TO: The Delaware River Basin Commission (DRBC)

RE: Comments on proposed fracking ban and treatment of fracked waste water

DATE: 26 February 2018

I am **Ned D. Heindel**. My wife and I are residents and property owners in Williams Township, Northampton County, whose real estate includes a heavily forested mountain side and a three -acre swamp from which flow headwaters of Fry’s Run, a Delaware River tributary and high-quality, cold-water trout stream. I am also the Howard S. Bunn Chair Professor of Chemistry at Lehigh University (although this submission is of my personal creation) where I have taught chemistry, pharmaceutical science, pharmacology, and toxicology for five decades. I have >300 publications, patents, and meeting presentations on the synthesis and pharmacological activity of chemicals.

In this hearing I wish to inject a few simple chemical principles and to submit for the record several recent publications by researchers who have investigated the impact of fracking on human health.

The 16th century iatrochemist, Theophrastus von Hohenheim (Paracelsus), espoused an important principle of toxicology when he stated: *Only the dose separates a poison from a medicament.*  By that he meant that virtually all xenobiotics have the potential to harm human life at the right exposure level. The dual challenges in dealing with fracking chemicals – including both those forced down the well-head and those retrieved in the extractant – are what exposure (dose) is to be anticipated and what are the specific materials to which the individual will be exposed. Dose/exposure depends on proximity, life style, and idiosyncratic metabolism.

Point 1: A very wide range of substances, many of which are proprietary – are involved, making the generation of a precise list impossible. The FracFocus Chemical Disclosure Registry (2018) lists 42 major fracking chemicals, T. Colborn (2011) identified 352, E. Elliott (2016) probed 1,000 fracking chemicals, and an EPA Study (2016) pinpointed 1,606, only 11% of which had any measured toxicity values in the literature. Elliott was able to find some published toxicity for 24% of the chemicals on his list, and 65% of the ones he found possessed human health risks. The Elliott and the Colborn studies are reviewed on page 4 in the P. J. Saunders “Review of Public Health Impacts of Unconventional Natural Gas Development” (copy attached). Colborn found that of his 352 chemicals, 25% were potential mutagens/carcinogens; >75% were linked to adverse skin, eyes, respiratory, and GI irritation; 37% had impact on the endocrine system; and 40-50% on nervous, immune, cardiovascular, and renal system.

Conclusion: Neither dose nor specific toxin can be precisely articulated, but the very wide range of structures, cautionary analyses based on those strtuctures, the unevaluated toxicities of most fracking chemicals, and their continuous use across time, make a very real adverse effect on human health highly probable.

# Point 2: The immediate direct exposure of humans to hazardous fracking chemicals (even if it occurs across time from the same water source) is not the sole concern. Biomagnification is an equally serious threat. Any environmental discharge often finds the effects of those chemicals enhanced by a biomagnification caused by persistence of the molecules in stream sediments with subsequent bioaccumulation and biological concentration through micro-organisms and thence in fish. Bioaccumulation has been well documented with mercury through organification to methyl mercury and inclusion in the aquatic food chain to an ultimate demonstrated health hazard to those who eat the fish. (see K. Rice, Environmental Mercury and its Toxic Effects, in [*J Prev Med Public Health*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3988285/). 2014, 47(2): 74–83). Not only is mercury a fracking extractant (see S. L. Brantley in [*Ground Water.*](https://www.ncbi.nlm.nih.gov/pubmed/25713828) 2015, 53(1):21-3), but one recent study suggests fracking has the potential to alter aquatic biodiversity and methyl mercury concentrations at the base of food webs proximal to fracking sites. (See C. J. Grant et al, Fracked ecology: Response of aquatic trophic structure and mercury biomagnification dynamics in the Marcellus Shale Formation. In [*Ecotoxicology.*](https://www.ncbi.nlm.nih.gov/pubmed/27743207) 2016, 25(10):1739-1750.)

It’s not just mercury and heavy metal inorganics that represent a biomagnification problem. Organic compounds are also capable of undergoing bioaccumulation as reported in a study of 842 organics in 219 aquatic species (see J. A. Arnot in *Environmental Reviews*, 2006, Vol. 14, No. 4. pp. 257-297). Furthermore, one can demonstrate the effects of this bioaccumulation of organics in fish by measurement of their Phase 1 metabolizing enzymes. These proved to be sensitive biomarkers for organic accumulation. (See Van der Oost in [*Environmental Toxicology and Pharmacology*](https://www.sciencedirect.com/science/journal/13826689),13 (2) 2003, pages 57-149).

Conclusion: Direct contact with fracking chemicals represents a serious exposure threat, but the indirect contact through ingesting a bioaccumulated food source represents an equally significant health threat.

Point 3: It is not possible to presume that all humans exposed to fracking chemicals will respond in the same way. Toxic levels cannot be viewed as average values. There are always individuals in any given cohort who at some stage present with a serious clinical response significantly differentiated from the average. Recall the life-threatening effects experienced by extremely low levels of peanut dust for a small subset of the human race. The phenomenon is not well understood, and several mechanisms have been suggested. One possibility is that these individuals bioconcentrate chemicals to which they have low exposure – perhaps even at an acceptable level -- up to a toxic level. Total body fat and suppressed metabolic clearance pathways can cause individuals to serve as bioconcentrators. PCBs, polycyclic aromatic hydrocarbons, alloxan, strontium, lead, mercury, and plasticizers (e.g., di-octylphthalate) are known to be bioconcentrated in a human host. Differences in polymorphic alleles in the human genome (a.k.a., pharmacogenomics) have been identified as affecting numerous differential chemical responses, for example, to rates and molecular consequences of pyrimidine, diterpene, and vitamin-A  metabolism. The range of chemicals studied has not been wide, and surely some fracking chemicals will also show this effect. (See J.L. Yen-Revollo, Race does not explain genetic heterogeneity in pharmacogenomic pathways, *Pharmacogenomics*, 2008, 9 (11): pp. 1639-1645.)

Conclusion: Unless fracking is ceased and no additional fracking chemicals are released into the environment, tragic toxicological responses can surely be anticipated in some exposed individuals.

Point 4: We can lay out a logical case for avoiding exposure to fracking chemicals using biomechanisms, toxicological principles, and molecular arguments, but there is increasing firm evidence of clinical pathologies associated with such unconventional natural gas development. In closing I attach four studies which link fracking and adverse clinical outcomes.

These research studies speak for themselves and reinforce the arguments above and our request to ban processing of fracking fluids and fracking itself in the Delaware River Basin.

Submitted,

Ned D. Heindel

“A Review of the Public Health Impacts of Unconventional Natural Gas Development,” in *Environ Geochem Health*, 2018, 40: pp 1-57.

“Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development,” in *Environmental Sci and Technology*, 2014, 48: 8307-8320.

“Unconventional Gas and Oil Drilling is Associated with Increased Hospital Utilization Rates” in *PLoS One*, 2015, 10 (7)” e0131093 [an abstract]

“Association Between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations,” in *JAMA Internal Med*., 2016, 176 (9): pp. 1334-43. [an abstract]

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