at the Pennsylvania Department of Environmental Protection's Bureau of Air Quality and regional offices for answering questions, providing records, and explaining the agency's regulations.

Cover Photo of the Bluestone Gas Processing Plant by Robert Donnan.

Definitions

Carbon Dioxide equivalent (CO2e) is a measure used so that the global warming potential of different Greenhouse Gases (GHGs) can be compared and assessed using a common metric. The three primary GHGs evaluated as CO2e in permit applications, with emissions inventories, and related documents are CO2, methane (CH4), and nitrous oxide (N2O).

Criteria pollutants are six of the most common air pollutants, for which the US Environmental Protection Agency (EPA) has established enforceable, federal air quality standards. They include Ozone (O3), Particulate matter (PM), Carbon monoxide (CO), Nitrogen oxides (NOx), Sulfur oxides (SOx), and Lead (Pb).

Environment Facility Application Compliance Tracking System (eFACTS) is an online database run by the Pennsylvania Department of Environmental Protection. It allows users to search for records on permits and inspections for facilities regulated by oil and gas, air quality, and other agency divisions.

General Air Permits (GPs) are developed and issued by regulatory agencies for certain sources of air pollution. They are "general" because regulatory agencies deem the sources to be similar enough in design and operation that they can be sufficiently regulated with standardized permit conditions.

Million square cubic feet of gas per day, (MMscfd) is a standard measurement of gas flow that is used to indicate the capacity of compression and processing facilities.

National Ambient Air Quality Standards, (NAAQS) are the limits on pollution volumes that the US Environmental Protection Agency has determined necessary to protect air quality and health. NAAQS have been established for the six criteria pollutants covered under the Clean Air Act.

Potential to Pollute (PTE) is the calculation made to determine the maximum volume of a pollutant that a facility could potentially emit given its physical and operational components. PTE calculations form the basis for the emission levels stated in air permit applications.

Synthetic Minor is the permitting status of an emissions source designated as "minor" by virtue of a design or operational limitation, such as the number of hours it operates or use of certain technologies.

I. Introduction

Communities surrounded by oil and gas development are increasingly confronted with an interconnected complex of well sites, compressor stations, and processing plants that transform neighborhoods and entire regions. Residents often and logically ask, "What's coming next?" and "When will it stop?"

They certainly have cause for concern and frustration: a growing body of science and widespread community reports clearly show the negative consequences of oil and gas operations on air, water, land, and health.

Government is charged with designing and implementing regulations and policies to both protect the public from pollution and to support and serve polluting industries. This is why operators receive permits that allow them to pollute, but which are supposed to limit that pollution in order to avoid widespread, lasting damage.

This report examines the inherent tension between industrial development, and public health and environmental protection, in the context of the shale gas boom in southwestern Pennsylvania. It focuses on three natural gas compression and processing facilities that have grown considerably in a relatively short time. We selected these facilities because of local residents' growing concerns about the pace of development and negative changes to their quality of life. In addition, initial research gave rise to questions about the adequacy and logic of how they have been regulated.

The broader context for the investigation has been the drive by industry and policymakers to expand natural gas extraction, processing, and transportation across Pennsylvania and the neighboring states of Ohio and West Virginia. In 2015, governors of the three states signed a cooperative agreement to advance natural gas development.[1] For communities across the tri-state region, such plans will bring even more drilling sites, heavy industry, and truck traffic. It also will inevitably mean even more negative impacts on the environment and quality of life.

Time will tell how policymakers will square exuberance for expanding oil and gas operations with the region's long, and ongoing, legacy of pollution from intense fossil fuel development. Also unclear is how regulatory agencies will fulfill their obligations to the public and under the law in the face of expanding oil and gas development and shrinking oversight and enforcement budgets.

These are not new questions, and they are being asked far beyond the Marcellus and Utica Shale region. The current project seeks to shed light on possible answers. It takes a comprehensive look at how air pollution from oil and gas operations is evaluated for two purposes that are often in conflict, but ideally wouldn't be: the protection of air quality and health, and the regulation and permitting of industrial operations.

This project builds on previous research in several states on health impacts experienced by gas and oil patch residents;[2] wide gaps in regulatory enforcement by public agencies;[3] and insufficient documentation, tracking, and reporting of oil and gas activities.[4] The current research is part of Earthworks' Community Empowerment Project (CEP), which supports people living near oil and gas facilities and promotes a regulatory response to pollution.[5] The centerpiece of CEP is documentation of air pollution at oil and gas sites nationwide using state-of-the-art Forward Looking Infrared (FLIR) cameras.

For the current project, over the course of a year we filmed emissions and conducted air sampling at the three project facilities in order to identify patterns in emissions and toxic pollutants to which nearby residents may have been exposed. In addition, we conducted in-depth research on the operations and permitting history of the facilities, which shed light on how emissions are tracked and regulated under the US Clean Air Act and by the Pennsylvania Department of Environmental Protection. Based on this comprehensive research and findings, Earthworks has developed recommendations that, if adopted, would help oil and gas regulators better fulfill their responsibility to safeguard air quality and communities.

II.Executive Summary

Permitted to Pollute is an unprecedented study of how state regulatory oversight of oil and gas operations, authorized by the Clean Air Act to protect air quality and public health, in some cases actually undermines both.

To do this we examined in depth three facilities in southwestern Pennsylvania:

- The Bluestone gas processing plant in Butler County owned by MarkWest.
- The Trilith compressor station in Butler County owned by MarkWest.
- The Shamrock compressor station in Fayette County owned by Laurel Mountain Midstream.

Each facility has numerous sub-facilities and has been expanded and modified significantly over time based on an initial, older operating permit. Over the course of a year at each facility we:

- **Measured air pollution to identify patterns of exposure for nearby residents.** Certified thermographers, using industry-standard infrared cameras, recorded normally invisible volatile organic compounds (VOCs) and other pollution from each facility. We also took air samples near each facility using Summa canisters that were analyzed by an independent accredited lab.
- **Researched the operations and permitting history of the facilities.** By conducting file reviews at the Pennsylvania Department of Environmental Protection (DEP), we determined how oil and gas operators seek authorization for their activities, how DEP permits changing activities at facilities, and how pollution from each facility is, and isn't, tracked.

FINDINGS

By assessing both public regulatory records and actual air pollution from these three facilities, we made five primary findings.

1. Deliberately or not, operators and DEP have prevented facilities that likely should have been categorized as "major" polluters under Title V of the Clean Air Act from being so categorized—thereby avoiding closer government oversight and greater public scrutiny.
2. Operators of large oil and gas facilities are allowed to continually expand, increase capacity, and change function without DEP's consideration of cumulative air quality impacts.
3. Emissions information provided by operators to DEP is insufficient to reflect the actual risks to air quality and health.
4. Reliance on generalized emissions estimates allows operators and regulators to ignore what actually occurs at specific facilities and potential impacts on nearby residents.
5. An emphasis on regional and state air quality thresholds ignores localized impacts and fluctuating emissions patterns, which can have the most negative effects on health.

RECOMMENDATIONS

To address these five findings and protect air quality and public health as intended by the Clean Air Act, we make the following general recommendations:

DEP should actively facilitate engagement of impacted residents and the public in facility oversight.

- DEP should make information on permitting and emissions publicly and easily available online in real time, or as close to real time as possible.
- DEP should give more weight to the complaints of residents regarding odors, noise, and health symptoms related to nearby oil and gas facilities, even if an inspector doesn't experience the problem when he/she is onsite.
- DEP should improve its existing Complaint Tracking System (CTS) to ensure that complaints records (with personal/private information redacted) are available to the public, including information on incidents, environmental and health impacts, how and when DEP employees responded to the complaint, remedial measures taken, and why DEP considers the complaint to be resolved.

DEP should take a comprehensive approach to facility permitting and oversight.

- DEP should require operators to present comprehensive plans for the development of interconnected gathering, compression, and processing facilities.
- When faced with requests for modifications and expansions to the same facility, DEP should examine prior permits and air pollution levels before issuing additional permits.
- DEP should explicitly review whether proposed changes in equipment and function would alter a facility's classification from a "minor" to "major" air pollution source under the Clean Air Act—and therefore become subject to tighter Title V permitting.

DEP should vastly improve its actual measurement of pollution.

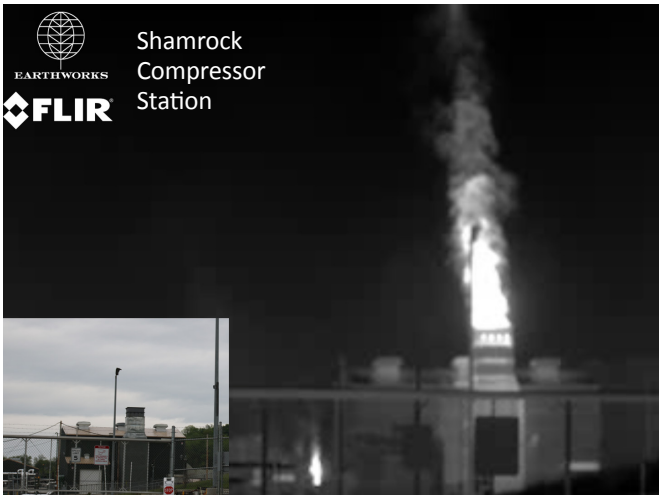
- DEP should measure actual pollution levels at facilities, without advance notice to the operators.
- DEP should require operators to conduct continuous fenceline monitoring for all Clean Air Act criteria pollutants and hazardous air pollutants.
- DEP should follow through on its plan to increase the number of air monitors statewide for fine particulate matter, and expand this monitoring effort for other pollutants, in particular VOCs and hazardous air pollutants (HAPs).

DEP should expand and act upon its pollution measurements.

- DEP should acknowledge that pollutant volume alone is an insufficient measurement on which to base conclusions about potential health impacts.
- DEP should identify patterns and changes in air quality and potential health exposures and increase emissions control requirements that are warranted by those patterns and changes.

Federal and state regulators should require leak detection and repair (LDAR).

- EPA and DEP should require operators to conduct LDAR and use effective methane and VOC emission controls for existing, new, and modified sources.



III. Project Facilities

Bluestone Gas Processing Plant by Robert Donnan

A. Bluestone Gas Processing Plant

Hartmann Road, Evans City PA
Jackson Township, Butler County
MarkWest Liberty Bluestone and MarkWest Liberty Midstream & Resources LLC

Bluestone is a large gas processing and cryogenic facility that has expanded in both size and function over time. Between 2011 and 2015, the footprint of both current and planned operations has grown from 31 to nearly 380 acres—about 288 football fields and a bit larger than the National Mall in Washington DC.

During this time, processing capacity has increased 10-fold (from 50 to about 500 million square cubic feet of gas per day, or MMscfd). Bluestone now includes four plants, multiple large storage tanks, and a rail yard. Initially owned by Keystone Midstream Services (KMS), MarkWest acquired Bluestone in 2011 along with several other facilities in Butler County.

The Course of Development

In December 2010, KMS applied for a general air permit (known as a GP-5) for a compressor station with three compressor engines, one dehydrator, and two condensate storage tanks. Eleven days later, KMS also submitted a plan approval application to DEP for the construction of a gas processing plant on the same site with additional engines, dehydrators, refrigerant capacity, and condensate storage tanks.

The Pennsylvania Department of Environmental Protection (DEP) considered the receipt of two different types of applications for activities at the same location to be a time-consuming and irregular process. A DEP environmental engineer stated that,

"Reviewing both the GP and plan approval is a duplication of efforts that impacts staff time" and noted that issuing the GP would have the effect of allowing Keystone Midstream to start construction even though land use and zoning issues with the site remained unresolved.[6] Nonetheless, DEP issued the general air permit for the compressor station project in January 2011.

In March 2011, just three months after its initial application for the processing plant, KMS modified its plans by adding yet more engines and expanding dehydration capacity. KMS stated that the facility would be renamed the Bluestone Gas Processing Plant, which later became known as Bluestone I.

In January 2012, MarkWest submitted a plan approval application for additional equipment, including heaters and flares. Then in May 2013, MarkWest submitted a plan approval application to "install and operate a deethanization facility at Bluestone," including a rail and truck loading operation and additional heaters.[7] In November 2013, DEP granted a plan approval for a 120MMscfd gas processing and fractionation plant with associated storage tanks and rail loading facilities, known as Bluestone II.

Less than a year later, in September 2014, MarkWest submitted a plan approval for construction of two completely new cryogenic plants with a capacity of 200 MMscfd each, to be built alongside the existing (by now with a capacity of 170MMscfd) facility. These were named Bluestone III and IV and approved by DEP in June 2015.

Despite being permitted as separate facilities over time, all of KMS and MarkWest's expansions were by this point rolled into the overall "Bluestone Gas Processing Plant" in DEP records and permitting files. However, DEP and MarkWest appear to have debated whether the addition of Bluestone III and IV would result in emissions going over the threshold for classifying the facility as a large source of pollution (see section on major versus minor sources).

As the size and complexity of Bluestone has grown, emissions have steadily increased, as seen in the table below. To date, the DEP emissions inventory includes data only from Bluestone I and a partial year (2014) for Bluestone II, which have a combined processing capacity of 170 MMscfd. Data for the facility with the addition of Bluestone III and IV—which tripled the processing capacity of the processing plant as a whole to about 500 MMscfd—won't be available until DEP releases emission inventories for 2015 and 2016, which could take another year or two.

BLUESTONE	Reported emissions, PADEP inventory (in tons per year)			
	2012	2013	2014	Change, 2012-2014
CO	46.46	67.55	78.74	69%
NOx	28.60	51.10	54.61	91%
PM10	6.00	5.72	6.36	6%
PM2.5	6.00	5.72	6.36	6%
SOx	0.19	0.35	0.40	106%
VOC	20.64	36.04	40.66	97%
Total HAPs *	1.38	4.16	4.65	238%
CO2	25,280.11	43,598.57	71,677.20	184%
Methane	15.65	25.76	61.76	295%
Nitrous Oxide	0.23	0.41	0.67	193%

** Sum of HAPs reported in the inventory: benzene, ethylbenzene, formaldehyde, n-hexane, toluene, xylene, and 2,2,4-trimethylpentane.*

B. Trilith Compressor Station

East Lancaster Road, Harmony PA
Lancaster Township, Butler County
MarkWest Liberty Bluestone and
MarkWest Liberty Midstream & Resources LLC

Trilith Compressor Station by Robert Donnan

The Trilith is a compression, dehydration, and separation facility on an approximately 30-acre site. In April 2011, Keystone Midstream Services (KMS) submitted permit applications for the plant under the name #3 Gas Processing Plant. The plant was never constructed by KMS.

DEP's electronic filing system, the Environment Facility Application Compliance Tracking System (eFACTS), lists all permits for KMS plants in the area at the time as "withdrawn." KMS later transferred ownership of the proposed site of the Trilith, along with other Butler County facilities and properties, to MarkWest.

The Course of Development

In February 2012, KMS changed the name of the #3 plant to Trilith, moved the location (but still within the same Township), and submitted a new plan approval application for a larger operation of 80 MMscfd (up from 50 in the initial project plan).

In December 2012, Mark West submitted applications for a general air permit for Trilith, which was to include four compressor engines, one flare, one dehydrator, and produced water and condensate tanks. In April 2013, Mark West withdrew these applications because of new plans to redesign the plant.

In June 2013, MarkWest submitted a new application and received approval from DEP to operate a compressor station with four engines, a dehydrator, five condensate and produced water tanks, and one flare. Just six months later, in December 2013, Mark West applied for another general air permit in order to add two new generator engines to combust wet gas, which DEP approved in January 2014. Just three months later, in April 2014, Mark West submitted yet another new plan approval application to DEP for the addition of two additional compressor engines, which DEP approved in July.

In early 2014, MarkWest received a permit to construct a pipeline to transfer gas from Trilith to the company's Bluestone processing plant, located about 3 miles away.[8] Because the Trilith facility became operational at the end of 2013, only one year of emissions data (2014) is available from DEP. If processing demand continues to increase at the Bluestone facility, or production picks up at nearby well sites, it is possible that the gas supply running through the Trilith station, and in turn pollution, will also rise.

TRILITH	Reported emissions, PADEP inventory, 2014 (in tons per year)
CO	10.84
NOx	16.62
PM10	1.34
PM2.5	1.34
SOx	0.07
VOC	10.02
TOTAL HAPs *	1.59
CO_2	11,251.13
Methane	197.39
Nitrous Oxide	0.02
Sum of HAPs reported in the inventory: benzene, ethylbenzene, formaldehyde, n-hexane, toluene, xylene, and 2,2,4-trimethylpentane.	

C.Shamrock Compressor Station

New Salem Road, Salem PA
German Township, Fayette County
Laurel Mountain Midstream LLC

Shamrock is a large gas compression and dehydration facility. Initially permitted on a 215-acre site, Shamrock also includes over four miles of pipeline, metering and pigging stations, and storage tanks.

Shamrock has had a changing, and sometimes unclear, regulatory status, fluctuating between being classified as a "minor source" compressor station and a "major source" for Greenhouse Gases. Following a relevant Supreme Court decision (see section on major versus minor sources), Shamrock's operator, Laurel Mountain Midstream (LMM), withdrew its major facility permit in 2015 and is awaiting official approval to revert the facility back to a minor emissions source.

In 2012, the Group Against Smog and Pollution (GASP) submitted comments to DEP objecting to LMM having submitted multiple permit applications within a short time. GASP emphasized that the company had already developed a detailed plan for the facility, so they knew from the start that the facility would need to be expanded and equipment added.[9]

The Course of Development

The Shamrock Compressor station was initially permitted with a general air permit in June 2010 based on a plan for three compressor engines, a dehydration capacity of 200 MMscfd, one reboiler, and a condensate storage tank. Less than two months later, LMM applied for a new GP-5 based on an expansion of the facility and doubling of the engines from three to six.

At some point over the fall or winter, LMM violated state law by starting construction of the three new engines without a permit, and was required to pay a fine to DEP. Not long after, in March 2011, DEP issued a new permit to LMM covering all six engines that the company had wanted, as well as a new 17,000 horsepower turbine.[10]

Just six months later, in November 2011, LMM applied for yet another permit to expand Shamrock by adding a second 20,000 horsepower turbine, a second 200 MMscfd dehydration tank, and a produced water tank.[11] Despite adding new, more effective catalysts designed to reduce pollution, projected emissions submitted by LMM for the much larger facility were starting to push up against "major source" permit thresholds for a few key pollutants. (See section on the mathematics of permitting.)

Documents and records in eFACTS indicate that Shamrock's permitting status was in limbo for a few years. During this time, DEP granted ten extensions to LMM's original general permit for "temporary operation pending issuance of a Title V Operating Permit." (See section on major versus minor sources.) Based on data reported to DEP by LMM, emissions appear to have increased from 2011 to 2012, but then dipped a bit for some pollutants and rose for others in 2013 and 2014.

SHAMROCK	Reported emissions, PADEP inventory (in tons per year)				
	2011	2012	2013 **	2014	Change, 2011-2014 *
CO	1.37	2.46	3.15	2.04	49%
NOx	12.22	19.52	30.51	18.66	53%
PM10	1.19	2.76	0.48	3.66	207%
PM2.5	1.19	2.76	0.48	3.66	207%
SOx	0.07	0.22	1.88	0.32	354%
VOC	5.01	6.26	0.53	4.04	-19%
Total HAPs ***	1.92	3.21	1.38	1.41	-27%
CO_2	n/a *	43,939	63,974	64,244	46%
Methane	n/a *	191.36	16.87	71.39	-63%
Nitrous Oxide	n/a *	0.08	0.13	0.14	69%

** The 2011 emissions inventory did not include CO_2, methane, or nitrous oxide (i.e., greenhouse gases). As a result, the % change for those pollutants is from 2012-2014. ** 2013 data were omitted from the online database; DEP provided all figures except for HAPs, which are from LMM's emissions statement made with a permit application for that year. *** Sum of HAPs reported in the inventory: benzene, ethylbenzene, formaldehyde, n-hexane, toluene, xylene, and 2,2,4-trimethylpentane.*

IV. Evaluating Air Emissions

A. The Clean Air Act

Adopted in 1970, the Clean Air Act (CAA) is the comprehensive federal law that regulates air pollution from different types of sources. Following is an overview of key provisions in relation to the facilities investigated in this report; see the Appendix for more detail on the CAA and oil and gas development more generally.

The CAA requires that the US Environmental Protection Agency (EPA) regulates emissions levels for six pollutants that have significant impacts on human and environmental health:

- Ozone (O3)
- Particulate matter (PM)
- Carbon monoxide (CO)
- Nitrogen oxides (NOx)
- Sulfur oxides (SOx)
- Lead (Pb).[12]

These six pollutants have associated, enforceable National Ambient Air Quality Standards (NAAQS).[13] NAAQS are federal air quality standards designed to limit average levels of pollution across a given area.

In addition, the CAA regulates Hazardous Air Pollutants (HAPs), or air toxics, which are considered particularly dangerous for air quality and human health. Greenhouse Gases (GHGs) are partially regulated based on science regarding their contribution to global climate instability (not direct human exposure).[14]

Although EPA oversees and sets standards for air quality overall, in most cases states hold authority over issuing permits to operators of pollution sources and adopting and enforcing necessary regulations. States are responsible for limiting pollution so that it doesn't exceed the NAAQS, known as being in "attainment," and preventing pollution that might cause areas to go into "non-attainment" instead.[15]

At the time the DEP first issued permits for the facilities investigated for this report, Butler County was in non-attainment for "fine" PM.[16] In addition, the entire state of Pennsylvania has the status of non-attainment for ozone and is part of the Ozone Transport Region, a 13-state area across which EPA requires additional measures to control pollutants that create ozone.[17]

B. Major or Minor?

Even though air emission sources receive permits to pollute, the amount and type of pollution they're legally allowed to cause is determined by what's spelled out in permits. The starting point for that decision is whether a pollution source is defined as "major" or "minor."[18] These definitions are based on the volume of federally regulated pollutants that the source is projected to emit.

For the six NAAQS pollutants, the minor/major "default" threshold is 100 tons per year (tpy).[19] Because of their intense impacts on health, projected emissions of more than 10 tpy of a single Hazardous Air Pollutant (HAP), or 25 tpy of all HAPs emitted together, is enough to qualify a facility as a major source.[20] The major source threshold for GHGs is 100,000 tpy. This limit is higher than for other pollutants because GHGs are generally emitted in much greater quantities.

However, in states with pollution levels above any of the NAAQS, the threshold for a major facility can be set lower. This includes many counties in Pennsylvania with existing pollution levels that are in non-attainment of CAA standards.[21] For example, pollution sources are limited to a maximum of 50 tpy of VOCs, some of which are pre-cursors to ozone.[22]

In the realm of air pollution regulation, "major" and "minor" aren't simply labels, but designations that carry significant consequences. Minor source facilities are subject to less stringent recordkeeping and emissions tracking requirements than major sources. This means lower costs and workloads for operators—and limited oversight by regulators, reduced documentation and transparency of operations, and weaker protections for the public. In addition, states often use "general permits" for minor sources that streamline the application review process through a uniform set of permit conditions and limited public participation.[23]

Facilities designated as "major sources" are subject to many more federal and state requirements and

operational criteria than minor sources. Four key ones are:

1. **Analyzing the potential impact** on local and regional air quality and taking measures to prevent further degradation.
2. **Obtaining federal operating permits** (known as Title V), which help ensure that operators comply with conditions spelled out in their plans and permit applications.
3. **Using more stringent emissions** control technologies to reduce or prevent pollution.
4. **Obtaining emission credits** to offset the pollution that will be caused by a new or expanded facility.

C. The Math of Permitting

Projected Emissions

Because of the requirements inherent in major source designation, oil and gas operators will make a significant effort to be classified as minor emission sources. All of the facilities reviewed in this report have operated as minor emissions sources under general air permits. This is because in permit applications, the operators have estimated that emissions from those facilities will be below the pollution thresholds that would trigger major source designation.

To do this, operators forecast levels of pollution, known as the Potential to Emit (PTE). Operators perform their own PTE calculations, which are submitted as part of the permit application reviewed by a state regulatory agency. The PTE is meant to reflect a "worst case" scenario, or the total volume of pollution emitted if a facility is in use every hour of the day, every day of the week, and every day of the year (i.e., a 24/7/365 basis).

Calculating PTEs involves three key steps:

1. **Create an inventory of the range of air pollution sources** at the planned facility. For example this could include engines, boilers, heaters, and storage tanks.
2. **Estimate the volume of emissions from each source included in an inventory.** This is done using "emission factors," which are a function of the time a source operates and the rate at which it emits pollutants. Operators decide which emission factors to use, based on manufacturer specifications, EPA guidelines, or measurements from a comparable source.
3. **Third, calculate total projected emissions for the year**, which requires simple multiplication. For example, the PTE for the 2013 Bluestone plant application included 1,480 horsepower engines running 24/7/365, or 8,760 hours. Multiplying the 2.5 grams per horsepower per hour emissions factor by the horsepower and the number of hours, and then converting the total into tons, resulted in a PTE of 35.73 tons of VOCs per engine.[24]

The selection of emissions factors is one way for operators to keep their PTEs down for the purpose of receiving air permits. For example, the engines and emissions control catalyst used in the original application for the Bluestone gas processing plant were the same make and model as those stated in modified plans for the expansion of operations. However, as seen in the table below, KMS modified its estimates for emissions from the engines when it applied for a plant expansion.[25]

BLUESTONE	Projected emissions for compressor engines (Waukesha 7042GSI, 1480 hp with DC75-14CC catalyst), in tons per year	
	December 2010, for each of 3 engines	March 2011, for each of 10 engines
CO	28.58	7.15
NOx	28.58	4.29
VOC	14.29	2.86
PM-10	0.49	0.49
Total HAPs	0.81	0.81

Notably, had the estimated emissions for the engines used in 2010 also been used in 2011, the proposed ten engines for Bluestone I would have accounted for nearly 290 tpy of both NOx and CO and 140 tpy of VOCs—or three times the threshold for being considered a major instead of a minor source of emissions. Interestingly, the projected levels of PM-10 and HAPs remained the same; multiplying these levels by the larger number of engines wouldn't have made a difference for minor vs. major designation.

In 2014, MarkWest decided to use different compressor engines at Trilith with more than triple the horsepower of the ones in the original application, leading the company to revise the emission factor for the engines downward.[26] Although the larger engines resulted in a significant jump in projected emissions, these estimates remained just below the thresholds for major source designation (93 tpy of NOx and 88,000 tpy of CO2e).[27]

Operators can also lower PTEs in permit applications by committing to install pollution control devices to reduce emissions. For example, MarkWest stated in a 2012 plan approval application for Bluestone that it planned to install additional pollution control devices, and was in turn revising previous estimates for CO emissions from compressor engines to much lower numbers.[28] Similarly, when LMM applied to significantly expand Shamrock in 2011, far lower PTEs were given for the same make and model of compressor engines than those already in operation, which the company explained was due to the use of a new catalyst to control pollution. [29]

In addition, operators may agree to certain operational limitations, such as the type or amount of fuels used or the number of hours a source will be in use. When a facility is a minor source only by virtue of an operational limitation, it is called a "synthetic minor" (rather than a "true minor").[30] In the 2013 permit application for Bluestone, MarkWest risked having the facility be designated as a major source of emissions based on the PTE for GHGs (99,100 tpy). However, the company avoided this by stating that it would limit its "throughput rate," or the amount of natural gas that will be burned by all equipment at the facility, and use a fuel meter to ensure compliance.[31]

Among the facilities reviewed for this report, Trilith and Shamrock are classified as synthetic minor. Until very recently, Bluestone was a synthetic minor as well—but after six plan approvals and multiple expansions, the Bluestone was finally classified as a Title V facility in December 2016.[32]

Reported Emissions

The national picture of actual emissions from the oil and gas sector remains blurry due to limited monitoring and reporting. According to a 2013 report by the Inspector General of the EPA on the National Emissions Inventory (NEI), 35 states had submitted oil and gas production emissions data for point sources (i.e., specific wells and facilities), but only 9 had submitted data for nonpoint sources (i.e., the various equipment used throughout the development process).[33] The report concluded that, "Because so few states submitted data for this sector, we believe the NEI likely underestimates oil and gas emissions. This hampers EPA's ability to accurately assess risks and air quality impacts from oil and gas production activities."[34]

Since 2011, DEP has collected annual emissions reports on unconventional production and processing operations in Pennsylvania. The DEP emissions inventory includes data on CO, NOx, PM (both 2.5 and 10 micrometers), SOx, VOC, seven HAPs, and since 2011 also the Greenhouse Gases CO2, methane, and nitrous oxide for each well and facility reporting to the inventory.[35] Operators are required to report emissions from whichever activities are applicable to their type of facility, including well drilling and completions; scheduled and planned venting and blowdowns; dehydrators; engines; heaters; pumps; and tanks; and fugitive emissions from leaks and unplanned events such as accidental blowdowns.[36]

Given that the starting point for PTE calculations is the "worst-case-scenario," in which it is assumed that all sources are operating and polluting 24/7/365, a facility's reported emissions can be expected to be much lower. However, if operators continually expand the functions and increase the capacity of facilities, there could come a point when they run out of options to reduce PTEs any further and they start to converge on reported emission levels.[37] This possibility was reflected in a 2013 study by the RAND

Corporation, which found that when compressor stations in Pennsylvania operate below capacity, they fall at the lower end of their estimated emissions—but whenever they don't, actual emissions are higher than volumes declared in permit applications.[38]

The emissions data in the DEP inventory are self-reported by well site and midstream (i.e., compression and processing) facility operators. When an operator reports its "actual emissions" to the inventory, it is in fact providing an estimate using (just as is done with PTEs) emissions factors for the different sources of pollution at a well site or facility (e.g., stacks, tanks, rigs, or dehydrators). However, instead of assuming all sources are in operation 24/7/365, operators calculate emissions based on the number of hours the specific source was in use, the quantity of fuel burned, the molecular composition of the gas that was emitted, temperature, and other factors.

Pollution sources in the oil and gas industry are generally not monitored continuously (e.g., a reading every several seconds or few minutes) or at fenceline, which would require several monitors along the perimeter of a facility. Yet this type of monitoring would capture emissions that do not originate from stacks or that are the result of events that may not be reflected in routine reporting, for example equipment malfunctions.[39]

Estimates based on operational assumptions and approximations is called the "bottom up" approach to calculating emissions; in contrast, a "top down" approach analyzes actual data of pollutants in the air and models their path to determine the source. A recent study applied both methods to estimate methane emissions from oil and gas operations in the Barnett Shale region of Texas, finding that actual measurements of emissions were 90% larger than the estimates submitted by operators to the EPA's Greenhouse Gas Inventory.[40]

Another recent study measured methane emissions coming from 114 gas gathering and 16 gas processing plants in 13 states, concluding that the facilities lost methane at an average rate of nearly 0.50% (with wide variation across facilities) and that most emissions were attributable to normal operations.[41]

Following direct measurements, researchers found that lost methane was much higher than figures that were based on estimates and reported to the EPA Greenhouse Gas Inventory.

As seen in the table below, DEP inventory data show a considerable increase in the volume of pollutants reported to the inventory in the last few years. Although this is to be expected given the expansion of the oil and gas industry, most pollutants grew at a much faster rate than the number of well sites and midstream facilities—suggesting that more pollution was either being emitted on average per site or facility in 2014 than in 2012, or that a number of facilities coming online had particularly high levels of emissions.

A notable exception is both methane and nitrous oxide, reported emissions of which went down between 2012 and 2013 (methane levels rose again in 2014). It is possible that this decline was due to variability in emissions among facilities; for example (as seen in the emissions tables in Section 2), reported methane emissions have increased for Bluestone but have decreased for Shamrock. Notably, reported emissions of CO2, the pollutant that accounts for the largest proportion of GHGs, has grown considerably.

Greenhouse Gases and the Supreme Court

In 2010, the EPA adopted the Greenhouse Gas Tailoring rule, which states that facilities with the potential to emit 100,000 tpy of GHGs or more must be designated as major emission sources.[42] However, a 2014 U.S. Supreme Court ruling determined that a facility can't be considered a major source by virtue of its GHGs alone.[43]

Given the time that passed between when the EPA rule took effect and the Supreme Court decision, there was a period when GHG emissions levels could trigger major source permitting. The Shamrock Compressor Station is a telling example of how rules on paper can change a facility's permitting status, regardless of the levels of pollution that it may emit.

In its November 2011 plan approval application, LMM estimated that Shamrock would emit nearly 185,000 tpy of GHGs, thereby triggering the major source threshold requirement.[44] In early 2012, LMM

DEP Emissions Inventory			Emissions Totals (tpy)										
Year	# Well Sites Reporting	# Midstream Facilities Reporting	CO	NOx	PM-10	PM-2.5	SOx	VOC	Total HAPs*	CO_2	Methane	Nitrous Oxide	CO_2e **
2012	8,966	453	7,350	16,361	600	548	101	4,024	589	4,291,316	123,884	209	4,415,409
2013	10,275	447	6,606	17,659	670	616	159	4,790	677	4,908,106	107,945	78	5,016,129
2014	10,009	508	8,230	21,663	864	819	263	6,389	750	6,068,990	109,219	35	6,178,244
Change 2012-2014	12%	12%	12%	32%	44%	49%	160%	59%	27%	41%	-12%	-83%	40%

** Sum of HAPs in the DEP emissions inventory: benzene, ethylbenzene, formaldehyde, n-hexane, toluene, xylene, and 2,2,4-trimethylpentane.*
*** Operators submit projections for GHGs in permit applications in terms of carbon dioxide equivalent (CO_2e), expressed as a combination of CO_2, methane, and nitrous oxide. The DEP doesn't include CO_2e, but the figures here include inventory data for the three pollutants added together.*

submitted an application for a federal Title V permit (discussed above), which EPA required for large stationary sources of GHGs. However, LMM withdrew the Title V application for Shamrock following the Supreme Court decision; the facility has retained its operational status as a minor emissions source.[45]

A similar outcome occurred with the Bluestone facility. In 2013, MarkWest applied for a permit to triple the capacity of Bluestone by adding cryogenic processing equipment and a completely new section of the facility, known as Bluestone II. At the time, emissions of CO were projected to reach a level of 90 tpy and VOCs a level of 44 tpy, both just under the limits for becoming a major source.[46]

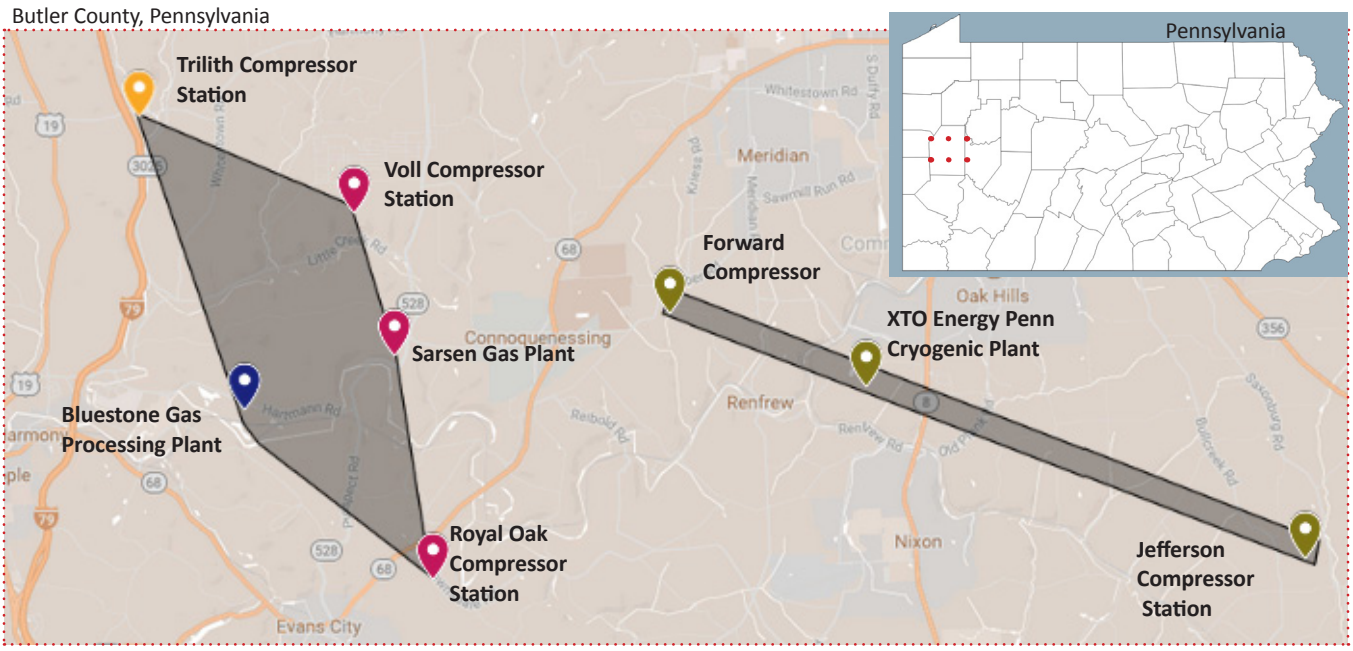
A year later, MarkWest's application for further expansions, known as Bluestone III and IV, put GHG emissions estimates at over 267,000 tpy, at which point DEP determined that, "if the expansion is authorized, the Bluestone Plant would be a Title V facility (major for NOx and VOC)."[47] However, MarkWest later modified its application and planned equipment so that estimates of those two pollutants came under major source thresholds—with the result that even a dramatic increase in GHGs was insufficient to trigger major source designation.[48] As noted above, even such changes couldn't hold off major source designation indefinitely; by December 2016, a sixth modification application triggered Title V requirements because projected emissions of CO exceeded major source thresholds.[49]

D. Single Source Determination (Aggregation)

Under the CAA, smaller sources of emissions that are under the control of a single operator and are related or near each other can be considered to constitute a single source of emissions. In other words, their emissions can be aggregated to allow for the regulation of multiple sources that, when concentrated in one area, may actually be as harmful as a single, larger source.

Sections of the CAA related to aggregation review do not apply to oil and gas wells. However, aggregation review requirements do apply to large compressor stations, processing facilities, and other oil and gas infrastructure. If emissions sources are aggregated, they are subject to regulations designed to limit pollution to the greatest degree possible. Another critical consequence of aggregation is that it increases the number of sources that an operator has to consider when seeking a permit to pollute, thus driving up the total estimated emissions used when applying for a permit.

Operators are required to address aggregation when applying for permits for multiple facilities in an area where there are other emission sources already, particularly if the same operator owns them. As illustrated by the map below, there are currently three compressor stations (Trilith, Voll, and Royal Oak) and two processing plants (Bluestone and Trilith) within an approximately eight-square mile area, all owned and operated by MarkWest. Also notable



Emission Estimates in Permits (tpy)	CO	NOx	VOC	CO_2e
Bluestone Gas Plant (2015)	91.95	81.98	41.12	267,030.00
Trilith Compressor Station (2014)	42.27	92.84	45.70	88,000.00
Voll Compressor Station (2013)	69.87	64.37	42.16	27,631.00
Sarsen Gas Plant (2012)	95.54	46.76	44.92	not included
TOTAL	299.63	285.95	173.90	382,661.00
2014 Emissions Inventory (tpy)	**CO**	**NOx**	**VOC**	**CO_2e ***
Bluestone Gas Plant	78.74	54.61	40.66	71,739.00
Triith Compressor Station	10.84	16.62	10.02	11,449.00
Voll Compressor	16.67	9.78	13.50	17,270.00
Sarsen Gas Plant	67.18	32.60	34.89	60,241.00
Royal Oak Compressor Station	5.76	9.65	5.11	7,318.00
TOTAL	179.19	123.26	104.19	168,016.00

** Operators submit projections for GHGs in permit applications in terms of carbon dioxide equivalent (CO_2e), expressed as a combination of CO_2, methane, and nitrous oxide. The DEP doesn't include CO2e in the emissions inventory, but the figures here include inventory data for the three pollutants added together.*

from an air quality perspective is the nearby location of two compressor stations (Forward and Jefferson) and a large processing plant (Penn Cryogenic) within a three-square mile area, all of which are owned and operated by Mountain Gathering LLC.

Following review of the 2011 permit application for the proposed Voll Compressor Station, DEP concluded that the facility should be aggregated with the existing Sarsen Gas Plant. The decision was based on the dependency of each facility on the other's operations and their physical relationship via a pipeline.[50] EPA (Region 3) reviewed and approved DEP's decision.[51]

KMS, the owner of Sarsen and Voll at the time, objected to DEP's decision on the grounds that the two facilities were separate operations. MarkWest, now the owner of the facilities, applied for a new permit for Voll in 2013. This time, DEP determined that "aggregation is not appropriate for this facility."[52] This reverse decision paved the way for subsequent non-aggregation decisions made by DEP for the other MarkWest facilities in the area.

Initial air permit applications for both the original Bluestone and Trilith facilities stated that, "lt will not be a support facility for other Keystone facilities in the area, nor will other Keystone facilities function as a support for it."[53] Similarly, the 2011 Plan Approval for the Bluestone I plant stated that, "The proposed facility will not be physically connected via pipeline to any of the existing or proposed Keystone Midstream facilities."[54]

However, the close and sequential timing of permits for different facilities in the area points to the likelihood that MarkWest was planning to develop a network of operations. In addition, despite having sought permits one-at-a-time, MarkWest clearly views its operations as related. In a 2015 presentation on company earnings, MarkWest described the "Keystone Complex" for gas processing and distribution as including Bluestone I, II, III, and the future IV plants together with the Sarsen gas processing plant. (Keystone is one of ten such complexes MarkWest is currently operating or developing in the Marcellus and Utica Shale region of Pennsylvania, Ohio, and West Virginia.)

In the 2013 aggregation analysis for the construction of the Trilith Compressor Station, MarkWest stated that, "120 MMscf/d of gas will routinely be transferred between the Trilith Compressor Station and the Sarsen Gas Plant or Bluestone Gas Plant."[55] In 2014, MarkWest received permits to operate the Royal Oak Compressor Station and construct the "Royal Oak to Bluestone" pipeline and the "Trilith to Bluestone" pipeline. In effect, additional equipment (e.g., pipe, valves, and engines) was constructed for the sole purpose of connecting different facilities and transferring gas among them.

The addition of pipelines and gas transmission goes directly against DEP's original reasoning in not aggregating Bluestone with other facilities in the area, i.e., a lack of physical connection. However, since reversing the agency decision that Voll and Sarsen should be aggregated, DEP appears to have abandoned basing aggregation decisions on such interconnections and shared functions.

MarkWest has continually asserted that the factor of distance among its facilities in the same area means their emissions should not be aggregated, and DEP has always agreed. During the application process for Trilith, DEP concluded that aggregation requirements didn't apply because the "spatial arrangement" among Trilith, Voll, Bluestone, and Sarsen were "typical of the oil and gas extraction industry."[56] However, this "typical" pattern illustrates the potential for an operator to avoid single source determinations simply by leaving some distance among the various facilities it develops—and then connect or integrate functions later.

In addition, the typical distance argument wouldn't apply to the Bluestone plant itself. Over time, MarkWest has received permits for different phases of operations and physically distinct operations (Bluestone I, II, and III) that are located directly next to each other. However, MarkWest regularly sought and received permits for modifications and expansions to the same original facility—but did not reveal to DEP plans for a larger complex. As a result, the aggregation question within the so-called single Bluestone plant alone has never been examined.

It does not appear that DEP ever considered whether the growing number and capacity of MarkWest's facilities in a single area has reached a point when previous non-aggregation decisions would no longer be valid. For example, it is clear that MarkWest has pursued, and DEP has supported, the development of multiple sources of air pollution in a relatively small geographical area in Butler County without consideration of the cumulative or additive impacts on air quality or the health of residents.

As discussed in the section below on air quality and health, emissions can travel long distances (much further than the quarter-mile that has become the regulatory standard for aggregation; see Appendix). As discussed below (see Section 4), certain pollutants, including VOCs and HAPs, can negatively impact quality of life and health for residents living near emission sources—and more development in a small area would increase this risk.

The table above shows that when combined, the emissions estimates that form the basis for permit decisions for four of the facilities in Butler County in effect constitute multiple "major" emissions sources

for key pollutants, based on the 100,000 tpy for CO2e, 100 tpy threshold for CO and NOx, and 50 tpy for VOCs.[57] Further, even based on the operational emissions reported by MarkWest to the DEP in 2014, the five facilities in the area owned by MarkWest effectively constitute far more than a major emission source for those key pollutants.

What If?

Treating Bluestone, Trilith, and Shamrock as major sources at different points in their permitting history is a plausible scenario, given that the facilities have often projected emissions just below the major source threshold—sometimes only by virtue of self-imposed technological conditions or restrictions on duration of operations.[58]

Both the Bluestone and Shamrock facilities got very close to the major source threshold for NOx and CO. Both facilities have at times also estimated VOC emissions above the major source threshold and well above the GHG 100,000 tpy threshold—so should have been treated as major emission sources.

Had the Bluestone, Trilith, and Shamrock facilities been considered as major sources, they would have been subject to air pollution control review. MarkWest and LMM—as well as DEP—would have been required to take into consideration existing pollution sources (including other oil and gas facilities) in the area. It is also likely that more stringent pollution controls would have been imposed.

For example, the use of electric compressor engines would have been necessary at the project facilities to meet pollution control equipment requirements. In 2015, MarkWest decided to replace ten gas-fired compressor engines with electric ones in order to stay below major source thresholds and avoid a Title V permit for the Bluestone facility as it moved into its third and fourth phases of expansion.[59] This action by an operator indicates that the installation of electric compressor engines could have had the effect of lowering emissions considerably at any time, but didn't occur until MarkWest wanted to avoid stricter permitting requirements. This is supported by the fact that EPA's Natural Gas STAR program recommends the installation of electric compressors because of its benefits in reducing pollution and the waste of methane gas.[60]

E. The Role of Fugitives

As the name implies, fugitive emissions are those that are lost or escape inadvertently. They are the result of equipment leaks and failures, evaporation, and accidental or unplanned venting and flaring to release pressure in the system.[61] DEP's oil and gas emissions inventory includes the category of fugitives, which are defined in federal law as, "Those emissions that could not reasonably pass through a stack, vent, or other functionally equivalent opening, including emissions from connectors, flanges, open end lines, pump seals, valves, etc."[62]

Estimates of fugitives may be as high as the emissions expected from "normal operation" of some pieces of equipment. For example, MarkWest's 2012 permit application for Bluestone estimated that as much methane and more than twice as much VOCs would be emitted due to equipment fugitives as from some heaters; in this case, fugitives were enough to tip VOC emissions for the facility over the 50 tpy major source threshold.[63]

In 2014, fugitives reported by all operators in Pennsylvania to the DEP emissions inventory accounted for more VOCs than did dehydrators (549 vs. 454 tpy).[64] That year, fugitives from the Shamrock compressor station accounted for twice as much methane loss as planned startup, shutdown, and maintenance (SSM), a process that can cause intense emissions in a short period of time.[65]

Even with these trends in mind, figures included in permit applications or reported to the DEP inventory tell only part of the fugitives story. This is because operators calculate the volumes of fugitives by estimating them using set emission factors, the number of hours the specific source was operating, the type of oil or gas that was being processed or compressed, and other factors.[66]

In the face of rapid expansion of oil and gas development nationwide, EPA has taken steps to improve the detection and repair of a key category of fugitives: equipment leaks. In 2012, the agency adopted New Source Performance Standards (NSPS)

for oil and gas operators to reduce leaks of VOCs; in 2016, additional facilities and equipment were added to the VOC rules and similar requirements were adopted to reduce leaks of methane, a potent greenhouse gas. [67]

As a result, processing plants that were covered under the 2012 VOC rules are now subject to the NSPS rules for methane, and compressor stations are now subject to both sets of NSPS rules.[68] However, these rules apply only to wells and facilities that are being permitted for the first time or existing ones that are undergoing major modifications.

The final EPA rules require operators to have a plan to survey leaks from all its equipment using optical gas imaging (such as a Forward Looking Infrared, or FLIR, camera) or other technologies. This process is known as Leak Detection and Repair (LDAR). Operators have to conduct quarterly surveys and repair any detected leaks within 30 days. However, if leaks can't be fixed without shutting down the plant, operators can wait to do repairs until shutdown is scheduled (but no longer than two years).[69]

Shamrock isn't subject to the federal VOC or methane rules because compressor stations weren't included in the facilities covered under the rules until 2016 (i.e., after Shamrock was built). However, Shamrock is still subject to LDAR requirements through its state general air permit; but, because these don't require submission of records to DEP—only that operators make them available to DEP upon request—related information is not available to the public.

Bluestone is subject to the VOC rules because it is a processing plant and all of its expansions (Bluestone I, II, III and IV) were permitted after the 2012 rules went into effect. However, no part of the plant is subject to the methane rules because DEP issued a plan approval to MarkWest for Bluestone III and IV in June 2015, a year before the rules were finalized. According to DEP, any equipment changes currently underway as part of the construction of Bluestone III and IV are not being defined as "major modifications."

Trilith is classified by DEP in eFACTS as a gas processing plant and as such, would logically be subject to the federal VOC rules because the facility became operational after they were adopted. However, the permits for Trilith classify the facility as a compressor station—which would not be subject to the VOC rules. This discrepancy may be the reason why the files for Trilith that Earthworks reviewed did not contain any documentation related to the federal LDAR rules.

Operators of facilities subject to the federal LDAR rules are required to file semi-annual compliance reports with state regulators. These were contained in the files Earthworks reviewed for Bluestone. As seen in the table below, the number of equipment parts at Bluestone subject to the VOC rules increased significantly as the facility expanded and added new functions. Compliance reports for 2013-2015 indicate that leaks were found in 1%-18% of equipment, with wide variation depending on the type of equipment and reporting period.

BLUESTONE	**Number of equipment parts subject to federal VOC leak detection and repair rules, from MarkWest reports filed with DEP ***			
	July-December 2013 (Bluestone I)	**July-December 2014 (Bluestone I and II)**	**July-December 2015 (Bluestone I, II, Storage, Loading)**	**% Change, 2013- 2015**
Connectors	4,489	7,742	10,450	133%
Valves	1,921	3,810	5,377	180%
Pumps	11	23	33	200%
Compressors	8	10	12	50%
Pressure relief devices	75	156	209	179%

** Reports are filed semi-annually; because the DEP files Earthworks reviewed included only one report for 2015, only data for the July-December period are provided here to ensure consistency across years.*

V. Evaluating Air Quality and Health Impacts

A. Measurements and Standards

The environmental and health effects of many of the chemicals and pollutants associated with oil and gas development are scientifically well-established.[70] Less clear is how to "connect the dots" from Point A, an emissions source; to Point B, exposure by a person; and to Point C, resulting health problems.

However, research to investigate such connections is rapidly emerging; a recent assessment of peer-reviewed literature on the environmental and health impacts of shale gas development found that 80% of all papers (which total nearly 400) have been published since 2013.[71] In addition, the vast majority of scientific studies show a link between shale gas development and impacts related to health (84%); water quality (69%); and air quality (87%).[72]

Two key challenges remain in gaining a full picture of the direct impact of emissions from specific well sites or facilities: limited data on air quality and inadequate health standards against which to evaluate pollutants identified in the air around such facilities and their operations.

Divergent approaches

State and federal environmental and regulatory agencies do not monitor the air directly around well sites and facilities, although some testing may be conducted when severe problems occur or in limited studies.[73] In addition, there is a lack of localized "baseline" air quality data that show conditions prior to oil and gas activities, which makes it difficult to pinpoint the effects of new sources after they begin operating.

A 2014 study concluded that in parts of the Marcellus Shale region with air monitors, emissions of some pollutants show an upward trend—but that a lack of monitors in many places obscures the picture and limits air quality management.[74] There are no EPA air monitors for the criteria pollutants in the counties where the facilities reviewed for this report are located (Butler and Fayette).[75] In addition, DEP considers both counties to be part of a very large air quality region (the "Pittsburgh-Beaver Valley Area"), so emissions generated by many sources that are spread out geographically are rolled together to determine whether standards are being met.[76]

Projecting and reporting emissions on a broad regional scale does not provide a full picture of the pollution that actually occurs. In large part, this is because reported data is based on estimates rather than comprehensive measurements (see Section 3C) and for single rather than aggregated facilities (see Section 3D).

In addition, regional air quality assessments and reporting limited to single facilities can not convey local health impacts, particularly in places where many emissions sources clustered together. For example, a 2013 RAND Corporation study showed that in Pennsylvania counties where oil and gas operations are concentrated, NOx emissions were 20-40 times higher than levels equivalent to thresholds for individual "major" emission sources.[77]

Monitoring air quality impacts on a more local level would help reveal the cause of varying pollution levels, which is reflective of oil and gas operations. Emissions vary depending on the phase of development (e.g., drilling, fracturing, production, or processing) and can greatly increase during events such as flaring, venting, and liquids unloading. Industry recognizes the fluctuating nature of pollution from such events; for example, blowdowns can last for several hours but emissions may be most intense during the first 30-60 minutes.[78]

Emerging environmental health research confirms that episodic emission events can cause health impacts immediately or in as little as 1-2 hours, largely because toxicity is determined by the concentration of the chemical and intensity of exposure.[79] As a result, longer-term, average measurements of emissions—what operators estimate in permits and report to regulators—do not provide a full picture of the types and patterns of pollution that result in the exposure of workers and residents to harmful pollutants.

Finally, emissions data in permit applications or inventories are expressed in total volumes over a period of time (e.g., pounds per hour or tons per year), while health standards are based on the concentration of a pollutant or chemical (e.g., micrograms per cubic meters or parts per million). In the absence of continuous air monitoring by operators and regulators in close proximity to sources of emissions, data on the concentrations of pollutants around oil and gas operations will remain relatively limited. In turn, operators can be "in compliance" with air quality standards on the basis of estimated volumes alone, even if they are emitting pollutants at concentrations that harm health.

Inadequate health standards

People living near gas wells and facilities day in and day out, as well as workers at job sites, are often subjected to multiple toxic substances simultaneously and on a chronic, long-term basis. Yet this experience is not reflected in the health standards used by agencies to determine the impacts of chemicals and the relative safety or risk of exposure to them. Regulators and health agencies have developed these standards through testing of individual chemicals and "safety" is based on one-time (generally 8-hour) exposures.[80]

Most of these risk assessments of exposure to a particular substance are based on healthy adults, so impacts on more vulnerable populations such as children, the elderly, and those with pre-existing health conditions, can be underestimated. In addition, risk assessments for many chemicals use a high dose as the starting point for calculating levels at which negative effects can be observed—potentially minimizing the exposure risks of low doses of multiple chemicals.[81] A 2012 study, for example, showed that endocrine (hormone system) disrupting chemicals can have different but still harmful effects at lower doses than at higher ones, concluding that fundamental changes in chemical testing and safety protocols are needed to protect human health.[82]

Such considerations have led some researchers to conclude that in order to determine exposure risks, it is necessary to understand what happens when multiple chemicals interact and mix.[83] Yet health reference values don't reflect the inherent complexity of "blended" industrial emissions, even though such pollution can increase health hazards.[84] As summarized by the Agency for Toxic Substances and Disease Registry (ATSDR), "most toxicological testing is performed on single chemicals, but human exposure is rarely limited to single chemicals…A particular issue is whether a mixture of components, each of which is present at less than guidance concentrations, may be hazardous due to additivity, interactions, or both."[85]

Finally, health standards don't exist for many of the pollutants known to be emitted from oil and gas facilities and to have negative health impacts. Although federal limits exist for some HAPs released by industrial activities (e.g., hydrogen sulfide and formaldehyde), oil and gas wells and associated equipment are not included as area sources of air pollution in the federal law governing HAPs.[86]

B. Sampling Results

Earthworks has sampled the air near oil and gas facilities as part of previous research projects in Pennsylvania and California.[87] For the current project, we conducted sampling at two sites on opposite sides of the Bluestone gas processing plant, one site near the Trilith compressor station, and one site near the Shamrock compressor station.

In order to see whether variation in results would occur over time and in different seasons, samples were taken every two months from March to September 2016. Four samples were taken at each of the Bluestone sites and at the Trilith site; due to logistical constraints, only three samples were taken at the Shamrock site.

All samples were collected using Summa canisters that were deployed for 13-17 hours, starting in the evening and ending in the morning. A certified laboratory provided the canisters and analyzed the air samples using the TO-3 test for Methane and TO-15 test for VOCs, methods developed by the US Environmental Protection Agency.[88] Based on results from the first test at one of the Bluestone sites, Earthworks had the laboratory analyze all subsequent samples for Tentatively Identified Compounds (TICs), an approach that can reveal any identifiable compounds in an air sample that were not included in the primary analysis method (i.e., in addition to chemicals included in the TO-15 method).[89]

On the dates that sampling occurred, Earthworks used a Forward Looking Infrared (FLIR) camera to identify emissions being released from stacks, flares, and other sources and the direction that the emissions plumes were moving.[90] However, due to limited public vantage points near the project facilities, we were unable to identify many potential sources of emissions with the FLIR camera that may have been the cause of the pollution we detected through air sampling. For example, because of distance, we could not get a clear view with the FLIR camera of the many valves and pipes at the Bluestone plant, while we did not have public access from which to view many parts of the Trilith and Shamrock compressor stations.

Sampling Site Summaries

Bluestone Site 1

This sampling site was located approximately 400-500 feet from the main part of the Bluestone gas processing plant and 0.3 miles from the main flare that was known to be emitting at the time. The tests were taken in an open location with no trees, hills, or buildings between the emission sources and the Summa canisters.

This site had the highest number of distinct chemicals detected at least once: 60. In addition, the highest concentrations of many of the chemicals detected in the study occurred at this site. One test detected 47 chemicals, including 19 that were not found in any of our other samples. On this sampling date, an infrared video showed the release of a dense and long plume of emissions being released from a flare at the Bluestone plant that was clearly moving far beyond the boundary of the facility in the direction of the sampling site.

In two of the samples taken at the Bluestone 1 site, single chemicals were detected in higher concentrations than the effects screening levels (ESL), or levels likely to trigger health symptoms. These included a concentration of Acrolein at 3.50 ug/m3, which is above the short-term ESL (3.2 ug/m3) and more than four times the long-term ESL (0.82 ug/ m3); and Biphenyl at 3.00 ug/ m3, which is above the short-term ESL (2.3 ug/ m3) and three times the long-term ESL (1.0 ug/ m3).[91] Acrolein can cause dizziness, headache, nausea, shortness of breath, and lung damage.[92] Biphenyl can cause coughing, nausea, and vomiting.[93]

In addition to methane, six chemicals were detected in all four samples taken at the Bluestone 1 site: Isobutane, Trichloroflouromethane, CFC-12, Toluene, n-Hexane, and Hexamethylcyclotrisiloxane. Three chemicals were detected in three samples: Propane, n-Butane, and n-Pentane.

Bluestone Site 2

This sampling site was located approximately 0.25 miles from the main part of the Bluestone gas processing plant and 750 feet from the main flare that was known to be emitting at the time. It had the second highest number of distinct chemicals detected at least once: 31.

With a few exceptions, these chemicals were detected at the same or lower concentrations than at the Bluestone 1 sampling site. It is likely that this difference was due to prevailing wind directions and different landscape conditions. At the Bluestone 1 site, sampling occurred north of the plant in an open area, while the Bluestone 2 site was south of the plant and trees and vegetation were located between emission sources and the Summa canisters.

In addition to methane, three chemicals were detected in all four samples taken at the Bluestone 2 site: Dichlorodifluoromethane (CFC 12), Trichloroflouromethane, and Toluene. Six chemicals were detected in all three samples for which TICs were analyzed: Isobutane, n-Butane, n-Pentane, Trimethylsiloxane, and Hexamethylcyclotrisiloxane; n-Hexane was also detected in three of the four samples for which it was analyzed.

Trilith site

The first air sample at the Trilith compressor station was collected approximately 0.3 miles east of the main part of the facility and stacks known to be emitting at the time. Due to changes in project logistics, all subsequent samples were collected closer to potential emissions sources, approximately 1000 feet east of the facility.

The Trilith site had the third highest number of distinct chemicals detected at least once: 27. The

sampling locations were in open areas, but stands of trees and vegetation were located between the compressor station and the Summa canisters.

In addition to methane, two chemicals were detected in all four samples taken at Trilith: Dichlorodifluoromethane (CFC 12) and Trichloroflouromethane. Two others were detected in three samples: toluene and n-hexane.

In two of the tests taken at the Trilith site, single chemicals were detected in higher concentrations than the ESLs, or levels likely to trigger health symptoms. These included concentrations of Acrolein at 2.90 ug/m3, which is almost four times the long-term ESL (0.82 ug/ m3); and of Acetaldehyde at 24 ug/ m3, which is 1.5 times the short-term ESL (15 ug/ m3) and more than half of the long-term ELS (45 ug/ m3).[94] Acrolein can cause dizziness, headache, nausea, shortness of breath, and lung damage, while acetaldehyde is a carcinogen that can also irritate the eyes, nose, throat, lungs, and skin.[95]

Shamrock site

The sampling site at the Shamrock compressor was located in an open area approximately 900 feet north of the main part of the facility and stacks known to be emitting at the time. The Shamrock site had the smallest number of distinct chemicals detected at least once: 17.

Notably, the Shamrock site had the least favorable weather conditions for sampling. During the three sampling periods, prevailing winds were generally from the north, east and west, rather than directly from the south. It appears that the pollutants were detected primarily during times of calm or when winds shifted directions for periods of at least a few hours.

In addition, due to changes in project logistics, three samples were collected at the Shamrock site rather than four (as at the other project sites). It is therefore possible that the number of pollutants detected would have been higher with additional sampling. Dichlorodifluoromethane (CFC 12) and ethanol were detected in all three samples and Toluene in two samples taken at this site.

Chemical Detections

As detailed in the table below, Earthworks' air sampling detected a total of 35 primary VOCs and 36 TICs. Methane was detected in every sample at all of the project sites. Since many of the chemicals detected in the current project are associated with both combustion and additives used in oil and gas activities, it is highly likely that they are the result of the nearby compression and processing operations.

These results—coupled with FLIR video of emissions plumes taken at the time of air sampling—indicate that pollution from the Bluestone, Trilith, and Shamrock facilities extend beyond the boundaries of the facilities and into surrounding properties.

It isn't possible to compare the individual VOCs detected in our sampling with those reported as being emitted by the project facilities because both permit applications and the DEP emissions inventory only include total VOCs (i.e., volumes; see section 4A above). However, some of the chemicals in our sampling (most notably toluene, ethylbenzene, propene, dichlorofluoromethane, and trichlorofluoromethane) are consistent with those detected in Earthworks' previous sampling near compressor stations in Pennsylvania.[96] A similar suite of VOCs was also detected in sampling by the Southwest Pennsylvania Environmental Health Project near a compressor station in New York[97] and by ATSDR at a compressor station in Pennsylvania.[98]

In addition, detection of a variety of VOCs at a range of concentrations is consistent with sampling results near various types of natural gas development operations conducted by both Earthworks and other researchers.[99] According to DEP, some of the VOCs detected in air sampling near oil and gas sites are present in ambient air because they were once widely used and persist in the atmosphere.[100] However, DEP air monitoring studies confirm that acetone and benzene, toluene, ethylbenzene, and xylene (known as the BTEX chemicals) can be attributed to gas development.[101]

Our project sampling detected five of the seven individual HAPs reported to the DEP inventory by oil and gas operators for facilities statewide, including those investigated for this report: benzene,

ethylbenzene, n-hexane, toluene, and xylene. A sixth, 2,2,4-trimethylpentane, was not included in the laboratory analysis of the project samples, while detection of the seventh, formaldehyde, would have required different sampling equipment.

Gas processing and compression are essentially the process of breaking down and refining hydrocarbons. Many of the TICs detected are hydrocarbons (e.g., propane, butane, pentane, and isoprene) and hydrocarbon by-products used as building blocks for other products (e.g., siloxanes and silanols).[102] One of the TICs detected in most of the samples, Trimethylsilanol, was also frequently detected in previous sampling conducted by Earthworks near oil production sites in California.[103]

C. Detection Patterns

Even with a large number of compounds detected, some consistency exists across sites. There were 11 compounds detected at all four of the sampling sites and 8 at three of the sampling sites. The tables below summarize both the number of detections at each sampling site and the known health effects of the chemicals. Some of the most common symptoms are consistent with statements from residents living near the facilities regarding health symptoms they have experienced since the facilities became operational, in particular eye, nose, and throat irritation, headaches, and respiratory problems.

As shown in the table, the concentrations of several chemicals varied considerably across samples, sometimes to a very large degree (e.g., 10-100 times). This variability is indicative of the relative intensity of emissions depending on which activities are underway at the facilities, as well as changing conditions related to sampling. It also points to the likelihood that pollutants could be present near the project sites at even higher concentrations than could be captured in our sampling—which represents a relatively short "moment in time" and was conducted at some distance from the main emission sources at each facility.

With a few notable exceptions (discussed above in the sampling site summaries), the concentrations of most of the VOCs and TICs detected were not high in relation to established health standards for a single chemical exposure. However, they are still a concern with regard to health impacts if exposures occur over a long period of time, which is possible given that compressor stations and gas processing plants can run continuously for weeks or months.

In addition, the wide range in the concentration of many of the chemicals detected demonstrate the potential for intense, short "peak" emissions from the project facilities—the kind of pollution event that can lead to exposures and health impacts for both workers and residents.[104] As discussed in Section 4, the episodic nature of emissions around oil and gas operations underscores the necessity of continuous monitoring in order to ensure a full picture of pollution and risks to air quality and health.

Taken together, results from the four testing sites confirm the influence of weather conditions on sampling and, in turn, potential exposures. All sampling occurred overnight and during periods with at least several hours of calm winds—conditions that cause VOCs to stay close to the ground and disperse slowly. In general, a larger number of chemicals were detected during periods of low wind.

This pattern also held when the prevailing winds came from a direction that moved air toward the testing sites. For example, the two Bluestone sites are on opposite sides of the processing plant. In the samples taken in March, ten TO-15 compounds were detected at Site 1 but only four at Site 2, likely due to a prevailing southwest wind. During sampling in July, calm winds were primarily from the north instead, and eleven TO-15 compounds were detected at Site 2 compared to six at Site 1. Similarly, the largest number (12) of TO-15 detections at the Trillith compressor station site occurred in March at a time with wind conditions that were most suitable for sampling.

In addition, the distance between key sources of emissions at the project facilities to the testing sites may have played a role in the number of chemicals detected. The two sites at the Bluestone facility are closer to identified emission sources and also had the largest number of detections; this was followed by results from Trilith, the third closest facility; and then Shamrock, the fourth closest. Such patterns may

be due to VOCs being light and dispersing as they move further from an emissions source. In turn, this finding underscores research showing that residents living closer to gas development experience negative health symptoms to a greater degree than those living further away.[105]

EARTHWORKS AIR SAMPLING	Number of chemical detections				
	All project samples (15)	Bluestone 1 samples (4)	Bluestone 2 samples (4)	Trilith samples (4)	Shamrock samples (3)
Methane: TO-3 test	15	4	4	4	3
Chemicals: TO-15 test					
Dichlorodifluoromethane	15	4	4	4	3
Trichlorofluoromethane	13	4	4	4	1
Toluene	13	4	4	3	2
n-Hexane	10	4	3	3	
Ethanol	9	2	2	2	3
Acetone	8	2	2	3	1
Propene	7	2	2	2	1
Ethyl Acetate	7	2	2	2	1
1,2,4-Trimethylbenzene	4	2	1		1
Styrene	3	1		2	
Ethylbenzene	2	1			1
Acrolein	2	1		1	
4-Methy-2-pentanone	2	2			
n-Heptane	2	1	1		
2-Hexanone	2	1		1	
2-Propanol	2	2			
n-Nonane	2	2			
alpha-Pinene	2	1	1		
d-Limonene	2	1			1
Napthalene	2	1	1		
Vinyl Acetate	1			1	
2-Butanone (MEK)	1	1			
Acetonitrile	1		1		
Tetrahydrofuran (THF)	1	1			
1,2 Dichloroethane	1	1			
Benzene	1	1			
Cyclohexane	1	1			
1,2-Dichloropropane	1	1			
Methyl Methacrylate	1	1			
n-Butyl Acetate	1	1			
n-Octane	1	1			
Tetrachloroethene	1	1			
m,p-Xylenes	1	1			
o-Xylene	1	1			
Methylene chloride	1	1			
Total number chemicals detected	35	33	13	12	10

Chemicals: TIC test	All project samples (13)	Bluestone 1 samples (4)	Bluestone 2 samples (3)	Trilith samples (3)	Shamrock samples (3)
Unknown chemicals (4)	13	2	5	6	
Isobutane	9	4	3	1	1
Trimethylsilanol	9	2	3	3	1
Hexamethylcyclotrisiloxane	9	4	3	2	
n-Butane	8	3	3	2	
Propane	8	3	1	2	2
n-Pentane	8	3	3	1	1
Unknown hydrocarbons (4)	5	4	1		
Unknown siloxanes (1)	5	1	2	2	
Methyl Alcohol	4	2		1	1
Isoprene	4	1	2	1	
Dimethylsilanediol	4	1	2	1	
2-Ethyl-1-hexanol	4	1	2		1
2-Methylpropene	2	2			
n-Butanal	2	2			
1-Butanol	2	1			1
Oxime-, methoxy-phenyl-	2		1	1	
C11H24 Alkanes: Straight Chain (2)	2	2			
Sulfur Dioxide	1			1	
Acetaldehyde	1			1	
Acetic acid	1			1	
Cyclopentane	1	1			
Biphenyl	1	1			
Diphenyl ether	1	1			
1-Butanol	1		1		
tert-Butanol	1	1			
2-Butoxyethanol	1		1		
Octamethylcyclotetrasiloxane	1		1		
2-Ethylhexylacetate	1	1			
n-Hexanal	1	1			
Total number chemicals detected	37	27	21	15	7

Compounds detected at all project sites	Concentration range (ug/m3)	Short-term/Long-term ESL ug/m3*	Potential health effects *
Methane	2.7-7.6 *(in ppm)*	*Simple asphyxiant*	Asphyxiant. Headache, dizziness, weakness, nausea, loss of coordination & judgment, increased breathing rate.
Dichlorodifluoromethane	1.8-2.3	50,000/5000	Eye, mouth, nose, and throat irritation; dizziness, lightheadedness, trouble concentrating. Exposure to high concentrations can cause heart to beat irregularly and stop.
Trichlorofluoromethane	1.1-1.7	28,000/5600	Lightheadedness, dizziness, lung irritation. Exposure to high concentrations can cause heart to beat irregularly.
Toluene	0.88-110	3500/1200	Eye, nose, throat irritation, wheezing; nervous system affects including trouble concentrating, headaches, slowed reflexes. Exposure to high concentrations can cause dizziness, lightheadedness, and fainting; prolonged exposure can cause skin problems and liver, kidney, and brain damage. Potential teratogen.
Ethanol (Ethyl alcohol)	6.7-94	1910/1880	Nose, throat, and lung irritation, headache, drowsiness, nausea, concentration and vision problems. Repeated exposure to high concentrations can affect the liver and nervous system.
Acetone	6.9-55	7800/4800	Skin, eye, nose, throat irritation, wheezing. Exposure to high concentrations can cause headache, nausea, dizziness, lightheadedness, fainting.
Propene (Propylene)	1-9.90	*Simple asphyxiant*	Dizziness, lightheadedness, fainting, lack of oxygen. Prolonged exposure to high concentrations can damage the liver, heart, and nervous system.
Ethyl Acetate	3-210	1400/1440	Skin, eye, nose, throat irritation. Exposure to high concentrations can cause dizziness, lightheadedness, fainting.
Isobutane	3.8-92	23,000/7200	Nose and throat irritation, wheezing. Exposure to high concentrations can cause dizziness, lightheadedness, irregular heartbeat, disorientation.
Trimethylsilanol	2.9-110	*ESL not available*	*Health information not available*
Propane	9.8-36	*Simple asphyxiant*	Headaches, dizziness, lightheadedness, weakness, nausea, coordination & judgment problems, fainting, death.
n-Pentane	3.3-45	4100/7100	Dizziness, drowsiness, headache, nausea, vomiting, fainting, dry/cracked skin.
Compounds detected at 3 project sites	**Concentration range (ug/m3)**	**Short-term/Long-term ESL ug/m3***	**Potential health effects ***
1,2,4-Trimethylbenzene	1-1.4	700/125	Skin and eye irritation, dizziness, lightheadedness, headache, lung irritation, respiratory problems.
n-Hexane	0.81-4.1	5300/200	Skin, eye, nose, throat, lung irritation, skin and eye burning, respiratory problems, headache, nausea, dizziness, lightheadedness, fainting. Prolonged exposure to high concentrations can cause weakness and skin and nervous system problems.
Isoprene	3.1-4.8	60/6	Skin, eye, nose, throat irritation, wheezing, headache, dizziness, lightheadedness, fainting. Possible carcinogen.
Hexamethylcyclotrisiloxane	21-170	*ESL not available*	*Health information not available*
n-Butane	3.7-13	*ESL not available*	*Health information not available*
Dimethylsilanediol	4.8-9.1	*ESL not available*	*Health information not available*
Unknown chemicals	2.7-22	*N/A*	*N/A*
Unknown siloxanes	2.7-27	*N/A*	*N/A*

* Based on 2014 Effects Screening Levels established by the Texas Commission on Environmental Quality to determine potential health exposures during air permitting. See https://www.tceq.texas.gov/toxicology/esl. ** Health information from Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, international chemical safety cards and New Jersey Department of Health, Workplace Health and Safety, Right to Know Hazardous Substance Fact Sheets.

D. Noise Impacts

One of the most common complaints of residents living near oil and gas operations is noise, which can result from truck traffic, drilling and fracturing, engines, flaring, venting, and other activities.

Changes in the level and type of noise may be particularly noticeable in rural or suburban areas, where residents are accustomed to quiet or only a few familiar and intermittent sources of noise.

Much oil and gas development occurs in such areas, including the facilities studied for this project. Compressor stations and processing plants can be constant sources of noise because they are generally in operation both day and night, all week long.

A recent comprehensive review of all available data and measurements of noise levels at oil and gas operations compared the information to various health-based standards, such as those from the World Health Organization.[106] The researchers concluded that modern oil and gas development can cause noise at levels that increase both short- and long-term health risks, including stress, sleep disturbance and deprivation, elevated blood pressure, and heart disease.

Noise is included in the CAA and defined by EPA as a form of pollution.[107] Noise is also regulated on the federal level as an occupational health and safety issue.[108] Many municipalities, counties, and states have established ordinances to limit noise considered to be a nuisance to residents. These may be based on maximum levels or averages over a period of time (i.e., in decibels, or dBA); vary depending on whether the activity is indoors or outdoors; and have such goals as minimizing neighborhood disturbance or preventing adverse health effects.[109]

Several jurisdictions with oil and gas operations have set residential noise limits of 45dBA.[110] EPA recommends a noise level limit of 55 dBA outdoors to protect against. interference with speech and sleep; this standard has been adopted by other agencies, including the Federal Energy Regulatory Commission for interstate pipelines and associated compressor stations.[111]

In **Pennsylvania, DEP has drafted noise regulations for oil and gas operations, but these were not included in the final package of regulations adopted in 2016**; the agency has indicated it will eventually develop guidelines for noise mitigation practices instead.[112] These could potentially include engine and fan silencers, specially designed buildings, sound dampening walls, vegetative buffers, and siting that takes into account wind direction and landscape features (which can effect the way sound travels).

Act 13, passed by the Pennsylvania legislature in 2012, stipulates that local ordinances related to oil and gas operations can not impose noise restrictions more stringent than those for other industrial uses and sets a noise limit for compressor stations and processing plants of "60dBA at the nearest property line or the applicable standard imposed by Federal law, whichever is less."[113] In addition, concerns over noise impacts on wildlife and visitors led the PA Department of Conservation and Natural Resources to issue guidelines for compressor stations on state forestland, with a limit of 55 dBA at 300 feet or further from the building.[114]

Earthworks' Sharon Wilson, Certified Operator of the Forward Looking Infrared (FLIR) camera.

Living with Noise

Given the impacts of noise on health and quality of life, Earthworks collaborated with researchers from Indiana University of Pennsylvania to record noise near the project sites continuously for periods of more than 60 hours.

Most of the noise levels recorded with a sound level meter were in the upper 50-70 decibel (dBA) range, which exceed state and federal standards. The frequent fluctuations in noise levels detected were determined to potentially heighten subsequent disturbances to nearby residents, as higher levels could occur suddenly and intensely and are difficult to adjust to.

This concern is supported by reports from local residents living near the Bluestone processing plant and Trilith compressor station, who told Earthworks that at times they hear very intense noise from the facilities. They assumed that this occurred during blowdowns or increased processing and described the noises as "an airplane taking off," "a constant roar," a sonic boom," and "continuous waves of noise shaking the house." One resident reported that when the noise is particularly intense, he is unable to sleep and experience ear pain and stress.

In addition, residents who track noise outside their house on a daily basis with a hand-held decibel reader reported to Earthworks that they could periodically hear sounds coming from the Bluestone processing plant, which is a half mile away. This seemed to occur most when readings reached 55 dbA or higher. Over the course of over two months, several noise readings reached 60-70 dbA or above.

VI. Findings and Recommendations

Several years into the Marcellus Shale boom, Pennsylvania has become the second largest natural gas producing state in the nation. An expanding drilling industry has given rise to many large gathering, processing, and transmission facilities similar to those investigated for this project.

It is the responsibility of state and federal regulators to protect the public from pollution associated with oil and gas development. The public reasonably assumes that when regulators issue permits to build and operate facilities, those permits don't allow harm to air quality and public health.

Unfortunately, the results of this research project demonstrate that is not the case. The reason is that, to paraphrase Ronald Reagan, regulatory agencies like the Pennsylvania Department of Environmental Protection (DEP) trust oil and gas operators' promises, but they don't verify that those promises are fulfilled.

In order to obtain permits to operate, oil and gas companies promise that they will keep pollution below levels required by the federal Clean Air Act, limiting harm done to regional air quality and the health of nearby communities. But DEP is not doing what's necessary to investigate whether harm is occurring or, even more concerning, to prevent it from getting worse. Instead, DEP takes only the bare minimum steps necessary under federal and state laws to issue and oversee permits, while relying on unverified operator assurances of compliance with the Clean Air Act. In reality, the agency bases its decisions on:

- Multiple applications by companies for frequent capacity and operational changes at the same facility, while still using the same initial, outdated permit.
- Estimated, rather than real-world, measurements of actual pollution impacts on air quality.
- Self-reported pollution estimates developed by operators.
- Operator assertions of adequate air quality that are never examined.

Behind this inadequate approach to permitting is the relentless political pressure to extract ever-more oil and gas. Nevertheless, DEP's mandate is to protect health and the environment, not the oil and gas industry.[115] To do so, DEP must:

- Explicitly incorporate the growing scientific evidence that oil and gas facilities threaten both air quality and people's health.
- Require the oil and gas industry to provide complete and reliable information on their actual operations and air emissions.
- Closely examine unsubstantiated operator assertions on the ground before issuing permits.

In the absence of such changes, oil and gas operators will continue to exploit gaps in the Clean Air Act, and how state regulators enforce it, to their financial advantage—and to the public's detriment.

Our analysis of regulations and industry documents, coupled with air sampling at the project sites, leads to the following findings and associated recommendations.

Finding #1. Deliberately or not, operators and DEP regulators have prevented facilities that likely should have been categorized as "major" polluters under Title V of the Clean Air Act from being so categorized—thereby helping operators to avoid closer government oversight.

For all three facilities we investigated, documents and data indicate that there were compelling reasons for DEP to classify these as "major" sources of pollution. In particular, emission projections always seemed to fall just under Title V thresholds despite extensive facility expansions. In all cases, DEP gave operators the "benefit of the doubt" and never actually examined whether a piecemeal approach to applying for permits was a way to hide plans for expansive, interconnected operations.

As the purpose of the Clean Air Act is to keep air clean, permitting in this fashion is illogical and directly harmful to communities. It not only increases the speed with which permits can be granted, but it also weakens the effectiveness of regulators and regulations, and prevents the public from knowing more about threats to air quality and health.

Recommendations:

- **Information on permitting should be publicly and easily available online in real time.** Readily accessible, updated information is necessary for residents to stay informed, to ensure that regulators adequately enforce the Clean Air Act, and to keep tabs on operator compliance with permits. DEP should post online in an easily accessible format all operator permit and plan approval applications and decisions, pollution estimates, and monitoring and inspection records.

- **Emissions data from the state and operators should be publicly, easily available online in as close to real time as possible.** This information is essential for communities and advocates to hold companies and regulators accountable for regulatory violations and any harm to health caused by operations. Greater transparency will also enable the public to provide information to regulators, in turn facilitating stronger industry oversight and reducing the likelihood that pollution problems will persist for a long time without being addressed.

- **Operators should notify nearby residents every time an emissions release is planned** so they can take steps to protect their health, including consulting medical professionals and using air filters or closing windows.

- **The results of fenceline air monitoring conducted by operators (see recommendation under finding #4 below) should be submitted to DEP on a monthly basis** and made available to the public through an online database. Resources should be budgeted for DEP to develop and run this database, similar to what is currently done for oil and gas production and waste reports.

Finding #2: Large oil and gas facilities continually expand, increase capacity, and change function but are still classified by DEP as "minor" sources of emissions subject to limited regulatory requirements and oversight. Many such facilities have been built and pollute in a relatively small geographical

area without any consideration of cumulative air quality impacts. Yet the basis for this classification is arbitrary, based solely on mathematical calculations that can be, and are, easily and frequently changed.

Nearly 30 years ago the US Environmental Protection Agency (EPA) warned against operators circumventing regulations by seeking multiple minor source operating permits and frequent operational expansions and modifications. In a memo on this issue, EPA stated that, "It is not only improper but also in violation of the Clean Air Act to construct a source or major modification with a minor source permit when there is intent to operate as a major source or major modification. Permits with conditions that do not reflect a source's planned mode of operation are sham permits."[116]

The three facilities examined for this report applied for numerous minor operating and modification permits within a relatively short time, continually requesting expansions of facility capacity and function. Yet DEP did not assess whether these piecemeal modifications prevented adequate environmental review or should trigger major emission threshold evaluations. Nor did DEP consider the impacts of additional operations and growing levels of pollution on nearby communities and households. This pattern seems to fit the definition of what EPA called "sham permits."

Recommendations:

- **DEP should require operators to present comprehensive plans** for the development of interconnected gathering, compression, and processing facilities.
- **DEP should comprehensively examine prior permits and air emission levels** before issuing additional permits whenever it is faced with multiple requests from operators for modifications and expansions to the same facility.
- **DEP should carefully review whether proposed changes in equipment and function would alter a facility's classification**, for example from compression to processing, or would constitute significant operational modifications. This has a direct bearing on whether a facility would be subject to federal pollution control laws, and potentially new state permit conditions, that would reduce methane and VOC emissions
- **When making permit decisions, DEP should review** whether levels of projected and reported emissions from facilities in an area are increasing, which can signify growing risks to local air quality and health.
- **DEP should consider existing sources of air pollution** when deciding whether to allow additional facilities or expansions of facilities—rather than only looking at projected emissions for a single facility in isolation.
- **DEP should examine whether the growing number and capacity of an operator's facilities** in an area warrants a review of previous non-aggregation decisions. Any future pipeline or operational interconnections among facilities should trigger such a review, particularly when an operator proposes a facility or expansion as part of a production, gathering, compression, or processing "complex."
- **DEP should periodically measure actual pollution levels** produced by facilities, including by using third-party verification and without advance notice to the operator.

DEP clearly has the authority to view permit requests more comprehensively. As discussed above, both the EPA's final rule and the DEP's guidance on aggregation underscore the importance of case-by-case analysis based on local air quality considerations.[117]

In addition, in 2008, the Pennsylvania Environmental Hearing Board (EHB) emphasized this fact in supporting the agency's decision that emissions from two parts of the same facility could trigger major source review requirements. EHB concluded that, "The Department must independently consider such factors as the relationship of the various tasks measured in time and space, the tasks' operational, technical, and economic interdependence, whether the tasks are geared toward achieving a shared objective, whether the tasks were conceived originally as part of a common plan, and other relevant considerations."[118]

Finding #3. Reliance on generalized emissions estimates allows operators and regulators to ignore what actually occurs at specific facilities and potential impacts on nearby households. The emissions calculations used to secure permits are

based on manufacturer specifications for equipment, hours of operation, and the volume of gas used. Emissions reported to the DEP inventory are based on similar assumptions and presume perfectly functioning equipment, as well as compliance tests that are scheduled with operators in advance.

Missing from this alternative reality are the real world facts of unplanned releases that result in large volumes of emissions in a short time, as well as leaks or equipment malfunctions that result in numerous small volumes of emissions over a long time.

As discussed above, recent studies indicate that actual pollution near active oil and gas operations is much higher than the pollution operators report to state and federal regulators. In addition, only a limited number of pollutants are included in estimates—in contrast to sampling studies (including the one reported on here) that have found the presence of dozens of chemicals in the air around oil and gas operations.

Recommendations:

- **EPA should develop and adopt leak detection and repair (LDAR) requirements for existing sources of emissions.** The recently adopted New Source Performance Standards (NSPS) for methane covers gas processing plants and compressor stations—but many such large facilities nationwide, like Shamrock, Trilith, and parts of Bluestone, aren't covered because they were built before the rules took effect. Nor are compressor stations permitted before 2012 covered by the NSPS for VOCs—an omission with real consequences for air quality and health that an existing source rule would address.
- **DEP should move quickly to develop and adopt measures that require operators to conduct LDAR** and use effective methane emission controls, both through proposed permit conditions for new sources and regulations for existing sources.[119]
- **State legislators and the Governor should prevent any bills from taking effect that would keep DEP** from developing and implementing air pollution control regulations or requiring oil and gas operators to conduct LDAR, fenceline air monitoring, and other protective measures.

Finding #4. An emphasis on regional and state air quality thresholds ignores localized impacts and emissions patterns. State and federal air emissions monitors are severely limited in the areas where oil and gas operations are rapidly expanding. As a result, many sources of emissions are combined into a single measurement of air quality across a large region, making it difficult to identify local pollution patterns or pinpoint the specific sources of air quality degradation.

These monitoring gaps are made worse by the fact that neither DEP nor oil and gas operators conduct continuous air monitoring at specific facilities or in the surrounding communities. Yet, continuous monitoring is necessary to capture fluctuations in emissions, and to evaluate the human health risks of short-term, intense and long-term, chronic exposures to air pollution. This is borne out by the air sampling that Earthworks conducted for this project, as well as by other studies, which indicate that wind and weather conditions influence the number of chemicals detected and that concentrations of detected chemicals can vary widely at different sampling times.

A federal health agency, the Agency for Toxic Substances and Disease Registry (ATSDR), reached a similar conclusion in a recent air sampling and health impacts investigation near a Pennsylvania compressor station: "Although this study collected 24-hour samples on many dates over a number of months, there remains a lack of continuous ambient air data from all breathing zone exposure points in the community through each season of the year. The sampling… may not have adequately captured uncommon but significant incidents when peak emissions (e.g. unscheduled facility incidents, blowdowns, or flaring events) coincide with unfavorable meteorological conditions (e.g., an air inversion) and downwind placement of active monitoring equipment."[120]

Recommendations:

- **DEP should require modeling of air emissions and patterns of dispersion** of different pollutants as part of permit applications for all gathering, compression, and processing facilities. Certified third party experts should conduct the modeling using scientifically verified methodologies.

- In early 2016, DEP issued a plan to increase the number of air monitors statewide for fine particulate matter (PM2.5), based on evidence that such pollution poses a growing health risk near oil and gas operations.[121] **DEP should continue to expand this monitoring** effort both to additional areas and for other pollutants, in particular VOCs and HAPs.
- Operators of gathering, compression, and processing facilities classified as both synthetic minor and major sources of emissions should be required to **conduct continuous fenceline monitoring** for all the Clean Air Act criteria pollutants and HAPs.

Finding #5. Information provided by operators on emissions is insufficient to reflect the actual risk of health impacts. Operators estimate and report emissions in terms of the *volume of a limited number of pollutants*—the minimum measurement needed to comply with regional and federal air quality standards. However, this is far different than ambient air sampling, which is based on measurements of the concentrations of *a variety of different pollutants*—an approach that is essential to assessing human health exposures.

Recommendations:

- **DEP should regularly assess the results of area and facility monitoring** (which would be conducted through the recommendations in finding #4 above) to bridge the gap between volumes of emissions and concentrations of pollutants. This would help identify patterns and changes in air quality and potential health exposures. For example, consistent detections of chemicals or peak emission events should be used by DEP to require the adoption of more effective air emission control technologies or to restrict the extent or duration of operations.
- **DEP should use both air monitoring and emissions inventory data to make decisions about whether to allow additional expansions** at synthetic minor and major facilities. For example, if the emissions inventory indicates a steady increase in methane emissions over time, DEP should assume that VOCs known to be associated with methane have also increased. In turn, this would indicate the need for permit conditions to limit health-harming emissions more effectively.
- **DEP should give more weight to the complaints of residents regarding odors, noise, and health** symptoms experienced as a result of nearby oil and gas facilities. Complaints should not be disregarded or left undocumented simply because an inspector doesn't smell, hear, or see a problem when he/she is onsite.
- **DEP should follow through with its stated intention to develop comprehensive regulations on noise** near oil and gas operations, based on scientific research and information on associated impacts on health and quality of life.
- **DEP should improve its existing Complaint Tracking System (CTS)** to ensure that complaints records (with personal/private information redacted) are available to the public. This should include information on incidents, environmental and health impacts, how and when DEP employees responded to the complaint, remedial measures taken, and why DEP considers the complaint to be resolved. Complaints should be listed in the CTS by operator and well site or facility (not just geographical location).

Appendix: Applying the Clean Air Act to oil and gas development

A. CAA Basics

Adopted in 1970, the Clean Air Act (CAA) is the comprehensive federal law that regulates air pollution from different types of sources rom different types of sources—area, mobile, and stationary sources. A key aspect of the CAA is its requirement that the U.S. Environmental Protection Agency (EPA) regulate emissions levels for six pollutants:

- Ozone (O3)
- Particulate matter (PM)
- Carbon monoxide (CO)
- Nitrogen oxides (NOx)
- Sulfur oxides (SOx)
- Lead (Pb).[122]

These six "criteria pollutants" are so named because they have enforceable federally set limits called National Ambient Air Quality Standards (NAAQS).[123] NAAQS are supposed to represent safe levels for both human and environmental health, based on established science and an adequate margin of safety. NAAQS are regional standards, concerned primarily with the average levels of pollution across a given area. NAAQS are periodically reviewed and updated in an attempt to reflect the latest science on air pollution and subsequent health impacts for the general population.

Throughout the history of the CAA, NAAQS have steadily been strengthened, reflecting two trends: growing concerns over air quality as traffic, industrial development, and other pollution sources have increased; and the scientific community's continued discoveries that certain types of air pollution are more dangerous than previously thought. For example, the lead standard has been lowered (strengthened) by 90% since it was first established in 1978.[124] Importantly, the ozone standard was recently updated to a maximum of 70 parts per billion (or ppb, i.e., 70 molecules in an air sample of one billion molecules)—down from the 75 ppb standard set in 2008.[125]

Also regulated under the CAA, Hazardous Air Pollutants (HAPs), or air toxics, are considered particularly dangerous for air quality and human health. EPA has developed a list of 187 HAPs; however, associated health-based standards are in place for only some of these.[126] Finally, Greenhouse Gases (GHGs) are partially regulated based on their contribution to global climate instability, and not direct human exposure.[127]

To comply with NAAQS standards and CAA restrictions on HAPs and GHGs, in most instances EPA has delegated authority over permitting and regulating sources of these pollutants to the states. This means that operators of facilities that cause air pollution must receive a "plan approval" permit from a state regulatory agency prior to starting construction. In addition, they must receive a permit to emit air emissions. Air permits can contain pollution limits, restrictions on certain activities, or requirements for the use of specific equipment and pollution control technologies.

Limits on the volume of pollution that facilities are allowed to emit depend on whether the new facility will be built in an area currently meeting the NAAQs. This is called being "in attainment;" places where existing air pollution exceeds the NAAQs have a status of "non-attainment."[128]

B. Major vs. Minor Source Designation

Even though air emission sources receive permits to pollute, the amount and type of pollution they're legally allowed to cause is determined by what's spelled out in permits. The starting point for that decision is whether a pollution source is defined as "major" or "minor," based on the volume of federally regulated pollutants that the source is projected to emit.

Some sources pollute so little that they are exempted from air permitting entirely. For instance, Philadelphia exempts air pollution sources in small residential

buildings.[129] Others, such as power plants, pollute so much that they are unquestionably designated as major sources.

In between these are sources with projected pollution levels near the major source thresholds that are at risk of exceeding them. Many oil and gas compression and processing facilities fall in this group, including the three reviewed for this report. Operators these facilities will often try to stay below the "major source" threshold to avoid triggering the accompanying, more stringent regulatory requirements.

Thresholds

The CAA requires major source designation and permitting for facilities that operators and regulators estimate will pollute at or above established thresholds for one or more pollutants.[130] For the six NAAQS pollutants, the minor/major "default" threshold is 100 tons per year (tpy).[131] Because of their intense impacts on health, projected emissions of more than 10 tpy of a single Hazardous Air Pollutant (HAP), or 25 tpy of all HAPs emitted together, is enough to qualify a facility as a major source.[132]

Operators locating facilities in areas that are in non-attainment for ozone are required to emit lower volumes of VOCs and NOx, the precursors of ozone pollution, than if they were in areas that are in attainment for ozone. Since all of Pennsylvania is part of a region in non-attainment for ozone (the Ozone Transport Region), pollution sources are limited to a maximum of 50 tpy of VOCs.[133]

The major source threshold for GHGs is 100,000 tpy. This limit is higher than for other pollutants because GHGs are generally emitted in much greater quantities. During the permitting process, operators in Pennsylvania estimate their GHG emissions as "Carbon dioxide equivalent" (CO2e), a category that comprises three pollutants: CO2, methane, and nitrous oxide.

Consequences

In the realm of air pollution regulation, "major" and "minor" aren't simply labels, but designations that carry significant consequences. Minor source facilities are subject to less stringent recordkeeping and emissions tracking requirements than are major sources. This means lower costs and workloads for operators—and limited oversight by regulators, reduced documentation and transparency of operations, and weaker protections for the public.

States have considerable discretion in how they permit minor sources of air pollution. For instance, Pennsylvania has exempted an entire class of minor sources in the oil and gas industry—unconventional natural gas wells—from needing air permits.[134] States can also approve minor sources using "general permits" that streamline the application review process through a uniform set of permit conditions and limited public participation.[135]

Facilities designated as "major sources" are subject to many more federal and state requirements and operational criteria. Four key ones are discussed here:

1. Analyzing the potential impact on local and regional air quality and taking measures to prevent further degradation.
2. Obtaining federal Title V operating permits.
3. Using more stringent pollution control technologies.
4. Obtaining emission credits.

1. Air quality impacts analysis

Major sources of air pollutants are subject to certain permitting processes based on whether they are located in a region that meets the NAAQS for those pollutants. If the region is in attainment for all NAAQS, regulators apply the EPA's Prevention of Significant Deterioration (PSD) impacts analysis.[136] If a major source facility will be located in an area not in attainment, regulators have to follow New Source Review (NSR) requirements when reviewing permits.[137]

PSD is designed to ensure that new major sources of pollution will not cause a region's overall air quality to violate the NAAQS. [138] To do this, states establish set amounts of allowable additional pollution, called PSD increments, which are the volumes of pollution above a presumed baseline of air quality that can be emitted without violating the NAAQS. In other words, some degradation of air quality is permitted, but the goal is to stop a "significant deterioration" whereby the region would fall out of compliance

with the NAAQS.[139] Thus, the PSD increments can impose an overall cap on the amount of pollution that can be emitted by the facility; however, if there are not enough increments available, the facility must lower its emissions.

Both PSD and NSR analyses must be conducted before a facility starts operating, i.e., when regulators such as DEP review plan approval applications. Although states can establish their own impacts analyses, in general they conduct both the NSR and PSD impacts analyses according to EPA's non-binding guidelines.[140] The analyses have to include an assessment of existing air quality in the region (also called background air quality) and of potential impacts on surrounding areas.

Modeling impacts

PSD and NSR analyses are the only processes that require operators of oil and gas facilities to assess local conditions and the potential impacts of their operations on air quality and health. This is done using air dispersion modeling, which forecasts air pollution levels surrounding the proposed facility.[141]

Through modeling, operators and regulators can estimate whether a facility will cause air pollution to reach, for example, a nearby school or residential community. Inputs for the models include projected air emissions from the facility; background air pollution levels; meteorological data to account for weather and wind variations; topographical information to account for how hills and valleys affect where air pollution travels; and facility design (e.g., stack height and structures that can determine ground-level concentrations of pollution).[142]

One limitation of air dispersion modeling is that it requires accurate estimates of background air pollution. Often regulators and operators will look to the nearest ambient air pollution monitor for such readings. However, if those monitors are too far away from the proposed facility, they cannot provide an accurate basis for measuring the potential local or area impacts of proposed facilities.

2. Title V permits

Operators of facilities with major source status must obtain federal Title V permits that are based on requirements in the CAA.[143] In contrast to general permits and the analyses that occur at the plan approval stage, Title V permits are operating permits applied for and granted after a facility is already in operation.

Title V permits are based on provisions designed to ensure that facilities meet their obligations spelled out in the plan approval. This generally occurs through monitoring, recordkeeping, and reporting requirements—a much lower level of which is required by the state-only operating permits granted for minor sources.

Even if a facility is deemed a major source because of emissions of just one criteria pollutant, the Title V permit would include requirements to reduce all pollutants emitted by the facility—offering a level of potential emissions reductions that can't be achieved through a general air permit. Finally, although state regulatory agencies implement the Title V program, they must meet minimum standards set by EPA when overseeing relevant facilities.[144]

In addition, the Title V permitting program requires that all of a facility's air regulatory obligations be contained in the permit itself, which eases documentation and transparency of information. In turn, this makes it easier for regulators to ensure compliance and enforcement and for the public to know what facilities are and aren't supposed to be emitting.

The extensive effort it took Earthworks to review documents for the three facilities considered in this report demonstrates the value of Title V permits. The state-only permit files for some of the facilities are hundreds of pages; information on emissions, operations, and regulatory requirements are contained in numerous, separate documents. A Title V permit is a more uniform, single document containing all of this information, which would have greatly streamlined the review. More importantly, this type of documentation would facilitate public engagement and knowledge about facilities that may be impacting air quality, health, and communities.

3. Pollution control technologies

Operators of major emissions sources are required to implement technologies that are more stringent than for minor sources; the technologies required depend on whether or not a facility will be polluting in a non-attainment area (e.g., ozone in Butler County). Operators are allowed to use a variety of sources to identify pollution control equipment, including permits for similar facilities, technical journals, pollution control vendors, and EPA's comprehensive clearinghouse on control technologies.[145]

Best Available Control Technology. In order to limit emissions in "clean" regions that are in attainment for regulated pollutants, the CAA requires major new or modified facilities to use standards known as Best Available Control Technology (BACT).[146] Importantly, even if a facility is a major source for just one pollutant, it must apply BACT standards to control all regulated pollutants that it emits.

BACT requires the maximum achievable pollution reduction. However, BACT is designed to limit pollution, not to dictate exactly how the limit is to be met. Operators therefore have some latitude in determining how to apply BACT. Operators, regulatory and permitting agencies, and environmental advocates may or may not differ on the interpretation of whether technologies are available, applicable, feasible, and cost effective—as well as how to prioritize these factors.

According to the CAA, operators are allowed to take into account "energy, environmental, and economic impacts and other costs . . ." while actual emissions reductions goals can be determined on a case-by-case basis and be achieved through the "application of production processes or available methods, systems, and techniques."[147] In cases where it is difficult to measure emissions, operators can instead adopt certain pollution control technologies, facility design standards, or operational limitations (rather than BACT).[148]

Lowest Achievable Emissions Rate. The inherent flexibility of BACT does not apply to air pollution control requirements in areas that are in non-attainment for regulated pollutants. In such "dirty" areas, facilities that emit non-attainment pollutants above established major source thresholds (discussed above) must meet the stricter Lowest Achievable Emissions Rate (LAER) standard.[149] This standard applies to major emission sources in Pennsylvania, since the entire state is in the Ozone Transport Region and therefore in non-attainment for ozone.[150]

EPA defines LAER as "The most stringent emissions limitation which is contained in the implementation plan of any State for such class or category of stationary source, unless the owner or operator of the proposed stationary source demonstrates that such limitations are not achievable; or . . . [t]he most stringent emissions limitation which is achieved in practice by such class or category of stationary sources."[151] In conducting a LAER analysis, operators cannot take cost into account.[152] Instead, the main constraint on LAER controls is achievability.

Maximum Achievable Control Technology. Hazardous Air Pollutants (also called air toxics) can have a significant impact on air quality and health at lower volumes than other pollutants.[153] As a result, major sources of HAP emissions are subject to air control standards known as Maximum Achievable Control Technology (MACT).[154] While even minor sources of air emissions can be subject to MACT, the standards imposed will be less stringent than those for major sources of the same type.

The CAA defines MACT as "[T]he maximum degree of reduction in emissions of the hazardous air pollutants subject to this section (including a prohibition on such emissions, where achievable) that the Administrator, taking into consideration the cost of achieving such emission reduction, and any non-air quality health and environmental impacts and energy requirements, determines is achievable for new or existing sources in the category."[155]

4. Emissions Reduction Credits

The CAA provides states with some flexibility in how to meet federal air quality standards—including by allowing operators of industrial facilities to use market-based approaches to limit emissions. A key strategy in Pennsylvania and many other states is the purchase of emissions reduction credits (ERCs).[156] ERCs allow operators whose facilities would violate air standards in a given area to offset

excessive emissions by trading or purchasing credits representing pollution elsewhere.

The overarching goal of ERCs is to bring the area into attainment with the NAAQS, so in areas with pollution levels significantly above those standards, the offset ratio will be higher than 1. For example, if a processing plant in a non-attainment area for ozone has an estimated Potential to Emit (PTE, discussed in Section 3C) of 100 tons of NOx, it will be required to purchase ERCs equivalent to 150 tons of NOx.

DEP allows ERCs for all of the criteria pollutants regulated under the CAA (NOx, VOCs, CO, SOx, PM -10 and 2.5, and lead).[157] ERCs can be represented by the shutdown of an existing emissions source, restrictions in capacity or hours of operations, use of new technologies or equipment, or measures to prevent or control actual emissions. [158]

The effectiveness of ERCs in actually reducing pollution is widely debated. ERCs still allow operators to release more pollution in areas where air quality standards already aren't being met. In addition, the volume of emissions to be offset is based on estimates developed for the purpose of obtaining a permit—which may or may not represent actual emissions that will occur after a facility is operational.

Operators may also purchase ERCs for new facilities that are based on pollution created by old facilities, so existing pollution isn't actually being offset. This is the case with Shell's gas ethane processing plant planned for Beaver County, PA, which would use ERCs from nearby coal-fired power plants that have been closed for years—risking that recent achievements in reducing air quality would actually be reversed.[159]

On the other hand, the ERC program forces operators of major sources of emissions to consider impacts on regional air quality and to take steps to reduce pollution that go further than the basic requirements in permits. Operators of large facilities classified as "minor" don't have to take this step, even if they expand capacity and emit emissions at higher levels than initially planned.

C. Calculating Emissions

Whether a facility is classified as a major or minor pollution source, or a Title V facility, depends upon how an operator estimates and reports the pollution released for that facility. Initially, operators have to forecast levels of pollution, or the Potential to Emit (PTE). Operators make their own PTE calculations, which are submitted as part of the permit application to be reviewed by a state regulatory agency.

The PTE is meant to reflect a "worst case" scenario, or the total volume of pollution emitted if a facility is in use every hour of the day, every day of the week, and every day of the year. PTE calculations involve three key steps which can quickly become complicated.

First, operators have to inventory a range of air pollution sources at the planned facility. Most oil and gas compression, processing, and transmission facilities (including those reviewed for this report) have to comply with New Source Performance Standards (NSPS) and National Emissions Standards for Hazardous Air Pollutants (NESHAP) for a range of equipment and processes. Because of this, multiple sources (such as internal combustion engines, boilers, and heaters) are included in PTEs, as well as fugitive emissions (e.g., leaks and venting) of certain pollutants.[160]

However, it is up to the operator to decide whether to include accidental or unplanned emission releases (due to, for example, equipment failures or pressure build up) in the PTE calculations provided to DEP, and if so the number and volume. Even though accidents and unplanned releases are inevitably part of operations, their relative contribution to pollution caused by a facility, if ignored by the operator, may never be considered during the permitting process for a facility.

Second, an operator uses "emissions factors" to estimate the volume of emissions from each source included in an inventory. These factors are a function of the time a source operates and the rate at which it emits a pollutant. Emissions factors are essentially estimates and may be based on unreliable, out-of-date, or variable data. For example, in a recent study of emissions from pneumatic controllers used in oil and gas operations, researchers found that methane emissions from these devices were 17% higher on average than what operators reported to the EPA's inventory of greenhouse gases.[161]

In addition, it is up to operators to decide which emissions factors to use. For example, in one of the plan approval applications for the Bluestone gas processing plant, MarkWest used the manufacturing specifications to estimate VOC emissions for engines, but then used EPA's compilation of emissions factors (known as AP-42[162]) to calculate PM and SOx emissions for the same engines.[163]

Another source of emissions factors is a stack test, which is a direct measurement of the exhaust stream from a comparable source elsewhere. By using stack test data, MarkWest was able to revise downwards the emissions factors for Bluestone. Because emissions can vary considerably even during the course of normal operations, a single stack test conducted over a short period of time (and when the operator had advance warning that the testing would occur) is unlikely to yield an accurate picture of emissions. In comments on the 2013 Bluestone permit, the Group Against Smog and Pollution (GASP) objected to DEP's approval of emissions factors based on one stack test without additional monitoring requirements to ensure compliance.[164]

Third, getting from emissions factors to the total projected emissions for the year requires simple multiplication. For example, the PTE for the 2013 Bluestone gas processing plant application rated inlet compressor engines at 1,480 horsepower and running 24/7/365, or 8,760 hours. Multiplying the 2.5 grams per horsepower per hour (g/hp-hr) emissions factor by the horsepower and the number of hours in a year, and then converting the total into tons, resulted in a PTE of 35.73 tons of VOCs per engine.[165]

Operators can choose which emissions factors to use for different equipment and processes, a selection that can have a direct bearing on calculated PTEs. As discussed in Section 3C with regard to the Bluestone gas processing plant, this is one way in which operators can keep PTEs down for the purpose of receiving air permits.

Operators can also lower PTEs in permit applications by committing to install pollution control devices to reduce emissions. In addition, operators may agree to certain operational limitations, such as the type or amount of fuels used or the number of hours an emissions source will be in use. Operators of facilities with PTEs very close to major source thresholds (including those investigated for this report) will often do this. When a facility is a minor source by virtue of an operational limitation alone, it is called a "synthetic minor" rather than a "true minor."[166] By having facilities designated as synthetic minor, operators can avoid the requirement to conduct a Prevention of Significant Deterioration analysis (discussed above) or being subject to Title V permits.

D. Single Source Determination (Aggregation)

Under the CAA, smaller sources of emissions that are under the control of a single operator and are related or near each other can be considered to constitute a single source of emissions. In other words, their emissions can be aggregated to allow for the regulation of multiple smaller sources that, when concentrated in one area, may actually be as harmful as a single, larger source.

Sections of the CAA related to aggregation review do not apply to oil and gas wells.[167] However, aggregation review requirements do apply to large compressor stations, processing facilities, and other oil and gas infrastructure.

If emissions sources are aggregated, they are subject to regulations (known as Maximum Achievable Control Technology, or MACT) designed to limit pollution to the greatest degree possible. Another critical consequence of aggregation is that it increases the number of sources that an operator has to consider when seeking a permit to pollute, thus driving up the total emissions forecast (known as the Potential to Emit, discussed above).

If emissions from multiple sources are considered, it becomes more likely that "major source" emissions thresholds would be exceeded. When emissions are not aggregated, multiple facilities can operate in an area under separate "minor" source permits. Operators are required to address aggregation when applying for permits for multiple facilities in an area where there are other emission sources already, particularly if the same operator owns them (i.e., there is "common control" according to the CAA).

With oil and gas development expanding nationwide, EPA has come under growing pressure to more clearly define aggregation analysis. Perhaps most hotly debated is the interpretation of two terms: "adjacent" and "contiguous." This question has direct bearing on how oil and gas facilities such as those reviewed in this report are sited and permitted—and therefore how they impact air quality.

Operators prefer a definition based on whether facilities are physically next to or abut each other and argue that if they are located a fair distance apart their emissions should not be aggregated. However, EPA has long asserted that the single source rule relates to emitting equipment both on properties that touch and those that don't but which are nonetheless part of a whole set of operations. According to EPA, "Had we intended 'adjacent' to mean exactly the same as 'contiguous,' we would not have included the word 'adjacent.'"[168]

For many years, EPA and state regulatory agencies have looked at whether physically separate facilities are part of the same overarching operation through the lens of "functional interrelatedness" or "operational dependence." In other words, do the facilities share functions and equipment and rely on the existence of each other to operate?

In 2016, EPA issued a rule that set the distance for determining "adjacency" at a quarter-mile; any newly permitted facilities within this radius and owned by the same operator should be considered as a single source.[169] The rule also effectively set aside the "interrelatedness" and "dependence" lens in favor of "shared equipment" when determining if multiple sources of emissions collectively meet the "common sense notion of a plant."

At the same time, in the final rule EPA maintained its longstanding position that, since air quality issues are complex and variable, state regulators can use their discretion to make case-by-case decisions. EPA clarified that, "States also remain free to adopt more stringent requirements in order to address local air quality concerns." In the case of Pennsylvania, DEP's 2012 guidance on single source determination encourages using a short distance (e.g., a quarter-mile) and direct physical adjacency as the basis for decisions—but it also emphasizes that this is not an absolute view and that decisions can be made "on a case-by-case basis."[170]

In 2015, a Pennsylvania court determined that even if emission sources are not located directly next to each other, they can still be aggregated if they are all part of the same physically connected process.[171] In addition, the state Environmental Hearing Board concluded in 2015 that DEP isn't bound by the quarter-mile limitation and can treat multiple sources as a single facility if it has other reasons for doing so.[172]

Endnotes

[1] "Agreement to enhance regional cooperation and job growth through the continuing development of shale gas in the Appalachian Basin." October 13, 2015. Available at http://www.governor.wv.gov/Documents/Tri%20State%20Summit%20agreement.pdf.

[2] See "Community Health Survey of Current and Former Residents of DISH, Texas,", 2009. http://earthworksaction.org/publications.cfm?pubID=438; "Community Health Survey Results of Pavillion, Wyoming," 2010, http://earthworksaction.org/PR_PavillionHealthSurvey.cfm; *Gas Patch Roulette: How Shale Gas Development Risks Public Health in Pennsylvania,* 2012, http://health.earthworksaction.org; and *Californians at Risk: An Analysis of Health Threats from Oil and Gas Pollution in Two Communities,* 2015, https://www.earthworksaction.org/files/publications/CaliforniansAtRiskFINAL.pdf.

[3] Earthworks 2012. *Breaking All the Rules: The Crisis in Oil and Gas Regulatory Enforcement.* National overview and state-specific reports at http://enforcement.earthworksaction.org; and *Reckless Endangerment While Fracking the Eagle Ford,* Earthworks 2013, https://www.earthworksaction.org/library/detail/reckless_endangerment_in_the_eagle_ford_shale.

[4] See Earthworks' reports *Blackout in the Gas Patch: How Pennsylvania Residents are Left in the Dark on Health and Enforcement,* 2014, http://blackout.earthworksaction.org; and *Wasting Away: Four states' failure to manage oil and gas waste in the Marcellus and Utica Shale region,* 2015, www.wastingaway.earthworksaction.org.

[5] See an overview of Earthworks' Citizens Empowerment Project and infrared videos from oil and gas areas in eight states at https://www.earthworksaction.org/voices/detail/citizens_empowerment_project.

[6] Email from Edward Orris, DEP Northwest Regional Office, to colleagues, January 7, 2011.

[7] MarkWest, May 16, 2013 addendum to the Plan Approval Application submitted for the Bluestone Gas Processing Plant on January 5, 2013.

[8] Project overview, Trilith to Bluestone Pipeline project application submitted to DEP Bureau of Waterways Engineering and Wetlands, December 13, 2013. According to an approval letter from the US Army Corps of Engineers, the project involved laying 7 miles of pipeline, projected to disturb over 80 acres, including 13 wetlands and 12 streams.

[9] Comments regarding Plan Approval PA-26-00588A for Laurel Mountain Midstream LLC's Shamrock Compressor Station, submitted to PA DEP Southwest Regional Office by the Group Against Smog and Pollution, November 26, 2012.

[10] PA DEP, Plan Approval, permit #26-00588, Shamrock Compressor Station, issued to Laurel Mountain Midstream, March 21, 2011.

[11] Laurel Mountain Midstream LLC, plan approval application for the Shamrock Compressor Station, November 2011.

[12] 42 US Code (The Public Health and Welfare), §§ 7408 & 7409; 40 Code of Federal Regulations (Protection of Environment), § 50.

[13] EPA, "Criteria Air Pollutants," https://www.epa.gov/criteria-air-pollutants/naaqs-table

[14] EPA, "Greenhouse Gas Emissions," https://www.epa.gov/ghgemissions

[15] There are gradations of nonattainment. Areas can be in moderate, severe, or extreme nonattainment, which can lead to different regulatory requirements.

[16] EPA Greenbook, *Pennsylvania Nonattainment/ Maintenance Status for Each County by Year for All Criteria Pollutants*, available at https://www3.epa.gov/airquality/greenbook/anayo_pa.html. Butler County was redesignated to "maintenance" for fine particulate matter in 2015, meaning EPA accepted a showing from DEP that the area was meeting the NAAQS for the pollutant.

[17] Regulations for Ozone Transport Regions are in CAA §184. See also EPA, Nonattainment and Ozone Transport Region (OTR) SIP Requirements," https://www.epa.gov/ozone-pollution/nonattainment-and-ozone-transport-region-otr-sip-requirements.

[18] In the context of hazardous air pollutants, the distinction is between major and area sources. For simplicity's sake, this paper generally uses only the major/minor nomenclature.

[19] 42US Code (The Public Health and Welfare), § 7479(1).

[20] 42 US Code (The Public Health and Welfare), § 7412(a)(2). Sources of HAPs with emissions below these thresholds are called "area sources" in the CAA, but here they are simply referred to as minor sources.

[21] For information on non-attainment areas in Pennsylvania, see https://www3.epa.gov/airquality/greenbook/ancl.html#PA.

[22] 40 Code of Federal Regulations (Protection of Environment), §70.2, "Major source" (3)(ii)" and Title 25, PA Code (Environmental Protection), §121.1, "Major facility" (i)(B)": "Fifty TPY of VOCs in an area within an ozone transport region except for a severe or extreme nonattainment area for ozone."

[23]See DEP's General Permits page at http://www.dep.pa.gov/Business/Air/BAQ/Permits/Pages/GeneralPermits.aspx. The permit for natural gas compression and processing facilities is the GP-5, most recently revised in 2015.

[24]MarkWest plan approval application for the Bluestone Gas Processing Plant combustion unit, May 2013.

[25]Keystone Midstream's Bluestone Gas Processing Plant, Permit 10-368A, emissions summary tables in the December 2010 plan approval application and March 2011 plan approval modification application.

[26]Letter from Dan Michaud, MarkWest, to Ed Orris, DEP NW regional office, August 8, 2014.

[27]Comparison of Potential to Emit tables in DEP's January and June 2014 Plan Approval letters for the Trilith Compressor Station.

[28]MarkWest, plan approval application for Bluestone Gas Processing Plant, January 2012.

[29]Laurel Mountain Midstream application supplement for Title V Operating Permit, February 2012.

[30]EPA, "True Minor Source and Synthetic Minor Source Permits," https://www.epa.gov/tribal-air/true-minor-source-and-synthetic-minor-source-permits.

[31]MarkWest, addendum to a State Only Operating Permit for the Bluestone Gas Processing Plant, September 2013. As discussed in Section 3E, the Supreme Court ruled that a facility cannot be a major source by virtue of its GHG emissions alone. However, MarkWest submitted this application prior to the ruling, leaving it vulnerable to be deemed a major source due to its expected GHG emissions.

[32]*Pennsylvania Bulletin* notice for Plan Approval 10-368E from DEP to MarkWest, December 10, 2016.

[33]USEPA, Office of the Inspector General. *EPA Needs to Improve Air Emissions Data for the Oil and Natural Gas Production Sector*. 2013. http://www.epa.gov/office-inspector-general/report-epa-needs-improve-air-emissions-data-oil-and-natural-gas-production

[34]Ibid.

[35]DEP Air Emissions Inventory from Natural Gas Operations, data tables for the unconventional natural gas industry. http://www.dep.pa.gov/Business/Air/BAQ/BusinessTopics/Emission/Pages/Marcellus-Inventory.aspx.

[36]DEP Air Emissions Inventory from Natural Gas Operations, summaries by Source Category. http://www.dep.pa.gov/Business/Air/BAQ/BusinessTopics/Emission/Pages/Marcellus-Inventory.aspx. Unfortunately, the two primary categories of data in the DEP inventory—pollutants and sources—are separated out in the inventory. It is therefore impossible for the public to determine which sources (e.g., venting or tanks) are the source of certain emissions (e.g., NOx or methane). This type of analysis would require an extensive review of DEP data that are available only through Right to Know requests, which was beyond the scope of the current study.

[37]There can be some discontinuity based on whether different sources are counted when developing PTE versus estimating actual emissions.

[38]Aviva Litovitz, Aimee Curtright, Shmuel Abramzon, et al., "Estimation of regional air-quality damages from Marcellus Shale natural gas extraction in Pennsylvania." *Environmental Research Letters,* January 31, 2013.

[39]Some facilities regulated under the New Source Performance Standard (NSPS), National Emissions Standards for Hazardous Air Pollutants (NESHAP), Title V, and other CAA programs are required to use continuous emissions monitoring systems (CEMS). However, CEMS are designed primarily for emissions from stacks and don't monitor for all sources, including leaks and fugitive emissions.

[40]Daniel Zavala-Araiza, David R. Lyon, Ramon A. Alvarez, et al. "Reconciling divergent estimates of oil and gas methane emissions," *Proceedings of the National Academy of Sciences*, December 2015.

[41] Anthony J. Marchese, Timothy L. Vaughn, Daniel J. Zimmerle et. al., "Methane Emissions from Natural Gas Gathering and Processing," *Environmental Science and Technology,* August 2015.

[42]75 Fed. Reg. 31514 (2010), https://www.gpo.gov/fdsys/pkg/FR-2010-06-03/pdf/2010-11974.pdf.

[43]*Utility Air Regulatory Group v. EPA*, 134 S. Ct. 2427 (2014).

[44]Laurel Mountain Midstream, Application for Plan Approval, Shamrock Compressor Station, table on Projected Total Emissions, November 2011.

[45]See Laura Legere, "Court ruling eases curbs on gas compressor plants." *Pittsburgh Post Gazette,* December 2, 2014.

[46]DEP General Plan Approval, table of total emissions from existing and proposed sources, Bluestone Gas Processing Plant, November 6, 2013.

[47]MarkWest, Application for Plan Approval, Bluestone Natural Gas Processing Plant, September 29, 2014; and internal DEP emails (Ed Orris to Staci Gustafson, NW Regional Office) about the application, October 2014.

[48]DEP Plan Approval, Bluestone Gas Processing Plant, June 17, 2015.

[49]*Pennsylvania Bulletin* notice for Plan Approval 10-368E from DEP to MarkWest, December 10, 2016.

[50]DEP memo, Keystone Midstream Services LLC, Single Source/Aggregation Determination: Voll Compressor Station and Sarsen Processing Plant. February 17, 2011.

[51]Letter from Kathleen Cox, Associate Director, Office of Permits and Air Toxics, EPA Region III to Ed Orris, Environmental Engineer Manager, DEP Northwest Regional Office, March 9, 2011.

[52]DEP Plan Approval letter to MarkWest Liberty Bluestone LLC-Voll Compressor Station, GP5-10-367C, April 29, 2013.

[53]Response to Aggregation Questionnaire, Keystone Midstream Services applications for Plan Approval for Bluestone Gas Processing Plant, December 2010; and Plan Approval for KMS #3 Gas Processing Plant, April 2011.

[54]DEP Plan Approval letter to Keystone Midstream Services, air quality permit number 10-368A, early 2011 (file copy omits specific date).application is at http://www.ch.cam.ac.uk/files/posters/Jones(Rod)1.pdf.

[55]MarkWest to DEP, responses to questions on aggregation, Plan Approval Application for Trilith Compressor Station, 2013.

[56]DEP, General Plan Approval/Operating Permit, MarkWest Liberty Bluestone LLC, Trilith Compressor Station No. GP5-10-370C, August 14, 2013.

[57]Emissions estimates are from MarkWest permit application documents obtained by Earthworks in hard-copy file reviews at the DEP regional office in 2016 for Bluestone and Trilith and 2013 for Voll and Sarsen. We did not conduct file reviews for the Royal Oak compressor station. The actual emissions figures are available for all of the facilities in the DEP Marcellus Air Emissions inventory (http://www.dep.pa.gov/Business/Air/BAQ/BusinessTopics/Emission/Pages/Marcellus-Inventory.aspx)

[58]In fact, many compressor stations and natural gas processing plants are major sources.

[59]Letter from MarkWest to Edward Orris, DEP Northwest Regional Office, February 6, 2015.

[60]EPA GasSTAR Partner Reported Opportunities for Reducing Methane Emissions. Fact Sheet No. 103, "Install Electric Compressors." https://www.epa.gov/natural-gas-star-program/install-electric-compressors.

[61]David Picard, Fugitive emissions from oil and natural gas activities," Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change, 2001.

[62]40 Code of Federal Regulations (Protection of Environment), §70.2, Definitions, "Fugitive emissions;" and DEP Air Emissions Inventory from Natural Gas Operations, summaries by Source Category. http://www.dep.pa.gov/Business/Air/BAQ/BusinessTopics/Emission/Pages/Marcellus-Inventory.aspx.

[63]Emissions estimates tables, MarkWest plan approval application for Bluestone Gas Processing Plant, January 2012. MarkWest appears to have revised this VOC estimate soon after, since the plant was never designated as a major source of emissions.

[64]DEP, 2014 natural gas emissions inventory by source type table, http://www.dep.pa.gov/Business/Air/BAQ/BusinessTopics/Emission/Pages/Marcellus-Inventory.aspx#.Vrqj5ZMrJPs.

[65]Laurel Mountain Midstream, site pollutant summary, emission inventory production report to DEP for the Shamrock Compressor Station, 2014. For information on SSM, see EPA's rule for industrial facilities, https://www.epa.gov/air-quality-implementation-plans/startup-shutdown-malfunction-ssm-emissions-industrial-facilities.

[66]Several sets of factors and guidelines exist for calculating fugitive emissions. See for example, those from the EPA (https://www3.epa.gov/ttnchie1/efdocs/equiplks.pdf); South Coast Air Quality Management District (http://www.aqmd.gov/docs/default-source/planning/annual-emission-reporting/guidelines-for-fugitive-emissions-calculations.pdf); the Texas Commission for Environmental Quality (https://www.tceq.texas.gov/assets/public/implementation/air/ie/pseiforms/ef_elfc.pdf); and the Intergovernmental Panel on Climate Change (http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf).

[67]See the EPA page on New Source Performance Standards and Permitting Requirements for the oil and natural gas industry at https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry/new-source-performance-standards-and.

[68]See EPA's chart of sources covered under the New Source Performance Standards and Permitting requirements for the oil and natural gas industry at https://www.epa.gov/sites/production/files/2016-09/documents/sources_covered_2012nsps.pdf.

[69]EPA fact sheet, "Overview of final amendments to air regulations for the oil and gas industry," https://www.epa.gov/sites/production/files/2016-09/documents/natural_gas_transmission_fact_sheet_2012.pdf.

[70]T. Colborn, C. Kwiatkowski, K. Schultz, and M. Bachran. "Natural gas operations from a public health perspective." 2011. *Human & Ecological Risk Assessment* 17(5): 1039-1056.

[71]Physicians, Scientists, and Engineers for Healthy Energy, *Toward and understanding of the environmental and health impacts of shale gas development: an analysis of peer reviewed scientific literature, 2009-2015.* Science summary, April 2016. For a complete overview of the scientific literature, see PSE's citation database at https://www.zotero.org/groups/pse_study_citation_database/items.

[72]Ibid.

[73]Examples of limited state efforts include:

- In 2015-2016, SoCal Gas and the South Coast Air Quality Monitoring District conducted periodic air testing around a massive methane leak from the Aliso Canyon gas storage fiend in southern California. Background and results are at http://www.arb.ca.gov/research/aliso_canyon_natural_gas_leak.htm
- In 2012, the Texas Commission on Environmental Quality conducted limited pollution detection in the Eagle Ford Shale in response to ongoing complaints by residents, but determined that pollution levels were too high for monitoring to be conducted safely. See *Reckless Endangerment While Fracking the Eagle Ford,* Earthworks 2013, https://www.earthworksaction.org/library/detail/reckless_endangerment_in_the_eagle_ford_shale.
- In 2010-2011, the Pennsylvania Department of Environmental Protection conducted what it referred to as "limited air sampling initiatives;" see regional reports at http://www.dep.pa.gov/Business/Air/BAQ/MonitoringTopics/ToxicPollutants/Pages/default.aspx
- In 2012, DEP launched a one-year, continuous monitoring study, the results of which had still not been released at the time of writing. http://www.ahs.dep.pa.gov/NewsRoomPublic/SearchResults.aspx?id=19520&typeid=1.

[74]Carlton, A. G.; Little, E.; Moeller, M.; Odoyo, S.; Shepson, P. B. "The data gap: Can a lack of monitors obscure loss of Clean Air Act benefits in fracking areas?" *Environmental Science and Technology,* 2014.

[75]EPA air quality monitors information page and interactive map, https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors.

[76]DEP, Proposed 2016 Annual Ambient Air Monitoring Network Plan. http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-113091/Proposed%202016%20PA%20Annual%20Monitoring%20Network%20Plan.pdf.

[77]Ibid.

[78]TransCanada. "Blowdown notification." http://www.transcanada.com/docs/Our_Responsibility/Blowdown_Notification_Factsheet.pdf

[79]David Brown, Beth Weinberger, Celia Lewis, and Heather Bonaparte. "Understanding exposure from natural gas drilling puts current air standards to the test." *Reviews on Environmental Health,* 2014.

[80]See, for example, NIOSH Pocket Guide to Chemical Exposures (including recommended exposure limits), Centers for Disease Control and Prevention. www.cdc.gov/niosh/npg/; and "Permissible Exposure Limits," U.S. Occupational Safety and Health Administration. www.osha.gov/SLTC/pel/.

[81]Birnbaum, L.S. "Envronmental Chemicals: Evaluating Low-Dose Effects." *Environmental Health Perspectives*, 120(4) A143-144, 2012.

[82]Vandenberg, L.N., Colborn, T., Hayes, T.B., et al. "Hormones and Endocrine-Disrupting Chemicals: Low-Dose Effects and Nonmonotonic Dose Responses." *Endocrine Reviews* 33: 0000–0000, 2012.

[83]Kassotis CD, Tillitt DE, Lin C-H, McElroy JA, Nagel SC. "Endocrine-Disrupting Chemicals and Oil and Natural Gas Operations: Potential Environmental Contamination and Recommendations to Assess Complex Environmental Mixtures." *Environmental Health Perspectives* 2015.

[84]David R. Brown, Celia Lewis, and Beth I. Weinberger. "Human exposure to unconventional natural gas development: A public health demonstration of periodic high exposure to chemical mixtures in ambient air." *Journal of Environmental Science and Health,* 2015.

[85]Assessment of Joint Toxic Action of Chemical Mixtures. Guidance Manual. Agency for Toxic Substances and Disease Registry. 2004. Available at www.atsdr.cdc.gov/interactionprofiles/ipga.html.

[86]See legal petition pertaining to the US Clean Air Act filed in 2014 by Earthjustice on behalf of over 60 groups nationwide: http://earthjustice.org/sites/default/files/files/OilGasToxicWellsPetition51314.pdf.

[87]See Earthworks' reports: *Gas Patch Roulette: How Shale Gas Development Risks Public Health in Pennsylvania,* 2012, http://health.earthworksaction.org; *Blackout in the Gas Patch: How Pennsylvania Residents are Left in the Dark on Health and Enforcement,* 2014, http://blackout.earthworksaction.org; and *Californians at Risk: An Analysis of Health Threats from Oil and Gas Pollution in Two Communities,* 2015, https://www.earthworksaction.org/files/publications/CaliforniansAtRiskFINAL.pdf.

[88]USEPA, air toxics monitoring methods, TO-15 and TO-3 method papers. https://www3.epa.gov/ttnamti1/airtox.html

[89]Tentatively Identified Compounds are identified by comparing substances detected in a sample against the library of known chemicals that is included with the software used to conduct analysis using the mass spectrometry method. Matches may be found for specific chemicals or for a class of compounds (e.g., hydrocarbons or siloxanes). For more information,

see the USEPA "Frequently Asked Questions" about TICs (2006) at https://www.epa.gov/sites/production/files/2015-06/documents/tics.pdf.

[90]See an overview of Earthworks' Community Empowerment Project and FLIR videos at oil and gas areas in ten states at https://www.earthworksaction.org/voices/detail/citizens_empowerment_project.

[91]Based on 2014 Effects Screening Levels established by the Texas Commission on Environmental Quality to determine potential health exposures during air permitting. See https://www.tceq.texas.gov/toxicology/esl.

[92]New Jersey Department of Health, Workplace Health and Safety, Right to Know Hazardous Substance Fact Sheets on Acrolein.

[93]Carlton, A. G.; Little, E.; Moeller, M.; Odoyo, S.; Shepson, P. B. "The data gap: Can a lack of monitors obscure loss of Clean Air Act benefits in fracking areas?" *Environmental Science and Technology,* 2014.

[94]Based on 2014 Effects Screening Levels established by the Texas Commission on Environmental Quality to determine potential health exposures during air permitting. See https://www.tceq.texas.gov/toxicology/esl.

[95]New Jersey Department of Health, Workplace Health and Safety, Right to Know Hazardous Substance Fact Sheets on Acrolein and Acetaldehyde.

[96]Case studies #1 (Judy) and #6 (Carr), *Blackout in the Gas Patch: How Pennsylvanians are Left in the Dark on Health and Enforcement,* Earthworks 2014.

[97]Southwest Pennsylvania Environmental Health Project, "Summary of Minisink Monitoring Results," 2015.

[98]Agency for Toxic Substances and Disease Registry, Health consultation/Exposure Investigation, Brigich Compressor Station, Washington County PA, 2016.

[99]Colborn, T.; Schultz, K.; Herrick, L.; Kwiatkowski, C. "An exploratory study of air quality near natural gas operations." Human Ecol. Risk Assess. 2014; McKenzie, L.M.; Witter, R.Z.; Newman, L.S.; Adgate, J.L. "Human health risk assessment of air emissions from development of unconventional natural gas resources." Science of the Total Environment 2012; Steinzor, N.; Subra, W.; Sumi, L. "Investigating links between shale gas development and health impacts through a community survey project in Pennsylvania." *New Solutions*, 2013; and Wolf Eagle Environmental Engineers and Consultants. *Town of DISH, Texas ambient air monitoring analysis final report*, 2009.

[100]For example, 1,1,2-trichloro-1,2,2-trifluoroethane, dichlorodifluoromethane, trichlorofluoromethane and chloromethane were once used as refrigerants and propellants but have been phased out due to destruction of the ozone layer. Carbon tetrachloride was used to produce these refrigerants but its production declined as use of the other chemicals was banned.

[101]See Pennsylvania Department of Environmental Protection, Northeastern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report; Northcentral Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report, 2011; and Southwestern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report, 2010.

[102]Carsten Lassen, Charlotte Libak Hansen, Sonja Hagen Mikkelsen, and Jakob Maag. *Siloxanes—Consumption, Toxicity, and Alternatives.* Danish Ministry of the Environment, 2014.

[103]Jhon Arbalaez and Bruce Baizel, *Californians at Risk:* An Analysis of Health Threats from Oil and Gas Pollution in Two Communities. Earthworks 2015. https://www.earthworksaction.org/files/publications/CaliforniansAtRiskFINAL.pdf

[104]David Brown, Beth Weinberger, Celia Lewis, and Heather Bonaparte. "Understanding exposure from natural gas drilling puts current air standards to the test." *Reviews on Environmental Health,* March 2014.

[105]L. Blair Paulik, Carey E. Donald, Brian W. Smith, Lane G. Tidwell, Kevin A. Hobbie, Laurel Kincl, Erin N. Haynes, Kim A. Anderson. "Impact of Natural Gas Extraction on PAH Levels in Ambient Air." *Environmental Science & Technology*, 2015; Steinzor, N.; Subra, W.; Sumi, L. "Investigating links between shale gas development and health impacts through a community survey project in Pennsylvania." *New Solutions*, 2013; and Lisa M. Mckenzie, Roxana Z. Witter, Lee S. Newman and John L. Adgate, Human health risk assessment of air emissions from development of unconventional natural gas resources. *Science of the Total Environment* March 21, 2012.

[106]Jake Hays, Michael McCawley, and Seth B.C. Shonkoff. "Public health implications of noise associated with oil and gas operations," *Science of the Total Environment,* 2016.

[107]US Clean Air Act, Title IV-Noise Pollution. https://www.epa.gov/clean-air-act-overview/clean-air-act-title-iv-noise-pollution.

[108]"Noise and Hearing Loss Prevention," National Institute for Occupational Safety and Health, https://www.cdc.gov/niosh/topics/noise/.

[109]Michael McCawley, "Assessing Environmental Impacts of Horizontal Gas Well Drilling Operations (ETD-10 Project)." Report prepared for the West Virginia Department of Environmental Protection Division of Air Quality, 2013.

[110]See Earthworks' webpage on Oil and Gas Noise, https://www.earthworksaction.org/issues/detail/oil_and_gas_noise.

[111]Federal Energy Regulatory Commission, "Revisions to Landowner Notification and Blanket Certificate Regulations," Order No. 700. 18 CFR Part 157, 2007.

[112]See discussion on noise mitigation requirements, Environmental Protection Performance Standards at Oil and Gas Well Sites, *PA Bulletin*, October 8, 2016. http://www.pabulletin.com/secure/data/vol46/46-41/1757.html

[113]Act 13, Chapter 33, "Local ordinances relating to oil and gas operations," §3304.

[114]*Guidelines for Administering Oil and Gas Activity on State Forest Land.* PA Department of Conservation and Natural Resources, 2013.

[115]The DEP mission statement reads in part, 'The Department of Environmental Protection's mission is to protect Pennsylvania's air, land and water from pollution and to provide for the health and safety of its citizens through a cleaner environment." See www.dep.pa.gov.

[116]Memo from John D. Rasnic, Office of Air Quality Planning and Standards, US EPA to George T. Czerniak, EPA Region V Air Enforcement Branch, June 23, 1993.

[117]EPA, "Source Determination for Certain Emissions Units in the Oil and Natural Gas Sector." *Federal Register,* Vol. 81, No. 107, June 3, 2016; and DEP, Bureau of Air Quality, *Guidance for Performing Single Stationary Source Determinations for Oil and Gas Industries.* Document 270-0810-006, October 6, 2012.

[118]Pennsylvania Environmental Hearing board, United Refining Co. v. DEP, EHB Docket No. 2007-100-L (Aug. 7, 2008).

[119] See "A Pennsylvania framework of actions for methane reductions from the oil and gas sector," January 2016, http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Methane/DEP%20Methane%20Strategy%201-19-2016%20PDF.pdf..

[120]Agency for Toxic Substances and Disease Registry, Health consultation/Exposure Investigation, Brigich Compressor Station, Washington County PA, 2016.

[121] DEP, "Pennsylvania DEP expands particulate matter air monitoring network." Press release, April 27, 2016. http://www.prnewswire.com/news-releases/pennsylvania-dep-expands-particulate-matter-air-monitoring-network-300258482.html

[122]42 U.S.C. §§ 7408 & 7409; 40 CFR § 50.

[123]EPA, "Criteria Air Pollutants," https://www.epa.gov/criteria-air-pollutants/naaqs-table

[124]https://www.epa.gov/lead-air-pollution/table-historical-lead-pb-national-ambient-air-quality-standards-naaqs.

[125]EPA, "2015 Revision to 2008 Ozone National Ambient Air Quality Standards (NAAQS) Supporting Documents," **https://www.epa.gov/ozone-pollution/2015-revision-2008-ozone-national-ambient-air-quality-standards-naaqs-supporting.** [106]Jake Hays, Michael McCawley, and Seth B.C. Shonkoff. "Public health implications of noise associated with oil and gas operations," *Science of the Total Environment,* 2016.

[126]EPA, "Hazardous Air Pollutants," https://www.epa.gov/haps.

[127]EPA, "Greenhouse Gas Emissions," https://www.epa.gov/ghgemissions

[128]There are gradations of nonattainment. Areas can be in moderate, severe, or extreme nonattainment, which can lead to different regulatory requirements.

[129]25 Pa Code § 127.14(a)(4).

[130]40 C.F.R. § 52.21(b)(1)(i).

[131]42 US Code (The Public Health and Welfare), § 7479(1).

[132]42 US Code (The Public Health and Welfare), § 7412(a)(2). Sources of HAPs with emissions below these thresholds are called "area sources" in the CAA, but here they are simply referred to as minor sources.

[133]40 CFR Sec 70.2 "Major source" (3)(ii)" and 25 Pa Code Sec. 121.1.Definitions "Major facility" (i)(B)": "Fifty TPY of VOCs in an area within an ozone transport region except for a severe or extreme nonattainment area for ozone."

[134]In Pennsylvania, unconventional natural gas wells are not required to obtain an air pollution permit. Instead they are exempt as long as operators can demonstrate compliance with a set of exemption criteria, known as Exemption 38; see DEP Air Quality Exemptions, http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-96215/275-2101-003.pdf.

[135]See DEP's General Permits page at http://www.dep.pa.gov/Business/Air/BAQ/Permits/Pages/GeneralPermits.aspx. The permit for natural gas compression and processing facilities is the GP-5, most recently revised in 2015.

[136]Codified in 40 Code of Federal Regulations, § 52.21. See EPA, Prevention of Significant Deterioration, Basic Information page, https://www.epa.gov/nsr/prevention-significant-deterioration-basic-information.

[137]EPA, New Source Review permitting overview, https://www.epa.gov/nsr.

[138]CAA § 165(a)(3); 40 C.F.R. § 52.21(m).

[139]The NAAQS will always take precedence over the PSD increments because they set a ceiling on allowable levels of criteria pollutants.

[140]A key document for PSD and NSR analysis is EPA's 1990 NSR Workshop Manual; see https://www.epa.gov/nsr/nsr-workshop-manual-draft-october-1990.

[141]EPA describes air dispersion modeling at 40 Code of Federal Regulations, part 51, appendix W. EPA recommends that states use the AERMOD modeling, described at https://www3.epa.gov/scram001/dispersion_prefrec.htm.

[142]Known as "building downwash," this phenomenon is a key consideration in air modeling; see EPA's paper at https://www3.epa.gov/ttn/scram/11thmodconf/presentations/3-6_Building_Downwash-CPP-11thMC.pdf.

[143]The Title V program is in the Clean Air Act §§ 502–507. See EPA's information page at https://www.epa.gov/clean-air-act-overview/title-v-permits.

[144]See 40 Code of Federal Regulations, Part 70, State Operating Permit Programs.

[145]EPA Technology Transfer Network, Clean Air Technology Center, RACT/BACT/LAER Clearinghouse, https://cfpub.epa.gov/rblc.

[146]Clean Air Act §165(a)(4). Steps for determining BACT are contained in the CAA Handbook, Chapter Six, "The New Source Review Program: BACT Determination." This is a different than the Reasonably Available Control Technology (RACT) standard required for existing sources in non-attainment areas, through which operators can determine whether an emissions control approach is technologically and economically "reasonable."

[147]40 C.F.R. §52.21(b)(12) (emphasis added). For emissions sources subject to other federal standards for emissions control (such as the National Emissions Standards for Hazardous Air Pollutants), BACT cannot be applied in such a way as to allow for higher emissions.

[148] Ibid.

[149]CAA §173(a)(2).

[150] CAA § 184.

[151]40 Code of Federal Regulations §51.165(a)(1)(xiii).

[152]It is possible that cost considerations could come into play where LAER requires controls that are so expensive the facility cannot be built.

[153]For information on HAPs and their health impacts, see EPA's Hazardous Air Pollutant information page, https://www.epa.gov/haps.

[154]42 U.S. Code, Public Health and Welfare, §7412(d)(2). Minor "area sources" of emissions, which pollute from numerous points across a small area (e.g., gas stations and dry cleaners) are also subject to MACT.

[155]Ibid.

[156]PA Code §127.206, ERC General Requirements; §127.207, Creditable emissions decrease or ERC generation and creation; and §127.209, ERC Registry System.

[157] PADEP, "Certified Emissions Reduction Credits in Pennsylvania's ERC Registry." http://www.dep.state.pa.us/dep/deputate/airwaste/aq/permits/erc/ERC_PA_October_1,2014.pdf.

[158]PADEP, Bureau of Air Quality, "Emission Reduction Credit Registry System." http://files.dep.state.pa.us/air/AirQuality/AQPortalFiles/Permits/erc/ercmain.pdf.

[159]Reid Frazier, "Could Shell's ethane cracker erase recent gains in air quality?" Allegheny Front, September 9, 2016.

[160]Sources subject to the New Source Performance Standards (NSPS) and the National Emissions Standards for Hazardous Air Pollutants (NESHAP) must include fugitive emissions in PTE calculations. See The Clean Air Act Handbook, Chapter 6 on The New Source Review Program: Applicability to New Sources (Julie R. Domike & Alec C. Zacaroli eds., 4th ed. 2016).

[161]Allen et al., "Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Pneumatic Controllers,' Environmental Science and Technology, 2014.

[162]EPA, "AP-42: Compilation of Air Emissions Factors." https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emission-factors ."

[163]MarkWest plan approval application for the Bluestone Gas Processing Plant combustion unit, May 2013. The AP-42 compilation can be found at https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emission-factors.

[164]Comments on MarkWest Bluestone Gas Processing Plant Operating Permit #10-00368, Group Against Smog and Pollution, November 4, 2013.

[165]MarkWest plan approval application for the Bluestone Gas Processing Plant combustion unit, May 2013.

[166]EPA, "True Minor Source and Synthetic Minor Source Permits," https://www.epa.gov/tribal-air/true-minor-source-and-synthetic-minor-source-permits.

[167] See explanation of this loophole and legislative efforts to close it at https://www.earthworksaction.org/issues/detail/Attempts_to_Close_Loopholes_for_Polluters.

[168]EPA, "Source Determination for Certain Emissions Units in the Oil and Natural Gas Sector." Federal Register, Vol. 81, No. 107, June 3, 2016.

[169]Ibid. This rulemaking was the result of a lengthy legal and administrative process that originated with the 2012 US District Court Case *Summit Petroleum v. EPA*, in which the Sixth Circuit determined that "adjacency" meant physical proximity, not functional interrelatedness. http://www.opn.ca6.uscourts.gov/opinions.pdf/12a0248p-06.pdf.

[170]DEP, Bureau of Air Quality, *Guidance for Performing Single Stationary Source Determinations for Oil and Gas Industries.* Document 270-0810-006, October 6, 2012.

[171]David Loring, "Aggregation Update: Oil & Gas Industry Permitting Under Heightened Scrutiny in 2015," *National Law Journal,* April 1, 2015. The case was *Citizens for Pennsylvania's Future v. Ultra Resources*, *Inc.,* tried in the District Court for the Middle District of Pennsylvania, 2015.

[172]Pennsylvania Environmental Hearing Board, *National Fuel Gas Midstream, et al. v. Commonwealth of Pennsylvania*, EHB Docket No. 2013-206-B.