**Methane Contamination – Freshwater Aquifers**

Gas, most commonly methane, can communicate with freshwater aquifers through both natural processes and human activities The buoyancy of gas allows it to travel upward through geologic formations and dissolve in or displace groundwater.

Natural communication pathways

* **Geological formations:** In some regions, gas-rich geological formations—such as coal seams or deep thermogenic gas deposits—are located beneath aquifers. Gas from these formations can naturally seep upward into the aquifer through faults and fracture networks.
* **Microbial activity:** Methane is naturally produced by microbes in low-oxygen subsurface environments like sediments and wetlands. This biogenic methane can migrate upward and dissolve in groundwater.
* **Venting and seeps:** Natural gas seeps, where gas vents directly to the atmosphere from underlying formations, have been documented globally. The upward migration of this gas can also affect groundwater systems.

**Anthropogenic communication pathways**

* **Failed or compromised wellbores:** A primary risk factor for gas communication is leaking wellbores from oil and gas operations. If the multiple layers of steel casing and cement fail due to poor construction, corrosion, or degradation over time, gas can migrate up the annular space between the casing and the surrounding rock and into a freshwater aquifer.
* **Hydraulic fracturing:** In some cases, the high-pressure injection of fluid during hydraulic fracturing can create or enlarge fractures that extend upward into overlying rock. If the fractures are extensive enough, they can create pathways for gas and other fluids to move from deep hydrocarbon formations into shallow aquifers. Research has shown that these issues are most likely to occur in areas with a high density of older, poorly constructed wells.
* **Underground gas storage:** Gas can escape from underground storage facilities and contaminate aquifers. Many of these storage facilities use depleted oil and gas reservoirs or converted aquifers, and poor well construction or over-pressurization can allow gas to leak.
* **Surface spills:** Spills of drilling fluids, wastewater, or other chemicals from oil and gas sites can seep into the ground and migrate to aquifers.
* **Landfills:** As organic matter decomposes, landfills produce methane gas. This gas can migrate laterally or vertically through the soil and into groundwater.
* **Injection wells:** Deep injection wells used to dispose of wastewater from energy operations can sometimes fail and leak, forcing gas, brine, and other chemicals into shallower formations and aquifers.

**Impact on freshwater aquifers**

When gas communicates with a freshwater aquifer, it can cause several changes:

* **Fire or explosion hazard:** High concentrations of dissolved methane can off-gas in an enclosed space, such as a water well or basement, creating a fire or explosive risk.
* **Altered geochemistry:** Methane can change the chemistry of groundwater. Methane-oxidizing bacteria, which consume the gas, also consume dissolved oxygen and other electron acceptors in the water. This can lead to the mobilization of naturally occurring elements like iron, manganese, and—in some cases—arsenic, which can be a health concern.
* **Poor aesthetics:** Changes in water chemistry from gas communication can result in bad taste, odor, or discoloration.
* **Mobilization of other contaminants:** Gas migrating through the subsurface can carry other contaminants, such as brine (salty water) or toxic chemicals like benzene and other hydrocarbons, into the aquifer.

**Methane in Pennsylvania** water wells is a known issue, with concentrations ranging from naturally occurring biogenic sources to potential contamination from nearby natural gas extraction, particularly hydraulic fracturing (fracking). While some studies suggest methane contamination is linked to fracking, others indicate it's primarily naturally occurring, especially in areas with specific geological formations and topographic features. USGS Study: A USGS study in Lycoming County, PA, found elevated levels of methane, along with arsenic and radon, in some private wells. Orphaned oil and gas wells and closed coal mines can leak methane, a potent greenhouse gas, into the atmosphere and groundwater. Methane from these sources can contaminate well water, making it a safety hazard. The risks are exacerbated by geological factors like [coal seams](https://www.google.com/search?client=firefox-b-1-d&cs=0&sca_esv=f2b4c39e3966b02c&q=coal+seams&sa=X&ved=2ahUKEwipwq7yvq2PAxUNVTABHeBhHP8QxccNegQIBRAB&mstk=AUtExfDkgupTvu0nvVsv83O_ApAt0jrpLHQDtdyn-b6B56jNCCMg7bXpACVl_vx_MdwEJ7TfwXgZqL-YnLJsB_CLCQHVXRwCRAxOClVBwvwuPKhlPLsXq44wlKBBgyYEfQ6OHYM&csui=3),, compromised oil/gas well casing damaged and infrastructure. Pennsylvania could have somewhere between 350,000 and 700,000 orphaned undocumented oil/gas wells, that will contribute to hydro-carbon gases in residential water well.