

# Blackout

## in the Gas Patch CASE STUDY



**PAM JUDY** Carmichaels, Greene County PA

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<http://blackout.earthworksaction.org>

## Summary

The area where Pam Judy lives is a poster child for how dense natural gas development can be in Pennsylvania. Pam and her husband built their house in 2006 on property that once belonged to her great grandparents and remained part of the family farm—but over the years the gas industry has changed Carmichaels and surrounding towns dramatically. Today, there is a large compressor station 900 feet from the Judy home and more than 35 drilled and producing wells within one mile.

Our research shows that there are very plausible reasons why air quality has been compromised and contributes to the health problems that the Judy family experiences. In 2011, the top two facilities for emissions of coarse particulate matter in Pennsylvania were gas wells located within about one mile of the Judy home. Five gas wells located at that distance emitted enough (CO), nitrogen oxide (NOx), coarse particulate matter (PM10), and sulfur oxide (SOx) to essentially be the equivalent of a second compressor facility.

Noise, odors, and traffic have diminished many of the benefits of country life, but Pam, her husband, and their two children have been most concerned about their health. They have often felt tired and had headaches, runny noses, sore throats, and muscle aches. Pam has had bouts of dizziness and vomiting, and both children had frequent nosebleeds before they moved away.

Soon after the Judy family moved to Carmichaels, they became one of the first high-profile cases of health problems in Pennsylvania's gas fields and helped to raise awareness among neighbors, policymakers, and the general public. Pam has filed odor, noise, and air quality complaints with DEP, spoken out at town meetings, written to state and federal officials, and shared her story with the media.

Because of Pam's persistence, in 2010 DEP conducted air testing near her home. Results revealed the presence of a cocktail of chemicals with known short- and long-term health effects, including carcinogens like benzene, toluene, and xylene. Earthworks' air testing at the Judy home in 2011 and 2013 also detected chemicals associated with the kinds of health symptoms reported by the family.

Taken together, emissions and events at nearby wells and facilities illustrate the myriad of impacts that gas operations can have on air quality and health. Yet DEP hasn't made a connection between the rapid expansion of gas wells and facilities in the area and the ongoing complaints made by the Judy family and their neighbors. It isn't clear whether this has had to do with time and resource constraints, the information and training given to inspectors, a lack of additional air testing, or other factors.

**For more about Pam Judy's experiences and fight, see:**

**Gas Rush Stories, Part 5: A Neighbor**

<http://vimeo.com/34688894>

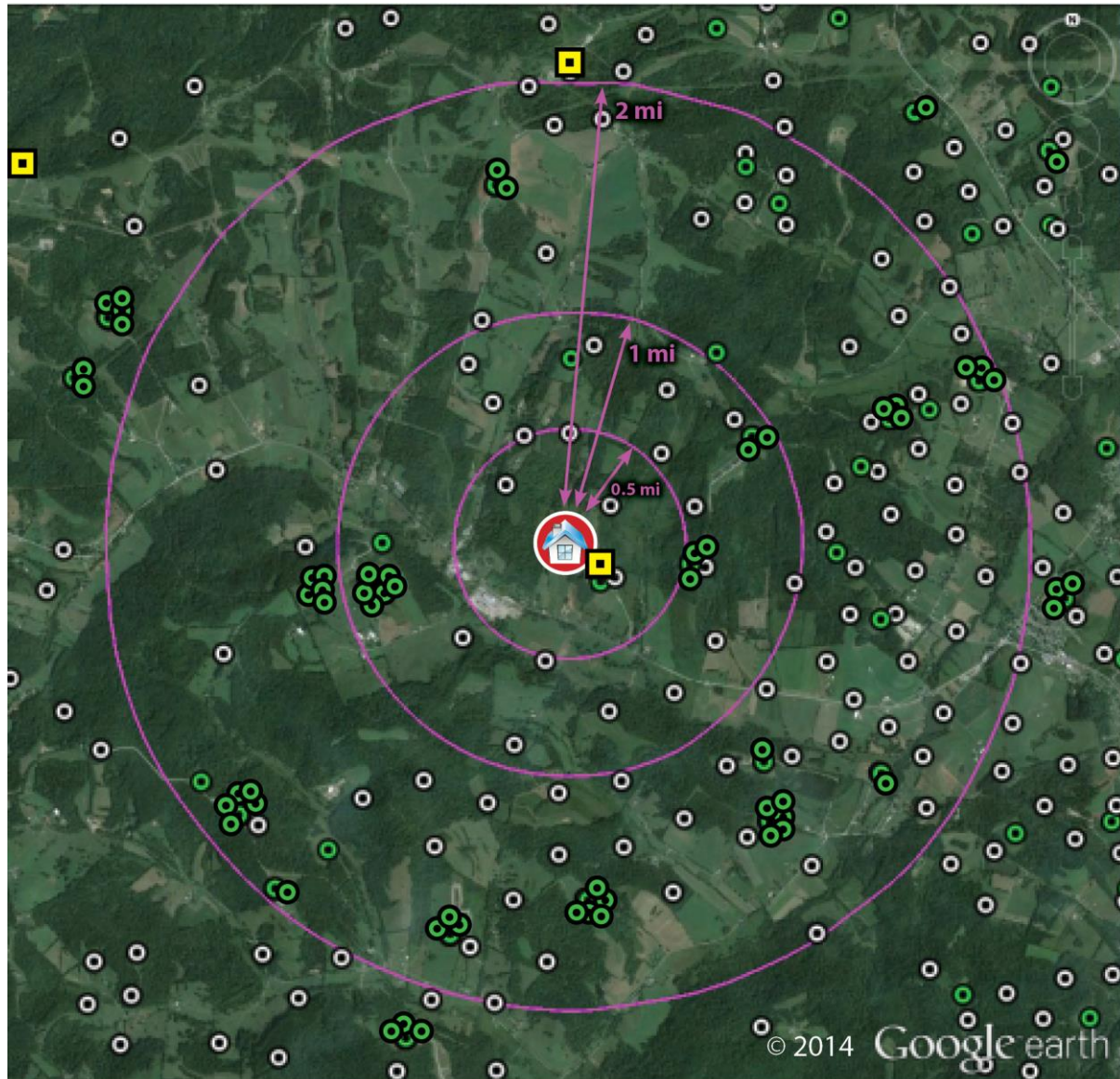
**Pam's story in her own voice at Earthworks**

[http://www.earthworksaction.org/voices/detail/pam\\_judy](http://www.earthworksaction.org/voices/detail/pam_judy)







# Wells and Facilities Around the Judy Home

The Judy family's home is surrounded by gas operations, with a compressor station and 16 unconventional and 21 conventional wells within one mile. The closest well is 0.21 miles away and the Cumberland/Henderson compressor station is just 0.16 miles away. An additional 116 wells and other oil and gas facilities are located between 1-2 miles of the Judy's home. Although oil and gas development has been underway in the area since 1982, 20 of the wells within one mile were drilled and the compressor station was built after the Judy family moved to the area in 2006.



KEY

-  Unconventional gas well
-  Conventional gas well
-  Compressor station
-  House



## Inspections and Violations

DEP has done a poor job of inspecting gas wells in the part of Greene County where the Judy family lives. Table 1 shows the number of oil and gas well inspections conducted at wells close to the Judy home (within one mile). Nearby unconventional wells have received less attention from DEP than the average for the 485 wells that we examined for the report issued at the same time as this case study, at approximately 3 inspections each compared to an average of 5.1 in the larger study.<sup>1</sup> Conventional gas wells near the Judy home were inspected even less, at an average of 1.8 inspections per well—and 10% have never been inspected. The fact that violations have been issued at several conventional wells in the area points to the strong possibility that problems may have occurred elsewhere that were never discovered or documented.<sup>2</sup>

**Table 1. Inspections at wells within one mile of Pam Judy’s home (through March 25, 2014)**

	Unconventional wells	Conventional wells
Number of drilled wells	16	21
Number of Inspections	52	38
Average inspections per well	3.3	1.8
Wells with zero inspections	0	2
% wells with zero inspections	0	10
Complaint inspections	8	1

Within one mile of the Judy home, DEP conducted inspections in response to citizen complaints at one conventional well (Decker 1) and three unconventional wells (Henderson/King 2MH, Phillippi 1 MH, and V Virgili 1). One of those inspections resulted in DEP finding a violation and issuing a penalty. To date, five violations have been issued at four wells within one mile of the Judy home, as well as at the compressor station; at a distance of two miles, 20 violations were issued at 13 wells. (See events timeline below for details.)

Between 2007 and 2014, DEP conducted 16 inspections at the Cumberland/Henderson compressor station, two of which followed citizen complaints. It is impossible to know what issues or incidents may have spurred the inspections, as only 7 of the 16 related reports were in the hard copy files we reviewed. All reports related to inspections spurred by citizen complaints were missing and DEP denied our Right-to-Know request to obtain them. However, records from DEP’s Complaint Tracking System (CTS) include several entries for odor and erosion and sedimentation problems at an Energy Corp facility in Cumberland Township, which is likely the same compressor station near the Judy home.

## Events Timeline

The following events related to natural gas development occurring within one mile of the Judy family's home have been compiled from DEP inspection reports and other documents available through file reviews, records in the Oil and Gas Compliance Database, and other information provided by residents. Given that some inspection reports were missing from files and other documents are unavailable to the public, this timeline is not necessarily complete.

### Events related to natural gas development within one mile of the Judy home

Date	Event
12/20/05	<b>Henderson 2:</b> A DEP drilling inspection finds a problem with the well, noting that, "Well blew out much gas at 1802'...will need to be redrilled deeper."
5/27/06	<b>Henderson 2:</b> A DEP drilling inspection finds a problem with the well, noting that, "Hole filled back in at 925'. Operator unsure whether to continue or possibly plug."
4/5/07	<p><b>Phillippi 9:</b> A DEP inspector finds problems at the site, including "Blowing well off to air, ground, equip, bench, tank. Housekeeping practices questionable. Hillside covered w/ drift of oil &amp;/or brine." A violation is issued to Energy Corp of America for discharge of polluttional material to waters of the Commonwealth.</p> <p><b>Martinez 2:</b> A DEP inspection report indicates that the well is "Blowing brine oil to hillside, tank equipment, bench. Bench/tank area with coating of oil residue." A violation is issued to Energy Corp of America for discharge of polluttional material to waters of the Commonwealth.</p> <p>According to inspection reports, the sprayed oil was cleaned up at both sites by the time of the next DEP visit (4/16/07).</p>
11/2/09 – 3/31/10	<b>V. Virgili 1:</b> According to inspection comments in DEP's Oil and Gas Compliance database, in November 2009 DEP conducts a complaint inspection at this site. In March 2010, DEP returns and inspects the well as part of an investigation following a water complaint. DEP closes the complaint, noting that, "the gas well drilling process did not appear to impact these 2 particular water wells on the adjacent property."
10/30/09	<b>Henderson/King 2MH:</b> DEP conducts an inspection due to a "Complaint in regards to odors originating at the fresh water impoundment," but determines that no action is needed because "The Department did not observe any odors at the time of this inspection. The Department did observe possible pollution concerns at the site."
11/16/09	<b>Henderson/King 2MH:</b> DEP conducts an inspection because a "Neighbor was concerned about odor from frac pit," but determines that no action is needed because "There was no odor at the time the well was inspected. I called the neighbor and she agreed that the odor was gone."

11/18/09	<p><b>Henderson/King 2MH:</b> A DEP inspector notes in a report that at 8:30 am, “Water trucks are pumping water into pit. Water smells like frac water.” But at 3:00 pm, another inspection occurs “after receiving a complaint in regards to odors originating at the fresh water impoundment. The Department did observe strong sulfur odors originating from the impoundment at the time of this inspection. The impoundment was leaking and in need of immediate attention. Samples were taken of the water seeping out of the hill below the pit.”</p> <p>DEP concludes that the pit liner was torn and the integrity of the impoundment compromised, resulting in wastewater leaking into the ground and posing a danger of water pollution. Two violations are issued related to §78.54, 78.56, and 78.57 of the Pa. Code on the stability and impermeability of impoundments and the potential of polluting waters of the Commonwealth. A Consent Agreement of Civil Penalty is reached on 10/12/2010 and Energy Corp of America is fined \$19,950.</p>
12/10/09	<p><b>Henderson/King 2MH:</b> DEP conducts a compliance inspection following the violations issued the previous month. The inspector notes that the pit has been drained and the site was being re-graded, but that weekly erosion &amp; sedimentation inspections are needed until the site is stabilized. DEP does not appear to have conducted another inspection at the site for nearly two years; an inspection report from 10/14/2011 is classified as for drilling or alteration but notes both that the “well is complete and producing” and that the “site is restored.” (The next inspection at this site wasn’t for nearly three years, on 6/9/14.)</p>
11/30/11	<p><b>Cumberland/Henderson Compressor Station:</b> According to a complaint record, Pam Judy files a complaint with DEP stating that upon returning home in the evening, both she and her husband could smell a strong odor of natural gas. One week later, a DEP investigator visits and concludes that no action is needed since, “no gas odors were detected near complainant’s house or at the compressor station.”</p>
12/21/11	<p><b>Cumberland/Henderson Compressor Station:</b> According to a complaint record, Pam Judy files a complaint with DEP stating that upon returning home in the evening, she could smell a strong odor of natural gas; she noted that the odors lasted for at least three hours and “you can’t breath outside.” The case was apparently assigned to an inspector, but no DEP response was noted in the record.</p>
1/19/12	<p><b>Cumberland/Henderson Compressor Station:</b> According to a complaint record, Pam Judy files a complaint with DEP about natural gas and “finger nail polish” odors that were “so potent it literally hit your face.” Neither the assignment of the case nor the DEP response was noted in the record.</p>
1/31/12	<p><b>Meadows 1MH:</b> DEP conducts an inspection because the site should have been restored by this time (i.e., 9 months after the last well was completed). The inspector notes there’s still an open pit on the well pad containing drill cuttings and that terms of the erosion and sedimentation permit haven’t been followed. A violation is issued to Energy Corp of America for failure to restore the well site. Because the well restoration report was missing from the file we reviewed, it isn’t possible to know when or how this violation was resolved.</p>

05/08/12	<b>Cumberland/Henderson Compressor Station:</b> According to DEP’s database eFACTS, DEP conducts a complaint inspection. Because the inspection report was missing from the file we reviewed, it isn’t possible to know what the complaint was related to or how DEP responded.
10/26/12	<b>Cumberland/Henderson Compressor Station:</b> DEP conducts an inspection classified as routine, although the inspection report notes it is specifically to check for malodors and visible emissions so may have been related to resident complaints. The inspector notes, “I did not observe any visible emissions. I also did not detect any malodors.”
03/7/13	<b>Cumberland/Henderson Compressor Station:</b> DEP conducts an inspection in response to a complaint. A Consent Agreement of Civil Penalty is reached on 10/7/13 and Energy Corp of America is fined \$4,500 for “Failure to submit adequate source reports in a format specified by the Department.”
10/21/13	<b>Gas odors in and around the house</b> prompt Pam Judy to file a complaint with DEP. The local fire department inspected and confirmed odors. A DEP employee tells Pam he’s waiting to talk to Energy Corp about any problems at the site before coming out, and that the smell was probably coming from her propane tanks (which weren’t in use at the time). Pam calls the National Response Center, which sends a Utility Commission inspector out—who confirms the odors and says that particulate matter could be settling in the Judy’s crawlspace and causing odors. <sup>3</sup> DEP never investigates.

## Water Quality

In 2013, the Times-Tribune published DEP data on complaints filed by residents who suspected oil and gas drilling activities polluted or diminished the flow of water to their drinking water wells, which FracTracker then compiled in a map.<sup>4</sup> According to the data, there were three water complaints involving concerns of water pollution and diminution at a location 2.1 miles from the Judy home (in 2008 and 2010), as well as two complaints about water diminution (in 2009 and 2012) at a site located 2.58 miles from the Judy home. DEP did not establish causality in any of these cases.<sup>5</sup>

However, the available data doesn’t necessarily give a complete picture of potential water contamination concerns in in Cumberland Township. For example, the information that DEP provided to the Times-Tribune was missing the water complaints related to the V. Virgili well located 0.8 miles from the Judy home. In addition, records obtained from DEP through a Right-to-Know request indicate there were 15 suspected cases of water supply impacts from gas development in Cumberland County between 2008 and 2010, but DEP provided Times-Tribune with information on just three related cases. Even if some of these complaints were for the same case, this is a large discrepancy.<sup>6</sup>

Pam Judy has indicated that her home is connected to public water, but that the supplier has issued advisories and boil water notices due to elevated levels of trihalomethanes. Although we did not research the source of that problem in the local water supply, it is worth noting that elevated levels of trihalomethanes (a byproduct of water disinfection) have being associated with gas drilling, due to the interaction of chlorination and bromides in the wastewater run through municipal water treatment plants.<sup>7</sup>



## Air Quality

The Judy family and other residents have good reason to worry about emissions from large facilities such as compressor stations, which are noisy and often connected with odor events. But in some cases, nearby gas wells can emit more pollution on a yearly basis than compressor facilities. This fact, combined with the density of well development, means that even “regular” operations can have a very detrimental, cumulative impact on air quality and health.

According to data in DEP’s annual emissions inventory, the two natural gas facilities that emitted the most particulate matter in Pennsylvania in 2011 were not large compressor stations, but gas wells—both of which were located within about one mile of the Judy home. The majority of coarse particulate matter (PM10) emissions from these wells (Cree 6MH and Phillippi 1MH) occurred during drilling and well completion.<sup>8</sup> Of the top 12 oil-and-gas-related emitters of PM10 in Pennsylvania in 2011, six (five wells and a compressor station) were located within 1.6 miles of the Judy residence.<sup>9</sup>

As seen in Table 2, unconventional wells and a compressor station near the Judy home emit a variety of contaminants into the air. Of particular concern with regard to health are the large volumes of particulate matter (as PM2.5 and PM10) and volatile organic compounds (VOCs), as well as hazardous air pollutants (HAPs) such as benzene, formaldehyde, and toluene. A recent study underscores that when people are exposed to multiple chemicals such as particulate matter, VOCs, and HAPs, the dose can increase synergistically, with a greater health effect felt than if these contaminants were inhaled separately.<sup>10</sup>

While in general the closer to the source of pollution (e.g., a well or compressor station), the greater the potential for exposure to contaminants and the likelihood of impacts to health, there is no scientifically definitive distance at which air contaminants cause health impacts, nor an established distance beyond which they would never occur. It is therefore possible that the Judy family and their neighbors are also exposed to emissions from the two other compressor stations and at least 20 wells located within 2.5 miles from their home.

**Table 2. Emissions (in tons per year) from unconventional wells and a compressor station within one mile of the Judy home (DEP’s annual emissions inventory, 2011)**

Facilities in emissions inventory	CO	NOx	PM10	PM2.5	SOx	VOC	Benzene	Ethyl-benzene	Formaldehyde	n-Hexane	Toluene	Xylene	2,2,4-trimethyl pentane
5 wells within 1 mile of Judy	44.7	167.0	15.7	2.4	0.1	7.2	0.05	0.03	0.04	0.04	0.03	0.02	0.01
1 compressor station within 1 mile	33.3	61.5	6.0	6.0	0.00	13.3	0.14	0.03	0.46	0.24	0.11	0.07	0.07
Total of all facilities within 1 mile	78.0	228.5	21.7	8.4	0.1	20.5	0.18	0.06	0.50	0.28	0.14	0.08	0.08

DEP’s Environment Facility Application Compliance Tracking System (eFACTS) provides annual emissions information for major facilities in the state.<sup>11</sup> As seen in Table 3 below, if taken as one facility, the emissions from the five wells within one mile of the Judy home cumulatively emitted more CO,

NOx, PM10, and SOx than the Cumberland/Henderson compressor station located 0.16 miles away. At the same time, 23 wells located within two miles of the Judy home emitted more CO, NOx, PM10, SOx, VOCs, and ethylbenzene than the Cumberland/Henderson compressor station. For its part, the compressor station was among the top five industrial facilities in Greene County with regard to emissions of NOx and benzene.

Table 3. Natural gas facilities near the Judy home in comparison to top emitters in Greene County (eFACTS, 2011)

Rank	CO	NOx	PM10	SOx	Benzene
1	Hatfields Ferry Power Station	Hatfields Ferry Power Station	Hatfields Ferry Power Station	Hatfields Ferry Power Station	Hatfields Ferry Power Station
2	Bailey Coal Prep. Plant	Bailey Coal Prep. Plant	Bailey Coal Prep. Plant	Bailey Coal Prep. Plant	Jupiter Comp Sta
3	Holbrook Compressor Station	5 wells near Judy home	5 wells near Judy home	Whitley Coal Plant	Holbrook Compressor Station
4	5 wells near Judy home	Holbrook Compressor Station	Whitley Coal Plant	Holbrook Compressor Station	Cumberland/Henderson Compressor Station
5	Pratt 47	Cumberland/Henderson Compressor Station	Holbrook Compressor Station	5 wells near Judy home	5 wells near Judy home



Table 4 shows that emissions of most chemicals from the nearby wells decreased in 2012. The only reported sources of CO, NOx, PM2.5, PM10, SOx, and formaldehyde from wells within one mile of the Judy home were drill rigs, well completions, and heaters.<sup>12</sup> It appears that because of this, the drilling and completion of fewer wells in 2012 resulted in lower emissions of these chemicals that year from wells near the Judy home. As seen in the chart below, the Cumberland/Henderson compressor station had lower emissions of CO, NOx, particulate matter, and most VOCs in 2012 than in 2011, but emissions of toluene and 2,2,4-Trimethylpentane increased and xylenes did not change.

**Table 4. Comparison of 2011 and 2012 emissions (in tons per year) within 1 mile of the Judy home (DEP annual emissions inventory)**

	Year	Number of wells	Number of wells drilled or completed	CO	NOx	PM10	PM2.5	SOx	VOC
<b>Wells</b>	2011	5	4	44.68	167.03	15.71	2.45	0.08	7.21
	2012	5	0	0	0	0	0	0	1.49
<b>Compressor</b>	2011	N/A	N/A	33.33	61.50	5.98	5.98	0	13.25
	2012	N/A	N/A	12.92	51.48	5.59	5.59	0	11.65

In 2011 and 2013, Earthworks conducted air canister testing outside the Judy home. In 2011, 10 gas wells had been drilled and/or stimulated (e.g., hydraulically fractured) within one mile of their home (and 19 total within two miles).<sup>13</sup> The Cumberland/Henderson compressor station was also in operation.

As seen in Table 5, this testing detected several VOCs known to be associated with gas development, including acetone, benzene, ethylbenzene, methane, and toluene, as well as HAPs. Known as toxic air pollutants or air toxics, HAPs cause or may cause cancer or other serious health effects, such as reproductive problems or birth defects, or adverse environmental and ecological effects, and are regulated by the United States Environmental Protection Agency.<sup>14</sup> According to DEP, some of the VOCs found near the Judy home are present in ambient air because they were once widely used and persist in the atmosphere, but others (e.g., acetone, benzene, propene, and toluene) are likely related to Marcellus shale activities.<sup>15</sup>

The number of chemicals detected and the concentrations of most chemicals were lower in our 2013 canister tests than the concentrations found in 2011. This is not surprising, since the majority of drilling and well stimulation occurred in the area between 2009 and 2011. Five more wells were drilled or fracked within two miles of the Judy home in 2012, but none in 2013. In addition, Pam Judy’s own research (including a file review) and persistence with DEP about emissions from the Cumberland/Henderson compressor station resulted in re-permitting of the facility in November 2011, which included the installation of additional emissions controls (oxidation catalysts and flare units).

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**Pam's research and persistence with DEP resulted in re-permitting of the compressor station, which included installation of additional emissions controls.**

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The Earthworks canister samples were taken during time periods when the Cumberland/Henderson compressor station was operating “normally.” Compressor stations occasionally undergo maintenance or emergency situations where they are “blown down,” which means they vent gas directly to the atmosphere. During these relatively short periods of time nearby residents may be exposed to much higher concentrations of chemicals than is typical. Unfortunately, there is no requirement for operators of compressor stations to monitor concentrations of chemicals at nearby residences during blowdowns. Without this information, it is not possible to fully assess the potential health effects related to emissions from compressor stations.

**Table 5. VOCs (including methane) detected in ambient air near the Judy home (Earthworks canister sampling)**

Concentrations are in micrograms per cubic meter (µg/m <sup>3</sup> )	Oct. 12, 2011	June 21, 2013	July 13, 2013	Aug. 17, 2013	Sept. 15, 2013
1,1,2-Trichloro-1,2,2-trifluoroethane	0.72	0.57	0.62	0.59	0.64
2-Butanone		1.8	--	--	--
Acetone		28	--	--	7.5
Benzene	0.36	--	--	--	--
Carbon tetrachloride	0.62	0.61	0.66	0.61	0.51
Chloromethane	1.2	0.95	0.95	0.95	0.95
Dichlorodifluoromethane	2.8				
Ethylbenzene	0.27	--	--	--	--
Methane	--	2.2	--	8.3	--
Methylene Chloride	2.3	--	--	--	--
Tetrachloroethylene	0.56	--	1.1	--	--
Toluene	0.86	0.59	--	--	--
Trichloroethylene	0.44	0.11	0.15	--	--
Trichlorofluoromethane	1.6	1.5	1.5	1.4	1.3
<b>Total number of VOCs detected</b>	<b>11</b>	<b>9</b>	<b>6</b>	<b>5</b>	<b>5</b>

Blank cell: not analyzed by lab

-- indicates contaminant not detected

→ **For the full report and other case studies go to <http://blackout.earthworksaction.org>**

Photos on page 1: (TOP) Mark Schmerling; (BOTTOM L-R): Frank Finan for the first three, Nadia Steinzor/Earthworks photo at right



# Endnotes

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<sup>1</sup> Earthworks. *Blackout: How Pennsylvania Residents are Left in the Dark on Health and Enforcement*. 2014. <http://blackout.earthworksaction.org>.

<sup>2</sup> In the past decade, violations have been issued at two conventional wells within one mile of the Judy home (Phillippi 9 and Martinez 2) and at five conventional wells between 1 and 2 miles away (Fuller 2, Groves 8, William Bartholomew 1, William Bartholomew 2, and Lochmiller 1).

<sup>3</sup> The potential for dust and particulate matter to trap and transport odors is well-documented, including with regard to industrial agricultural operations. See for example Robert W. Botcher, "An Environmental Nuisance: Odor Concentrated and Transported by Dust." *Chemical Senses*, Vol. 26, No. 3, 2001.

<sup>4</sup> Scranton Times-Tribune, May 19, 2013. "Gas Drilling Complaints Map." <http://thetimes-tribune.com/news/gas-drilling-complaints-map-1.1490926>.

<sup>5</sup> We mapped the complaint locations and distance from the Judy home using GIS coordinates provided by the Times-Tribune on their web site and the [BatchGeo.com](http://BatchGeo.com) mapping program.

<sup>6</sup> The Times Tribune site contains information on three complaint inspections in Cumberland Township (Greene County): Letter [398](#), letter [399](#) and letter [400](#). Clean Air Council received complaint records from DEP through a RTK request indicating 15 separate complaints in Cumberland Township between 2008 and 2010 and shared this information with Earthworks.

<sup>7</sup> Don Hopey, "Bromide: a concern in drilling wastewater." *Pittsburgh Post-Gazette*, March 13, 2011. See also Shankar Chelam, "Bromide Influence on Trihalomethane and Haloacetic Acid Formation." *Water Encyclopedia 2005*.

<sup>8</sup> According to the DEP Emissions Inventory, the sources for the wells near the Judy home that emitted PM10 included completion, drill rigs, and heaters. (Reports requested and received from M. Rudawski, Environmental Group Manager, DEP on January 17, 2013.)

<sup>9</sup> The wells were Cree 6MH (rank 1 out of top 10), Phillippi 1MH (rank 2), Cumberland/Henderson compressor station (rank 4), Blaker Minor 1MH-A (rank 7), Meadows 1MH (rank 8) and Pechin Leasing 1MH (rank 12). Combined, these facilities emitted 35.4 tons of particulate matter in the form of PM10.

<sup>10</sup> 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.

<sup>11</sup> eFACTS. Searched Facility Emissions. Year: 2012. County: Greene. Top records: 10. Pollutant: CO, NOx, PM10, SOx and Benzene. [http://www.ahs.dep.pa.gov/eFACTSWeb/criteria\\_facilityemissions.aspx](http://www.ahs.dep.pa.gov/eFACTSWeb/criteria_facilityemissions.aspx)

<sup>12</sup> Earthworks received detailed Natural Gas Inventory data from DEP that allowed us to search for emissions from particular wells and that broke down emissions by "source type," such as drill rigs, well completion, tanks, heaters, and blowdowns. (Reports requested and received from M. Rudawski, Environmental Group Manager, DEP, January 2013.)

<sup>13</sup> Data from DEP's Permitted Well Inventory database and Frac Focus.

<sup>14</sup> EPA Air Toxics website: "Pollutants and Sources." [www.epa.gov/ttn/atw/pollsour.html](http://www.epa.gov/ttn/atw/pollsour.html)

<sup>15</sup> PA DEP. *Southwest Pa. Marcellus Short-Term Air Sampling Report*. 2010.

