I. Professional Experience and Expert Qualifications

I am Laura Dagley, a Registered Nurse and the Medical Advocacy Coordinator for Physicians for Social Responsibility (PSR). PSR is an organization dedicated to protecting public health, the environment, and communities. I have also worked in the community as a home health nurse. I have attached my CV under Appendix A.

II. Expert Opinion

While the role of doctors and nurses is to treat an illness, the role of public health is to prevent the illness from occurring. Both approaches are evidence based practices, but public health decision making does not rely on absolute certainty of causation. Public health decision making leans on the precautionary principle approach. The precautionary principle “asserts that the burden of proof for potentially harmful actions by industry or government rests on the assurance of safety and that when there are threats of serious damage, scientific uncertainty must be resolved in favor of prevention.” [3] The core of the precautionary principle is that an action should not be taken if scientific evidence shows an uncertainty of the outcome. If there is a plausible pathway of exposure suggesting a public health risk, that is enough cause to suggest the exposure risk should be mitigated in favor of public safety.

It is worth noting that historically we have not been able to rely on government regulatory actions to respond in a timely manner to health threats. One example of this is the removal of lead in gasoline. For almost 40 years, it was believed that lead in gasoline was safe because the majority of studies at the time were funded by the industry and showed no health detriment. After independent studies emerged showing the consequences of lead even at low doses, it took another 25-30 years before lead was out of gasoline. [4] It can be concluded from this example that the precautionary principle should be applied much sooner when there is any question of a health threat (i.e. conflicting studies), and it is my recommendation that the
precautionary principle be implemented by local decision-makers where possible, while waiting for state and federal regulations to catch up.

A study completed in 2015 looked at current state setback distances in Pennsylvania for well pads, and found that current standards are not sufficient to protect the health and safety of the public. In the conclusion, it states “based on historical evacuations and thermal modeling, people within these setback distances are potentially vulnerable to thermal injury during a well blowout. According to air measurements and vapor dispersion modeling, the same populations are susceptible to benzene and hydrogen sulfide exposure above health-based risk levels.” [9] This study suggests we cannot rely solely on the current standards when considering public health.

PSR and Concerned Health Professionals of New York recently released the 6th edition of the Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking, which I reviewed and evaluated in preparing this report. This is a public and open-access document that can be found online at psr.org and an excerpt is also attached as Appendix B. This compilation summarizes the growing evidence linking fracking infrastructure and negative effects on health and communities. This document concludes its review of studies by stating: “Emerging data from a rapidly expanding body of evidence continue to reveal a plethora of recurring problems and harms that cannot be sufficiently averted through regulatory frameworks. There is no evidence that fracking can operate without threatening public health directly or without imperiling climate stability upon which public health depends.” [2]

Physicians, Scientists, and Engineers assessed the peer-reviewed scientific literature from 2009-2015 that pertained to unconventional oil and gas development and its potential impacts on public health, air, and water. 84% of the papers that focused on the impact to public health found adverse health outcomes. The majority of all the papers called for a larger epidemiological research to be done. [5] For a health professional, the call for more studies does not invalidate preliminary findings. One cannot get to causation without first showing correlation. Correlation is an important indicator in public health, and one that is not taken lightly by the public health community.

Studies on the impacts of unconventional oil and gas development on health is a fairly new field of inquiry, and most have been published only in the last 5-10 years. These studies therefore cannot capture long-term health effects that may see a latency period of 10+ years. In addressing any public health concern, the first field of study is going to be self-reported symptoms as this is the first warning sign of a potential risk and leads the way to further research. Large scale epidemiologic studies are simply not going to be seen in the early stages of
research. Self reported symptoms are always the first warning signal when it comes to public health issues.

Further, when it comes to science and health, there will always be areas of uncertainties. One of the prominent areas of uncertainty is the individualized reaction to chemicals. While we may know how certain chemicals affect the body, we do not fully understand the cumulative effect when exposed to multiple chemicals. Children, pregnant women, and older adults may also react to chemical exposure differently than the average adult.

It is important to note that every scientific study has limitations, no matter what the area of study or the conclusion. Every study should list its limitations for transparency, but this does not invalidate the results. Individual studies show us important information, but public health professionals will not base opinions on one study alone. It is the group as a whole that can show recurring themes. As demonstrated previously, there is a growing body of research suggesting a link to unconventional oil and gas activity and negative health effects.

I have reviewed many of the studies through my role at PSR, and have listed below some of the strongest research to date on potential health impacts:

- Casey (2016) found that pregnant women who live near active fracking operations in PA, had an increased 40% risk of giving birth prematurely, and a 30% increased risk for having high risk pregnancies. High risk pregnancies included hypertension, high pre-pregnancy body mass index, and asthma. [1]
- Stacy (2015) also observed an association with pregnant women’s exposure to gas wells and low birth weights. This was determined by the residence of the pregnant woman’s proximity to wells, in addition to the density of wells. Mothers who lived closest to the high density of wells were 34% more likely to have small for gestational age babies. [8]
- Rabinowitz (2015) found dermatologic and respiratory symptoms that increased in frequency as distances between household and gas wells decreased. Rashes and upper respiratory issues were more prevalent among persons living less than one kilometer from drilling and fracking operations. This study is the largest of its kind to date, and the findings are consistent with earlier reports. It also references literature that demonstrates the biological plausibility between oil and gas activities and the health effects reported. [6]
- A study by University of Pennsylvania and Columbia University found an association with drilling and fracking activity and increased rates of hospitalization in Pennsylvania. During 2007 and 2011, drilling activity increased dramatically alongside inpatient admissions for people living near shale gas wells. Cardiology and neurology inpatient rates were significantly associated with well density. Inpatient prevalence for cancer, skin issues, and urological problems also increased. The study observed a control county with
no drilling activity during this time period, and no increase in hospitalizations was noted. [7]

Noise

Noise pollution has a high impact on communities living near UGD. In 2013, Ferrar, et. al. reported that the most common concern cited by 76% of residents living in proximity to natural gas wells was “stress.” [10] Stress can be caused by a number of factors associated with the gas industry, including noise. Noise associated with gas operations, such as drilling, hydraulic fracturing, flaring, regular pipeline maintenance, and truck traffic, keeps people awake at night and on edge during the day. Sleep deprivation is a known and powerful trigger of anxiety and depression. [11][12] Around wellpads, workers and nearby residents are exposed to continuous noise and light pollution from drilling, fracking, flaring, and compressor stations. Increases in traffic and congestion from thousands of trucks during construction, drilling, fracking and waste disposal have seen rises in the rates of road accidents linked to the fracking industry [15].

Exposure to noise pollution is linked to cardiovascular disease, cognitive impairment and sleep disturbance, while there is emerging evidence that continuous artificial light exposure is linked to breast cancer in women[16]. Huntley and Huntley have applied to have a noise exemption during the day, which means residents living in this community will have a greater risk of being impacted by these health stressors. It is worth noting that “noise” is defined as unwanted sound. While it is possible to experience negative health effects like hearing loss from wanted sounds such as music or birdsong, noise pollution is specifically referring to unwanted sound from sources such as industry. The EPA lumps noise pollution with air and water pollution in its potential to cause negative health effects, and makes the distinction that “sound” and “noise” and very different things [18].

Air Quality

The PA DEP Long Term Air monitoring project of Marcellus Shale Gas Facilities states that “It is important to note that this project did not examine potential acute or chronic impacts to individuals working in, adjacent to, or in the immediate vicinity of natural gas extraction, gathering and/or processing facilities.” While the data collected suggests no potential harm to human health in surrounding areas, the report states there is high uncertainty in this conclusion due to gaps in the data. Several times they state they had insufficient data due to small sample
sets, and there was a need for further data collection to better understand the impact these sites would have on the public (see p. 108-112 of DEP report).

This monitoring, in my professional opinion, was inadequate. The DEP took 24 hour samples one day a week which is not sufficient to catch spikes in pollutants. There is no other health risk that we would look at data from one day a week and believe we have the full picture. Even temporary spikes in air pollution can cause acute symptoms for those with underlying respiratory or cardiovascular issues.

It is also of concern to me the exemptions that exist for this permit. Trucks and construction vehicles are exempt from air permitting requirements, and temporary activities related to well construction, drilling, and completion activities are exempt from air permitting requirements under Exemption 38(c). This is excluding a significant portion of the well development that while not considered for the permit, will have an impact on the residents. It is worth note that even if these well sites meet NAAQS, the research around UGD demonstrates that adverse health impacts are still being seen.

By Huntley&Huntley’s own reports, they will be emitting Carbon Monoxide, Nitrogen Oxides, Sulfur Dioxide, Benzene, Ethylbenzene, Formaldehyde, Toluene, and particulate matter small enough that it can become embedded deep in the lung. All of these pollutants have known health effects, even with low levels of exposure.

Local Community Impact

The location of the proposed Titan well pad is problematic for its proximity to the many residents in the immediate one-mile and greater two-mile radius, especially for vulnerable populations and the many patrons of the sites for exercise and outdoor recreation (please see Appendix C). Some highlights of the problems with the location include the following:

- There are 50 households with well water within 3,000 feet of the proposed site. This is of concern because spills, leaks and accidents of fracking and drilling fluids or waste at the surface can also pose a threat to water. With estimates of well failure on newly drilled wells between 5-9%, and at upwards of 50% during their lifespan the threat to water posed by potential spills, leaks and accidents of fracting and drilling fluids or waste at the surface are concerning. [13] • In 2016, researchers at Duke University reported evidence of widespread and persistent contamination of water and soils with salts, heavy metals, radioactive elements and other toxic materials associated with unconventional oil drilling in North Dakota. More than 3,900 spills of fracking wastewater were documented, more
than one for every three wells drilled. [14] A 2014 study by the Pennsylvania Department of Environmental Protection revealed that 243 private water supplies had been contaminated by waste ‘flowback fluid’. This flowback fluid contains both substances introduced during drilling and fracking and toxins naturally occurring in the ground, including carcinogens and naturally occurring radioactive materials [17] that are a threat to public health.

- Within 1 mile from the site are areas where people are outside exercising and impacted by air quality. These areas include Murrysville Community Park, Walter Nature Reserve, and Idle Creek Stable. Within 2 miles there is White Valley Park, Export Community Park, the Beaver Run Reservoir, and Tambler Stables. Murrysville Park is home to the Miracle League of Western PA. This means children and adults with mental and physical disabilities will be at greater risk for exposure from air pollution from the Titan site.

- Less than 3 miles from the site is Sloan Elementary School, where about 590 students from K-5 attend. Children are more vulnerable to environmental exposures. They breathe in more air, therefore more air pollution, per pound of body weight than adults. Because children’s brains and organs are still developing, they are more at risk from toxins interfering with the developmental process. Their bodies also do not eliminate toxins as efficiently as adults.

- Apart from children, the other groups most at risk from air pollution are the elderly and those with pre-existing respiratory or cardiovascular issues. Westmoreland has a high number of adults over age 65. It also has 21,000 people living with COPD, over 33,000 with cardiovascular disease, 28,000 adults with asthma, and 5,778 children with asthma. Westmoreland County has already seen higher hospitalization rates for COPD in comparison with the rest of the state. Any additional exposure to air pollution would put nearly 90,000 people in the county already suffering from the burden of disease more at risk.

Conclusion

It is my professional opinion that the available body of research demonstrates a trend towards negative health outcomes associated with unconventional oil and gas development. Implementing the precautionary principle, which is necessary for protecting public health, and even acknowledging the limitations of these studies, the potential for the Titan Well Pad to harm
to the community’s health is clear. The location of this well pad would put some of the most vulnerable populations in the community at risk.

Respectfully Submitted by:

/s/ Laura Dagley
Laura Dagley, BSN, RN
Appendix A: Laura Dagley CV
LAURA M. DAGLEY, BSN, RN
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540-556-0132

EDUCATION
Bachelor of Science in Nursing, Messiah College, Grantham, PA (May 2012)

CURRENT EMPLOYMENT
● Medical Advocacy Coordinator, Western PA (May 2016-present)
Physicians for Social Responsibility/Southwest Pennsylvania Environmental Health Project

PROFESSIONAL EXPERIENCE
● Registered Nurse, Hospice (December 2017-March 2019)
  Allegheny Health Network Healthcare @ Home
  • Care and management of patients given diagnosis of less than 6 months to live
  • Pain and symptom management with the goal of increased quality of life
  • Education and emotional support of patient and family on dying process
● Case Manager, Visiting Nurse (March 2014-January 2016)
  Affilia Home Health, Harrisburg branch
  • Care and management of patients with various central lines, drains, and wound care
  • Communication and care planning with doctors, therapists, social workers, and other community resources to provide holistic care for patients and prevent hospital readmission
  • Patient education regarding disease process and maintenance
  • Independent assessments in the field with reporting to doctors my recommendations for patient care
● Registered Nurse (January 2013- February 2014)
Pinnacle Health, CGOH, Ortho/Spinal/Bariatric Unit
  • Completed surgical dressing changes and wound care
  • Assisted patients with physical and occupational therapy post surgery
  • Careful administration of medications
  • Extensive communication and care planning with residents, attending physicians, respiratory therapists, PT/OT, and case managers
  • Complete head to toe assessment and thorough documentation

RELATED EXPERIENCE
● Volunteer at Bethesda Mission Free Clinic (February 2011-January 2016)
  • Established a free HIV testing program for mission residents
  • Improved assessment skills
  • Increased knowledge of community health nursing
● Certified Nursing Assistant (March 2011- August 2012)
  Select Specialty Hospital (LTAC), Camp Hill, PA
  • Increased knowledge and skill of care for patients with ventilators and other advanced support equipment
  • Enhanced ability to assess vital changes in patient status
● Caregiver and personal assistant (May 2009- August 2009)
Alice Walton, Bar Harbor, ME
• Assisted client with ADLs (bathing, dressing, hair care, meal preparation, laundry, etc)
• Assisted with medication administration and O2 equipment
• Gained skills in therapeutic conversation and listening
• Increased in compassion and patience towards those living with medical conditions

• Nursing assistant (October 2006- August 2007)
  Carilion Hospital, Roanoke, VA
  • Assisted patients with activities of daily living
  • Floated throughout hospital and shifts
  • Gained knowledge of a wide variety of patients, from NICU to geriatric patients
  • Increased organizational skills and ability to give quality nursing care to several patients in a limited amount of time
  • Established positive rapport with clients and coworkers

OTHER WORK EXPERIENCE
• Outreach Coordinator (March 2011- January 2013)
  Christians for the Mountains, non-profit organization
  • Used effective communication and emotional intelligence
  • Gained understanding of politics and public health advocacy
  • Led community health surveys in West Virginia and Kentucky that influenced health legislation

MEMBERSHIP
• Active member of PSNA and ANA
• PSNA Environmental Health Committee Board member
Appendix B: Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking, 6th edition, pg. 21-45
Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction)

Sixth Edition

June 2019
Introduction to Fracking

Since the end of the 20th century, horizontal drilling has been combined with high-volume hydraulic fracturing to create a novel approach to extracting dispersed oil and natural gas, primarily from shale bedrock, that would otherwise not flow to the surface. Typically, these unconventional extraction methods (collectively known as “fracking”) take place on clustered multi-well pads where individual wellbores extend vertically down into the shale formation and then turn horizontally, tunneling through the shale in various directions. These lateral tunnels can extend as far as two miles underground.

To liberate the gas (methane) or oil trapped inside the shale, many small explosive charges followed by high volumes of pressurized fluid are sent into the shale layer to expand and extend its many naturally occurring cracks, bedding planes, and faults. Silica sand grains (or sometimes ceramic beads) are carried by the pressurized fluid into these spaces and remain there after the pressure is released, acting to prop open these now-widened fissures in the shale and allowing the methane or oil trapped within to flow up the well.

Fracking fluid consists of millions of gallons of fresh water to which is added a sequence of chemicals that include biocides, lubricants, gelling agents, anti-scaling, and anti-corrosion agents. Some of the water used to frack wells remains trapped within the fractured zone and, as such, is permanently removed from the hydrologic cycle. The remainder travels back up to the surface. This flowback fluid contains not only the original chemical additives, many of which are toxic, but also harmful substances carried up from the shale zone, which often include brine, heavy metals, and radioactive elements.

Once in production, a fracked well continues to generate liquid throughout its lifetime. This produced water, which contains many of the same toxic substances as flowback fluid, is a second component of fracting waste, and it also requires containment and disposal. In addition, fracting waste includes solid drilling cuttings, which are typically laced with various chemical substances used to aid the drilling process. These cuttings, which can also contain radioactive elements, are typically disposed in municipal waste landfills. Fracking waste is exempt from federal hazardous waste regulations that would otherwise prohibit this practice.

Downstream elements of fracting infrastructure, which lie between the wellhead and the point of combustion, include processing plants, transport infrastructure such as pipelines and compressor stations, distribution lines storage facilities, gas-fired power plants, and LNG liquefaction plants and export terminals. Upstream elements include silica sand mining operations and water withdrawal operations.

As fracting operations in the United States have increased in frequency, size, and intensity, and as the transport of extracted materials has expanded, a significant body of evidence has emerged to demonstrate that these activities are dangerous to people and their communities in ways that are difficult—and may prove impossible—to mitigate. Risks include adverse impacts on water, air, agriculture, public health and safety, property values, climate stability, and economic vitality, as well as earthquakes.
Researching these complex, large-scale industrialized activities and the ancillary infrastructure that supports them takes time and has been hindered by institutional secrecy. Nonetheless, research is gradually catching up to the last decade’s surge in fracking from shale. A growing body of peer-reviewed studies, accident reports, and investigative articles has detailed specific, quantifiable evidence of harm and has revealed fundamental problems with the entire life cycle of operations associated with unconventional drilling, fracking, and fracked-gas infrastructure. Industry studies, as well as independent analyses, indicate inherent engineering problems including uncontrolled and unpredictable fracturing, induced seismicity, extensive methane leakage, and well casing and cement failures that cannot be prevented with currently available materials and technologies.

Fracking-related problems also originate from sources independent of engineering. These include habitat destruction; inadequate solutions for wastewater disposal; the presence of abandoned wells or vertical fault lines that can serve as pathways for fluid migration into aquifers; and standard operational industry norms (venting, flaring, blowdowns) that contribute to methane releases and air pollution.

Earlier scientific predictions are now bolstered by extensive empirical data, confirming that the public health risks from unconventional gas and oil extraction are real, the range of adverse environmental impacts wide, and the negative economic consequences considerable. Our examination of the peer-reviewed medical, public health, biological, earth sciences, and engineering literature uncovered no evidence that fracking can be practiced in a manner that does not threaten human health.

Despite this expanding body of knowledge, industry secrecy continues to thwart scientific inquiry, leaving many potential problems—especially cumulative, long-term risks—unidentified, unmonitored, and largely unexplored. This problem is compounded by non-disclosure agreements, sealed court records, and legal settlements that prevent families and their doctors from discussing injuries and illnesses that result from fracking and frack-related operations. Consequently, no quantitative and comprehensive inventory of human hazards yet exists.

The long-entrenched problem of secrecy shows no sign of resolving. The identity of chemicals used in fracking fluids remains proprietary and lies beyond the reach of federal right-to-know legislation that governs other industries. The nation’s largest public database on chemicals used in fracking operations, FracFocus, operates on a voluntary basis, and while 23 states have adopted it to serve as a de facto chemical disclosure registry, its data has, over time, become increasingly less, rather than more, comprehensive and transparent. As documented in a 2016 study by a Harvard University team, rates of withheld information and claims of trade secrecy have increased since FracFocus was first launched in 2011. (See footnotes 1445, 1446.)

The incomplete picture created by lack of transparency in regard to chemicals used, produced, emitted, or created during the drilling and fracking process complicates the task of identifying potential hazards and exposure pathways. Nevertheless, the evidence to date indicates that fracking operations pose severe threats to health, both from water contamination and from air pollution.

In the United States, more than two billion gallons of water and fracking fluids are injected daily under high pressure into the earth for the purpose of enabling oil and gas extraction via fracking.
or, after the fracking is finished, to flush the extracted wastewater down any of the more than 187,000 disposal wells across the country that accept oil and gas waste. All of that two billion daily gallons of fluid is toxic, and the wells that ferry it pass through our nation’s groundwater aquifers on their way to the deep geological strata below, where the injection of fracking waste demonstrably raises the risk for earthquakes.

In the air around drilling and fracking operations and their attendant infrastructure, researchers have measured strikingly high levels of toxic pollutants, including the potent carcinogen benzene and the chemical precursors of ground-level ozone (smog). In some cases, concentrations of fracking-related air pollutants in communities where people live and work exceed federal safety standards. Research shows that air emissions from fracking can drift and pollute the air hundreds of miles downwind. (See footnotes 182-184.)

About one-third of the natural gas inventory in the United States is used to generate electricity, and, enabled by fracking, natural gas has, as of 2016, exceeded coal as the nation’s leading source of electricity. With hydraulically fractured wells now producing 70 percent of U.S. natural gas and half of U.S. crude oil, and with hydraulic fracturing used in 95 percent of new wells, the “unconventional” techniques of fracking can no longer be considered atypical nor can the question of their public health risks be considered inconsequential.

Drilling and fracking operations and their ancillary infrastructure have profoundly altered Earth’s landscape. The flare stacks and artificial lights from major shale plays are visible from space, as is the upward buckling of Earth’s surface that is caused by the high-pressure injection of fracking wastewater into disposal wells.

The dramatic increase in fracking over the last decade in the United States has pushed oil and gas extraction operations into heavily populated areas. In the Marcellus Shale alone, which underlies much of the Mid-Atlantic United States, 15,939 wells were drilled and fracked between 2008 and 2018. More than 11,000 of these wells are in Pennsylvania.

At least six percent of the U.S. population—17.6 million Americans—now live within a mile of an active oil or gas well, a number that includes 1.4 million young children and 1.1 million

elderly people.\textsuperscript{50, 51} About 8.6 million people are served by a drinking water source that is located within a mile from an unconventional well. (See footnote 302.) Understanding the potential for exposure and accompanying adverse impacts is a public health necessity.

**Emerging Trends**

1) **Regulations are simply not capable of preventing harm.**

Studies reveal inherent problems in the natural gas and oil extraction process, such as well integrity failures caused by aging or the pressures of fracking itself, and in the waste disposal process. These issues lead to water contamination, greenhouse gas emissions, air pollution with carcinogens and other toxic chemicals, earthquakes, and a range of environmental and other stressors inflicted on communities.

Some of fracking’s many component parts—which include the subterranean geological landscape itself—are simply not controllable.

Compounding the innate unpredictability of the fracking process: The number of wells and their attendant infrastructure continue to proliferate, creating burgeoning cumulative impacts, and the size of individual wells keep growing. With the horizontal portions of a single well now extending as far as two miles or more underground, fluid injections, once typically three to five million gallons per fracked well, now can easily reach 10 to 20 million gallons per well.

The injection of ever-increasing volumes of fluids into an ever-increasing number of wells creates significant deformations in the shale. These are translated upwards, a mile or more, to the surface. Along the way, these “pressure bulbs” can impact, in unpredictable ways, faults and fissures in the overlying rock strata, including strata that intersect fresh water aquifers. Such pressure bulbs may mobilize contaminants left over from previous drilling and mining activities. (See footnotes 370, 371.) No set of regulations can obviate these potential impacts to groundwater.

No set of regulations can eliminate earthquake risks. (See footnote 752.) In spite of growing knowledge about the mechanics of how fracking and the underground disposal of fracking waste trigger earthquakes via activation of faults, no model can predict where or when earthquakes will occur or how powerful they will be. New research demonstrates that induced earthquakes can occur many miles from fracking sites. (See footnote 73.)

Regulations cannot prevent air pollution. The state of California determined that fracking can have “significant and unavoidable” impacts on air quality, including driving pollutants to levels that violate air quality standards. (See footnote 173.) In northeastern Colorado, ambient levels of atmospheric hydrocarbons have continued to increase even with stricter emission standards. (See

\textsuperscript{50} Czolowski, E. D., Santoro, R. L., Srebotnjak, T., & Shonkoff, S. B. C. (2017). Toward consistent methodology to quantify populations in proximity to oil and gas development: A national spatial analysis and review. *Environmental Health Perspectives*, 125(8). doi: 10.1289/EHP1535

footnote 188.) Tighter state regulations and tougher enforcement, including unannounced visits by state health inspectors equipped with infrared cameras, have reduced leaking methane and toxic vapors at individual well sites, but total air emissions continue to rise as the total number of wells continues to increase. At this writing, there are 53,000 active oil and gas wells in Colorado.\textsuperscript{52}

Leakage rates among active wells are wildly variable: Four percent of wells nationwide are responsible for fully half of all methane emissions from drilling and fracking-related activities. Predicting which wells will become “super-emitters” is not possible, according to a 2016 survey of 8,000 wells using helicopters and infrared cameras. Further, much of this leakage is engineered into the routine operation of fracking extraction, processing, and transport infrastructure, as when vapors are vented through release valves in order to regulate pressure. (See footnotes 994, 995.)

Long after they are decommissioned, well sites continue to leak in ways that are not always fixable. Abandoned wells are a significant source of methane leakage into the atmosphere, and, based on findings from New York and Pennsylvania, may exceed cumulative total leakage from oil and gas wells currently in production. Plugging abandoned wells does not always reduce methane emissions, and cement plugs themselves deteriorate over time. (See footnote 475.)

Further, countless abandoned wells are unmapped and their locations unknown. Many have no apparent owner. Across the nation, there are as many as three million abandoned wells. Pennsylvania alone is home to 200,000 to 750,000 abandoned wells, most of which are not charted or even visible on the surface.\textsuperscript{53} No state or federal agency routinely monitors methane leakage from abandoned wells. (See footnotes 854, 859.) In Alberta, Canada, there are roughly 90,000 inactive wells in need of plugging, a number that is expected to double in the next eleven years. The Alberta Energy Regulator has estimated that the time required to plug and prepare 180,000 wells for clean-up and reclamation is 126 years. Another 77,000 wells in Alberta are plugged but not yet reclaimed.\textsuperscript{54}

2) Fracking and natural gas are incompatible with climate solutions.

On the grounds that natural gas emits, when combusted, only 53 percent of the carbon dioxide emitted by coal, early promoters of fracking argued that natural gas could serve as a “bridge fuel” while renewable energy sources ramp up. Scientific evidence now disproves these claims and shows that natural gas is as damaging to the climate as coal, and may be worse.

Natural gas is 85-95 percent methane, a short-lived but much more potent greenhouse gas than formerly appreciated. The Intergovernmental Panel on Climate Change estimates that, over a 20-

\textsuperscript{52} Finley, B. (2019, April 21). Colorado’s unannounced air-pollution inspections at oil and gas sites are showing results—yet emissions are up as production continues. \textit{Denver Post}. Retrieved from \url{https://www.denverpost.com/2019/04/21/colorado-air-pollution-oil-gas-sites/}


year time frame—longer than the dozen years remaining to limit global warming to 1.5°C—methane can, pound for pound, trap 86 times more heat than carbon dioxide. (See footnote 1045.)

Real-world methane leakage rates from drilling and fracking operations greatly exceed earlier estimates. Methane escapes into the atmosphere from all parts of the extraction, processing, and distribution system, all the way to the burner tip. In the heavily drilled Barnett Shale of northeastern Texas, methane emissions were shown to be 50 percent higher than the EPA had estimated. Fracking operations and associated infrastructure contributed 71-85 percent of the methane emissions in the region. A 2018 analysis of methane leaks from the U.S. oil and gas supply chain as a whole found leakage rates were 60 percent higher than reported by the EPA, and a 2019 study in southwestern Pennsylvania found shale gas emissions that were underreported by a factor of five when compared to EPA estimates. (See footnotes 944, 962.)

Much of the methane emitted from drilling and fracking activities and associated infrastructure originates not from accidental leaks but from purposeful losses that are inherent to the design of the industry’s machinery or to normal operating use and are, therefore, not possible to mitigate. (See footnotes 1147-1149.) Methane is vented into the atmosphere during routine maintenance on compressor stations and pipelines; to create evaporative cooling for LNG storage and transport; during the flowback period after a well is fracked; and as an emergency procedure to control pressures. Inactive, abandoned wells are also significant methane emitters. Methane leakage at the levels now being documented, using multiple approaches in measurement and modeling, negates previously hypothesized benefits from burning methane instead of coal in most existing power plants.

Rising methane levels in the atmosphere make increasingly difficult the urgent task of limiting global warming to below levels called for in the Paris Agreement, which was based on older presumptions that global methane levels had plateaued. Instead, methane levels began to rise in 2007 and then shot up sharply in 2014.

At this writing, the cause of this ongoing methane surge is a subject of scientific debate. One hypothesis holds fossil fuel sources as the major driver. Another attributes the increase to biogenic sources, especially ruminant livestock. A third possibility is that rising global temperatures may be triggering methane release from wetlands, particularly in the southern tropics. Alternatively, the atmosphere’s ability to break methane molecules apart may have become impaired, slowing the natural decay rate of methane.55

The fossil fuel hypothesis is supported by a major 2017 study led by NASA researchers using satellite measurements and isotopic analysis that can distinguish methane produced by microbes from methane emissions arising from oil and gas extraction. (See footnote 963.) Building on this research in a forthcoming study, Cornell University earth systems scientist Robert Howarth used isotopic analysis to identify shale gas and oil extraction as the source of at least one-third of total

methane emissions, showing that the North American fracking boom is globally important in the current rise in global methane levels and “may well be the leading cause of the increased flux.”

Climate researcher Euan Nisbet, who has called for a renewed emphasis on reducing methane emissions to combat climate change, notes that, whatever the relative contribution of its various sources, fossil fuel extraction represents a powerful lever for intervention. “If the increased methane burden is driven by increased emissions from natural sources, and if this is a climate feedback—the warming feeding the warming—then there is urgency to reduce anthropogenic emissions, which we can control.” Reducing methane emissions from fossil fuels is the highest priority because they are relatively large and “thus offer attractive targets for rapid reduction, which are essential if the Paris Agreement aims are to be attained.” (see footnote 952.)

3) Fracking and the disposal of fracking waste threaten drinking water.

Cases of drinking water sources contaminated by drilling and fracking activities, or by associated waste disposal, are proven. Contamination occurs through three confirmed pathways: spills; discharge of fracking waste into rivers and streams; and underground migration of chemicals, including gas, into drinking water wells.

Methane and fracking-related contaminants can reach drinking water sources through cracks in well casings, through spaces between the casing and the wellbore, through naturally occurring fractures and fissures connecting shale layers with aquifers, and through abandoned wells. Methane migration into drinking water aquifers can change water chemistry in ways that mobilize metals or release hydrogen sulfide. (See footnote 248.)

Researchers working in Texas found 19 different fracking-related contaminants—including cancer-causing benzene—in hundreds of drinking water samples collected from the aquifer overlying the heavily drilled Barnett Shale, thereby documenting widespread water contamination. In Pennsylvania, a solvent used in fracking fluid was found in drinking water wells near drilling and fracking operations known to have well casing problems. In California, state regulators admitted that they had mistakenly allowed oil companies to inject drilling wastewater into aquifers containing clean, potable water. (See footnotes 352, 356, 360.) A 2017 study found that fracking wastewater discharged into rivers and streams through treatment plants created dozens of brominated and iodinated disinfection byproducts that are particularly toxic and “raise concerns regarding human health.” (See footnote 286.)

Fracking also threatens drinking water supplies through water depletion, especially in arid regions. According to a 2019 report, the volume of water used for fracking U.S. oil wells has more than doubled since 2016. (See footnote 245.) Oil and gas operations in the arid Permian Basin used eight times more water for fracking in 2018 as they did in 2011, threatening groundwater supplies. (See footnote 17.) In Arkansas, researchers found that water withdrawals for fracking operations deplete streams used for drinking water and recreation.

With increasing volumes of wastewater now exceeding the storage capacity for underground injection wells—and with underground injection linked to earthquake risk—Texas, Colorado, and New Mexico are now petitioning the EPA to allow release of fracking wastewater into rivers and streams and to allow its use for irrigation and watering livestock. These practices further imperil drinking water sources.\(^{57}\)

The trend toward mega-fracking, with longer and more extensive horizontal wellbores per well pad, coupled with the ongoing proliferation in the number of wells, has pushed the demand for water use in fracking operations ever higher, exacerbating both the problem of drinking water depletion and the problem of how to dispose of ever-increasing amounts of toxic fracking wastewater. A 2018 study found that water used for U.S. fracking operations increased by 770 percent per well between 2011 and 2016, while the amount of wastewater generated increased by 1,440 percent. (See footnote 259.)

As we went to press, a new study in Pennsylvania shows that, of the wastewater that remains in-state, 52 percent is reused in additional extraction operations, a practice that further concentrates chemical contaminants, including radioactive substances. The final destination for 35 percent of the total volume of liquid oil and gas waste generated in Pennsylvania from 1991-2017 is unknown because of gaps in reporting systems.\(^{58}\)

4) Drilling and fracking contribute to toxic air pollution and ground-level ozone at levels known to have health impacts.

More than 200 airborne chemical contaminants have been detected near drilling and fracking sites. Of these, 61 are classified as hazardous air pollutants, including carcinogens; 26 are endocrine-disrupting compounds that have been linked to reproductive, developmental, and neurological damage. (See footnotes 134, 146.) Drilling and fracking operations emit fine particles and vapors that combine to create ground-level ozone (smog). Exposure to these pollutants is known to cause premature death, exacerbate asthma, and contribute to poor birth outcomes and increased rates of hospitalization and emergency room visits.

Of the lower 48 states, six states (Texas, Oklahoma, Colorado, North Dakota, West Virginia, and Pennsylvania) produce nearly 70 percent of the nation’s natural gas and over 74 percent of onshore crude oil. These six states experience the highest levels of ground-level ozone and fine particle pollution attributable to oil and gas extraction activities.

Volatile organic compounds (VOCs) from drilling and fracking operations, together with nitrogen oxides, are responsible for 17 percent of locally produced ozone in Colorado’s heavily drilled Front Range. (See footnote 160.) Colorado has exceeded federal ozone limits for the past decade, a period that corresponds to a boom in oil and gas drilling (See footnote 158.) Air

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pollution near drilling and fracking operations is high enough in some Colorado communities to raise cancer risks, according to a 2018 study. (See footnote 145.)

Living near drilling and fracking operations significantly increases asthma attacks for residents of Pennsylvania. Those living near active gas wells are 1.5-4 times more likely to suffer from asthma attacks than those living farther away, with the closest group having the highest risk. (See footnotes 636, 637.)

In California, fracking occurs disproportionately in areas already suffering from serious air quality problems and can drive ozone and other federally regulated air pollutants to levels that violate air quality standards. (See footnotes 172, 173.) This increased air pollution and smog formation poses a serious risk to all those already suffering from respiratory issues, such as children with asthma. With an average of 203 high-ozone days a year, intensely fracked Kern County, California, is the fifth-most ozone-polluted county in the nation, according to the American Lung Association.

Several studies have documented a sharp uptick in atmospheric ethane, a gas that co-occurs with methane and whose presence is attributable to emissions from oil and gas wells. This trend reverses a previous, decades-long decline. Ethane is a potent precursor to ground-level ozone. (See footnote 162-164.)

The United States leads the world in the number of drill site flaring operations. Flares are used to control pressure but, more frequently, to burn off natural gas as waste during oil drilling in places that lack infrastructure for gas capture and transport. The ongoing boom in domestic oil production enabled by fracking has caused natural gas flaring to proliferate. Emissions from flare stacks contribute to ozone creation and include several carcinogens, notably benzene and formaldehyde. Flaring also releases carbon monoxide, soot, and toxic heavy metals. In 2016, the EPA acknowledged that it had dramatically underestimated health-damaging air pollutants from flaring operations. (See footnotes 156, 157.) A 2017 study of plume samples from gas flares in North Dakota found that incomplete combustion from flaring is responsible for 20 percent of the total emissions of methane and ethane from the Bakken shale fields—more than double the expected value. (See footnote 152.) Results of a 2019 study of flaring in the Eagle Ford Shale region of Texas suggest that flaring may be a significant environmental exposure in counties where flare stacks are concentrated. (See footnote 137.)

5) Public health problems associated with drilling and fracking include poor birth outcomes, reproductive and respiratory impacts, and cancer risks.

Poor pregnancy outcomes and exacerbation of asthma have been linked to fracking activities in multiple studies in multiple locations using a variety of methodologies. (See footnote 1410.)

Studies of mothers living near oil and gas extraction operations consistently find impairments to infant health, including elevated risks for low birth weight and preterm birth. A 2017 study that examined birth certificates for all 1.1 million infants born in Pennsylvania between 2004-2013 found indicators of poorer infant health and significantly lower birth weights among babies born to mothers living near fracking sites. A 2015 Pennsylvania study found a 40 percent increase in the risk of preterm birth among infants born to mothers who lived nearby active drilling and
fracking sites, while a 2014 Colorado study found elevated incidence of neural tube defects and congenital heart defects. New studies in Texas and Colorado likewise found associations with infant deaths, high-risk pregnancies, and low birth weight. A 2017 pilot study in British Columbia found elevated levels of muconic acid—a marker of benzene exposure—in the urine of pregnant women living near fracking sites. (See footnotes 625, 627, 642, 664.)

As we went to press, a new pilot study reported elevated levels of barium and strontium in urine and hair samples of indigenous women living in an area of intense fracking activity in northeastern British Columbia. These trace metals, known to be released during hydraulic fracturing, are known developmental toxicants.59

An emerging body of evidence, from both human and animal studies, shows harm to fertility and reproductive success from exposure to oil and gas operations, at least some of which may be linked to the dozens of known endocrine-disrupting chemicals used in hydraulic fracturing. (See footnotes 642, 1438, 1443, 1444.)

Other documented adverse health indicators among residents living near drilling and fracking operations variously include exacerbation of asthma as well as increased rates of hospitalization, ambulance runs, emergency room visits, self-reported respiratory problems and rashes, motor vehicle fatalities, trauma, drug abuse, and gonorrhea. Pennsylvania residents with the highest exposure to active fracked gas wells were nearly twice as likely to experience a combination of migraine headaches, chronic nasal and sinus symptoms, and severe fatigue. (See footnote 634.)

A 2017 Colorado study found higher rates of leukemia among children and young adults living in areas dense with oil and gas wells, while a Yale University research team reported that carcinogens involved in fracking operations had the potential to contaminate both air and water in nearby communities in ways that may increase the risk of childhood leukemia. The Yale team identified 55 known or possible carcinogens that are known to be used in fracking operations and that may be released into the air and water. Of these, 20 are linked to leukemia or lymphoma. (See footnotes 632, 1424.)

As we went to press, the Pittsburgh Post-Gazette documented 27 cases of Ewing’s sarcoma, a rare bone cancer that tends to strike young people, in four counties in southwestern Pennsylvania that are at the center of the Marcellus Shale fracking boom.60 Six cases occurred in the same school district. (The typical rate is 250 cases of Ewing’s sarcoma per year in the United States as a whole. The cancer has no known cause.) There are also high numbers of other childhood cancers in the region, which is home to several polluting legacy industries. The Pennsylvania Department of Health reported “no conclusive findings” of a cancer cluster in the Canon-

McMillan School District and Washington County, but as additional cases have come to light, calls for more comprehensive investigations are ongoing.  

6) Occupational health and safety risks for workers are severe and include both physical and chemical hazards.

Drilling and fracking operations are exempt from federal Occupational Safety and Health Administration (OSHA) standards designed to prevent catastrophic releases of toxic, flammable, or explosive chemicals in workplaces. They are also exempt from OSHA rules written for the construction industry designed to prevent falls and other accidents on the job. Although announced by the agency as forthcoming in 1983, federal safety regulations for the oil and gas industry have never materialized. Instead, inspectors can only apply the “general duty clause” which is widely recognized as grossly inadequate for an industry with unique hazards and a fatality rate far above the national average. Fatality rate data for the oil and gas industry are limited, but available data in the seven years leading up to 2015 show fatality rates in oil and gas extraction that are four to seven times the national fatality rate. In 2017, the most recent year for which data are available, 81 oil and gas extraction workers died on the job, accounting for 72 percent of the fatal work injuries in the mining sector, which overall has a fatality rate nearly four times the national average.

Studies in specific states, as well as some national studies, have provided additional details on regional rates and circumstances of injuries and deaths. Fatality rates among workers in the oil and gas extraction sector in North Dakota were seven times the national fatality rates in this industry, which itself has more deaths from fires and explosions than any other private industry.

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An increase in workplace deaths likewise accompanied the initial fracking boom period in West Virginia.

Between 2011 and 2016, at least 60 workers at oil and gas drilling sites in Oklahoma were killed on the job. In January 2018, a natural gas rig exploded in southeastern Oklahoma, killing five workers when natural gas exploded during the drilling process. A “factual update” issued in August 2018 as part of an ongoing investigation by the U.S. Chemical Safety Board (CSB), determined that a piece of safety equipment was unable to fully close on the day of the accident and that other safety corners had been cut (See footnotes 532, 533, 537.) As we went to press, the CSB, released the final report on the accident, emphasizing that, in fact, two preventive barriers designed to prevent uncontrolled gas blowouts had failed as a consequence of significant lapses in safety protocols. Warning alarms did not sound. All five workers who died were trapped inside the driller’s cabin when fire blocked both exit doors. This problem, inherent to the design of the cabin, is not exceptional. The CSB investigation found that “there is no guidance to ensure that an emergency evacuation option is present onboard these rigs or can protect workers in the driller’s cabin from fire hazards.”

Pipeline construction workers also suffer elevated rates of injuries and fatalities, dying on the job 3.5 times more than workers in other industries.

All together, according to a 2018 investigation, 1,566 U.S. workers in the oil and gas drilling industry died from on-the-job injuries in the decade between 2008 and 2017.

A University of Tennessee study assessed the occupational inhalation risks from the hazardous and carcinogenic air pollutants emitted from various sources around fracking wells and found that chemical storage tanks presented the highest cancer risk. Benzene has been detected in the urine of wellpad workers in Colorado and Wyoming. The National Institute for Occupational Safety and Health named oil and gas extraction industry workers among those at risk for silicosis, an incurable lung disease caused by exposure to silica dust, from the silica sand that is used extensively in fracking operations. (See footnotes 548, 586, 594.)

7) Earthquakes are a proven consequence of both fracking and the underground injection of fracking waste.

Injection of fracking wastewater into underground disposal wells is a known trigger of earthquake swarms in multiple locations, as demonstrated by several major studies, using different methodologies. Newer research in Canada, Oklahoma, and China links the practice of fracking itself to earthquakes, including some that take place many miles from well sites and

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many years later, suggesting that seismic risks have been previously underestimated with much larger areas at risk and for longer periods of time.\textsuperscript{72, 73}

A 2017 study of the Fort Worth Basin showed that a recent swarm of small earthquakes in northern Texas was originating in long-inactive fault lines in deep formations where fracking wastewater was being injected. Human activity is the only plausible explanation. (See footnote 499.) Another study using satellite-based radar imagery provided proof that the migration of fracking wastewater into faults increased pressures in ways that triggered a 4.8-magnitude earthquake in east Texas in 2012, while a third study documented the rupture of a fault plane that set off a 4.9-magnitude earthquake in Kansas in 2014 immediately following a rapid increase in fracking wastewater injection nearby. (See footnotes 747, 748.)

The number of earthquakes of magnitude 3.0 or higher skyrocketed in Oklahoma starting with the advent of the fracking boom—with fewer than two per year before 2009 and more than 900 in 2015. The 5.8 earthquake that struck near Pawnee on September 3, 2016 was the strongest in Oklahoma’s history and prompted an order from state regulators to shut down 67 wastewater disposal wells in the area. (See footnotes 745, 746.) In October 2016, the EPA recommended a moratorium on the underground injection of fracking wastewater in certain earthquake-prone parts of Oklahoma because regulations had not solved the problem. (See footnote 743.) Earthquake frequency began to decline in the state in 2017. In February 2018, after a new cluster of earthquakes, the state further restricted fracking activities.\textsuperscript{74}

There is no evidence that fracking-induced earthquakes can be prevented solely by limiting the rate or volume of injected fluid. A 2018 analysis of shale basins across the United States found that shallower disposal wells can help lower the risk of earthquakes. However, injection of fracking waste into shallow formations increases the risk of groundwater contamination. (See footnote 707.)

In China’s Sichuan Province, a series of recent earthquakes have been linked to fracking, including one in December 2018 with a magnitude of 5.7, the largest fracking-induced earthquake to date. The likely cause was reactivation of unmapped faults by underground fluid pressure.\textsuperscript{75} In February 2019, three additional earthquakes, all with a magnitude of over four, struck Sichuan Basin, killing two people, injuring 13, and damaging 20,000 homes. The government temporarily suspended fracking operations in the area.\textsuperscript{76}

\begin{thebibliography}{99}
\bibitem{75} Lei, X., Wang, Z., & Su, J. (2019). The December 2018 M\textsubscript{L} 5.7 and January 2019 M\textsubscript{L} 5.3 earthquakes in south Sichuan Basin induced by shale gas hydraulic fracturing. \textit{Seismological Research Letters}, \textbf{90}(3), 1099-1110. doi: 10.1785/0220190029
\end{thebibliography}
8) Fracking infrastructure poses serious potential exposure risks to those living nearby.

Drilling and fracking activities are relatively short-term operations, but compressor stations are semi-permanent facilities that pollute the air 24 hours a day as long as gas is flowing through pipelines. Day-to-day emissions from compressor stations are subject to highly episodic variations due to pressure changes and maintenance-related deliberate releases and can create periods of potentially extreme exposures. Compressor stations generally have shorter emissions stacks than other polluting facilities such as power plants, which means their harmful emissions are more concentrated at ground level than if released from a greater height. As we went to press, a new study of air emissions from 74 compressor stations in New York State found 39 chemicals known to be human carcinogens and documented large releases of greenhouse gases.77

Because of their high pressures, compressor station explosions can have catastrophic consequences. On January 30, 2019, a compressor station in rural Michigan malfunctioned during a period of extreme cold and released a large amount of methane gas that ignited and exploded. On May 13, 2019, Boston-area physicians released a report detailing safety-related risks at a proposed natural gas compressor station in Weymouth, Massachusetts. In a worst case scenario explosion, injuries could extend for thousands of feet into densely populated residential neighborhoods, ignite an nearby industrial diesel fuel storage tank, and kill motorists driving on an adjacent highway.78

Pipelines themselves can freeze, corrode, break, and leak. Low-pressure flow lines alone are responsible for more than 7,000 spills and leaks since 2009. (See footnote 1120.)

Significant pipeline accidents happen roughly 300 times each year in the United States and, between 1998 and 2017, killed 299 people and injured 1,190 others, according to the Pipeline and Hazardous Materials Safety Administration (PHMSA). In May 2019, PHMSA sent a warning to pipeline operators about increased risks of leaks and explosions caused by more frequent flooding, sinkholes, and severe rainfall patterns in the eastern United States.79 In September 2018, heavy rains and landslides triggered the explosion of a pipeline in Beaver County, Pennsylvania, destroying a house.80 All together, landslides have caused six pipeline explosions in the Appalachian region since early 2018.81

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Gas-fired power plants are major emitters of carbon monoxide and nitrogen oxides, which contribute to smog.

In the Upper Midwest, Wisconsin residents living near silica sand mining operations that service the fracking industry reported dust exposure and respiratory problems. Silica dust is a known cause of silicosis and lung cancer. West Texas is also experiencing a fracking sand boom where roughly 20 new sand mines have opened since July 2017. (See footnote 17.)

Fracking infrastructure in the United States also includes 400 underground gas storage facilities in 31 states, with aging equipment and scant federal oversight. The four-month leak at the nation’s fifth largest facility, Aliso Canyon in southern California, between October 2015 and February 2016 resulted in exposures of a large suburban population to an uncontrollable array of chemicals. With a release of nearly 100,000 metric tons of methane, it became the worst methane leak in U.S. history. (See footnote 1185.)

The Aliso Canyon blow-out exposed residents in the region to benzene spikes, high ongoing odorant releases, hydrogen sulfide at levels far above average urban levels, and many other contaminants of concern. More than 8,300 households were evacuated and relocated, with residents reporting multiple symptoms, including headaches, nosebleeds, eye irritation, and nausea. In May 2019, state investigators announced that the cause of the massive leak at Aliso Canyon was rupture of a well casing caused by microbial corrosion within a well that had been originally drilled in 1954. Over the years, the casing had come in contact with groundwater. The report also faulted the operator, SoCalGas, for failure to monitor and investigate more than 60 previous leaks at the gas storage complex.

In a 2018 analysis of the safety risks of all 14 facilities in California that store gas in depleted oil fields, the California Council of Science and Technology found that gas companies do not disclose the chemicals they are pumping underground nor do state regulators possess the necessary information to assess risks. Further, many wells servicing the storage fields are 60 to 90 years old with no regulatory limit to the age of the well. (See footnote 1178.)

LNG facilities—and the pipelines, coastal terminals, and ships that service them—are a rapidly growing component of fracking infrastructure as the shale gas boom has allowed the United States to seek long-term supply contracts for natural gas exports. In July 2017, the United Kingdom received its first delivery of LNG from the Sabine Pass export terminal in Louisiana. The Cove Point LNG export facility in Maryland sent its first shipments of Marcellus Shale gas, destined for Japan and India, in spring 2018. The United States is now a top international seller of natural gas with LNG exports expected to double by the end of 2019. At this writing, three LNG export terminals are in operation in the United States with another 22 in construction or approved for construction.

LNG is purified methane in the form of a bubbling, super-cold liquid. It is created through the capital-intensive, energy-intensive process of cryogenics and relies on evaporative cooling to keep the methane chilled during transport. Explosive and with the ability to flash-freeze human flesh, LNG creates acute security and public safety risks. Its greenhouse gas emissions are 30 percent higher than conventional natural gas due to refrigeration, venting, leaks, and flaring, which is used to control pressure during regasification. The need to strip volatile impurities such as benzene from the gas prior to chilling it also makes LNG liquefaction plants a source of toxic air pollutants. (See footnotes 1226-1242.)

Cheniere Energy’s Sabine Pass terminal in Louisiana became the subject of a federal investigation in January 2019 after a steel storage tank cracked and escaping LNG quickly vaporized into a flammable cloud. Another tank was found to be leaking gas from multiple places. PHMSA ordered both tanks shut down.86

In May 2019, the state of Oregon denied a Clean Water Act permit for the proposed Jordan Cove LNG export terminal, and the fracked gas pipeline that would serve it, over concerns about likely harm to streams, estuaries, and wetlands. This infrastructure project cannot be built without the state permit, but the company has reapplied.87

9) Drilling and fracking activities bring naturally occurring radioactive materials to the surface.

Naturally occurring radioactive materials that occur in shale layers containing oil and natural gas are brought to the surface in the solid waste removed during drilling (drill cuttings) and in fracking wastewater. Radionuclides can also build up in pipes and equipment, and fracking itself can open pathways for the migration of radioactive materials. Exposure to increased radiation levels from fracking materials is a risk for both workers and residents.

Radon levels in Pennsylvania homes have risen since the advent of the fracking boom, and buildings in heavily drilled areas have significantly higher radon readings than areas without well pads—a discrepancy that did not exist before 2004. (See footnote 511.) As we went to press, a new study reported a similar pattern in Ohio.88

Also in Pennsylvania, a 2019 study measured levels of radium in drill cuttings that would exceed regulatory limits for disposal in landfills if drill cuttings were not exempt from federal regulations governing hazardous waste. Drill cuttings from Pennsylvania fracking operations are

routinely dumped in municipal waste landfills in Ohio and New York. (See footnote Swiedler, 2019.)

A variety of radioactive substances—including radium, thorium, and uranium—have been detected in fracking wastewater. A 2018 study in the Marcellus Shale region showed that extreme salinity, as well as the chemical composition of fracking fluid, interacts with the shale during the fracking process in ways that mobilize radium and make fracking wastewater radioactive. (See footnote 497.)

A 2018 simulation study of radium-226 in fracking wastewater from North Dakota’s Bakken Shale found potential risk to human health from fracking wastewater spills into surface water. (See footnote 500.)

10) Drilling and fracking activities harm wildlife through multiple pathways.

Animals serve as sentinels for chemical exposures that may also affect human residents who share their environment. In addition, animals perform ecosystem services essential to human existence, as confirmed by a landmark United Nations report in May 2019.89 For both reasons, harm to wildlife by fracking operations has consequences for public health.

Birds and other wildlife have been poisoned by fracking wastewater held in open pits, while spills and discharges of fracking waste have precipitated mass die-offs of fish, as documented in Ohio, Kentucky, and Pennsylvania. (See footnotes 406, 434.) Freshwater mussels, which are endangered throughout North America, accumulate contaminants, including strontium, when fracking wastewater is discharged through sewage treatment plants. (See footnote 255.) Chemicals in fracking waste are toxic to, or otherwise disrupt development in, many fish and amphibian species. (See footnotes 246, 326.) In remote locations in Pennsylvania, streams once classified as high-quality brook trout habitat had no fish at all after the arrival of drilling and fracking operations. (See footnote 311.) Overall, aquatic habitats impacted by fracking activities show decreased biodiversity.

Wildlife is harmed by fracking through loss of food resources. Water fleas (Daphnia spp.), the basis of freshwater aquatic food chains, become unable to vertically navigate through water columns upon exposure to trace amounts of fracking fluid. (See footnote 241.) In West Virginia, populations of Louisiana Waterthrush, which rely on aquatic food sources, have declined in areas of drilling and fracking. (See footnote 247.)

Light and noise pollution from oil and gas production disrupt wildlife behavior, including in protected areas and critical habitats of endangered species, and have been linked to mass die-offs of waterfowl and declines in songbird populations in Alberta, Canada and New Mexico. (See footnotes 678, 693.) Chronic noise from drilling and fracking operations interferes with the ability of birds to respond to acoustic cues. (See footnotes 1111, 1112.)

Fracking harms wildlife through climate change and habitat destruction. Oil and gas infrastructure, including compressor stations, has caused declines in grassland songbirds in Canada. Sand mining operations in Texas are imperiling the dunes sagebrush lizard. The proposed route of the Atlantic Coast Pipeline cuts through critical habitat for four endangered species. A 2019 study found that forest disturbances driven by drilling and fracking activities are altering the abundance of songbird populations in central Appalachia, particularly harming species whose habitats are forest interiors. ⑨ Well pad construction hastens the spread of invasive non-native plant species which harms wildlife habitat. (See footnote 925.)

According to economists, the cost of wildlife habitat fragmentation due to fracking is $3.5-4.45 billion. (See footnote 1276.)

11) **The risks posed by fracking in California are unique.**

Hydraulic fracturing in California is practiced differently than in other states, making its risks different as well. Wells are more likely to be vertical rather than horizontal, and the oil-containing rock layer is shallower. Hence, much less water is used per well for fracking as compared to other states. However, the fracking fluid used is much more chemically concentrated, the fracking zones are located closer to overlying aquifers, and the risk of a fracture reaching groundwater is higher.

California is the only state that allows wastewater from oil fields to be held in unlined open pits, which creates risks for both air and groundwater contamination. As of July 2018, 1,086 such pits were operational in the Central Valley, with the vast majority in Kern County. An investigation by reporters for NBC Bay Area found additional pits not on the state’s official list. In at least two instances, toxic wastewater from the pits had migrated underground for more than a mile. ⑩

In 2014, the discovery that companies had, for years, been wrongly allowed to inject fracking waste directly into California’s freshwater aquifers led to the closing of 175 disposal wells. Impacts on drinking water are unknown. (See footnotes 289, 290.)

Most new fracking operations in California take place in areas with a long history of oil extraction. A high density of old and abandoned wells provides potential leakage pathways, should fractures intersect with them. And although fracking requires considerably less water per well in California, it takes place disproportionately in areas of severe water shortages and can compete with municipal and agricultural needs for freshwater.

The combination of ongoing drought and lack of disposal options has resulted in the diversion of fracking wastewater to farmers for irrigation of crops, raising concerns about contaminated water potentially affecting food crops and draining into groundwater. Investigative reports in 2015

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revealed that Chevron Corporation piped 21 million gallons of recycled oil and gas wastewater per day to farmers for crop irrigation. Tests showed the presence of several volatile organic compounds, including acetone, which is linked in lab studies to kidney, liver, and nerve damage. (See footnotes 924-926.)

These activities project fracking’s impacts onto geographically distant populations, especially in cases where wastewater is used in crop irrigation and livestock watering. Food is a troubling possible exposure route to fracking chemicals, in part because so little is known about these chemicals. According to a hazard assessment of chemicals used in California oil drilling operations that reuse wastewater for livestock watering and other agricultural purposes, more than one-third of the 173 chemicals used are classified as trade secrets: Their identities are entirely unknown. Of the remainder, ten are likely carcinogens, 22 are toxic air contaminants, and 14 had no toxicity data available. Estimating risks to consumers of the food produced with wastewater irrigation is thus not possible. (See footnote 919.)

The other area in California where fracking is concentrated, the Los Angeles Basin, is located directly under one of the most populous cities in the world. As of 2018, there were 3,468 active and 1,850 inactive oil and gas wells in Los Angeles County. (LA Dept of Health 2018). At least 1.7 million people in Los Angeles live or work within one mile of an active oil or gas well. California does not currently limit how close to residences or schools drilling and fracking activities may be conducted. A 2017 study shows that many of the same chemicals used to stimulate wells during fracking operations are also used in urban oil wells located in densely populated areas of southern California. (See footnote 295.)

12) Fracking in Florida presents many unknowns.

Gas and oil drilling in Florida, now only a minor industry, is currently concentrated in two areas: the western Panhandle near Pensacola and the Everglades area of southwest Florida. So far, fracking has been used at least once—in 2013 at a test well located in the Corkscrew Swamp Sanctuary near Naples in Collier County. The Texas company that fracked this well, using high-pressure acid fracturing techniques to dissolve the bedrock, received a cease and desist order from the Florida Department of Environmental Protection.92

Renewed interest in oil and gas exploration in Florida has prompted public debate about fracking and whether to promulgate state regulations or prohibit it outright, possibly including a ban on the use of acid-dissolving technologies in addition to hydraulic fracturing per se. Bills that sought to ban fracking but not matric acidizing failed to pass in the Florida legislature in the 2019 legislative session.93

Florida has more available groundwater than any other state; it is the drinking water source for 93 percent of Florida’s population. Groundwater is also pumped to irrigate crops and provide

frost protection to winter crops. Most of this water is held in the Floridan Aquifer, which extends across the entire peninsula and into parts of Georgia, Alabama, and South Carolina. This aquifer provides drinking water to ten million people in both rural and urban communities, including residents of several major cities: Gainesville, Jacksonville, Orlando, Tallahassee, and Tampa. Overlain by smaller, shallower aquifers in southern Florida, it is a highly permeable, highly interconnected subterranean system, with water moving rapidly in multiple directions through massive shelves of limestone, which represent the dissolved shells and fossilized skeletons of prehistoric marine organisms. Honeycombed with pores, fissures, joints, and caves, the underground terrain of the Floridan Aquifer resembles a vast, brittle, sponge partly covered with sand and clay. Springs and sinkholes are common.94, 95

It is not known whether fracking in Florida could induce sinkholes to open up or whether alterations in underground pressures could cause springs to go dry. Certainly, Florida’s porous geology makes it vulnerable to groundwater contamination. Crumbly, soluble limestone offers pathways for contaminants spilled on the surface to travel deep into the aquifer, where they can be dispersed over great distances by the aquifer’s river-like currents. A 2003 experiment with a dye tracer showed the special susceptibility of Florida’s groundwater to potential contamination; within a few hours, the red dye traveled through the aquifer a distance (330 feet) that researchers had presumed would take days.96

Compounding these risks, Florida’s exposure to hurricanes makes it vulnerable to spills of fracking-related chemicals. In August 2017, flooding from Hurricane Harvey shut down fracking sites in Texas and triggered 31 separate spills at wells, storage tanks, and pipelines. (See footnotes 888-890.)

It is unclear where Florida would send any potential fracking wastewater for treatment and/or for underground injection. Florida currently injects other types of liquid waste into disposal wells that are located above, rather than below, oil- and gas-producing zones. The injection of fracking waste in these same shallower layers may make earthquakes less likely than, for example, in Oklahoma (where it is injected into deep formations), but it would also locate that waste closer to the aquifers, which are poorly mapped. To undertake the necessary study to determine how securely Florida’s geological formations could contain wastewater from drilling and fracking operations and protect drinking water would be, in the words of two geophysicists, “a monumental task requiring full-time work…for decades.”97 There are reasons to be concerned. In

South Florida in the 1990s, 20 stringently regulated disposal wells failed and leaked sewage waste into the Upper Floridan Aquifer, a potential future source of drinking water for Miami.98

13) The economic instabilities of fracking exacerbate public health risks.

Fracking is not a stable business. Although the fracking boom has lifted U.S. oil and gas production to all-time highs, shale wells drilled in the past five years are pumping significantly less oil and gas than their operators predicted to their investors. Because the production of individual shale wells falls precipitously over the course of a few years, operators must continue drilling new wells at an ever-swifter pace to maintain growth targets—even as owners are under pressure to cut costs in the face of price declines.

The result is lack of profits, dependency on Wall Street financing and low interest rates, and asset sell-offs throughout the fracking industry as a whole. (See footnote Olson, Wall St. J., Jan 2, 2019.) Between 2008 and 2018, leading fracking companies spent $230 billion more than they earned, covering the gap with debt.99

Even as oil prices have rebounded somewhat during the past two years, fracking companies are, collectively, still spending more on drilling than they receive by selling oil and gas. By 2018, only five of the largest 20 fracking companies were making more cash than they spent, and the stock prices of all 29 shale producers fell.100, 101

These unstable economic fundamentals have multiple consequences for public health and safety as cumulative impacts mount from wells both old and new.

Pressures to cut costs incentivize cutbacks in safety measures and leave landscapes pock-marked by increasing numbers of hastily abandoned wells in need of remediation and long-term monitoring. Orphaned wells left behind by industry during energy price downturns or after bankruptcy are poorly monitored and, as conduits for gas and fluid leakage, become health and safety threats. Abandoned wells pose risks for soil and water contamination and can emit toxic air pollution and greenhouse gases. Some have exploded.102, 103, 104

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In both North Dakota’s Bakken Shale and western Texas’ Permian Basin, cost-cutting pressures, coupled with a desperate rush to drill new oil wells to compensate for declining rates of production from older wells, have meant that waste natural gas generated as a byproduct of oil drilling is simply vented or flared rather than captured, in order to speed up the rate of oil drilling.\(^{105, 106}\) By April 2019, the amount of natural gas burned off via flaring in the Permian oil fields had reached a record high and exceeded the amount of gas needed to power every residence in Texas.\(^{107}\) Flaring, a leading source of toxic air pollution and smog, is a public health menace.\(^{108}\)

Independent economic analyses also show that the promise of local job creation has been greatly exaggerated, with many jobs going to out-of-area workers. Reports show that oil and gas jobs increasingly will be lost to automation.

With the arrival of drilling and fracking operations, communities have experienced steep increases in rates of crime including sex trafficking, rape, assault, drunk driving, drug abuse, and violent victimization—all of which carry public health consequences, especially for women. Social costs include road damage, failed local businesses, loss of affordable rental housing, and strains on law enforcement and municipal services. School districts report increased stress. Economic analyses have found that drilling and fracking activities threaten property values and can diminish tax revenues for local governments. Additionally, drilling and fracking on private lands pose an inherent conflict with mortgages and property insurance due to the hazardous materials used and the associated risks.

14) Fracking raises human rights and environmental justice issues.

Inequalities in opportunities to participate in environmental decision-making and uneven impacts of environmental hazards among racial and socioeconomic lines are signature issues of environmental justice. In multiple regions where fracking is practiced, well pads and associated infrastructure are disproportionately sited in non-white, indigenous, or low-income communities.\(^{109, 110}\)

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A 2019 analysis of socio-demographic characteristics of people living close to drilling and fracking operations in the states of Colorado, Oklahoma, Pennsylvania, and Texas found strong evidence that minorities, especially African Americans, disproportionately live near fracking wells.\textsuperscript{111}

Similarly, a pattern of racially biased permitting was documented in the heavily fracked Eagle Ford area of southern Texas where a public health research team showed that disposal wells for fracking wastewater were more than twice as common in areas where residents are more than 80 percent people of color than in majority white communities.\textsuperscript{112} Since 2007, more than 1,000 waste disposal wells have been permitted in the Eagle Ford Shale region where groundwater is the primary source of drinking water.\textsuperscript{113}

In intensely drilled Denton, Texas, a study found that those benefiting most from Denton’s mineral wealth tended to live elsewhere, while the environmental burdens remained local and fell hardest on those who did not have a voice in mineral-leasing decisions. “Non-mineral owners are essentially excluded from the private decisions, as the mineral owners not only receive the direct monetary benefits, but also hold a great deal of state-sanctioned power to decide if and how [shale gas development] proceeds.”\textsuperscript{114}

Poor communities of color are disproportionately affected by drilling activities in California. Of Los Angeles residents living within a quarter-mile of a well, more than 90 percent are people of color. In November 2015, civic groups led by youth sued the city of Los Angeles for racial discrimination based on allegations of a preferential permitting process and unequal regulatory enforcement for oil wells located in neighborhoods of color. Together, these differential practices have resulted in a higher concentration of wells with fewer environmental protections in Black and Latino communities.\textsuperscript{115} South Coast Air Quality Management District records show that oil drilling operations in Los Angeles neighborhoods released into the air 21 million pounds of toxic chemicals between June 2013 and February 2017. These emissions included crystalline silica, hydrofluoric acid, and formaldehyde.\textsuperscript{116}

Across California, gas-fired power plants are disproportionately located in disadvantaged communities, as classified by an environmental justice screening tool developed by the state

\begin{itemize}
  \item \textsuperscript{114}Fry, M., Briggle, A., & Kincaid, J. (2015). Fracking and environmental (in)justice in a Texas city. \textit{Ecological Economics}, 117. doi: 10.1016/j.ecolecon.2015.06.012
\end{itemize}
Office of Environmental Health Hazard Assessment. More than three-quarters of the 21,397 new oil wells drilled in California between 2011 and 2018 are located in low-income minority communities, according to state data.

In Greeley, Colorado, a massive well pad housing 24 wells was sited near Bella Romera Academy, an elementary school in a low-income community where 82 percent of students are Latino, after earlier plans were scrapped for a site near a charter school where students are majority white and middle-class.

In May 2018, community groups in North Carolina filed an environmental justice complaint against the Atlantic Coast Pipeline, alleging the project poses disproportionate risk of harm to people of color. Thirteen percent of those living along the pipeline route are Native Americans in a state where Native Americans make up only 1.2 percent of the population.

A compressor station in Virginia that would service this pipeline is located in a historically African-American community.

In Pennsylvania, evidence shows that gas-fired power plants are disproportionally located in low-income and minority communities. A geographic study found a higher concentration of drilling and fracking operations in impoverished communities throughout the state of Pennsylvania as well as in localized areas of West Virginia, but it did not find differences with respect to race. “The results demonstrate that the environmental injustice occurs in areas with unconventional wells in Pennsylvania with respect to the poor population.” These findings are supported by census tract data in western Pennsylvania showing that among nearly 800 gas wells, only two were drilled in communities where home values exceeded $200,000.

Similarly, in Ohio, geographic evidence reveals that disposal wells for fracking wastewater are

---


disproportionately located in lower-income, rural communities.  

Apart from disparities circumscribed by race and income, fracking raises other fundamental questions of human rights. A comprehensive analysis that charts the international legal development of water rights as they apply to oil and gas extraction concluded that the right to water for residents living near fracking sites is “likely to be severely curtailed.” Noting that access to clean and safe drinking water is codified by the United Nations General Assembly as a human right essential to the full development of life and all other human rights, the authors argue that, because the fracking industry does not face the true societal cost of water in their production decisions, ownership of this essential-to-life resource is effectively transferred from society to industry, with no protection for this essential human right. In the United States alone, “there is considerable evidence that the human right to water will be seriously undermined by the growth of the unconventional oil and gas industry, and given its spread around the globe this could soon become a global human rights issue.”

Three international human rights bodies have called for prohibitions on fracking. In February 2019, the Committee on Elimination of Discrimination Against Women, which monitors the implementation of the 1979 United Nations treaty that serves as an international bill of rights for women, called on the United Kingdom to ban fracking on the ground that fracking damages communities and imperils the climate in ways that disproportionally harm women and girls living in rural areas. In October 2018, the United Nations Committee on Economic, Social and Cultural Rights warned Argentina that its plans for large-scale fracking in the Vaca Muerta Shale region would create adverse economic and cultural rights impacts on the indigenous Mapuche people. In May 2018, the Permanent People’s Tribunal, a Rome-based forum focused on human rights violations, issued an advisory opinion based on a two-year investigation that collected testimonies and reports from scientists and fracking-impacted communities.

In the words of the court,

The evidence clearly demonstrates that the processes of fracking contribute substantially to anthropogenic harm, including climate change and global warming, and involve massive violations of a range of substantive and procedural human rights and the rights of

nature. Thus the industry has failed to fulfill its legal and moral obligations…. The
dangers of fracking to the rights of people, communities, and nature are inherent in the
industry….We will go beyond the call for a moratorium and recommend that fracking
should be banned.\textsuperscript{131}

15) **Health professionals are increasingly calling for bans or moratoria on fracking, based
on a range of health hazards and as reviews of the data confirm evidence for harm.**

In May 2015, the Medical Society of the State of New York passed a resolution recognizing the
potential health impacts of natural gas infrastructure and pledging support for a governmental
assessment of the health and environmental risks associated with natural gas pipelines. (See
footnote 856.) The American Medical Association (AMA) adopted a similar resolution that
supports legislation requiring all levels of government to seek a comprehensive Health Impact
Assessment regarding the health and environmental risks associated with natural gas pipelines.
(See footnote 855.)

In May 2016, Physicians for Social Responsibility called for a ban on fracking. (See footnote
1079.)

In July 2016, the UK health professional organization Medact released an updated assessment of
the potential health impacts of shale fracking in England, concluding that the United Kingdom
should abandon its policy to encourage shale gas extraction and urged an “indefinite
moratorium” on fracking. (See footnote 1077.)

In October 2016, a group of health care professionals in Massachusetts called for an immediate
moratorium on major new natural gas infrastructure until the impact of these projects on the
health of the communities affected could be adequately determined through a comprehensive
Health Impact Assessment. (See footnote 1074.) The group noted that the operation of natural
gas facilities increases the risk of human exposures to toxic, cancer-causing, and radioactive
pollution due to the presence of naturally co-occurring contaminants, toxic additives to the
hydraulic fracturing process, and through the operation of transmission pipelines.

Also in 2016, in a unanimous vote of the society’s 300-member House of Delegates, the
Pennsylvania Medical Society called for a moratorium on new shale gas drilling and fracking in
Pennsylvania and an initiation of a health registry in communities with pre-existing operations.
(See footnotes 1071, 1072).

In 2017, health officials in Los Angeles called for a comprehensive health study in the aftermath
of the massive methane leak in Aliso Canyon. (See footnote 1068.)

In March 2019, Doctors for the Environment Australia announced the reinforcement of its
position that no new gas extraction of any kind should occur in Australia.

\textsuperscript{131} Permanent People’s Tribunal. (2018, May 14-18). Session on human rights, fracking and climate change—
APRIL-2019.pdf
Concerned Health Professionals of New York, which provided scientific and medical guidance for the successful effort to ban fracking in New York State, has inspired affiliations of like-minded public health scientists and health care providers that have been advocating for moratoria or bans on fracking in various other regions. These include Concerned Health Professionals of Maryland, Concerned Health Professionals of Ireland, Concerned Health Professionals of Neuquén, Argentina, and Concerned Health Professionals UK.
Conclusion

All together, findings to date from scientific, medical, and journalistic investigations combine to demonstrate that fracking poses significant threats to air, water, human health, public safety, community cohesion, long-term economic vitality, biodiversity, seismic stability, and climate stability.

The rapidly expanding body of scientific evidence compiled and referenced in the present volume is massive, troubling, and cries out for decisive action. Across a wide range of parameters, from air and water pollution to radioactivity to social disruption to greenhouse gas emissions, the data continue to reveal a plethora of recurring problems and harms that cannot be sufficiently averted through regulatory frameworks. There is no evidence that fracking can operate without threatening public health directly and without imperiling climate stability upon which public health depends. The only method of mitigating its grave harm to public health and the climate is a complete and comprehensive ban on fracking.

In the words of investigative journalist Andrew Nikiforuk:

Industry swore that its cracking rock technology was safe and proven, but science now tells a different story. Brute force combined with ignorance … has authored thousands of earthquakes … [and] called forth clouds of migrating methane…. The science is complicated but clear: cracking rock with fluids is a chaotic activity and no computer model can predict where those fractures will go. The regulatory record shows that they often go out of zone; extend into water; and rattle existing oil and gas wells, and these rattled wells are leaking more methane.\textsuperscript{132}

In closing, we cite comments by epidemiologist Irena Gorski, co-author of the 2019 review of fracking’s health concerns published in the Oxford Research Encyclopedia of Global Public Health. Her words speak for all who have contributed to this Compendium:

What we found pushes back against the narrative we often hear that say we don’t know enough about the health impacts yet. We have enough evidence at this point that these health impacts should be of serious concern to policymakers interested in protecting public health….As a fossil fuel, natural gas extraction and use is contributing to climate change, of course. But before conducting this study, I didn’t realize the amount of evidence we have that it may be even worse than coal. We included this in our study because climate change has its own contributions to health impacts. These indirect impacts will take longer to appear than the direct health impacts, but they have the potential to be significant.\textsuperscript{133}


Appendix C: Health Impact Assessment for Titan Wellpad
This Health Impact Assessment (HIA) revolves around one central question:

Do you have enough information to determine that it is safe to have the well pad in your community?

This HIA organizes information on the Titan Well Pad planned for Murrysville in Westmoreland County, PA, to help promote informed decision-making. It is a tool for gathering information to protect the community’s public health and highlight community concerns. Further, the HIA provides information about the immediate area surrounding the well pad, and any county or local health data profiling the area surrounding the well pad.

This assessment will allow you to start answering three critical questions:

1) What environmental contaminants are being emitted or leaked?
2) Are people being exposed to emissions?
3) What are the health risks from exposure, and who will bear those risks?

This information is NEEDED to protect human health. This HIA highlights what information is available, and what issues are still uncertain. If information does not exist to fully complete the HIA, then a decision about the Titan Well Pad should not be made until all information can be collectively evaluated as it relates to public health.
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OVERVIEW

This Health Impact Assessment brings together community concerns about the Titan well pad, information about the well pad, and emissions and public health data. The nearby communities have legitimate concerns and questions about the well pad’s potential effects on their health and safety. These concerns are based on well-documented air and water contamination by the shale gas industry and about risks specifically posed by Huntley & Huntley at other sites. Not enough information has been provided to community members or public officials to assure that it is safe to site this set of wells in this location. The current evidence points to the contrary, that it will introduce health risks to those living, working, going to school, and enjoying the outdoors in the area of the site. The question is not one of fairness to the company – whether this new site produces emissions within certain standards and should therefore have the right to pollute – the question is one of fairness to the public’s health.

The Titan Wells will be drilled in close proximity to homes (many with well water), parks and a school. Huntley & Huntley’s materials list 50 households with well water within 3,000 feet of the site. The closest residence is approximately 800 feet. They will be impacted by intense truck traffic with diesel emissions as well as chemicals, fine particulate matter, light and noise from the well pad. Air pollutants generated on and around the site will include Carbon Monoxide, Nitrogen Oxides, Sulfur Dioxide, Benzene, Ethylbenzene, Formaldehyde, Toluene. The fine and ultra-fine particles present can enter the deep lung and carry with them the chemicals in the air. The company’s truck traffic report reveals that, during the completion stage of development alone, there are expected to be 806 daily trips. Emitting below regional air quality thresholds across a year, does not necessarily protect health because high spikes throughout the days and weeks pose danger. Furthermore, research has shown that health impacts can and do occur even below National Ambient Air Quality Standards.

Fracturing water contains a large number of chemicals, some with known serious health effects, and many that have not been studied for their effects on humans. The produced water at the site will contain those fracking chemicals and additives along with material from the shale itself, that can include radioactive material, known to cause cancer. A discussion of the air emissions and potential water contamination and the health risks they pose are at the end of this document.

Westmoreland County already has high rates of respiratory and cardiovascular disease and individuals who are already sick are at increased risk for exacerbation of symptoms. Others who are not sick will be put at risk due to exposure from the site. Children are at particular risk. Research has also shown that there are greater risks and poorer outcomes for pregnancies in women exposed to shale gas wells than those who are not.

The Titan well pad will not exist in isolation. Although the property is in a Rural Residential District, there are three other well pads within a 3-mile radius of the Titan site. The Huntley & Huntley Athena well pad is proposed to have 14 wells. There is also a Dominion Energy compressor station about 2 miles from the Titan
site. The additional wells at the Titan site will add to existing air contamination. Procedurally, each site may be judged on its own, but with responsibility to the public’s health, the Titan site must be considered in context.

### WELL PAD HEALTH IMPACT ASSESSMENT CHECKLIST
Have you been provided the information you need?

<table>
<thead>
<tr>
<th>Item</th>
<th>NOT ADDRESSED</th>
<th>INCOMPLETELY ADDRESSED</th>
<th>ADDRESSED TO SATISFACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention to resident concerns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schedule of activities – when will each phase begin and end</td>
<td></td>
<td>Only years and seasons provided</td>
<td></td>
</tr>
<tr>
<td>Listing of chemicals emitted and at what concentrations</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>What emissions will occur for each stage of well development</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Projected exposure within a half mile radius of site – including peak levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projected exposure within a mile radius of site – including peak levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radioactive material present</td>
<td>No evidence of pre-drilling tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air monitoring plan specified</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Water monitoring plan specified</td>
<td></td>
<td>Management plan shared; monitoring measures unclear</td>
<td></td>
</tr>
<tr>
<td>Plan for wastewater</td>
<td></td>
<td>Location of waste disposal sites not provided</td>
<td></td>
</tr>
<tr>
<td>Warning system in place for high releases or emergencies</td>
<td>Emergency plan not available for review online</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions from flares estimated</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Criteria</td>
<td>Addressed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sufficient distance from schools, daycares, and other sensitive locations</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HEALTH IMPACTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health effects of PM 2.5 addressed</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health effects of VOCs addressed</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic and episodic exposure effects on children addressed</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health risks to pregnancy/ fetal development addressed</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I. INTRODUCTION

1. What is the primary issue?
   New well pad being constructed – Titan Well Pad, Murrysville, PA

2. Why does this call for an HIA?

   Huntley & Huntley Energy Exploration, LLC. has proposed to build an unconventional natural gas well pad on approximately 4 acres of a 71-acre plot in Murrysville, Westmoreland County, PA. The well pad is proposed for Murrysville near the southeast border of Washington Township and would be the first Marcellus well to be drilled in Murrysville. There are currently proposed and active shale gas infrastructure within three miles of the Titan site, including a Dominion Transmission compressor station (see Question 16). There is reason to expect that the Titan Well Pad will put the nearby communities at risk due to air and water contamination, as well as increased pollution from truck traffic.

   Huntley & Huntley has had 188 violations, over 100 remain unresolved, according to DEP compliance reports.

   https://docs.google.com/spreadsheets/d/1pKuE6IMQ8bfOVNFGDne_GAJLczwDRK5GMCuqeyzl/edit#gid=401149904

3. Who is raising the health impact concern? Who is preparing or commissioning the HIA?

   Many community members are concerned about the site. Protect PT has been instrumental in making this HIA possible.

WELL PAD INFORMATION

4. What do you know about the proposed or active site?

   According to Huntley & Huntley’s materials, the site will be on 4 acres (9.3 acres in total affected by activity) within a 71-acre property (about one-tenth of a square mile). According to the Truck Traffic Impact Study, construction is to begin in summer 2019, with drilling starting in 2021. The completion phase would start between fall 2022 and 2023, with the length of production undetermined. The site diagram includes:

   • Tank Farm
   • Barite Silos
   • Cuttings Boxes
   • Centrifuge
The property is in a Rural Residential district. According to the Murrysville Code, this type of district “is intended to protect environmentally sensitive areas and portions of the Municipality that are not otherwise suitable for development at higher densities. Single-family residential uses on large lots where needs for traffic facilities and utilities are low and where it is appropriate to reserve the rural atmosphere of the Municipality are primary considerations.” Introducing a source of pollution into this district does not align with the Murrysville Code definition to protect this area or preserve the rural atmosphere.

Sources:
https://ecode360.com/11539535?highlight=residential,residentially,rural,rural%20residential&searchId=45051221722029#11539535

II. COMMUNITY CONTEXT

CONCERNS OF RESIDENTS

5. Check the concerns that have been raised by community members. You can rank them and/or add others to the list.

- Personal health and safety
- Air contamination
- Well water contamination
- Soil contamination
- Loss of property values near shale sites
- Risks to wildlife and local habitats
- Concerns about accidents, emergency response, safety records [THESE ARE OF PARTICULAR CONCERN]
- Health and well-being of local community
- Noise

Other: Murrysville has a strict noise ordinance that the developer cannot adhere to during drilling and production phases.

COMMUNITY DESCRIPTION & THE IMMEDIATE AREA

6. Describe the community within a 2-mile radius from the proposed or active site:

There is a list provided by HHEX of “interested parties,” which are landowners and water purveyors with water supplies within 3,000 feet (0.56 miles). There are 50 households listed with well water supplies within this distance from the Titan site. Wellington Estates apartment and mobile home complex lies within a 1-mile buffer of the site, with additional denser residential neighborhoods off Wiestertown Rd. on Field Stream Dr., Sanria Ct., Fox Chase Dr., and Carriage Cir. within a 2-mile radius. Export, PA is also located within a 2-miles radius of the site and also has denser housing communities. Individuals living along Kemerer Rd. are in the 0.5 – 1 mile-radius buffer. Houses along Hilty Rd. will be most impacted by truck traffic to and from the site. With increased truck traffic will come increased noise pollution that will occur throughout the day and night, along with the noise that will come from drilling and fracturing activities. Further, Huntley & Huntley is applying for a noise exemption due to the inability to remain under the daytime noise limit set forth in Murrysville ordinances. This exemption would be required because the noise pollution study noted that Titan will not be able to stay under the noise limits at night, even with additional buffers put in place.

7. The closest residence is roughly 800 feet from the site. Murrysville setback requirements are 750 feet.

8. What else is located near the proposed or active site?

Roughly 2.77 miles from the site is Sloan Elementary school, where approximately 590 K-5 students attend. Murrysville Community Park (1 mile), Walter Nature Reserve (1 mile), White Valley Park and Export Community Park (2 mile), Kovalczik Park, Franklin Estates Park, and Newhouse Park (3 mile) are all areas where people of all ages are outside and impacted by air quality. The Beaver Run Reservoir is less than two miles from the site as well. Other areas where individuals could be exposed to changes in air quality would be at the Idle Creek Stable (1 mile) and Tambler Stables (2 miles).

Source: https://www.niche.com/k12/sloan-elementary-school-murrysville-pa/ & Google Maps

9. Anything else you want to say about the immediate community?

Roughly 1 mile from the Titan Site is the Murrysville Community Park, which is home to the Miracle League of Western PA. The Park includes youth soccer and baseball fields as well as basketball courts where children and young adults with mental and physical disabilities are able to play outdoor sports. Games through the Miracle League are happening nearly every day of the week during season play, putting this vulnerable group at great risk for exposure to air pollution that will come from the Titan site.

COMMUNITY HEALTH

10. Please describe any relevant community health information (ex. Asthma rates, cancer rates, etc.).

Compared to the whole state of PA, Westmoreland County has seen higher rates of hospitalizations for chronic obstructive pulmonary disease (COPD) per 10,000 people, and higher number of adults 65+ living in the county, a population at more susceptible to poor air quality (Simonie et al., 2015). Data from the American Lung Association shows that in Westmoreland County, there are over 5,778 cases of pediatric asthma, over 28,000 cases of adult asthma, over 33,000 with cardiovascular disease, and over 21,000 with COPD. This is an area already burdened with the types of diseases that are exacerbated by shale gas wells.

As stated, the children and young adults who participate in Miracle League games at the Murrysville Community Park are at a higher risk for effects from exposure to poor air quality. Emissions from the Titan site will increase this burden throughout their developmental years and reduce the level of enjoyment and health-promotion of playing sports, something that is meant to promote their health and wellbeing.

Sources:
III. WELL SITE EMISSIONS

EXPECTED AIR EMISSIONS

A typical well pad can include road access, truck traffic, drill rig, fracking chemical tanks, fracturing pumps, sand storage, flowback storage, well pad compressor engines, separators (processing units), dehydrators, condensate and brine tanks, flaring apparatus, and vapor recovery unit [See Question 4 for a list provided in HHEX’s materials].

Have well emission estimates been provided? If so, please list them here or attach the permit as an appendix:

The materials on the Titan Well Pad provide some expected emissions (see below). They do not include, however, important operational emissions, including engines and pigging operations, both of which will generate significant emissions, nor do they include truck emissions which can be significant as well. Members of the community believe that the company narrows its scope of disclosure to spills and a subset of releases purposefully, to minimize attention to operational air emissions. What is reported is in tons per year, a common metric to report emissions in, but to understand the risks to the health of those in the area, it is critically important to know the expected peaks in exposure in hours because those peak exposures can pose the most serious threats to health.

Table 1. Comparison of Titan Well Pad Emissions to Exemption Thresholds

<table>
<thead>
<tr>
<th>Emission Source</th>
<th>NOₓ</th>
<th>CO</th>
<th>CH₄</th>
<th>VOC</th>
<th>SO₂</th>
<th>PM</th>
<th>Formaldehyde</th>
<th>Total HAPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Heaters</td>
<td>5.18</td>
<td>4.35</td>
<td>0.12</td>
<td>0.28</td>
<td>0.00</td>
<td>0.39</td>
<td>0.004</td>
<td>0.09</td>
</tr>
<tr>
<td>Desiccant Dehydrator</td>
<td>6.77</td>
<td>0.04</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>Pneumatic Controllers</td>
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<td>0.10</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
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<td>0.00</td>
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<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>Produced Water Tanks</td>
<td>35.94</td>
<td>1.24</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td>0.21</td>
</tr>
<tr>
<td>Equipment Fugitives</td>
<td>14.63</td>
<td>0.08</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5.18</td>
<td>4.35</td>
<td>61.04</td>
<td>1.74</td>
<td>0.00</td>
<td>0.39</td>
<td>0.004</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>Exemption Threshold</strong></td>
<td>10</td>
<td>20</td>
<td>200/source</td>
<td>2.7</td>
<td>8</td>
<td>3</td>
<td>0.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The table provided in the AQ Study submitted includes a row for “Exemption Threshold.” An exemption threshold is one factor that establishes whether a company needs to apply for an air permit from the State. It is important to note, however, levels at or below these thresholds are not necessarily health protective levels.

Air contaminants reported from gas development include: carbon monoxide, nitrogen oxides, particulate matter less than 10 micrometers in diameter (PM10), particulate matter less than 2.5 micrometers in diameter (PM2.5),
sulfur dioxide, volatile organic compounds, and additional hazardous air pollutants including benzene, ethylbenzene, formaldehyde, N-hexane, toluene and 2,2,4-trimethylpentane.

In addition to the emissions from the site, there will be considerable and dangerous diesel truck emissions, which will be especially intense during the completion stage. The traffic study shows that there are expected to be 806 daily trips during that stage alone. Based on the route highlighted in the impact study, around 16-20 homes will be directly on the proposed truck route. The report does not identify the route past 0.5 miles, so the number of impacted homes is likely to be underestimated. Increased truck traffic specifically can increase localized pollution at the gas well site and along the truck route. This pollution can lead to respiratory and other health effects of diesel emission exposure (McCawley, 2017 & 2015; Sydbom et al., 2001). A typical gas well can include road access, vehicle idling, and truck traffic at all hours of the day. Pollutants from diesel trucks include harmful volatile organic compounds (VOCs), like benzene and toluene, particulate matter, nitrous oxides (NOx), and ozone. Ultrafine particles found in diesel emissions can penetrate cell membranes and enter our blood system, reach the brain, or enter deep into our lungs up to 83% of the time when exposed (McCawley, 2017; Sydbom et al., 2001). Exposure to diesel emissions from increased truck traffic can also lead to aggravated allergic reactions and respiratory irritation; those who already suffer from pulmonary conditions and asthma are at an increased risk due to particulate matter reaching the deep lung (Sydbom et al., 2001).

Sources:
http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Regulations%20and%20Clean%20Air%20Plans/Natural_Gas_Inventory_Fact_Sheet_02-11-13.pdf

WATER CONTAMINATION

People can potentially come into contact with water contaminants by ingestion, skin contact, soil contamination, and inhalation in the form of steam. Pathways of groundwater and surface water contamination from shale gas development activities include leaks from deteriorating or improperly constructed wells, surface spills, and improper wastewater use, storage and disposal. Water can become contaminated with substances originating in the shale itself and from the chemical content of the fracturing fluid. Classes of constituents in this “produced water” include: a) inorganic substances and metals; b) volatile organic gases; c) hydrocarbons; and d) naturally occurring radioactive materials

12. Has any information been provided about the site’s plan for storing waste water on or near the site?  
Yes.
13. If any pre- or post-drilling water tests have been done in the immediate area, please provide the results in the table below.

<table>
<thead>
<tr>
<th>Pre-drilling test</th>
<th>Location:</th>
<th>Distance from site:</th>
<th>Who conducted sample and analysis:</th>
<th>Findings:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaver Run Reservoir</td>
<td>2 miles</td>
<td>Protect PT contracting with experts*</td>
<td>In progress</td>
<td></td>
</tr>
</tbody>
</table>

* Protect PT has requested the testing samples from the Municipal Authority of Westmoreland County and has hired someone to look at the results it gathers from the Authority in order to assess if the water quality has changed with fracking on the reservoir.

14. What is the water monitoring plan going forward?

We did not see a Huntley & Huntley water monitoring plan for residences near the well pad. If that exists, we would welcome the opportunity to see it.

EXISTING POLLUTION SOURCES

15. Are there other polluters already in the area? Shale or non-shale?

Yes, there are 3 well pads within a 3-mile radius of the Titan site. The Huntley & Huntley Athena well is permitted and proposed to have 14 wells on the pad, 2 of which have already been drilled. There is an active gas well by Great Oak Energy. Both sites are 1.5 miles from the Titan site. There is one more well pad with Apex Energy located 3 miles from the Titan site. This pad has three wells and the site has an existing violation. The Dominion Energy compressor station is 2 miles from the Titan site. Compressor stations are known to be heavy polluters.

Source: [http://maps.fractracker.org/latest/?appid=28041aae3e674e04b0f987f047f3fe59](http://maps.fractracker.org/latest/?appid=28041aae3e674e04b0f987f047f3fe59)

16. Are there plans for additional build-out of these sources?

In 2017, the Dominion Energy compressor station was given permission to expand the size of the site. As for the nearby gas wells, the Athena well pad has 14 proposed fracking operations, which would increase the impact of pollution over many years to come.
17. Is there anything you can say about your current air quality?

In 2018, a report titled the *State of the Air* completed by the American Lung Associated gave Westmoreland County a D for air quality based on high ozone days. Poor air quality puts all individuals at risk, and particularly individuals with asthma, COPD, lung cancer, and young children. Though given an A for particulate pollution across the County generally, the quality of air hyper-locally will be influenced by the fracking operations of the Titan well pad, and 7 other pads within the county noted by Protect PT, which will potentially lower the overall air quality.

Sources:  [https://www.protectpt.org/wells-in-pt](https://www.protectpt.org/wells-in-pt)  

18. Is there anything you can say about water quality in your area?

CNX has drilled over 50 Marcellus and Utica wells surrounding Beaver Run Reservoir, which is the drinking water source for over 130,000 residents. According to the Post Gazette, there was a loss of pressure at one gas well while there were four flaring shallow wells. By the time the damaged well was “killed” there were nine flared wells. The community was not officially informed about the nature of the air or potential water contamination. The incident points to how easily faulty infrastructure can contaminate important drinking water sources. Residents around Titan are either on well water or supplied public water from Beaver Run. Though there are no major water quality issues at present within 2 miles of the Titan site, it is clear that water bodies can become impacted by shale gas development operations. In fact, this operator has contaminated at least one water well, as determined by DEP.

19. Are there any relevant state or local environmental or public health laws, regulations, ordinances, that you know about and would like to highlight?

Municipality of Murrysville, PA/The Code/ Part 11: General Legislation/Zoning/220-11 Districts and purposes

- As previously mentioned, rural residential districts are given special protection from environmental harm, which would be violated by the construction of a gas well in this district

- While this is a DEP duty, the General Assembly has noted that it is not the sole duty of DEP, but instead should be a collective effort by state, regional, county, and municipal agencies. 25 Pa. Code § 9.201(b)
IV. HEALTH RISKS FROM AIR AND WATER CONTAMINANTS

Medical and Public Health professionals understand that certain types of particles and chemicals have well known health effects, and chemical toxicity in the human body can – but doesn’t always – occur within minutes or hours of exposure. Repeated episodes of exposure can increase the potential and degree of harm and high exposures to chemicals and mixtures of chemicals can increase the seriousness of the damage. Understanding the changes in exposures is essential to understanding the health risks.

CHILDREN, BIRTH OUTCOMES, AND EXPOSURE TO SHALE GAS DEVELOPMENT

Children and pregnant women are especially sensitive to pollution and are at higher risk than other healthy adults. Exposing them to well pad emissions puts them at risk for both short- and potentially long-term health effects. Multiple well-conducted studies have been published on the effects of shale development activity and birth outcomes. The studies found a range of overlapping outcomes associated with exposure to well pads, including low birth weight, low APGAR scores, prematurity, and neural tube defects (Casey et al., 2015; McKenzie et al., 2014; Whitworth et al., 2018; Stacy et al., 2015).

Children do not respond to emissions as though they are little adults; they are especially vulnerable because:

- Children have higher respiratory rates and as a result, children exposed to air contaminants breathe in more toxicants per pound of body weight than adults.
- Children accumulate more toxics in their bodies than adults. They don’t detoxify as efficiently.
- Children spend more time engaged in vigorous activity outside, increasing their air and potentially soil exposures.
- Children’s brains are still developing. Many toxic agents are known to interfere with developmental processes within the brain.

HEALTH EFFECTS FROM EXPOSURE TO VOLATILE ORGANIC COMPOUNDS (VOCs)

VOCs, present at well sites, are a varied group of compounds which can range from having no known health effects to being highly toxic. Short-term exposure to some VOCs can cause eye and respiratory tract irritation, headaches, dizziness, visual disorders, fatigue, loss of coordination, allergic skin reactions, nausea, and memory impairment. Long-term effects can include loss of coordination and damage to the liver, kidney, and central nervous system. For more information, see National Institutes of Health: https://toxtown.nlm.nih.gov/text_version/chemicals.php?id=31
HEALTH EFFECTS FROM EXPOSURE TO PARTICULATE MATTER
Particulate Matter (PM), is the term for a mixture of particles and liquid droplets. PM 2.5 are very fine particles; 30 times smaller than the diameter of a single hair. Because it is composed of such tiny components, it can reach deep into the lungs (McCawley, 2017; Sydbom et al., 2001). Exposure to PM 2.5 can also affect the heart. Health effects include: heart attacks, irregular heartbeat, asthma attacks; and respiratory symptoms, such as airway irritation, coughing, and difficulty breathing (Rassmuseen et al., 2012). See the EPA’s website for additional information on PM: https://www.epa.gov/pm-pollution

NOISE-RELATED HEALTH EFFECTS
Research has demonstrated that chronic noise exposure can cause a wide array of health effects, including sleep disturbance, annoyance, noise-induced hearing loss, cardiovascular disease and endocrine effects. The cardiovascular and endocrine effects appear to be associated with the sleep disruption and psychosocial stress of the chronic noise. For additional information on noise, go to https://ehp.niehs.nih.gov/1307272/

POTENTIAL HEALTH EFFECTS FROM EXPOSURE TO WATER CONTAMINANTS
FracFocus.org presents an extensive list of hydraulic fracturing chemicals that are used at well pads. They include chemicals serving as biocides, friction reducers, scale inhibitors, and surfactants. Chemicals often documented are: ethylene glycol, naphthalene, xylene, toluene, ethylbenzene, formaldehyde. Studies have found increases in organics.

Chemicals are used as corrosion inhibitors, biocides, surfactants, friction reducers, gels and scale inhibitors, among others. In addition to the chemicals forced into the shale, flowback water includes a brine of salts, radioactive elements and metals such as Barium and Strontium, which are brought to the surface at the well site. Research has shown potential short-term health effects from fracturing chemicals can impact the skin, eyes, respiratory, gastro-intestinal, liver, brain and nervous system. Long-term organ and system damage can occur in the nervous system, immune system, kidney, and cardiovascular, also cancer (Elliot et al., 2017; Webb et al., 2014). Also, naturally occurring substances are being brought up to the surface with produced water and could be migrating through subsurface channels. These natural occurring substances include chloride, bromide, arsenic, strontium, and heavy metals.
V. RECOMMENDATIONS/REQUESTS FROM THE COMMUNITY

RECOMMENDATIONS AND MITIGATION (IF PERMIT GRANTED)

- Perform a baseline health study to establish population health status before the infrastructure is built.
- Require best practices to ensure that effective emissions control measures are kept up to date.
- Establish an alert system for water risks, large volumes of air emissions and/or noise events.
- Put emergency plans in place that have been developed with community input and distributed once complete and before drilling and fracturing begins.
- Institute an air monitoring strategy at the well pad and surrounding locations and make the data public.
- Note times when it’s just too dangerous to emit; for instance, when air is still, the sky is overcast, or children are likely to be outside.

POINTS TO KEEP IN MIND

- Well pads are more than just drilling rigs and wells. They include multiple pieces of machinery and a variety of processes and opportunities for leaks and venting. See below for a list of online sites that provide information on well pads.
- Emissions from well pads are significant.
- Exposures to emissions do not occur evenly over time. They vary by stages of development and, within stages, periodically spike in intensity.
- The extent to which people are exposed to air toxicants is determined by the concentration of emissions vented and leaked, distance from well pads and weather conditions.
- The extent to which people are exposed to water contamination is determined by the integrity of the well casing or impoundment pit, leaks or spills, hydrogeology of their area, and use of groundwater.
- There is now an abundance of information about shale gas site emissions and their potential to do harm.

For an introduction to the drilling process, see FrackTracker’s *Oil & Gas Drilling 101* at [https://www.fractracker.org/resources/oil-and-gas-101/](https://www.fractracker.org/resources/oil-and-gas-101/)

For a “virtual tour” of a well pad site, see FracTracker’s *Explore a Fracking Operation - Virtually.* [https://www.fractracker.org/resources/oil-and-gas-101/explore/](https://www.fractracker.org/resources/oil-and-gas-101/explore/)

In addition, many industry websites describe the structures and activity at a well pad.
REFERENCES


Appendix D: References


