# Responses to Frequently Asked Questions and Comments About the Shale-Gas Paper by Osborn *et al.*

by

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The many responses to our paper "*Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing"* published last month in the Proceedings of the National Academy of Sciences, U.S.A.[1], have made it difficult for us to reply to queries individually. This short document has three purposes:

1) To respond to questions and suggestions about our sampling design,
2) To address misconceptions about our work, and
3) To propose a new joint experiment with industry to answer the question, "Does shale-gas drilling affect the quality of well water?"

## Frequently Asked Questions and Comments About our Experimental Design

**Comment 1) The experiment lacked baseline sampling:**

True. A paired pre- and post-sampling design would have been the ideal way to test if and how well-water quality changes through time after horizontal drilling and hydraulic fracturing. Because we were unable to travel back in time and sample every home pre-drilling, our initial experiment used the next-best approach to evaluate systematic variations in methane concentrations and isotopic fingerprints. Here is an analogy to describe why.

What were the earliest tests examining a possible link between smoking and lung cancer? Scientists didn't follow people for years through their lives, sampling the people before they started smoking and then tracking their health for decades afterwards. That would have been the ideal experiment to prove cause and effect. Instead, scientists asked a simpler question first: "If you smoke, are you more likely to get lung cancer?" That the answer was "yes" didn't prove cause and effect. It did suggest that something important was occurring and that follow-up research was needed to identify the mechanism of any link between smoking and cancer.

Based on our data for concentrations of methane and ethane and for isotopic signatures of methane and water, our experiment suggests that there are significant differences in water located near shale-gas wells compared to water farther from gas wells in the region where we worked. This was to our knowledge the first peer-reviewed study to suggest that deep, thermogenic methane is migrating into drinking water near shale-gas wells. Now that we have a baseline of pre-drilling sampling in some areas, we will be taking samples after drilling and hydraulic fracturing has occurred to extend our results. We have also proposed a joint experiment to address the issue more completely, as described below.

**Comment 2) The sample was not random**

Random sampling of homeowners is always difficult when you have to obtain homeowner permission to sample their well water. We worked through homeowner associations in the area to obtain as random a sample as possible. More than half of the homes were in locations with no gas wells within 1 km, providing a baseline for future measurements. Some of these homeowners have already had, or are soon to have, drilling near their homes.

[1] Osborn, SG, A Vengosh, NR Warner, RB Jackson 2011 Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. Proceedings of the National Academy of Sciences, U.S.A.; DOI: 10.1073/pnas.1100682108.

**Comment 3) The conclusions apply only to Dimock, PA:**

High methane concentrations had been documented by the Pennsylvania Department of Environmental Protection (DEP) along Carter Road in Dimock, PA and attributed to faulty gas well casings (PA DEP press release; April 15th, 2010). We sampled some homes in Dimock to obtain geochemical data associated with this problem. Beyond Dimock, we were unaware of any documented gas analyses for the remaining water wells in the study.

The suggestion that our conclusions were driven by the data for Dimock is incorrect. Average methane concentrations for our dataset were *higher* when the values from Dimock were excluded: ~22 mg $CH_4$/L without Dimock compared with ~17 mg $CH_4$/L for Dimock alone, in water less than 1 km from a gas well. The highest methane concentration we observed, 64.4 mg $CH_4$/L, was found outside of Susquehanna County where Dimock is located.

The fact that we found similar patterns outside of Dimock raises the question of how general the leakage is from shale gas wells and highlights the need for more research. New developments in PA should decrease the likelihood of future problems, including the updated drilling recommendations that PA implemented in February of 2011 (after our sampling for the PNAS paper took place) and the new DEP proposal last week to seek legislative approval to strengthen PA's Oil and Gas Act. Their proposed change in the distance of presumptive liability from 1,000 feet to 2,500 feet closely matches our recommendation, based on the distance that we observed for methane contamination in Osborn *et al*. We welcome the chance to work with the DEP and industry to test new sites in which these regulations are implemented.

**Comment 4) Some observed methane solubilities were above saturation values:**

At atmospheric pressure, methane saturates in water at solubilities of ~26 and 42 mg $CH_4$/L at 20ºC and 10ºC, respectively. The highest value we observed was 64 mg $CH_4$/L, super-saturated for methane at atmospheric pressure. Such values are observed, however, because water underground and under pressure can hold more gas in solution than water at the surface can at atmospheric pressure. When the ground water is pumped to the surface in a water well, methane can be super-saturated when the water comes out of the well. This phenomenon can be observed with the appearance of bubbles in well water.

**Comment 5) We did not measure all of the chemicals found in fracking fluids.**

True. The conclusion that we found "no evidence for contamination of drinking-water samples with deep saline brines or fracturing fluids" was based on our comparisons of alkalinity, salinity, radioactivity (from deep formation waters or "produced waters"), water isotopes, and specific elemental analyses, including Cl, Na, Ca, and B. Our comparison was made with ground water currently and also with background chemical data collected from ground water in the area in the 1980s. We did not test comprehensively for organics or other additives in hydraulic fracturing fluids.

## Misconceptions About our Work

**Comment 6) We hired a public relations firm to publicize our work.**

No. Period.

**Comment 7) We refused to cooperate with the PA Department of Environmental Protection (DEP)**

Secretary Michael Krancer reportedly stated in a public meeting that we refused to cooperate with the DEP. That statement is incorrect, and we have sought clarification from the Secretary for this and other statements.

Duke University welcomes a research partnership with DEP. In what limited discussions we have had with DEP personnel so far, they requested our original data, and we pledged to release the data publicly after obtaining homeowner permission. In return, we asked the DEP to share their extensive baseline data with us in a mutual partnership or to make their data available publicly. We hope that they will make a similar pledge.

## Proposed Joint Experiment with Industry

More sampling is needed in the Marcellus and in other regions of the United States. With the goals of having more pre- and post-drilling data and obtaining as close to a random sample as possible, we propose to work with industry, the DEP, and homeowners to perform such an experiment. Here is one possible design.

Industry has hundreds, even thousands, of archived pre-drilling estimates of water quality from individual homeowners in Pennsylvania alone. Working together, we would randomly select 100-200 homeowner wells from the pre-drilling database in Pennsylvania. After obtaining homeowner permission, we would resample those homes that have had gas wells drilled in their area. The goal would be to see the extent to which water quality changed after horizontal drilling and hydraulic fracturing. An independent entity, Isotech Laboratories Inc., could conduct the methane measurements, without knowledge of any pre-drilling data or identifiers for specific wells. If desirable, independent laboratories could also perform the other measurements, including tracers of hydraulic fracturing fluids.

At the end of the experiment, we would have at least 100-200 pre- and post-drilling comparisons for individual homes, enough to obtain a clearer picture of what is occurring in the Marcellus in Pennsylvania. The experiment could be completed in a year, free of charge to homeowners. If needed, Duke University would even seek to raise the money to perform it. We look forward to collaborating with industry, the DEP, and homeowners in the endeavor.