Review Report

Analysis of limitations for using Pennsylvania Marcellus Region air monitoring studies for long-term health assessments or state-wide set back distances

On behalf of:

Environmental Integrity Project

Marc Glass

April 6, 2025

Downstream Strategies
Ideas that sustain.

911 Greenbag Road
Morgantown, WV 26508
downstreamstrategies.com

TABLE OF CONTENTS

1. Introduction 1
1.1 Investigator background 1
2. Background 2
3. Analysis of PADEP AIR Studies 4
3.1 Short term air study (2010) 4
3.2 Long Term Study (2018) 6
3.3 PADOH/ATSDR Health Consultation 6
3.4 Contaminants of concern 8
4. Other Air Monitoring Initiatives 10
4.1 Yonker well site study, Washington County 11
5. Discussion 13
References 16

TABLE OF FIGURES

Figure 1: UOG well permits in Allegheny, Fayette, Greene, Washington, and Westmoreland counties 3
Figure 2: Overview of Yonkers well pad air study 12
Figure 3: Yonker and area UOG well pads 13

1. INTRODUCTION

I, Marc Glass of Downstream Strategies, LLC (DS), have prepared this report at the request of the Environmental Integrity Project (EIP).

I have conducted a limited review of several air monitoring studies conducted in Pennsylvania's Marcellus Shale region proximal to unconventional oil and gas (UOG) wells and infrastructure between 2010 and 2013. Herein, I provide comments identifying some of the strengths and weaknesses, as well as contaminant exposures identified by these studies.

My objective was to provide an opinion on the following:

- whether sufficient data had been gathered to draw definitive conclusions about the risks from exposure to air contaminants from Marcellus shale UOG development UOG; and
- whether the risks have been characterized well enough to evaluate if the current well set back distances under Chapter 78a are sufficient to minimize human health impacts.

Several studies have identified exposures, mostly above short term health-based reference levels or standards, for contaminants expected to be associated with Marcellus shale unconventional oil and gas development (UOGD). However, for various reasons discussed herein, public health investigators have concluded that available data is insufficient for assessing specific emissions impacts from the natural gas sources on ambient air quality in the communities where sampling has been conducted.

To date, a comprehensive, risk-based air quality study, designed to accurately measure and evaluate the combined emissions from the expanding oil and gas industry infrastructure sufficient to quantify human exposure to both short-term and cumulative impacts from UOGD in Pennsylvania is lacking. Data gaps exist when quality data that is critical to effective decision-making is not readily available.

My review restates the conclusions of public health professionals including PADEP, PADOH, and ATSDR, who have investigated air quality in the Marcellus shale region of Pennsylvania, that a data gap exists with regard air quality exposures caused by Marcellus shale development.

1.1 Investigator background

I am a Principal and Senior Scientist at Downstream Strategies, LLC (DS), a Morgantown, West Virginia–based environmental consulting firm, at which I direct the environmental monitoring and remediation program. I am a West Virginia Department of Environmental (WVDEP) Protection Licensed Remediation Specialist (No. 175), with twenty-five years of direct experience conducting environmental investigation, site characterization, and cleanup of environmental releases. I have been retained by public and private clients where my expertise has been utilized for site assessment and data review and interpretation. I have managed numerous site investigations and cleanup

projects dealing with heavy metals, petroleum hydrocarbons, dense non-aqueous phase liquids (DNAPLs), light non-aqueous phase liquids (LNAPLs), polychlorinated biphenyls (PCBs), various chlorinated solvents, and other hazardous substances. From 2011 through 2017, I served as the court-appointed remediation technical expert for a class action settlement resulting from heavy metals contamination from a former zinc smelter in West Virginia, where exterior soil and interior dust remediation was performed over a 35–square mile area. I currently serve as the Technical Advisor to the Harvey-Crosby environmental remediation Settlement near Houston, Texas overseeing characterization and remediation of structures and soils impacted by dioxin particulate fallout. I have performed ambient air monitoring studies, conducted research, and authored reports pertaining to the monitoring and management of unconventional oil and gas waste streams in solid waste landfills. I have also provided testimony in federal court pertaining to environmental contaminants in wastes generated by unconventional oil and gas development in West Virginia and led or provided consultation regarding site assessment and cleanup of oil and gas production waste release sites in Pennsylvania and West Virginia.

2. BACKGROUND

In 2010, PADEP conducted a short-term, screening level air quality sampling initiative near natural gas operations in Pennsylvania. The study was centered in Greene and Washington counties with background sampling conducted in Washington County (PADEP, 2010). PADEP published its findings in a report titled “Southwestern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report”.

As a follow up, in 2012-2013 PADEP conducted long-term ambient air monitoring near natural gas production and operations at four locations in Washington County, Pennsylvania (PADEP, 2018). For the long-term study, PADEP selected air monitoring locations proximal to the density of unconventional oil and natural gas development (UOGD) exploration and production (E&P) operations which included: compressor plants, gas production wells, associated truck traffic, and drilling infrastructure. PADEP also collected background air samples from locations expected to be removed from UOG E&P operations, but within the southwestern Pennsylvania regional airshed.

PADEP prepared a report of their findings titled “Long-Term Ambient Air Monitoring Project: Marcellus Shale Gas Facilities”.

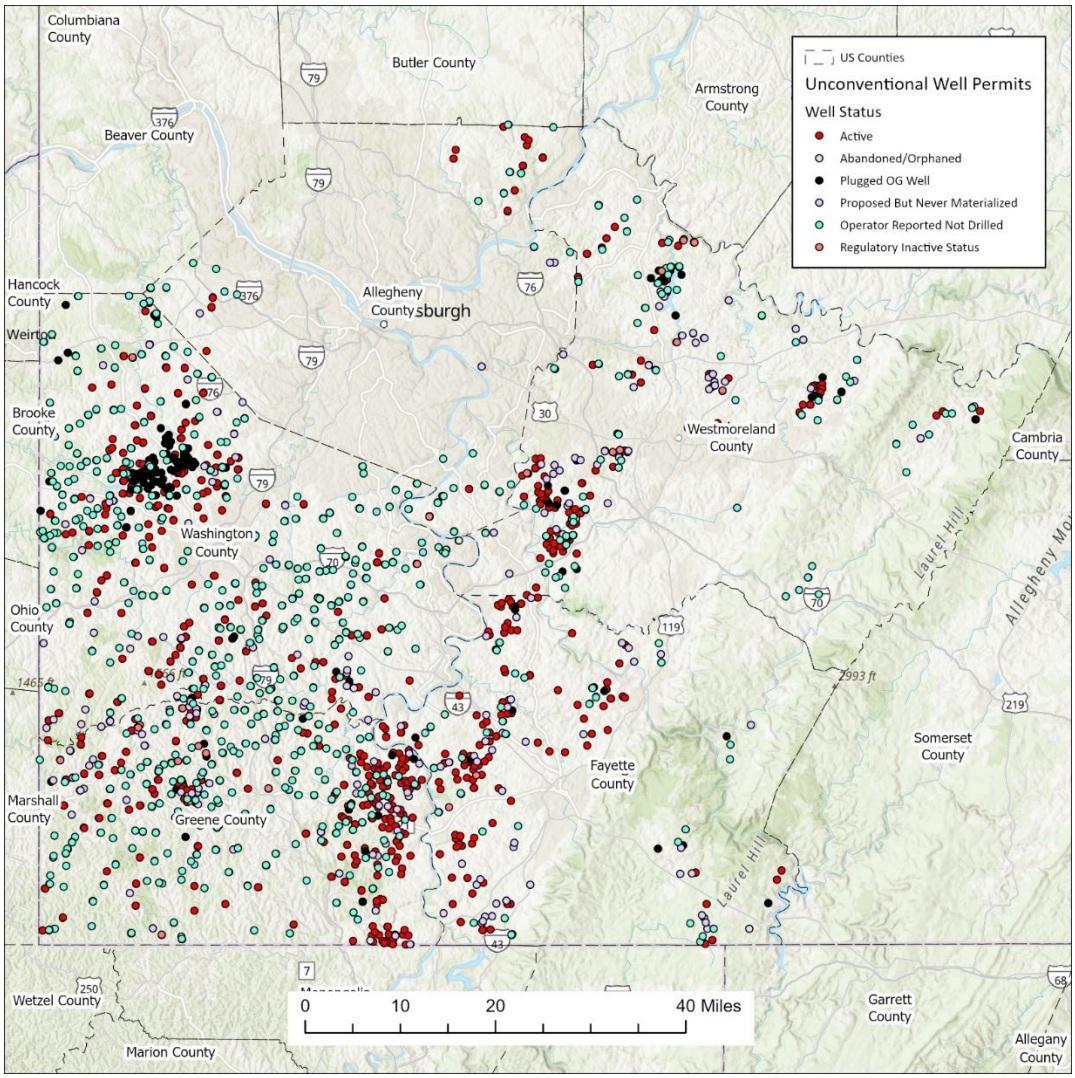
The timing of the above-referenced PADEP air studies, both complete by 2013, must be considered in the context that since that time, UOGD in the Marcellus region has continued to expand rapidly.

Prior to 2015, there were 15,702 unconventional oil and gas wells permitted in Pennsylvania. In the decade since, the number of wells has increased more than 50%, with an additional 8,889 unconventional wells permits added, plus 462 permits for which no date is provided, for a total of 24,323 UOG wells permitted in Pennsylvania as

of September 30, 2024. Of these, 3,763 (189 with no date provided) unconventional wells are permitted within Allegheny, Fayette, Greene, Washington, and Westmoreland counties. (PADEP, 2025).

Figure 1 indicates the locations of UOG well permits across Allegheny, Fayette, Greene, Washington, and Westmoreland counties obtained from the most Pennsylvania Spatial Data Access (PASDA) portal.

Figure 1: UOG well permits in Allegheny, Fayette, Greene, Washington, and Westmoreland counties



Source: PADEP Oil and Gas Mapping https://gis.dep.pa.gov/PaOilAndGasMapping/.

The increased density of UOG wells and associated airborne pollution emissions, particularly near populated areas, has raised concerns about associated air quality impacts.

Along with the increase in UOGD, industry practices and regulations have also evolved to help reduce emissions. As one example, in 2024, the U.S. EPA issued New Source Performance standards for facilities constructed or modified after December 6, 2022, aimed at reducing emissions from the oil and gas sector.

Even with such improvements, to date a comprehensive, risk-based air quality study designed to accurately measure and evaluate the combined emissions from the expanding oil and gas industry infrastructure sufficient to quantify human exposure to both short-term and cumulative impacts from UOGD in Pennsylvania and to support health-based decision making is lacking.

3. ANALYSIS OF PADEP AIR STUDIES

3.1 Short term air study (2010)

As noted by PADEP, the short-term screening study was not intended to address "the cumulative impact of air emissions from natural gas operations in southwestern Pennsylvania" (PADEP, 2010).

The study period occurred over five weeks and utilized a mobile laboratory and limited cannister sampling to collect ambient air samples near two compressor stations, a condensate tank farm, a wastewater impoundment, and a background site in Washington County.

Notably, the short-term air studies did not involve air monitoring at wet gas well sites and did not include monitoring for acutely toxic substances known to be associated with UOG E&P, such as acrylamide and glutaraldehyde (Joint Stipulation, 2016).

PADEP stated that sampling results were intended to provide basic information for the type of pollutants emitted to the atmosphere during selected phases of gas extraction operations in the Marcellus Shale Formation (PADEP, 2010).

PADEP detected multiple compounds during the sampling event that were selected as target pollutants near Marcellus Shale exploration and production activity.

However, for several compounds of interest—hydrogen sulfide, methyl mercaptan, among others—the detections limits were too high to confirm if a compound was actually present in the air, or to allow comparison to health-based reference values.

Methyl mercaptan was found in samples collected at several of the PADEP monitoring sites. In the 2010 report, PADEP originally did not calculate hazard quotients or report acute, non-cancer health risk associated with these detections. Hazard quotients below one are not expected to cause non-cancer health effects; above one the risk is increased. Later, when PADEP sourced an appropriate reference value to complete the calculation of hazard quotients for the methyl mercaptan detections, hazard quotients as high as 145.75 were found (Joint Stipulation, 2016). This finding by PADEP indicates a high level of acute risk for at least some of the samples collected near Marcellus shale waste impoundments.

Comparing the mobile and canister measurements, the shorter-term mobile measurements were typically significantly higher. The mobile unit sampling method employed a constant flow rate to collect a 0.5-Liter volume of air over a 5-minute time period, once per hour. In contrast, the cannisters were collected as composite samples, drawn continuously over an approximately 24-hour period. An illustration of the stark contrast between the concentrations achieved by the respective sampling methods is shown below in Table 1.

Table 1: Comparison of 2010 mobile and canister measurements

Pollutant name	Maximum mobile meaurement (ug/m3)	Maximum canister measurement (ug/m3)
Carbon Disulfide	<872	0.25
Styrene	439.00	0.35
Ethylbenzene	10,553.00	0.36
1,2,4-Trimethylbenzene	2,345.00	0.44
m-Xylene	<638	1.30
p-Xylene	<1776	1.30
Benzene	2,421.00	1.70
Chloromethane	<1037	1.80
Toluene	<1284	6.40
2-Methoxy-2-methylpropane (MTBE)	700.00	<0.148

Source: Adapted from PADEP, 2010.

Short sampling intervals are more effective at capturing short-term, acute exposures than longer sampling intervals. Longer sampling intervals may mask short periods of high contaminant concentrations ("spikes") by diluting or combining contaminated and not-contaminated air over time.

To evaluate acute-health risks, PADEP screened their mobile measurement results against health-based reference concentrations developed by other agencies, including ATSDR, CalEPA, and several lists provided by U.S. EPA. In summary, as a screening-level effort, the 2010 PADEP air sampling identified multiple compounds of interest for further investigation and in some cases, high levels of acute health risk were identified by short-term exposure sampling (Table 2).

Another noteworthy observation is that, according to PADEP, both mobile samples, analyzed by Gas Chromatography/Mass Spectrometry (GC/MS), and canister samples, analyzed via Method TO-15, contained Tentatively Identified Compounds (TICs), which were not listed or identified in the PADEP report. TICs are compounds confirmed likely to be present in a sample but cannot be accurately quantified by the analytical methodology. It is common practice when conducting screening level or investigative sampling efforts to report TICs, so that future sample collection and analytical methods can be refined to confirm and quantify these compounds for use in health-risk based

assessments. In their 2010 report, PADEP did not list the TICs detected and It is unknown what chemicals they were. It is also unknown whether PADEP refined their future sampling methods and analytical approaches to be able to quantify the TICs identified during their 2010 sampling.

3.2 Long Term Study (2018)

In 2018, PADEP published the results of a follow up sampling exercise completed during 2012-2013 (PADEP, 2018). The objective of the one-year project was to examine potential toxic air pollution near permanent facilities handling, transporting and processing unconventional natural gas extracted from the Marcellus Shale formation in Washington County.

As noted by PADEP, the project was not to be used as a substitution for a full inhalation pathway risk/hazard assessment (i.e., the formal tiered community level inhalation risk assessment described by the U.S. EPA in its ambient air toxics risk assessment guidance) (PADEP, 2018).

PADEP planned to use this and future monitoring data to support efforts by the public health/industrial hygiene community to assess the potential localized risk. As part of this, PADEP requested a health consultation review by the Pennsylvania Department of Health (PADOH) under agreement with the U.S. Department of Health and Human Services, Agency for Toxic Substances Disease Registry (ATSDR).

3.3 PADOH/ATSDR Health Consultation

PADOH in cooperation with ATSDR conducted a review of the 2018 PADEP Long-term ambient air monitoring project: Marcellus shale gas facilities (PADOH, 2018).

The stated purpose of the PADOH/ATSDR health consultation was twofold:

1. Evaluate if the data was sufficient to assess community-wide exposures to chemicals emitted by this oil and gas industry.

2. Based on the available data, determine if communities near these natural gas operations are being exposed to levels of chemicals in the air that could impact their health.

In light of these objectives, PADOH/ATSDR concluded:

1. The data was insufficient for assessing specific emissions impacts from the natural gas sources on ambient air quality in these communities. Data was sufficient to assess overall ambient air quality in the residential areas sampled with regard to only the six most common priority air pollutants under the Clean Air Act, which are not unique to development of the Marcellus shale.

2. The location of air monitors did not capture air quality data with discreet sampling downwind of the targeted emissions sources on most of the days that samples were collected.

In other words, the 2018 study did not provide data sufficient to evaluate whether communities near natural gas operations are being exposed to levels of chemicals in the air that could impact their health.

Other significant limitations to achieving the purpose of the Health Consultation are discussed below.

Some of the chemicals known by PADOH/ATSDR to be associated with the oil and gas industry were not investigated by PADEP. Some chemicals analyzed had detection limits that were too high for comparison to ATSDR health-based comparison values. And some of the sample collection periods were too long to allow analysis of short-term peak exposures.

Due to these data limitations, PADOH/ATSDR were generally not able to consider health impacts from acute exposures (< 24 hours) to hazardous air pollutants other than six most common criteria pollutants (carbon monoxide, lead, ground-level ozone, particulate matter, nitrogen dioxide, and sulfur dioxide), and hydrogen sulfide, noting that some chemicals emitted by the oil and gas industry have the potential to cause health effects and/or symptoms from exposure durations that are less than 24 hours.

Due to the variability in operations at oil and gas sites, PADOH/ATSDR could not determine if the sampling data reflected worst case, typical, or non-typical emissions.

Still, even considering these limitations, PADOH/ATSDR determined that average levels of some chemicals (e.g., acetaldehyde, formaldehyde), exceeded levels typically seen in U.S rural areas. Maximum levels for some of the chemicals (e.g., benzene, carbon tetrachloride) exceeded levels typically seen in ambient air from mixed (urban, suburban, rural) areas across the U.S.

Exposure to some of the higher levels of ozone (8-hour average), hydrogen sulfide (24-hour average), and PM2.5 (24-hour average and annual average) levels detected are considered unhealthy for sensitive (ozone and hydrogen sulfide) or unusually sensitive (PM2.5) populations. These exposures are primarily of health concern for active children and adults with respiratory diseases, such as asthma and chronic respiratory disease.

The 2018 PADOH/ATSDR findings should be considered in the context of more recent observational epidemiological studies conducted by the University of Pittsburgh School of Public Health (Pitt Public Health) in 2023. The Pitt Public Health studies investigated health impacts of human exposure to environmental risk factors, including UOGD activities, in an eight-county region in Southwest Pennsylvania (Pitt Public Health 2023a, 2023b, 2023c).

The Pitt Public Health studies evaluated:

- Whether living near unconventional gas development activities or other environmental hazards in Southwestern Pennsylvania increases the risk for specific health issues

- The relationship between unconventional natural gas development and three health issues (described below)

Pitt Public Health produced and publicly released three separate, observational epidemiological study reports presenting observed data-based health outcomes associated with asthma (Pitt Public Health, 2023a), birth outcomes (Pitt Public Health, 2023b), and childhood cancer (Pitt Public Health, 2023c) in the 8-county study region. Pitt Public Health also publicly released summary of key findings of the three studies, which are listed below:

1. People with asthma living close to wells during the production phase had an increased chance of their asthma getting worse.

2. Children who lived within 1-mile of one or more wells had 5 to 7 times the chance of developing lymphoma, a relatively rare type of cancer, compared to children who lived in an area without wells within 5-miles.

3. Infants born to pregnant women who lived near wells during the production phase were 20-40 grams (about 1-ounce) smaller at birth.

3.4 Contaminants of concern

There are 187 hazardous air pollutants (HAPs) and pollutant classes regulated under the Clean Air Act, but studies of UOGD air emissions have generally focused on a select and limited few of these known to be associated with UOG operations.

Based on review of the 2010 and 2018 PADEP air studies, a non-exhaustive list of contaminants of potential concern (COPCs) in air proximal to UOGD operations in southwest Pennsylvania is provided below as Table 2.

Table 2: Non-exhaustive list of COPCs identified in 2010 and 2018 studies

Carcinogens	**Basis**
Acetaldehyde	2018 report shows levels > cancer SL
Benzene	2010 and 2018 reports show levels > cancer SL
1,3-butadiene	2018 detection limit too high
Carbon tetrachloride	2018 report shows levels > cancer SL
Chloroform	2018 (based on PADOH/ATSDR report)
Chloromethane	2018 (based on PADEP Table 47)
1,2-dibromoethane	2018 detection limit too high
1,2-dichloroethane	2018 detection limit too high
Ethylbenzene	2010 report shows levels > cancer SL
Formaldehyde	2010 and 2018 reports show levels > cancer SL
Hexachloro-1,3-butadiene	2018 detection limit too high
2-Methoxy-2-methylpropane (MTBE)	2010 report shows levels > cancer SL
Naphthalene	2010 report shows levels > cancer SL
1,1,2-trichloroethane	2018 detection limit too high
Noncancer – acute (2010 report)	
Benzene	Exceeds acute health threshold
Carbon disulfide	Lab test not sensitive enough
Chloromethane	Lab test not sensitive enough
Formaldehyde	Lab test not sensitive enough
Hydrogen Sulfide	Lab test not sensitive enough
Methyl mercaptan	Exceeds acute health threshold
Naphthalene	Exceeds acute health threshold

Nitric Acid	Lab test not sensitive enough
Nitrogen dioxide	Exceeds acute health threshold
n-Hexane	Exceeds acute health threshold
Sulfur dioxide	Exceeds acute health threshold
1,2,4-Trimethylbenzene	Lab test not sensitive enough
Noncancer – chronic (2018 report)	
Acrolein	Unreliable data
PM2.5	Possible risk to sensitive individuals
Ozone	
Hydrogen sulfide	

However, as noted by PADOH, there are other chemicals that may be of concern from UOGD that were not included, or appropriately tested for, to draw conclusions regarding exposure and health implications (PADOH, 2018).

4. OTHER AIR MONITORING INITIATIVES

Air pollutants measured from UOGD air sampling investigations commonly included fine particulate matter (PM2.5), nitrogen dioxide (NO2), sulfur dioxide (SO2), acetaldehyde, benzene, ethylbenzene, formaldehyde, n-hexane, toluene, xylenes, hydrogen sulfide (H2S) (Long et al, 2019), while some also included additional individual volatile organic compounds (VOCs).

Another more recent, industry-funded study (Long et al, 2021) discussed collection of PM2.5 and 58 selected VOC emissions measurements at varying distances from a Marcellus Shale UOG well pad over various stages of well pad development and operating conditions.

While the study consistently detected VOCs in the ambient air samples, many of which were similar to those detected in the earlier PADEP studies, increased VOCs during the flowback phase, and increased PM during the hydraulic fracturing phase, the authors found few exceedances of short-term or long-term health-based screening benchmarks and concluded there was little evidence of likely health impacts.

However, the authors acknowledged substantive shortcomings from the potential dilution of short-term effects by composite sampling over a 24-hour period and that the

study design did not include monitoring sites in the predominant down wind direction or closer than 1,000 feet from the well pad.

Thus, characterization of the full range of potential air exposure levels associated with the well pad development was not possible (Long et al, 2021).

4.1 Yonker well site study, Washington County

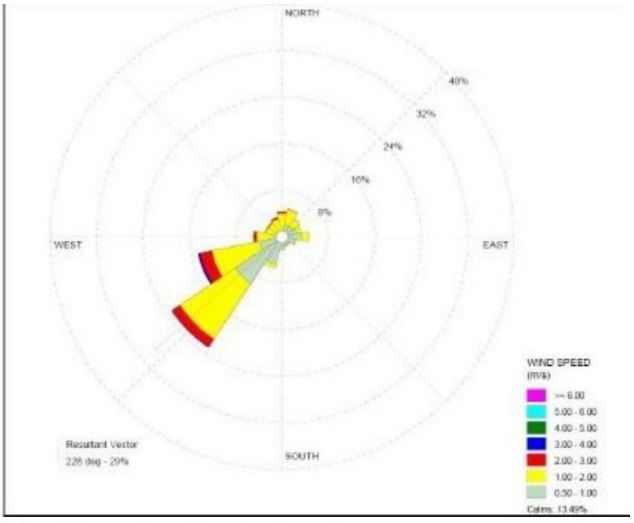
A limited air study was conducted by consultants for oil and gas operator Range Resources (Gradient, 2019; Long et al, 2021) to evaluate potential exposures from the Yonker UOG well pad, operated by Range Resources, to the Fort Cherry School District campus, which includes an Elementary, Junior, and Senior High School

As represented in Figure 2, the Fort Cherry School District campus is located upwind or crosswind of the Yonker well pad and upwind or crosswind of all of the study's air monitoring stations. In fact, the wind rose diagrams from the study period show that the wind almost never blew from the Yonker well pad toward the school campus of interest. Therefore, this study provides almost no information about potential exposure to UOG air contaminants from the Yonker well pad at the school.

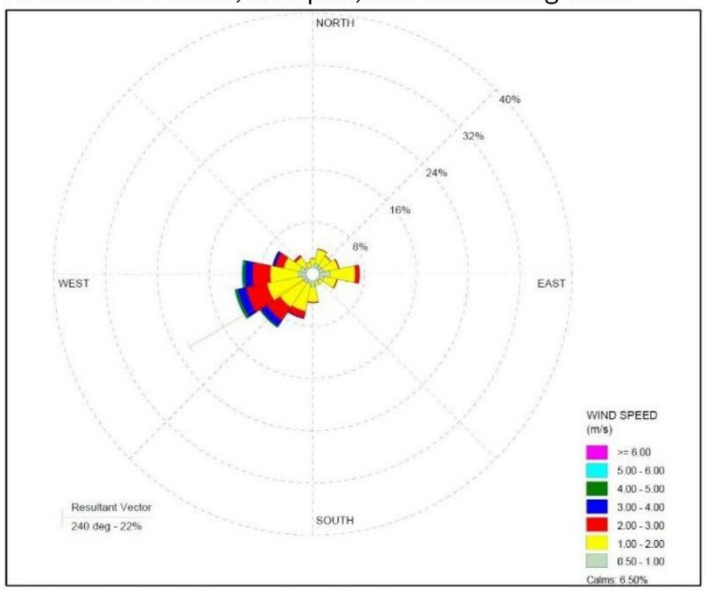
With regard to the well pad, two of the air monitoring sites (Site 1 and Site 2) were situated northwest and primarily upwind of the Yonker well pad. The third site, Site 3. was located southwest and also primarily upwind of the well pad. Although occasionally, Site 3 was downwind of the Yonker pad.

Figure 2: Overview of Yonkers well pad air study

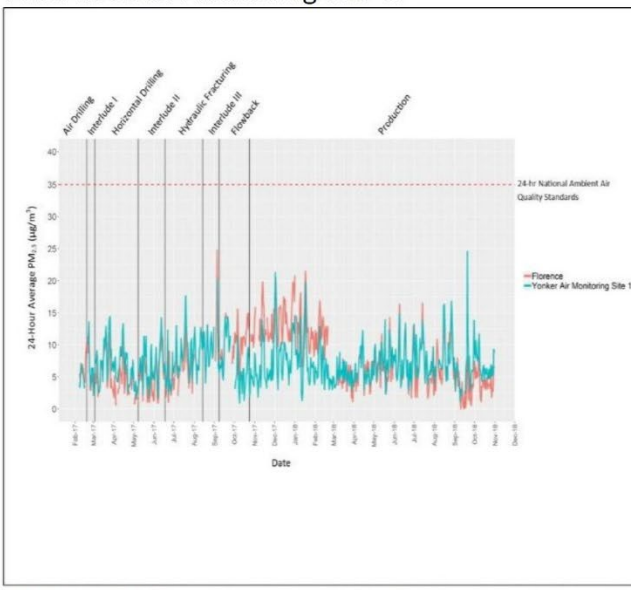
Location of school, well pad, and monitoring sites.



Wind Rose for Monitoring Site 1.



Wind Rose for Monitoring Site 2.

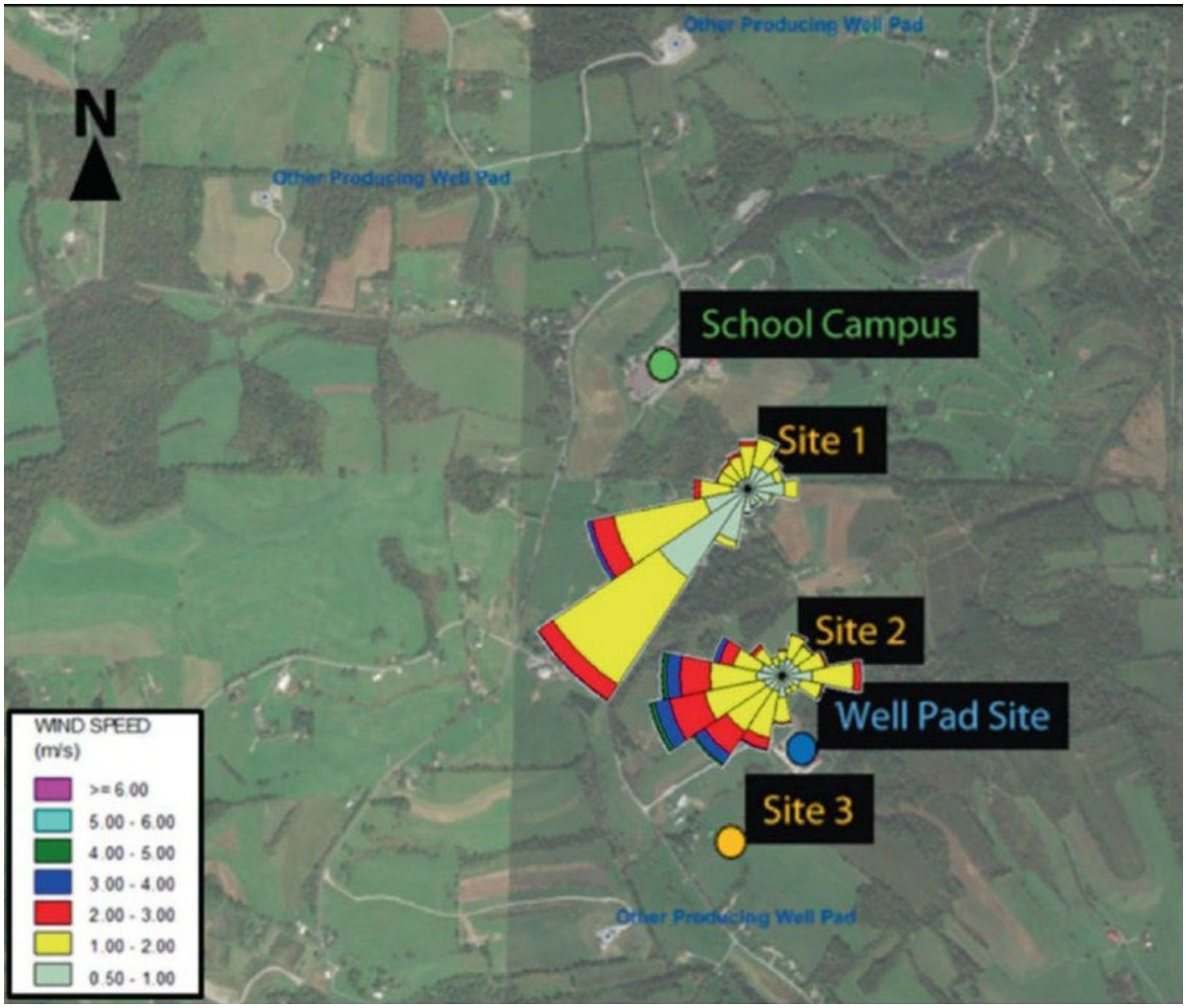


Well pad PM measurements vs background.

Source: Adapted from Gradient, 2019.

Site 3 was upwind of both the well pad and the school, so the Site 3 sampling data was interpreted by the authors to provide insight to whether other local sources, including the other UOG wells in the area, also visible in Figure 2, may impact the air quality at the school. The authors drew this conclusion even though all of the well pads shown are at distances greater than 3,000 feet from the school and no air monitoring site is located directly downwind of a well pad at distances comparable to the distance between the school and any upwind well pad.as shown more clearly in Figure 3.

Figure 3: Yonker and area UOG well pads



Source: Adapted from Long et al, 2021

From this approximately two-year study, the authors concluded that there was no evidence of air quality impacts or potential health concerns from PM2.5 and VOC at the school. In my opinion, this conclusion is utterly unremarkable since none of the monitoring stations are situated similarly with regard to distance from UOG well pads and prevailing wind direction at the school.

5. DISCUSSION

In general, each of previously referenced studies identified exceedances of short and or long-term health exposure limits, or levels that could or would be harmful to sensitive subpopulations (i.e. asthmatics, elderly, chemical specific sensitive groups) but were almost always inconclusive regarding long-term health effects or recommendations for actions other than refinement of future monitoring approaches. Most acknowledged the complexity and challenges with assessing the health impact from exposures to the complex mixtures of airborne toxic chemicals presented by UOG air emissions. Each of

these studies was also limited to a screening level study and did not collect the information needed for a full inhalation pathway risk/hazard assessment.

What is evident from the literature is that emissions from well pads and UOGD infrastructure that can exceed short and/or long-term health-based benchmarks for individual VOCs or HAPs do occur in intermittent contaminant plumes that can only be captured by intentionally designed sampling programs that have not been in wide use to date.

Perhaps the most comprehensive and recent air quality study of UOGD emissions conducted air monitoring from 2018-2022 during development of several large, multi-well pads in the Denver-Julesburg Basin near Broomfield, Colorado (Ku et al, 2023). The study documented increased VOC concentrations during well drilling, completions, and production phases with up to several hundred parts per billion volume (ppbv) of benzene measured in transient contaminant plumes generated from the well pads.

This study suggests that future monitoring should include sensors that can detect contaminant plumes in real time and activate short-term sampling collection devices. Similarly, as noted by Long et al 2021, future sampling should include 1-hour sampling intervals for comparison to acute screening levels and to help capture the spikes caused by transient contaminant plumes.

With regard to evaluating whether current set-back distances are likely to be protective, none of the studies discussed herein were designed to evaluate exposures from upwind UOG air emissions located within the current Chapter 78a permissible set-back distances of 500 feet from existing buildings.

Similar to the 2018 PADEP study, the Long et al study design did not include monitoring sites in the predominant wind direction or closer than 1,000 feet from the well pad, while other studies have shown that contaminants from Marcellus shale development may travel long distances in air.

Studies of gaseous emission plumes in Pennsylvania and New York (Payne et al, 2017) have demonstrated elevated levels of methane and presumed gaseous co-pollutants within one mile from compressor stations. These effects were found to be highly variable based on weather conditions, including temperature inversions, and the timing of activities performed at the site.

A 2020 study of PM 2.5 air emissions from a Marcellus shale well pad with only two operating wells demonstrated statistically significant transport of PM2.5 originating from the well pad, that declined with distance and remained distinguishable from other sources at distances of 7-kilometers (~4.3-miles) (Nye et al, 2020).

A distance of 2,500 feet is commonly cited in Pennsylvania environmental statutes (ie. Act 2, Act 13, 25 Pa. Code Chapter 78a et al) as the distance for a rebuttable presumption of liability for diminution or contamination of water supplies by regulated operators of potential surface or underground pollution sources (i.e. gas wells,

underground storage tanks). Based on the limited evidence and data gaps that exist for evaluating air exposures from UOG air emissions, a reasonable consideration may be to establish **a rebuttable presumption of liability for diminution or contamination of the air.** This may compel operators to conduct defensible and representative pre-development air studies as a basis for rebuttal prior to development and production of UOG operations.

Still lacking, however, is a quantitative human health risk assessment to characterize any potential human health risks associated with community-level air quality impacts of Marcellus Shale development that address potential health risks associated with both episodic peak exposures as well as chronic exposures. This information is needed to inform whether current Chapter 78a set back distances or other mitigation strategies are needed to prevent community exposure to elevated risk from Marcellus shale UOGD air contaminants.

REFERENCES

Pennsylvania Department of Health (PADOH). 2018. Health Consultation, Public Health Evaluation of Long-Term Air Sampling Data Collected in the Vicinity of Natural Gas Operations, Washington County, Pennsylvania. July 18.

Gradient. 2019. Results from Long-term Air Monitoring at the Yonker Well Site Nearby the Fort Cherry School Campus in Washington County, PA. May 10.

Joint Stipulation. 2016. The Delaware Riverkeeper Network, Clean Air Council, David Dk, Jennifer Chomicki, Anthony Lapina, And Joann Groman, Appellants, V. Commonwealth of Pennsylvania, Department of Environmental Protection and R.E. Gas Development, LLC, Permittee. EHB Docket No, 2014-142.

Li, L., Blomberg, A.J., Spengler, J.D., Coull, B.A., Schwartz, J.D., and Koutrakis, P. 2020. Unconventional oil and gas development and ambient particle radioactivity. Nature Communications (2020) 11:5002. https://doi.org/10.1038/s41467-020-18226-w

Long, C.M., Briggs, N.L., Cochran, B.A., Mims, D.M. 2021. Health-based evaluation of ambient air measurements of PM2.5 and volatile organic compounds near a Marcellus Shale unconventional natural gas well pad site and a school campus. Journal of Exposure Science & Environmental Epidemiology. February 22.

Long, C.M., Briggs, N.L., Bamgbose, I.A. 2019. Synthesis and health-based evaluation of ambient air monitoring data for the Marcellus Shale region. Journal Of the Air & Waste Management Association. VOL. 69, NO. 5, 527–547. January 15.

Martin, K.A.V., Lin, E.Z., Hilbert, T.J., Pollitt, K.J.G., and Haynes, E.N. 2021. Survey of airborne organic compounds in residential communities near a natural gas compressor station: Response to community concern. Environmental Advances 5 (2021) 100076. https://doi.org/10.1016/j.envadv.2021.100076

Nye, N., Knuckles, T., Yan, B., Ross J., Orem W., Varonka M., Thurston G., Dzomba A., Michael McCawley, M. 2020. Use of Tracer Elements for Estimating Community Exposure to Marcellus Shale Development Operations. International Journal of Environmental Research and Public Health. March 12.

Pennsylvania Department of Environmental Protection. 2025. Pennsylvania Spatial Data Access (PASDA). Oil Gas Locations – Conventional Unconventional. https://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=1088. Accessed April 3, 2025.

Pennsylvania Department of Environmental Protection. 2018. Long-Term Ambient Air Monitoring Project: Marcellus Shale Gas Facilities. July.

Pennsylvania Department of Environmental Protection. 2010. Southwestern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report. November 1.

University of Pittsburgh School of Public Health. 2023a. Hydraulic Fracturing Epidemiology Research Studies: Asthma Outcomes. Final Report for Pennsylvania Department of Health, Bureau of Epidemiology. July 31, 2023.

_____. 2023b. Hydraulic Fracturing Epidemiology Research Studies: Birth Outcomes. Final Report for Pennsylvania Department of Health, Bureau of Epidemiology. July 31, 2023.

_____. 2023c. Hydraulic Fracturing Epidemiology Research Studies: Childhood Cancer Case-Control Study. Final Report for Pennsylvania Department of Health, Bureau of Epidemiology. August 3, 2023.

_____. 2023d. Presentation on Hydraulic Fracturing Epidemiology Research Studies. PowerPoint Presentation.