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Impact of Oil and Gas Development on Groundwater Resources

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Introduction

My name is Dominic DiGiulio. I am a senior research scientist at PSE Healthy Energy based in Oakland, California. PSE Healthy Energy is a multidisciplinary, nonpartisan, nonprofit research institute that studies the way energy production and use impacts public health and the environment. Prior to joining PSE Healthy Energy, I was a research associate at Stanford University where I continue as a visiting scholar. In 2014, I retired from the U.S. Environmental Protection Agency's (EPA) Office and Research Development after 34 years of federal service. I wish to thank members of the Committee for the opportunity to provide written and oral testimony today on the issue of impact to groundwater resources from oil and gas development.

Groundwater resources are vital to the economic development of the United States and the well-being of its citizens. Groundwater resources are especially important in arid regions of the country experiencing rapid population growth, where surface water rights for irrigation are often fully appropriated, and where drought, population growth, and climate change are expected to further exacerbate water demand[1]. For example, the 2012 – 2016 drought in California was unprecedented over the past 1200 years[2] due in large part to elevated temperatures having an anthropogenic signature and increased resultant evapotranspiration[3,4]. The 2012 – 2016 drought resulted in substantial groundwater depletion in the Central Valley[5]- a world-class agricultural production region that supplies over one-third of the country's vegetables and two-thirds of the country's fruits and nuts[6].

The emergence of a climatic regime in which all future dry years coincide with unusually warm years has significantly increased the likelihood of sustained severe droughts in the mid-continent[1] and western states[3,4,7] and has placed greater emphasis on preserving fresh and brackish groundwater resources in these areas. Brackish groundwater is typically defined as groundwater having levels of total dissolved solids between 1,000 and 10,000 mg/L[8]. Total dissolved solids are essentially dissolved salts. The use of treated brackish groundwater for municipal water supply has substantially increased throughout the United States because of declining freshwater availability, the difficulty in securing surface water and groundwater legal rights, the high costs of infrastructure required to transport and store fresh water, and advances in membrane water treatment technology[9,10] such as reverse osmosis. Because of the growing importance of the use of brackish groundwater to supplement freshwater use, in 2017, the United States Geological Survey conducted a national assessment of brackish groundwater resources[10].

In this testimony, I will discuss peer-reviewed research conducted by myself and coworkers at Stanford University and PSE Healthy Energy on the impact to groundwater resources from oil and gas development and its relevance to regulatory rulemaking.

Injection of Well Stimulation Fluids into Formations Containing Groundwater Resources

In 2016, building on previous work at the EPA[11] that was subject to a Congressional hearing in 2012[12], we published a paper[13] that demonstrated impact to groundwater resources meeting the definition of an Underground Source of Drinking Water (USDW) at the Pavillion, WY Field. An USDW is defined, in part, as groundwater having a concentration of total dissolved solids less than 10,000 mg/L under EPA's Underground Injection Control Program pursuant to the Safe Drinking Water Act[14]. While it was known at the time that hydraulic fracturing occurs in formations meeting the definition of an USDW, this was the first publication that demonstrated that injection of acid and hydraulic fracturing stimulation fluids into formations containing USDWs impacts USDWs.

In 2004, in an EPA report on hydraulic fracturing associated with coal bed methane recovery, the EPA found that hydraulic fracturing was occurring or likely occurring in USDWs at 10 of 13 coal bed methane basins evaluated[15]. However, the EPA did not explicitly acknowledge impact to groundwater resources from this practice but instead stated that dilution, adsorption, and biodegradation would reduce contaminant concentrations in groundwater to safe levels prior to impacting domestic water wells, which are generally shallower than CBM wells[15]. Hence, the EPA essentially stated that impact to groundwater resources would occur but not affect shallow domestic water wells. There was no consideration in this report of protection of deeper groundwater resources for potential present or future use.

The 2004 EPA report was subsequently used as justification, in part, to largely exempt hydraulic fracturing from the Safe Drinking Water Act in the Energy Policy Act of 2005[16]. This Act essentially stripped federal protection of groundwater resources on non-tribal and non-federal lands during hydraulic fracturing. In 2014, in an apparent reversal of its 2004 report, the EPA stated that direct injection of fluids into USDWs did pose an immediate risk to groundwater resources and public health because it can directly degrade groundwater quality[17].

Hydraulic fracturing also occurs into USDWs on federal and tribal lands. In 2011, in response to a Congressional inquiry by then Congressman Markey, the U.S. Bureau of Land Management (BLM) conducted a review of randomly selected oil and gas production wells and determined that hydraulic fracturing occurred in formations containing USDWs at 49 of 389 gas production wells (13%) reviewed[18].

In 2015, the BLM issued a Final Rule on the regulation of hydraulic fracturing on federal and tribal lands. In this rule, the BLM defined protected groundwater as groundwater having a total dissolved solids level ≤ 10,000 mg/L[19] - the same criterion as that used for an USDW. The BLM stated that desalination of groundwater within this range of total dissolved solids for municipal use is technically and economically feasible[19]. In 2015, an expert panel convened by the California State Water Resources Board to develop criteria for monitoring groundwater during well stimulation arrived at the same conclusion[20]. However, in 2016, the United States District Court for the District of Wyoming set aside the BLM rule based on a ruling that the Energy Policy Act of 2005 precluded the BLM's rulemaking[21]. In 2017, the BLM rescinded the rule[22]. Hence, groundwater resources are not adequately protected, even on tribal and federal lands.

In 2016, in its national study on hydraulic fracturing, the EPA examined 1650 produced water samples from stimulated wells in five states and found that 1200 samples (~73%) had levels of total dissolved solids indicative of USDWs indicating well stimulation into USDWs[23]. EPA concluded that the overall frequency of hydraulic fracturing in USDWs is relatively low but is concentrated in particular areas of the country[23]. A more accurate statement would be that the frequency of this occurrence is unknown but likely concentrated in specific areas of the country. Based on our research[9,13], impact to USDWs by injection of stimulation fluids into USDWs is likely limited to coal bed methane development and tight gas formations deposited under non-saline (<10,000 mg/L total dissolved solids) fluvial (e.g., river flow) depositional paleo-environments. Coal bed methane development and non-saline fluvial depositional environments are common in oil and gas basins in the Rocky Mountain states where exemption of hydraulic fracturing from the Safe Drinking Water Act is likely to be of greatest impact.

Due to exemption from the Safe Drinking Water Act, definitions of protected groundwater during well stimulation vary from state to state. In 2018, we published a paper[9] examining definitions of protected groundwater in states having significant brackish groundwater resources. While some states such as Oklahoma and Mississippi currently define protected groundwater as an USDW during well stimulation, definitions of protected groundwater in most states are either ambiguous or do not protect brackish groundwater resources. In this paper[9], we recommended that states uniformly utilize criteria for an USDW to protect groundwater resources. The American Petroleum Institute has recommended setting surface casing at least 100 ft below the deepest USDW during hydraulic fracturing[24] and hence essentially defined protected groundwater during well stimulation as an USDW consistent with our recommendation.

Vertical Separation Between Groundwater Resources and Well Stimulation

When direct injection of stimulation fluids into formations containing groundwater resources does not occur, consideration of the vertical separation length between groundwater resources and hydraulic fracturing is important since fractures can propagate as much as 2000 feet vertically upward[25]. In some areas of the country, especially in the Rocky Mountain states, USDWs or groundwater resources can extend well in excess of 5000 feet below land surface[13]. Since relatively shallow (e.g., <1000 feet below the surface) groundwater resources are present throughout most of the county, as assessment of depths of hydraulic fracturing can be used as a preliminary indicator of risk to groundwater resources.

In 2015, we published a paper[26] in which we found that at least 6% of hydraulic fracturing in the United States occurs within 3000 feet of the surface. We believe that this is an underestimate of the magnitude of shallow hydraulic fracturing because at the time of publication, hydraulic fracturing in a number of shallow shale formations (e.g., New Albany Shale in southeastern Illinois, southwestern Indiana, and northwestern Kentucky and the Antrim Shale in Michigan's Lower Peninsula) was not being reported to FracFocus (the source of our data analysis).

In some states such as California, current regulations[27] require the production well operator to estimate the vertical propagation of fractures during hydraulic fracturing. However, most states do not require estimation of vertical fracture propagation length to ensure an adequate separation between depths of hydraulic fracturing and groundwater resources.

Impact of Oil and Gas Wastewater on Water Resources

The focus of our most recent work has been investigating the management of oil and gas wastewater (i.e. produced water) and its impact on surface and groundwater resources. Earlier this year, we published a paper that examined oil and gas management practices in Pennsylvania. We found that, while most wastewater is now being reused for oil and gas production, 35% of the wastewater could not be tracked[28]. Only intermediary locations for transfer or storage were provided[28]. Because of exemption of produced water from Subtitle C of the Resource Conservation and Recovery Act, there is no "cradle to grave" tracking of produced water in Pennsylvania or any other state.

There has recently been an increased emphasis on the "beneficial use" of produced water. In a commentary published in 2017[29], we stated that that an assessment of the risk posed by the reuse of produced water for agricultural irrigation or any other use outside an oil and gas field requires the identification and quantification of chemical compounds present, sufficient information on physiochemical and biological properties of compounds present to understand fate and transport processes, and adequate information on mammalian and ecological toxicity to estimate safe aqueous concentrations. This fundamental information is lacking for many constituents in produced water.

Finally, we are examining the impact of disposal of produced water directly onto the land surface and into unlined produced water ponds in California[30]. There are 541 active and 509 inactive unlined produced water ponds in California – nearly all of which lie in the southern portion of the San Joaquin Valley[31]. Since the primary purpose of unlined produced water ponds is to percolate produced water into subsurface media, this method of disposal provides a direct pathway for contaminant migration to groundwater of current or potential future use.

Almost all produced water disposed to land surface or unlined produced water ponds is saline[32] (>10,000 mg/L total dissolved solids). The primary known constituents of concern in produced water in the San Joaquin Valley are elevated levels of total dissolved solids, chloride, boron, other trace elements (e.g., arsenic, strontium, thallium, lithium), metals, petroleum hydrocarbons, polynuclear aromatic hydrocarbons, volatile organic compounds including benzene (a known human carcinogen), and radionuclides[33]. One radionuclide, radium-226, is carcinogenic and has a half-life of 1600 years resulting in little dissipation in soil over time.

At least one billion gallons per year of produced water is disposed in unlined active produced water ponds in the San Joaquin Valley[31]. Based on an average daily discharge rate provided to the Central Valley Regional Water Quality Control Board, at just one facility (McKittrick 1 & 1-3)[34], over 54 billion gallons of produced water has been disposed in unlined produced ponds since the 1950s. This disposal practice has resulted in contamination of a regional aquifer at this location and at other locations throughout the San Joaquin Valley[34,35].

The ongoing practice of disposal of produced water into unlined produced water ponds and resultant groundwater contamination is, in part, a consequence of exemption of oil and gas exploration and development waste from Subtitle C of the Resource Conservation and Recovery Act and regulation under the less rigorous requirements of Subtitle D. This exemption has resulted in a patchwork of regulations in various states to manage oil and gas production waste that have continued to evolve over time. As a result of a consent decree in filed in 2016[36], the EPA was required to reevaluate regulation of oil and gas production waste under Subtitle D. In April 2019, the EPA determined that revision of regulation under Subtitle D was unnecessary[37,38].

Conclusion

Groundwater resources are vital to economic development in the United States and the well-being of its citizens. Exemption from federal regulation and often inadequate state regulation has caused impact to groundwater resources as a result of oil and gas development. At present, this situation can only be remedied by reconsideration of exemptions from federal regulations or by improved regulation on a state-by-state basis. This testimony has been provided to inform the committee of the need for increased regulation at the federal and state level.

Again, I wish to thank members of the Committee for the opportunity to speak on the issue of impact on groundwater resources from oil and gas development.

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