

March 30, 2018

The Sierra Club opposes hydraulic fracturing (fracking) for many reasons including:

- It is a non-renewable fossil fuel that adds to increasingly dangerous levels of CO<sub>2</sub> in our atmosphere and in our oceans.
- The process of extraction and transport of natural gas results in large, but still not precisely measured, leaks of methane, a greenhouse gas that is 86 times more potent than methane over a 20-year period.
- The fracking process contaminates air at drilling and compressor sites and results in massive amounts of toxic waste.
- The amount of water used in fracking has, in many cases left too little water to maintain healthy streams and adequate supplies for human consumption.
- The construction of wells, pipelines and compressor stations has devastating effects on the landscape, rendering it much less habitable for humans and wildlife.

The Delaware Chapter of the Sierra Club strongly supports a permanent ban on fracking in the Delaware River Basin. However, based on the reasons given above, we must also oppose with equal strength any regulations that would allow export of water from the Delaware River and its tributaries and/or to allow transport, treatment or deposit of wastes anywhere in Delaware River Basin (DRB or Basin).

We believe that the regulations not only encourage increased gas extraction in areas near the DRB, a result contrary to our views on this issue, but that the proposed regulations offer neither sufficient protection of the volume of water in the Basin nor adequate protection of the quality of that water. We discuss our reasons for these views below.

## DISCUSSION

### The Proposed Rules Facilitate more Fracking

As noted above we oppose both the export of water for fracking and the import of wastewater from that process because it is likely to facilitate this extraction process in other areas. Deep-well injection is generally accepted as the most economical way to dispose of toxic wastes<sup>1</sup>, but large-scale injections have been clearly linked to increased earthquake activity, limiting acceptance of wastes. There are also few sites deemed appropriate for this process near the wells in Pennsylvania's Susquehanna River Basin. Since the Susquehanna watershed has historically had far less heavy industry than the DRB, it is unlikely to have the commercial waste treatment facilities that would be

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<sup>1</sup> "Ways of Disposing of Flowback Water", Lehigh University, College of Arts and Sciences publication on Marcellus Shale, 2017. <http://marcellus.cas2.lehigh.edu/content/ways-disposing-flowback-water>

exempt from the 2016 EPA rule banning fracking wastes from publicly-owned sewage treatment plants. Thus disposal of wastes will clearly be a factor limiting large-scale growth of the industry if the wastewater is not exported.

Water acquisition is a major expense and limiting factor in hydraulic fracturing in many parts of the country. There are also cases where water has been taken at the expense of residential needs.<sup>2</sup> While the Delaware River Basin has much better water supplies, there are many more needs to supply and fracking in the Marcellus requires unusually large amounts of water. The DRBC proposed rules greatly underestimate the water needed by using old data that doesn't reflect the volumes required by wells with multiple long laterals.

It is clear that availability of water will be a limiting factor in increasing fracking in the Susquehanna Basin. Allowing export of significant amounts of water is facilitating a practice that emits significant amounts of CO<sub>2</sub> and methane at a time when low-lying states like Delaware are already recording problems with sea-level rise.

#### Negative Effects to the DRB of Exporting Water

The rulemaking document clearly delineates many of the myriad negative impacts that water withdrawals could have during drought periods. However, it is not clear that there is sufficient data to appropriately regulate withdrawals during rainy winter and spring months when there is flooding. These conditions lead many to assume that there is sufficient water for frequent, large-scale withdrawals. But the watershed benefits when water levels are high: underground aquifers are replenished and vernal ponds support a variety of important animal and plant species vital to maintaining the biological diversity of a healthy environment.

What appears to be an excess of water isn't necessarily a true excess. But the DRBC does not seem to have documented studies on the effects of cumulative withdrawals under such conditions. Without this data, it will be difficult to design regulations that can be objectively enforced to limit withdrawals during times of apparent excess water. Considering the combined financial and political power of drilling interests, it seems unlikely that regulations not based on strong data will be allowed to stand. In the absence of enforceable regulations for periods of high water levels, we may frequently find ourselves with inadequate supplies later in the year.

#### Negative Effects to the DRB from Importing Fracking Wastes

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<sup>2</sup> "Fracking is depleting water supplies in America's driest areas, report shows," The Guardian (U.S Edition), Feb. 5, 2016 <https://www.theguardian.com/environment/2014/feb/05/fracking-water-america-drought-oil-gas>

The DRBC proposed rules demonstrate an awareness of the many environmental and health issues that have been reported in areas where fracking is occurring. Although some such issues (contamination of ground water with methane and chemicals; air contamination from volatile organics from both fracking fluids and the gas/oil deposits being extracted) are specific to the fracking/gas extraction process, many serious contamination problems will be imported with the wastes. Spillage during transport and transfer to treatment facilities will inevitably occur.

The treatment of the wastes will also create disposal issues which are not adequately addressed: 1) Inadequacies of available approaches to properly remove all toxic species 2) the failure of the proposed regulations to address the toxic effects of some chemicals in the effluent and 3) the failure to specify safe standards for the disposal of the hazardous solids formed in the treatment processes. These problems are discussed below.

### Treatment of Wastewater

Water returned from fracking operations can contain a huge number of chemicals, many of which are highly toxic. Among 1084 chemicals identified as having been used in fracking operations<sup>3</sup> are moderate to high levels of benzene, a known carcinogen, along with the other components of diesel: toluene, ethylbenzene and xylenes. Naphthalene, another aromatic organic compound toxic to humans<sup>4</sup> and to aquatic life,<sup>5</sup> has also been frequently identified in fracking wastes.<sup>6</sup> Also frequently present are biocides, which are likely to have high toxicity for many species; methanol; 2-butoxyethanol a surfactant that is toxic through ingestion, inhalation and skin contact and ethylene glycol.

Another 599 materials were listed in the EPA study<sup>3</sup> as being brought up from deep in the earth with the water returned after fracking. These contain toxic heavy metals; arsenic, selenium, aluminum and barium; radioactive elements such as radium, strontium, thorium and uranium; and high levels of bromides and sodium chloride. Wastewater that has been used recently in fracking operations will contain sand, mud and many metal salts that are dissolved in or suspended in the fluid. In wastewater that

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<sup>3</sup> Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States; US Environmental Protection Agency, 2016, p. ES-42.

<sup>4</sup> Fisher Chemical MSDS for naphthalene <https://fscimage.fishersci.com/msds/16120.htm>

<sup>5</sup> *ibid.* Section 12 (Ecological Information)

<sup>6</sup> H. Chen and K.E. Carter, "Characterization of the chemicals used in hydraulic fracturing fluids for wells located in the Marcellus Shale Play," *Journal of Environmental Management*, v.200. 9-15-2017. pp. 312-324

has been stored for months or years, many of the metals, including radioactive ones, will have precipitated out, leaving behind a toxic, radioactive residue.<sup>7</sup>

The first step in treating wastewater, whether sewage or waste from industrial and chemical operations, is to add chemicals such as lime that will cause many chemical species to form insoluble salts that precipitate, often bringing other organic matter down with them. This works well for municipal sewage and drinking water treatments and can be very successful with industrial waste if the components are known, so that appropriate precipitating agents can be used.

However, these techniques have generally been grossly inadequate in both sewage plants and central waste facilities that have treated fracking wastes. High levels of two radium isotopes have recently been found in sediment below such a plant.<sup>8</sup> High levels of bromides are also likely to be released by industrial treatment facilities if special treatments are not used to remove them. Organic compounds including xylenes and naphthalene must be tested for and appropriate removal techniques, such as adsorption on activated charcoal, utilized.

The most intractable problem in treating wastes from fracking, and even wastes from conventional gas extraction in the Marcellus Shale is the presence of a great variety of radionuclides. Because radioactive elements are found in very different places on the periodic table, we predict, and find, that they differ widely in their chemistry and in the water solubilities of their various salts. Thus no single precipitating agent will remove all the radionuclides. The situation is further complicated by the fact that the radioactive elements form complex salts involving other elements that may change their solubilities, but the changes occur over periods of months. The result is that the success of precipitation techniques will vary with a wide variety of factors including: location of drilling site(s), additives used in drilling, how often the drilling fluids have been reused and how long they were stored before shipment to a treatment site. The only currently known ways to reliably remove soluble radionuclides such as radium involve techniques such as reverse osmosis and ion exchange.<sup>9</sup> These are likely to be expensive to carry out on the large quantities of water involved in treating fracking wastes.

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<sup>7</sup> C. Nebelungm "Solubility of uranium oxide and radium sulfate in brines,"

[http://www.iaea.org/inis/collection/NCLCollectionStore/\\_Public/36/055/36055503.pdf](http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/36/055/36055503.pdf)

<sup>8</sup> [\*Sources of Radium Accumulation in Stream Sediments Near Disposal Sites in Pennsylvania: Implications for Disposal of Conventional Oil and Gas Wastewater\*](#); Nancy Lauer, Nathaniel Warner, Avner Vengosh, Environmental Science and Technology, DATE Jan. 4, 2018, DOI: 10.1021/acs.est.b04952

<sup>9</sup> M.A. Barakat, "New trends in removing heavy metals from industrial wastewater," Arabian Journal of Chemistry, Vol. 4, pp. 361-377, Oct 2011

<https://www.sciencedirect.com/science/article/pii/S1878535210001334>

## Disposal of Liquid Wastes

While the proposed rules offer protection from a number of toxic chemicals through promising adherence to clean drinking water standards, these do not include monitoring naphthalene (which is often added to fracking solutions,<sup>10</sup> and is a suspected carcinogen for humans and is also associated with extreme anemia, organ damage, and fatalities from high vapor concentration.<sup>11</sup> Aquatic species are extremely susceptible to naphthalene poisoning. Although naphthalene has moderately low solubility in water (31 mg/l in water at 25 °C), this level is about 5 times as high as the LC<sub>50</sub> for fathead minnows and 20 times higher than that for rainbow trout.<sup>4</sup> Aquatic bacteria, algae and insects are also highly sensitive to naphthalene poisoning. Clear, protective standards must be set for disposal of naphthalene.

Because of the high levels of TDS (Total Dissolved Solids) present in water from Marcellus shale, we also have concerns about their disposal in the Delaware River, particularly in Zone 5. The proposed rules allow solutions with TDS levels of 1000mg/l to be released here. This is an area within the tidal zone of the river that is known to be a spawning area for the endangered Delaware River species of Atlantic sturgeon. Atlantic sturgeon spawn are intolerant of salt levels above 250mg/l.<sup>12</sup> Dumping large amounts of water with four times that level of salt in the spawning areas could be extremely deleterious dangerous for the spawn. If withdrawals of water are carried out during the spring spawning season, the situation would be even worse.

## Disposal of Solid Wastes

If the separations of toxic and radioactive wastes from the wastewater are successful, all these dangerous materials will be in the solid residue. But the proposed regulations essentially ignore the question of what should be done with these solids. The assumption may be that, as generally insoluble solids, they can be safely stored anywhere. This is absolutely not the case for radioactive waste.

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<sup>10</sup> H. Chen and K.E. Carter, "Characterization of the chemicals used in hydraulic fracturing fluids for wells located in the Marcellus Shale Play," *Journal of Environmental Management*, v.200. 9-15-2017. pp. 312-324

<sup>11</sup> Section 12 (Ecological Information) in Fisher Chemical MSDS for naphthalene <https://fscimage.fishersci.com/msds/16120.htm>

<sup>12</sup> M.W. Breece et al, "Shifting Distributions of Adult Atlantic Sturgeon Amidst Post-Industrialization and Future Impacts in the Delaware River: a Maximum Entropy Approach," *PLOS ONE* Nov. 8. 2013 2013 <https://doi.org/10.1371/journal.pone.0081321>

Recent studies<sup>13</sup> have focused on the problems involved in accurately determining the concentration of radionuclides in fracking wastes. One study found that using radium alone to estimate the levels of all radionuclides gave results that became increasingly inaccurate as the wastes were stored under conditions where radon gas formed from radium decay was trapped and decayed to give other radionuclides of varying stability. The authors found that radiation levels increased rapidly in the first 15 days of storage, becoming more than 5 times as high as initially measured. They predicted the levels would reach a maximum of more than 8 times the original level in about a century. Thus levels of radioactivity that might originally have seemed safe for human exposure could become clearly unsafe.

Solid wastes from treatment of fracking fluids and from drill cuttings are being stored in standard landfills in western Pennsylvania now. It was found<sup>14</sup> that the levels of fracking waste to ordinary landfill that had been calculated to be safe proved not to be acceptable when return measurements were made. The ingrowth phenomenon may have been involved.

Aside from ingrowth of radioactivity, there are other reasons why radioactive fracking wastes should not be stored in ordinary landfills. First, some of the radionuclides, particularly radium, may form salts that have moderate solubility so that they can slowly be leached out by rainwater. Anaerobic bacteria in landfills can facilitate oxidation-reduction reactions that create more soluble salts. Radium sulfate, which has fairly low solubility, could be converted to the much more soluble sodium sulfide.

Radium compounds are known to accumulate in sediment.<sup>15</sup> Eventually they are incorporated into small organisms and introduced into the food chain of aquatic life, becoming increasingly concentrated in large fish and birds of prey. Once the Delaware Estuary and Bay become contaminated with radionuclides, there appears to be little chance that it could be cleaned up.

Radionuclides deposited in ordinary landfills, which are often located near rivers, could also be physically washed into the water by rising sea levels, storm surges and the heavy

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<sup>13</sup> A. W. Nelson, et al. "Understanding the radioactive ingrowth and decay of naturally occurring radioactive materials in the environment: an analysis of produced fluids from the Marcellus Shale." *Environ. Health Perspect* v. 123 pp. 689-696 (2015)

<sup>14</sup> A. Litvak, "Pennsylvania Department of Environmental Protection Changes Rules oil and gas sludge at landfills," *Pittsburgh Post-Gazette*, Jan. 28, 2015 <http://www.post-gazette.com/powersource/policy-powersource/2015/01/28/DEP-changes-rules-for-oil-and-gas-sludge-at-landfills/stories/201501280051>

<sup>15</sup> A. Vengosh et al, "Sources of Radium Accumulation in Stream Sediments Near Disposal Sites in Pennsylvania: Implications for Disposal of Conventional Oil and Gas Wastewater," *Environmental Science and Technology*, DATE Jan, 4, 2018, DOI: 10.1021/acs.est.7b04952

rains and winds from hurricanes can wash toxic materials into the Delaware or its tributaries.<sup>16</sup>

As more evidence is collected, the danger of inadequate disposal techniques for radioactive wastes is becoming increasingly obvious. Laws concerning waste handling have not caught up with the science. Some experts in hazardous waste have suggested that only a cradle-to-grave tracking of disposed material will prevent future liability for agencies regulating disposal<sup>17</sup>.

## CONCLUSIONS

The proposed DRBC regulations fail to ensure that no significant damage will be done to either the quantity or quality of the water in the Delaware River. For Delaware, the negative effects of importing waste will not differ significantly from those that would occur if fracking were allowed in the DRB in Pennsylvania.

The issue of determining when, where and if water can be withdrawn from the Delaware is a complicated one. It seems that there is far too little data available to form a science-based decision. For that reason, the Delaware Chapter of the Sierra Club believes that there should be no current option for withdrawals.

The regulations on contaminants in treated wastewater offer some level of protection. This could be improved by adding naphthalene to the list of contaminants that must be reduced to very low levels. Allowance of Total Dissolved Solids of 1000mg/l in the river starting at the Delaware border should not be allowed because of the possibility that the high levels of salt in such water could kill the spawn of the endangered Delaware River species of Atlantic sturgeon.

A second difficulty concerning treated wastewater is that we have seen no indication that there are any existing plants that could actually reduce contaminants to the levels described. Treatment to drinking water standards is unlikely to be economically feasible for the large volumes involved here, but we fear that some plants might try to convince regulators that they are capable of doing it

The most serious problem with the proposed regulations is that they do not take into account the dangers of the materials in the solid residues from cleaning the water. In

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<sup>16</sup> F. Bajak and L. Olsen, "Hurricane Harvey's toxic impact deeper than public told." Assoc. Press, March 23, 2018 <https://www.apnews.com/e0ceae76d5894734b0041210a902218d/Hurricane-Harvey's-toxic-impact-deeper-than-public-told>

<sup>17</sup> "TENORM Waste: A guide to Regulatory & Disposal Concerns" a monograph published on <https://www.hazardouswasteexperts.com/tenorm/> by Hazardous Waste Experts, a national provider of hazardous waste disposal services. <https://www.hazardouswasteexperts.com/tenorm/>

particular, they do not take into account the high level of radionuclides in the waste and the fact that radioactive materials could be leached out or washed out of ordinary landfills. The only acceptable disposal sites for them would be ones specifically designed for hazardous wastes.

Because enforcing regulations on both water and solids disposal will be difficult without adequate personnel, and neither the states nor DRBC have budgets that could cover such personnel, we oppose all importation of fracking waste for treatment and disposal. A permanent ban on all fracking-related activities is the only way to protect the environment and the economic value of the Delaware River Basin.

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