

# PSR



# PHYSICIANS FOR SOCIAL RESPONSIBILITY

U.S. AFFILIATE OF INTERNATIONAL PHYSICIANS FOR THE PREVENTION OF NUCLEAR WAR

February 18, 2022

Re: proposal concerning importations of water into and exportations of water from the Delaware River Basin related to high-volume hydraulic fracturing

Delaware River Basin Commission  
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**Submitted via email: <http://dockets.drbc.commentinput.com>**

On behalf of our 33,000 health professional and concerned citizen members and the populations we serve, Physicians for Social Responsibility (PSR) is pleased to submit these comments concerning the Delaware River Basin Commission's proposal to amend its Comprehensive Plan and Water Code concerning importations of water into and exportations of water from the Delaware River Basin; to amend *Special Regulations – High Volume Hydraulic Fracturing* to prohibit the discharge of wastewater from high volume hydraulic fracturing ("fracking) and related activities to waters or land within the Delaware River Basin; and to incorporate key elements of the latter proposed amendments into the Commission's Water Quality Regulations.

PSR is a national non-profit organization based in Washington, DC and with chapters and members nationwide. Guided by the values and expertise of medicine and public health, PSR works to protect human life from the gravest threats to health and survival.

PSR believes that the Commission's proposal to ban the discharge of high-volume fracking wastewater to water and land is a laudatory but incomplete step to protect the Basin from pollution. This proposal leaves the Basin's water supplies at risk of serious contamination from wastewater related to high-volume fracking because this wastewater could still be imported into the Basin for disposal, processing, reuse, or storage. Nor would the proposal place any limitation on the discharge, disposal, processing, reuse, or storage of wastewater from low-volume fracking and other oil and gas extraction techniques. These lapses leave the Basin vulnerable to highly dangerous toxic and/or radioactive substances.

In particular, we would like to direct your attention to the possibility that wastewater from oil and gas extraction could contain highly toxic per- and polyfluoroalkyl substances (PFAS) that PSR recently identified as having been used in oil and gas operations.<sup>1</sup> We are also concerned that the wastewater could contain toxic chemicals whose identities are withheld by the public through trade secret protections or other regulatory gaps, potentially leaving people unknowingly

exposed. Our analysis, discussed below, of fracking chemical use in the two Pennsylvania counties closest to the Delaware River Basin found extensive use of trade secret chemicals, including some that may be more likely to be PFAS.

In 2021, the Commission wisely prohibited high-volume hydraulic fracturing in the Basin because of pollution risks, including risks related to wastewater.<sup>2</sup> It makes no sense to allow this wastewater into the Basin simply because the fracking or other extraction activities occurred elsewhere. The U.S. EPA has warned that wastewater could leak or spill in multiple scenarios, including during transportation and in spills at facilities that treat fracking wastewater for reuse.<sup>3</sup> Wastewater from low-volume fracking sites could be discharged into the waters of the Basin, risking direct contamination of water supplies. Pennsylvania's Attorney General and peer-reviewed studies have found serious and disproportionate health impacts among those living near oil and gas operations. This evidence indicates that risks from exposure to substances found in oil and gas wastewater are not just hypothetical.

Separately, we believe that the Commission should prohibit the export of water from the Basin for use in oil and gas extraction. The Commission should not assist in creating pollution risks for other communities.

### **Background on Oil & Gas Wastewater: Toxic and Voluminous**

The Delaware River Basin Commission is justified in its concern about fracking wastewater due to the toxicity and the volume of this fluid. In fracking, oil and gas companies inject into oil and gas wells a mixture of up to tens of millions of gallons of water, sand, and chemicals at high pressure to fracture underground rock formations, unlocking trapped oil and gas.<sup>4</sup> The chemicals serve a variety of purposes including killing bacteria inside the wellbore, reducing friction during high-pressure fracking, and thickening the fluid so that the sand, suspended in the gelled fluid, can travel farther into underground formations.<sup>5</sup>

After fracking is complete, oil and gas companies turn off the pressure in the well and a portion of the injected fluid reverses course, coming up and out of the well in the form of wastewater.<sup>6</sup> Naturally occurring water in the underground formation where the oil and/or gas is located also emerges from the well as wastewater after fracking.<sup>7</sup> The contaminants found in the wastewater can thus include both those that oil and gas companies injected during fracking as well as naturally occurring substances from underground formations, such as radium, BTEX (benzene, toluene, ethylbenzene, and xylene), and high levels of salt.<sup>8</sup> Each well can generate millions of gallons of wastewater.<sup>9</sup>

The contaminants found in fracking fluid and fracking wastewater pose significant health and environmental risks. The EPA found in its 2016 report on fracking and drinking water that 1,606 chemicals were associated with fracking, including 599 chemicals that had been detected in wastewater.<sup>10</sup> While the agency found high-quality information on health effects for only 173 of these chemicals, that information was troubling. EPA found that

health effects associated with chronic oral exposure to these chemicals include carcinogenicity, neurotoxicity, immune system effects, changes in body weight, changes in blood chemistry, liver and kidney toxicity, and reproductive and developmental toxicity.<sup>11</sup>

Some of the chemicals with these toxic effects, such as benzene, were found in both fracking chemicals and wastewater,<sup>12</sup> while others such as radium, were found only in wastewater.<sup>13</sup>

The Commission should prohibit the importation of all wastewater generated by oil and gas extraction. EPA did not distinguish between high-volume and low-volume fracking in its analysis of chemicals, leaving open the possibility that wastewater from both types of fracking could be toxic. The Delaware River Basin Commission defines high-volume fracking as “using a combined total of 300,000 or more gallons of water during all stages in a well completion.”<sup>14</sup> In some cases analyzed by EPA in its 2016 report on fracking and drinking water, oil and gas companies used less than 300,000 gallons of water.<sup>15</sup> Therefore, it is possible that oil and gas wells could produce toxic wastewater after either low-volume or high-volume fracking.

Other types of oil and gas extraction may also produce toxic wastewater, such as the drilling that precedes fracking. According to EPA regulators, chemicals used in the drilling stage can pose health risks including developmental toxicity and the formation of tumors.<sup>16</sup> A disclosure form filed with the state of Ohio, perhaps the only state to require disclosure of drilling chemicals, shows that Statoil, Norway’s state oil company (since renamed Equinor), has used a neurotoxic chemical, xylene, in drilling.<sup>17</sup> If wastewater were generated from the drilling process, it too could contain these chemicals.

### **PFAS Could be a Risk in Oil & Gas Wastewater**

A new concern is that oil and gas wastewater could contain a class of chemicals known as per- and polyfluoroalkyl substances (PFAS). In 2021, PSR publicized for the first time evidence that PFAS had been used in fracking. We located this evidence in a database maintained by FracFocus, a nongovernmental organization run by the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission. The database, which began operating in 2011, contains records on the hydraulic fracturing chemicals used in thousands of wells across the nation. Twenty-seven states require or allow reporting of hydraulic fracturing chemicals to the database, including Pennsylvania, which requires reporting of fracking chemicals to FracFocus for unconventional gas wells.<sup>18</sup> FracFocus data show that between 2012 and 2020, oil and gas companies used PFAS or chemicals that could break down into PFAS in fracking in more than 1,200 wells in six U.S. states: Arkansas, Louisiana, Oklahoma, New Mexico, Texas, and Wyoming.<sup>19</sup> We have subsequently learned that oil and gas companies have used PFAS to frack oil and gas wells in multiple other states. Because these chemicals were used in fracking, it is likely that they were also present in wastewater from these wells.

PFAS are a class of thousands of manmade chemicals known for having properties that are valuable in multiple industries and products, including being slippery, oil- and water-

repellant, and able to serve as dispersants or foaming agents.<sup>20</sup> However, PFAS have been linked to cancer, birth defects, pre-eclampsia, and other serious health effects.<sup>21</sup> Toxic in minuscule concentrations, they accumulate inside the human body and do not break down in the environment – hence their nickname, “forever chemicals.”<sup>22</sup> PFAS were widely used for decades in non-stick cookware, stain-resistant carpeting, fire-fighting foam and other products before their highly toxic characteristics became public around the year 2000. The use of PFAS or PFAS precursors in oil and gas operations adds an especially hazardous class of chemicals to the list of harmful substances associated with oil and gas extraction and is another potential route of exposure to PFAS.

Mounting evidence of PFAS’s risks has led ten states to develop guidelines for concentrations of PFOA and other types of PFAS in drinking water.<sup>23</sup> One of these states is Michigan, which set standards in 2020 for drinking water and cleaning up groundwater for PFOA and six other forms of PFAS. Michigan’s maximum allowable level of PFAS is no more than eight parts per trillion for PFOA.<sup>24</sup> By extension, these standards indicate that one measuring cup of PFOA could contaminate almost 8 billion gallons of water, six times the 1.3 billion gallons of water used each day by New York City, or the amount of water needed to fill almost 12,000 Olympic-sized swimming pools at about 660,000 gallons per pool.<sup>25</sup> A minuscule amount of PFAS in oil and gas wastewater could contaminate huge volumes of drinking water.

### **Undisclosed Use of Dangerous PFAS Chemicals Could be Occurring in PA**

Evidence shows that PFAS have been used in oil and gas operations in Pennsylvania, and additional information suggests that the use of these chemicals in oil and gas extraction could be much broader than our July 2021 report showed. Following publication of our report, the Philadelphia Inquirer found that a PFAS known as PTFE had been used for fracking in eight wells in western Pennsylvania.<sup>26</sup> Other articles that we cite in our 2021 report and in a followup 2022 report – one in a peer-reviewed scientific journal,<sup>27</sup> the other in an oil and gas industry-related publication<sup>28</sup> – provide evidence that PFAS, especially a class of chemical called fluorosurfactants, have been used in the oil and gas industry for decades.

Both PTFE and fluorosurfactants pose health and environmental risks. PTFE belongs to a class of chemicals known as fluoropolymers and are a type of plastic.<sup>29</sup> Scientists’ and environmentalists’ major concerns about PTFE and other fluoropolymers are not related so much to these substances themselves but rather are based on the associated impacts of their production, use, and disposal:<sup>30</sup> Highly toxic PFAS are used as production aids in the production of PTFE and other fluoropolymers. As several authors noted in a 2020 scientific paper, these other PFAS have included PFOA, which has been phased out as a manufacturing aid in the U.S. but is still used in Asia, and GenX, which is similarly harmful and has replaced PFOA in fluoropolymer production.<sup>31</sup> Fluoropolymers like PTFE can contain these more toxic PFAS fragments as impurities and release the compounds if they break down under heat or pressure.<sup>32</sup> The authors of the 2020 paper noted that

The levels of leachables...in individual fluoropolymer substances and products depend on the production process and subsequent treatment processes; a comprehensive global overview is currently lacking.<sup>33</sup>

In addition, the authors noted that the persistence in the environment of PTFE and other fluoropolymers could pose problems during disposal. “Landfilling of fluoropolymers leads to contamination of leachates with PFAS and can contribute to release of plastics and microplastics,” they wrote.<sup>34</sup> One of the authors added in an email to PSR that if PTFE were used in high-temperature oil and gas wells, it could undergo a process called “thermolysis” and generate toxic PFAS called perfluoroalkyl carboxylic acids (PFCAs). As a result, he wrote, “there could be some additional problems that need some investigation.”<sup>35</sup>

In 2021, a coalition of environmental groups including the Center for Environmental Health, Clean Water Action, Ecology Center, Environmental Working Group, Natural Resources Defense Council, Safer States, and the Sierra Club shared similar concerns, based on multiple scientific articles, regarding the risks of fluoropolymers such as PTFE. The groups also noted that fluoropolymers are manufactured with chemicals that have an outsized negative effect on climate change.<sup>36</sup>

Fluorosurfactants are a subset of a larger group of chemicals known as “surfactants.” According to EPA, surfactants

lower the surface tension of a liquid, the interaction at the surface between two liquids (called interfacial tension), or that between a liquid and a solid. Surfactants may act as detergents, soaps, wetting agents, degreasers, emulsifiers, foaming agents and dispersants.<sup>37</sup>

Surfactants are commonly used in fracking.<sup>38</sup> Fluorosurfactants are said to be “superior in their aqueous surface tension reduction at very low concentrations and are useful as wetting and leveling agents, emulsifiers, foaming agents, or dispersants.”<sup>39</sup> Fluorosurfactants encompass PFOA, PFOS, and hundreds of other less-studied replacement chemicals and mixtures.<sup>40</sup> Some are known to be extremely toxic to people,<sup>41</sup> could be harmful to animals,<sup>42</sup> and are expected to persist in the environment.<sup>43</sup> Most of the chemicals we identified as PFAS or PFAS precursors in our 2021 report were fluorosurfactants.<sup>44</sup>

### **Disclosure Gaps Make PFAS Use Near Delaware River Basin Difficult to Determine**

Due to incomplete disclosure requirements in Pennsylvania law that allow oil and gas companies to withhold chemical identities from the public, it is difficult to determine whether PFAS have been used in oil and gas wells near the Delaware River Basin. These gaps create the risk that people could be unknowingly exposed to PFAS and other dangerous substances. PSR tried to determine whether PFAS was being used in Pennsylvania’s oil and gas wells near the Delaware River Basin by searching FracFocus for fracking chemicals used between 2011 and 2021 in wells in Susquehanna and

Wyoming Counties. We searched through the open-source version of FracFocus, OpenFF,<sup>45</sup> an open-source database that is more readily searched and informative than the original version of FracFocus.<sup>46</sup>

Under Pennsylvania law, chemical disclosure requirements are complex and incomplete. Oil and gas well operators must disclose to FracFocus only the chemicals used for fracking in unconventional wells.<sup>47</sup> These wells are defined by the law as those drilled for natural gas below a particular geologic layer and that require hydraulic fracturing or other techniques that expose more of the formation to the wellbore for economic production.<sup>48</sup> This definition excludes other gas wells and any wells drilled for oil. Fracking chemicals used in these other wells must be disclosed to the state, where the public must search for them in individual well completion reports.<sup>49</sup> This process is far more cumbersome than searching in FracFocus, where the public can search for chemicals across multiple wells simultaneously.<sup>50</sup>

In addition, limited disclosure requirements in Pennsylvania result in significant gaps in the information that is made available to the public. The state allows oil and gas companies to withhold from the public the identity of fracking chemicals that the companies designate as a trade secret, whether these chemicals are used in unconventional or conventional wells.<sup>51</sup> Oil and gas companies in Pennsylvania have used trade secret claims extensively over the years. Pennsylvania also does not require disclosure of chemicals used in the drilling that precedes fracking, or in other stages or methods of oil and gas extraction.<sup>52</sup> Finally, Pennsylvania does not require fracking chemical disclosure from chemical manufacturers, who are the entities with the most detailed knowledge of what chemicals are being injected into oil and gas wells. Instead, the state requires fracking chemical disclosure from well operators, who operate further down the supply chain.<sup>53</sup> In some cases, including in Pennsylvania, well operators have stated that they do not know all of the chemicals that they are injecting into their wells.<sup>54</sup> Therefore, even the use of FracFocus provides incomplete access to the fracking chemicals used in Pennsylvania's oil and gas wells. However, the information that we did discover in FracFocus was consistent with these data gaps and suggests that people could be unknowingly exposed to toxic fracking chemicals, whether directly or through fracking wastewater.

### **Further Uncertainty in Counties Close to the Delaware River Basin**

PSR searched for PTFE and fluorosurfactants in oil and gas wells fracked between 2011 and 2021 in Susquehanna and Wyoming counties, the two Pennsylvania counties with fracking chemical disclosures in FracFocus that are closest to the Delaware River Basin. We did not find any disclosures of these substances. However, we found that oil and gas companies had used at least one trade secret chemical in 1,167 wells in those two counties, and that the mass of these trade secret chemicals totaled a staggering 28 million pounds. We also found that oil and gas companies had injected 508 wells with at least one trade secret chemical labelled as an unspecific surfactant. These surfactants could be fluorosurfactants, but the public cannot know for sure without specific chemical identifiers that are withheld from the records by trade secret claims.

A database maintained by the Pennsylvania Department of Environmental Protection showed that only unconventional wells were drilled in the two counties during the ten-year period,<sup>55</sup> so the FracFocus data would have encompassed fracking chemical disclosures from all wells drilled in the two counties over that timespan. But the data would not have disclosed drilling chemicals used in phases of extraction prior to fracking, nor any chemicals not disclosed to well operators by chemical manufacturers. Combined with the extensive use of trade secret chemicals, the net result is that any wastewater generated from these wells is likely to contain unknown chemicals, and those unknowns could include PFAS or other toxic substances.

### **U.S. EPA has Expressed Concerns Over PFAS and PFAS Precursors**

EPA has found that dozens of chemicals proposed for use in oil and gas extraction, and labelled as trade secrets, pose health risks. The chemicals they examined include three PFAS precursors,<sup>56</sup> suggesting that trade secret chemicals may be toxic. In 2011, the agency approved these three chemicals for commercial use that had been proposed for use in drilling and/or fracking under the Toxic Substances Control Act's New Chemicals program. In its application to use the chemicals commercially called a premanufacture notice, the chemicals' manufacturer and/or importer withheld the chemicals' specific identities as trade secrets, and did the same with its own name. EPA approved the chemicals for commercial use despite concerns that the chemicals might degrade into substances similar to one of the most infamous PFAS in modern chemistry, PFOA.<sup>57</sup> In a consent order, EPA wrote

EPA is concerned that these perfluorinated degradation products may be released to the environment from incomplete incineration of the PMN [premanufacture notice] substances at low temperatures. EPA has preliminary evidence, including data on other [REDACTED], that suggests that, under some conditions, the PMN substances could degrade in the environment. EPA has concerns that these degradation products will persist in the environment, could bioaccumulate or biomagnify, and could be toxic (PBT) to people, wild mammals, and birds based on data on analog chemicals, including PFOA and [REDACTED]. The presumed perfluorinated degradants for these PMN substances include [REDACTED].<sup>58</sup>

The acronym PBT stands for (P) persistent, (B) bioaccumulative, and (T) toxic.<sup>59</sup> EPA did not answer a question sent via email by PSR about the circumstances in which the substances described in the premanufacture notice might be incompletely incinerated. In discussing PFOA, to which EPA regulators had likened the degradation products of the three chemicals, the regulators added that

toxicity studies on PFOA indicate developmental, reproductive and systemic toxicity in various species. Cancer may also be of concern. These factors, taken together, raise concerns for potential adverse chronic effects in humans and wildlife.<sup>60</sup>

EPA also expressed significant health concerns in its health and ecological hazard assessment. The agency wrote:

For the potential incomplete incineration/environmental degradation product, based on the test data for the analogue [REDACTED], concerns are liver toxicity, blood toxicity, and male reproductive toxicity....There is also concern for immunosuppression and oncogenicity based on data for [REDACTED].<sup>61</sup>

On November 29, 2011, the undisclosed company that had requested the approval of the three new chemicals began importing one of the chemicals for commercial use, known by EPA case number P-11-0091, according to a document filed with EPA.<sup>62</sup> (The related chemicals, P-11-0092 and P-11-0093, had not been used commercially).<sup>63</sup> In 2021, PSR was unable to identify use of the chemical in FracFocus by searching for its generic name, fluorinated acrylic alkylamino copolymer. The absence of the chemical in fracking chemical disclosure could reflect the potential that the chemical was not used for fracking. But it could also reflect the possibility that the chemical was used under trade secret protection in Pennsylvania and other states. Because of the potential that risky chemicals such as this one could be used without the public's knowledge and wind up in oil and gas wastewater, the Delaware River Basin Commission should prohibit all oil and gas wastewater imports into the Basin.

### **Potential for Leaks, Spills**

One of the potentially risky scenarios in which fracking wastewater could enter the Delaware River Basin is for treatment at a Centralized Waste Treatment (CWT) facility. In these facilities, wastewater is treated so that it can be reused for new fracking in additional oil and gas wells. In its 2016 report on fracking and drinking water, EPA found that such treatment and reuse was especially popular in Pennsylvania.<sup>64</sup> "Of the 74 CWT facilities identified by the EPA...as having accepted or having the ability to accept hydraulic fracturing wastewater...40 are located in Pennsylvania," EPA reported.<sup>65</sup>

EPA has found that fracking wastewater could leak or spill during treatment and reuse even if the wastewater were not intended to be discharged. The agency wrote that "the storage and handling of wastewater at CWTs could impact nearby surface water through leaks and spills."<sup>66</sup> Similarly, EPA wrote that "wastewater being transported by truck or pipeline to and from a CWT can also present a vulnerability for spills or leaks"<sup>67</sup> and added that "for companies employing reuse as a wastewater management strategy, surface spills and leaks can occur during wastewater transport to and from a treatment facility or from storage tanks/pits located at the treatment facility or at the well site."<sup>68</sup> Overall, EPA found that several "combinations of activities and factors are more likely than others to result in more frequent or more severe impacts" to drinking water. Some of these combinations of activities and factors include "spills during the management of hydraulic fracturing fluids and chemicals or produced water [EPA's term for wastewater] that result in large volumes or high concentrations of chemicals reaching groundwater resources."<sup>69</sup> The potential for such spills would pose a serious risk to water supplies in the Basin, considering the likelihood of known or unknown toxic chemicals in fracking wastewater.

## **Health Effects Associated with Oil and Gas Operations**

Residents living near oil and gas operations have increasingly reported illnesses that they believe are related to chemical exposures, while expressing frustration about the secrecy surrounding many of the chemicals used by the oil and gas industry.<sup>70</sup> These reports suggest that residents of the Delaware River Basin might experience similar problems if they were exposed to imported oil and gas wastewater. In 2020, Pennsylvania’s Attorney General issued a report based on a criminal grand jury investigation of oil and gas drilling pollution in Pennsylvania, where drilling for gas in shale formations has surged over the past 15 years.<sup>71</sup> That surge has vaulted Pennsylvania into the number two spot among gas-producing states and brought thousands of Pennsylvanians into contact with gas drilling and its impacts. Based on testimony from over 70 households, the attorney general found that

Many of those living in close proximity to a well pad began to become chronically, and inexplicably, sick. Pets died; farm animals that lived outside started miscarrying, or giving birth to deformed offspring. But the worst was the children, who were most susceptible to the effects. Families went to their doctors for answers, but the doctors didn’t know what to do. The unconventional oil and gas companies would not even identify the chemicals they were using, so that they could be studied; the companies said the compounds were “trade secrets” and “proprietary information.” The absence of information created roadblocks to effective medical treatment. One family was told that doctors would discuss their hypotheses, but only if the information never left the room.<sup>72</sup>

In addition to these and other self-reported or anecdotal reports, peer-reviewed studies of people living near oil and gas operations provide scientific evidence of illnesses and other health effects. A 2018 study in the *Journal of Health Economics* found that babies born between 2003 and 2010 to Pennsylvania mothers living near a functioning shale gas well had a higher incidence of low birth weight compared to babies born of mothers living near a permitted well that had not yet gone into production.<sup>73</sup> Low birthweight is a leading contributor to infant death in the United States.<sup>74</sup> In 2019, Pennsylvania-based FracTracker Alliance conducted a meta-analysis of 142 health studies published between 2016 and 2018 focusing on health impacts of unconventional oil and gas development (UOGD). The analysis concluded, “The results of this study indicate that a variety of health impacts in every major organ system are being experienced by individuals living near UOGD.” Specific health effects included cancer, early infant mortality, pre-term birth, and poor infant health.<sup>75</sup> The Southwest Pennsylvania Environmental Health Project,<sup>76</sup> and PSR and the Concerned Health Professionals of New York,<sup>77</sup> have likewise compiled the substantial and growing number of scientific studies that have found serious health effects associated with oil and gas drilling. The Commission, in banning the importation of fracking wastewater, would be taking an important step to shield Basin residents from dangerous health consequences.

## **Exports of Freshwater for Oil and Gas Would Perpetuate Pollution**

Considering the potential impacts of toxic substances utilized in oil and gas extraction, as well as the climate impacts associated with oil and gas production and use, the Commission should

prohibit the export of freshwater from the Basin for oil and gas extraction elsewhere. This water could be used to contribute to practices in other areas, including high-volume fracking, low-volume fracking and other oil and gas extraction techniques, that could expose those areas to the very types of pollution that the Commission rightfully seeks to protect the Basin from. The Commission should not facilitate pollution in other communities, especially when the Commission has already acted to protect its own water supplies by banning high-volume fracking.

Physicians for Social Responsibility appreciates this opportunity to comment. Please let us know if you have any questions.

Sincerely,

Barbara Gottlieb, Program Director, Environment & Health  
Dusty Horwitt, consultant to Physicians for Social Responsibility

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<sup>1</sup> Dusty Horwitt. Fracking with Forever Chemicals. Physicians for Social Responsibility (July 2021). Accessed Jan. 12, 2022, at <https://www.psr.org/wp-content/uploads/2021/07/fracking-with-forever-chemicals.pdf> (additional data on file with PSR). Dusty Horwitt and Barbara Gottlieb. Fracking with “Forever Chemicals” in Colorado. Physicians for Social Responsibility (January 2022). Accessed February 8, 2022, at <https://www.psr.org/wp-content/uploads/2022/01/fracking-with-forever-chemicals-in-colorado.pdf>.

<sup>2</sup> Delaware River Basin Commission. Final Rule with Respect to High Volume Hydraulic Fracturing and Final Amendments to the Rules of Practice and Procedure Concerning Project Review Classifications and Fees. Final Rule: Findings and Determinations (Feb. 25, 2021). Accessed Feb. 8, 2022, at [https://www.nj.gov/drbc/about/regulations/final-rule\\_hvhf.html#2](https://www.nj.gov/drbc/about/regulations/final-rule_hvhf.html#2).

<sup>3</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 7-42, 8-33, 8-34, 8-60. Accessed Jan. 12, 2022, at <https://www.epa.gov/hfstudy>.

<sup>4</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 3-18 through 3-22, 5-7, 5-8. Accessed Jan. 12, 2022, at <https://www.epa.gov/hfstudy>.

<sup>5</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 5-11, 5-16, 6-67. Accessed Jan. 12, 2022, at <https://www.epa.gov/hfstudy>.

<sup>6</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 3-23. Accessed Jan. 12, 2022, at <https://www.epa.gov/hfstudy>.

<sup>7</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 3-23. Accessed Jan. 12, 2022, at <https://www.epa.gov/hfstudy>.

<sup>8</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at ES-33, ES-34, 3-15, 8-11, 9-81. Accessed Jan. 12, 2022, at <https://www.epa.gov/hfstudy>.

<sup>9</sup> Julie Grant. Allegheny Front. Pa. sends a lot of fracking waste to Ohio. People there want more say in where injection wells go (Feb. 22, 2021). Accessed Feb. 10, 2022 at <https://stateimpact.npr.org/pennsylvania/2021/02/22/pa-sends-a-lot-of-fracking-waste-to-ohio-people-there-want-more-say-in-where-injection-wells-go/>.

<sup>10</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 9-1. Accessed Jan. 12, 2022, at <https://www.epa.gov/hfstudy>.

<sup>11</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 9-1. Accessed Jan. 12, 2022, at <https://www.epa.gov/hfstudy>.

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- <sup>12</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016 at Table G-1e. Available qualitative cancer classifications for chemicals reported to be used in hydraulic fracturing fluids (noting that chemicals in italics including benzene were found in both fracking fluids and wastewater). Accessed Feb. 9, 2022, at <https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990>.
- <sup>13</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016 at Table G-2a. Chemicals reported to be detected in produced water, with available chronic oral RfVs, OSFs, and qualitative cancer classifications from United States federal sources. Accessed Feb. 9, 2022, at <https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990>.
- <sup>14</sup> Proposed Amendments to Delaware River Basin Commission’s Special Regulations at 18 C.F.R. Part 440. Accessed Feb. 9, 2022, at [https://nj.gov/drbc/meetings/proposed/notice\\_import-export-rules.html#4](https://nj.gov/drbc/meetings/proposed/notice_import-export-rules.html#4).
- <sup>15</sup> U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 4-11, 4-12. Accessed Jan. 12, 2022, at <https://www.epa.gov/hfstudy>.
- <sup>16</sup> See, e.g., U.S. Environmental Protection Agency. Focus report for chemical with EPA case number P-06-0676. Washington, DC: New Chemicals Program; 2006 (on file with PSR).
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- <sup>61</sup> U.S. Environmental Protection Agency. Focus Report for chemicals with EPA case numbers P-11-0091, P-11-0092, P-11-0093 (Jan. 3, 2011), at 2 (on file with PSR).
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