Hydraulic Fracturing and Your Health:
Water Contamination

What is Fracking?

- High-volume horizontal hydraulic fracturing, commonly known as "fracking," is a method of extracting natural gas and oil from deep underground bands of porous rock.
- The process forces a highly pressurized mixture of water, sand, and chemicals underground, fracturing deep rock formations.
- Bubbles of fossil fuel trapped in the rock, usually shale, are freed to enter the well and make their way up to the surface. The captured gas is partially processed, then transported to its point of use via pipelines.
- 137,000 wells in the U.S. are now using the hydraulic fracturing method.[1] These wells are located across the U.S., with significant concentrations in the Marcellus Shale (PA, NY, OH, MD, WV, VA, NJ, KT, TN), the Bakken Shale (ND, MT), the Haynesville Shale (AR, LA, TX), the Eagle Ford Shale (Southern TX), and in Colorado, Wyoming, New Mexico, Kansas, and the Gulf of Mexico.[2]
- Fracking also releases methane into the atmosphere—methane is a powerful accelerator of climate change. – it is a potent greenhouse gas, 86 times more powerful than carbon dioxide during its first 20 years in the atmosphere.

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[a] We use the term "fracking" to refer to both the process of fracturing the rock formations, and the associated operations that extract, process and transport the natural gas or oil. This encompasses land clearing, well drilling, construction of the well casing, flaring, wastewater extraction and storage, processing, compression, disposal of wastes, and transportation. While the process presents risks to health at many steps, we focus here on impacts on water.

Massive Water Consumption

- Fracking operations consume and contaminate enormous quantities of water. In order to fracture a *single* well site, natural gas companies can use anywhere from 1.5 to 16 million gallons of water per well.[3]
- Such intensive water use places hydraulic fracturing in competition with other consumers of water including households, agriculture, industry, and recreation.
- 31-40 percent of fracking occurs in areas experiencing or on the verge of experiencing water stress.[4]

Massive Water Contamination

- Hydraulic fracturing combines huge amounts of clean water with an array of chemicals, some of which are carcinogenic, endocrine-disruptive, or otherwise toxic. The result: Contamination of vast quantities of water.
- Only a fraction of injected fracking liquids (an estimated 20-40 percent) is brought back up to the surface, where it is classified as wastewater.[5] It is estimated that fracking operations in the U.S. produce more than two *billion* gallons of wastewater a day.[6]
- This wastewater is categorized by the EPA as "special wastes" and as such is exempted from federal hazardous waste regulations under the Resource Conservation and Recovery Act (RCRA).
- Only partial information about fracking chemicals is available. Companies may decline to identify the chemicals they use, citing confidential business information ("trade secrets"). Some cannot identify the chemicals because they receive them as a pre-mixed chemical cocktail.

- The Endocrine Disruption Exchange examined the toxicity of 353 chemicals used in fracking and found that 25 percent can cause cancer and mutations; 37 percent affect the endocrine system; 40 to 50 percent affect the brain, kidneys, and nervous, immune, and cardiovascular systems; and more than 75 percent affect other organs and organ systems.[16]

Selected Chemicals of Concern in Hydraulic Fracturing Fluid	
Benzene	Known carcinogen. Can lessen white blood cell count.[7] Pro- longed exposure may result in blood disorders like leukemia, reproductive and developmental disorders, and other cancers.[8]
Toluene	Long-term exposure may affect the nervous system and cause birth defects.[9]
Ethylbenzene	Long-term exposure may result in blood disorders.[10]
Xylenes	Short-term exposure to high levels may cause nausea, vomiting, gastric irritation, and neurological effects. Long-term exposure at high levels may affect the nervous system.[11]
Ethylene Glycol	At high exposures, may affect the central nervous system, heart and kidneys.[12]
Napthalene	May cause abdominal pain, nausea, vomiting, and fever. Chronic exposure can result in coma, confusion, convulsions, tachycardia, low blood pressure, and/or jaundice.[13]
Formaldehyde	A probable human carcinogen. Chronic exposure associated with lung and throat cancer.[14]
Acrylamide	A probable human carcinogen. Short-term exposure may cause damage to the nervous system.[15]

The fracking wastewater that is returned to the surface combines withdrawn fracking fluids with naturally occurring brines–waters that are heavily saline–and other substances that are also found deep underground.[17]

Naturally Occurring Toxics Coming to Surface with Fracking Water	
Arsenic	Can cause partial paralysis, blindness, and cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate.[18]
Strontium	Linked to bone cancer, cancer of the soft tissue near the bone, and leukemia.[19]
Iron and Magnesium	Low levels of exposure may cause diarrhea, nausea and abdominal cramping. High levels of exposure may cause nausea, vomiting, depression, muscle weakness, difficulty breathing, extreme hypotension, irregular heartbeat, and cardiac arrest.[20]
Methane, Ethane, Propane	May cause rapid breathing, rapid heart rate, clumsiness, emotional upset and fatigue. At greater exposure, may cause vomiting, collapse, convulsions, coma and death.[21]
Radon and Radium	Radioactive elements for which long-term exposure via ingestion or inhalation increases the risk of developing lymphoma, leukemia and aplastic anemia; can increase risk of cancer in all tissues and organs.[22, 23]

- Natural brines may contain toxic levels of elements like barium and arsenic.[24]
- In some parts of the country, notably the Marcellus Shale, radioactive radon gas also occurs naturally underground. When brought to the surface, radon (or its breakdown products, which are also radioactive) travels through the pipelines with the methane, extending its dangers to locations far distant from the point of extraction.

Pathways to Exposure

Toxic fracking chemicals and wastes can come into contact with humans at numerous points in the fracking process, creating risks for health. One risk is the contamination of aquifers, which are huge natural reserves of underground water.

Contamination of Underground Aquifers

- Hydraulic fracturing pipes often pass through shallow aquifers. If well casings crack, fracking chemicals can contaminate the aquifer, which may be the sole water source supplying local wells.
- As a result, nearby residents may be exposed to harmful chemicals as they drink water, cook, bathe, etc. (More than 15 million American households regularly depend on well water.)[25]
- In one study conducted in northeastern Pennsylvania, methane was detected in 82% of drinking water samples. Homes less than one kilometer from natural gas wells exhibited average concentrations six times higher than those located far away. Ethane and propane were also found, again with higher concentrations close to fracking wells.[26]

Surface Contamination

- When fracking wastes are returned to the surface, they can threaten workers, local residents, and animals, as well as possibly contaminating local surface waters and shallow groundwater. Exposure can arise from spills, leaks, unintentional and intentional releases.
- A few states still allow untreated wastewater to be sprayed on roads to deice them or for dust control, or even to be used for agricultural irrigation.
- Holding ponds, where fracking wastewaters sit until disposal, are another potential source of exposure. These open-air pits may be located near households and agricultural sites, placing children, pets and farm animals at particular risk. Farm animals that drink water contaminated with fracking fluids may bring unidentified chemicals into the human food chain through the sale of their meat and milk.
- Pipeline construction and operation threaten surface and underground drinking water sources via soil compaction and excavation, surface spills, blasting and trenching, alterations of topography, exposed geology, hydrostatic testing, sinkhole filling and development, and erosion due to clearcutting.[27]

Wastewater Treatment and Disposal

- Fracking wastewater is generally so severely contaminated that conventional water treatment facilities cannot purify it.[28]
- Common disposal methods include spreading as a deicing product, transporting to wastewater treatment plants, deep injection, and disposal in landfills.[29]
- Some wastewater is sent to desalination facilities, but those plants are often unable to adequately complete the task. A study of one such facility in western Pennsylvania, where treated water was discharged to local streams, found increased stream levels of chloride and bromide, as well as radium levels 200 times

greater than background levels, exceeding radioactive waste disposal threshold regulations and posing potential risks of radium bioaccumulation.[30]

- Wastewater is increasingly being used for agricultural irrigation. Further research is needed to determine the safety of this practice or and its effect on our food.
- In the U.S., over 95 percent of fracking wastewater is pumped into injection wells.[31] Most are old oil wells where wastewater performs the function of flushing out additional oil. An estimated 180,000 injection wells, however, serve as permanent storage sites for fracking fluids.[32] In areas with porous rock, these processes can contaminate underground aquifers.[33]
- Deep injection wells have been linked to earthquakes in Texas, Colorado,[34] Ohio,[35] and Oklahoma,[36] which in November 2011 experienced a destructive 5.7-magnitude quake.

Due to the expense of proper disposal of fracking fluids, many drilling companies use misters to spray wastewater into the air so as to speed evaporation,[37] thus reducing the volume of waste fluids. This has the effect of transferring toxic substances from the water to the air, where they may cause harm to health via inhalation.

PSR's Conclusion: Ban Fracking

- The chemicals used in hydraulic fracturing include chemicals known to be toxic and dangerous to human health.
- **In light of these facts and many other environmental impacts, Physicians for Social Responsibility calls for a ban on fracking,** as well as a **rapid transition to cleaner, healthier, carbon-free sources of energy.**
- As we make that transition, the oil and gas industry must make significant changes in their operations**,** including:
  - Full and timely public disclosure of the chemicals and chemical mixtures they use in fracking, the amounts of waste generated, and procedures used for waste disposal;
  - Appropriate strategies to manage safely the threats to health and the environment;
  - The costs of such health-protective measures should be assumed by industry and should not be paid by the general public; and
  - Independent testing of water supplies and bodies of water should be conducted prior to, during and after fracking, and findings should be fully and timely disclosed to the public.

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[1] Environment America Research & Policy Center, "Fracking by the Numbers," Retrieved Jul 27, 2018 from <https://environmentamerica.org/reports/ame/fracking-numbers-0 >.

[2] U.S. Department of Energy, U.S. Energy Information Administration, Form EIA-895A, "Annual Quantity and Value of Natural Gas Production Report," EIA estimates based on data from the Bureau of Safety and Environmental Enforcement, and predecessor agencies; state agencies. Retrieved Jul 27, 2018 from <http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm>.

[3] US Geological Survey, "How much water does the typical hydraulically fractured well require?" Retrieved Jul 27, 2018 from < https://www.usgs.gov/faqs/how-much-water-does-typical-hydraulically-fractured-well-require?qt-news_science_products=0#qt-news_science_products>.

[4] Lorenzo, R. et al. (2018), The Water-Energy Nexus of Hydraulic Fracturing: A Global Hydrologic Analysis for Shale Oil and Gas Extraction, *Earth's Future*. DOI: 10.1002/2018EF000809

[5] Layman, M. (2017). The Shale gas industry and waste disposal. *Stream of Consciousness*, 48(1), 24. Retrieved from <https://scholar.dickinson.edu/cgi/viewcontent.cgi?article=1047&context=stream_of_consciousness>

[6] Jackson, R.B., et al. (2014). "The Environmental Costs and Benefits of Fracking," *Annual Review of Environment and Resources*. 39(1). https://doi.org/10.1146/annurev-environ-031113-144051

[7] Centers for Disease Control and Prevention. (4 April 2018). Emergency Preparedness and Response: Facts about Benzene. Retrieved from <http://www.bt.cdc.gov/agent/benzene/basics/facts.asp>.

[8] United States Environmental Protection Agency. (21 Feb 2016). Outdoor Air – Industry, Business, and Home: Oil and Natural Gas Production – Additional Information." Retrieved from <http://www.epa.gov/oaqps001/community/details/oil-gas_addl_info.html>.

[9] United States Environmental Protection Agency. (21 Feb 2016). Outdoor Air – Industry, Business, and Home: Oil and Natural Gas Production – Additional Information." Retrieved from <http://www.epa.gov/oaqps001/community/details/oil-gas_addl_info.html>.

[10] United States Environmental Protection Agency. (21 Feb 2016. Outdoor Air – Industry, Business, and Home: Oil and Natural Gas Production – Additional Information." Retrieved from <http://www.epa.gov/oaqps001/community/details/oil-gas_addl_info.html>.

[11] United States Environmental Protection Agency. (21 Feb 2016. Outdoor Air – Industry, Business, and Home: Oil and Natural Gas Production – Additional Information." Retrieved from <http://www.epa.gov/oaqps001/community/details/oil-gas_addl_info.html>.

[12] Centers for Disease Control and Prevention. (9 Nov 2017). ETHYLENE GLYCOL:Systemic Agent. Retrieved from <https://www.cdc.gov/niosh/ershdb/emergencyresponsecard_29750031.html >.

[13] MedlinePlus, A service of the U.S. National Library of Medicine, From the National Institutes of Health. Naphthalene poisoning. Retrieved 27 Jul, 2018 from <http://www.nlm.nih.gov/medlineplus/ency/article/002477.htm>.

[14] U. S. Environmental Protection Agency, (2000). Formaldehyde: Hazard Summary. Retrieved from <http://www.epa.gov/ttn/atw/hlthef/formalde.html>.

[15] U. S. Environmental Protection Agency. (2000). Acrylamide: Hazard Summary. Retrieved from <http://www.epa.gov/ttnatw01/hlthef/acrylami.html>.

[16] Colborn, T. et al. (2011). Natural Gas Operations from a Public Health Perspective. *International Journal of Human and Ecological Risk Assessment.* 17:1039-1056. https://doi.org/10.1080/10807039.2011.605662

[17] The Institute for Energy & Environmental Research for Northeastern Pennsylvania, Marcellus Shale Information Clearinghouse. What is flowback, and how does it differ from produced water? Retrieved 27 Jul, 2018 from <http://energy.wilkes.edu/pages/205.asp>.

[18] U. S. Environmental Protection Agency. (14 Feb 2018). Drinking Water Requirements for States and Public Water Systems. Retrieved from <http://water.epa.gov/lawsregs/rulesregs/sdwa/arsenic/index.cfm>.

[19] U.S. Environmental Protection Agency, Radiation Protection, Strontium. (Aug 2017). Retrieved from <http://www.epa.gov/radiation/ radionuclides/strontium.html#healtheffects>.

[20] National Institutes of Health, Office of Dietary Supplements. (2 Mar 2018). Factsheets for Health Professionals, Magnesium. Retrieved from <http://ods.od.nih.gov/factsheets/ Magnesium-HealthProfessional/#h8>.

[21] Canadian Centre for Occupational Health and Safety. (24 July 2018). Chemicals and Materials, Chemical Profiles, Propane. Retrieved from <http://www.ccohs.ca/oshanswers/ chemicals/chem_profiles/propane.html>.

[22] US. Environmental Protection Agency, Radiation Protection. (23 May 2017). Radium. Retrieved from <https://www.epa.gov/radiation/radionuclide-basics-radium >.

[23] Watershed Council. What is hydraulic fracturing? Retrieved Jul 27, 2018 from <http://www.watershedcouncil.org/learn/hydraulic-fracturing/>.

[24] Jackson, R.B., Vengosh, A., Carey, J.W., R.J., Darrah, T.H., O'Sullivan, F., Pétron, G. (2014). The Environmental Costs and Benefits of Fracking. *Annual Review of Environment and Resources.* DOI: 10.1146/annurev-environ-031113-144051

[25]Centers for Disease Control and Prevention. Private Ground Water Wells. Retrieved Jul 27, 2018 from <http://www.cdc.gov/ healthywater/drinking/private/wells/>.

[26] Jackson, R.B., et al. (2013). Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction, *Proceedings of the National Academy of Sciences*. 110(28), 11250-11255. https://doi.org/10.1073/pnas.1221635110

[27] Clingerman, J., Betcher, M., Hansen, E. (23 May 2018). Threats to Groundwater from the Mountain Valley Pipeline and Atlantic Coast Pipeline in Virginia. *Downstream Strategies.* 1-24. Retrieved from <https://assets.nrdc.org/sites/default/files/downstream-strategies-threats-to-groundwater-from-the-mountain-valley-pipeline-atlantic-coast-pipeline-in-virginia_2018-05-25.pdf?_ga=2.16237365.2044144064.1532706638-134973638.1530289526>

[28] Jackson, R.B., et al. (2014). "The Environmental Costs and Benefits of Fracking," *Annual Review of Environment and Resources*. 39(1). https://doi.org/10.1146/annurev-environ-031113-144051

[29] Alessi, D. S., Zolfaghari, A., Kletke, S., Gehman, J., Allen, D. M., & Goss, G. G. (2017). Comparative analysis of hydraulic fracturing wastewater practices in unconventional shale development: Water sourcing, treatment and disposal practices. *Canadian Water Resources Journal/Revue canadienne des ressources hydriques*, *42*(2), 105-121. https://doi.org/10.1080/07011784.2016.1238782

[30] Warner N, Christie C, Jackson R and Vengosh A. (2013). Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania. *Environ. Sci. Technol. 47*(20), 11849–11857. https://pubs.acs.org/doi/abs/10.1021/es402165b

[31] U.S. EPA (U.S. Environmental Protection Agency). 2016. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. Executive Summary. Office of Research and Development, Washington, DC. EPA/600/R-16/236ES.

[32] Class II Oil and Gas Related Injection Wells. (2017, December 18). Retrieved from https://www.epa.gov/uic/class-ii-oil-and-gas-related-injection-wells

[33] Alessi, D. S., Zolfaghari, A., Kletke, S., Gehman, J., Allen, D. M., & Goss, G. G. (2017). Comparative analysis of hydraulic fracturing wastewater practices in unconventional shale development: Water sourcing, treatment and disposal practices. *Canadian Water Resources Journal/Revue canadienne des ressources hydriques*, *42*(2), 105-121.

[34] Kuchment, A. (28 Mar 2016). Drilling for Earthquakes. Retrieved July 26, 2018 from https://www.scientificamerican.com/article/drilling-for-earthquakes/

[35] Skoumal, R. J., Brudzinski, M. R., & Currie, B. S. (2015). Distinguishing induced seismicity from natural seismicity in Ohio: Demonstrating the utility of waveform template matching. Journal of Geophysical Research: Solid Earth, 120(9), 6284-6296. doi:10.1002/2015jb012265

[36] Rubinstein, J. L., & Mahani, A. B. (2015). Myths and Facts on Wastewater Injection, Hydraulic Fracturing, Enhanced Oil Recovery, and Induced Seismicity. Seismological Research Letters, 86(4), 1060-1067. doi:10.1785/0220150067

[37] U.S. Environmental Protection Agency. (2016). Hydraulic Fracturing
for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. Office of Research and Development, Washington, DC. EPA/600/ R-16/236Fa.