

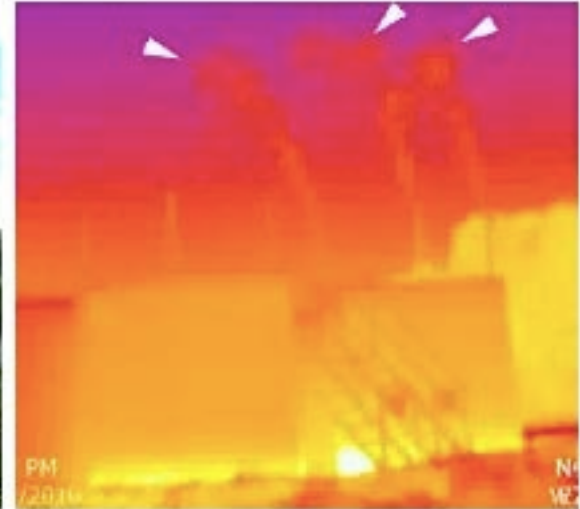
# Shale Gas and Water Quality



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Duke University, [jackson@duke.edu](mailto:jackson@duke.edu)  
EU – University of Pittsburgh, March 21<sup>st</sup>, 2014

# Public Concerns About Unconventional Energy

- Water for hydraulic fracturing, 3-5M gallons per well
- Drinking-water quality
- Disposal of produced waters (salinity – 10-times sea water, bromide, arsenic, barium, radioactivity, )
- Air quality interactions
- Earthquakes from hydraulic fracturing and disposal
- Community Impacts



# Some Air Quality Benefits in Switching Coal to Natural Gas for Electricity Generation (>90% less SO<sub>2</sub> and Mercury; less NO<sub>x</sub> and particulates)

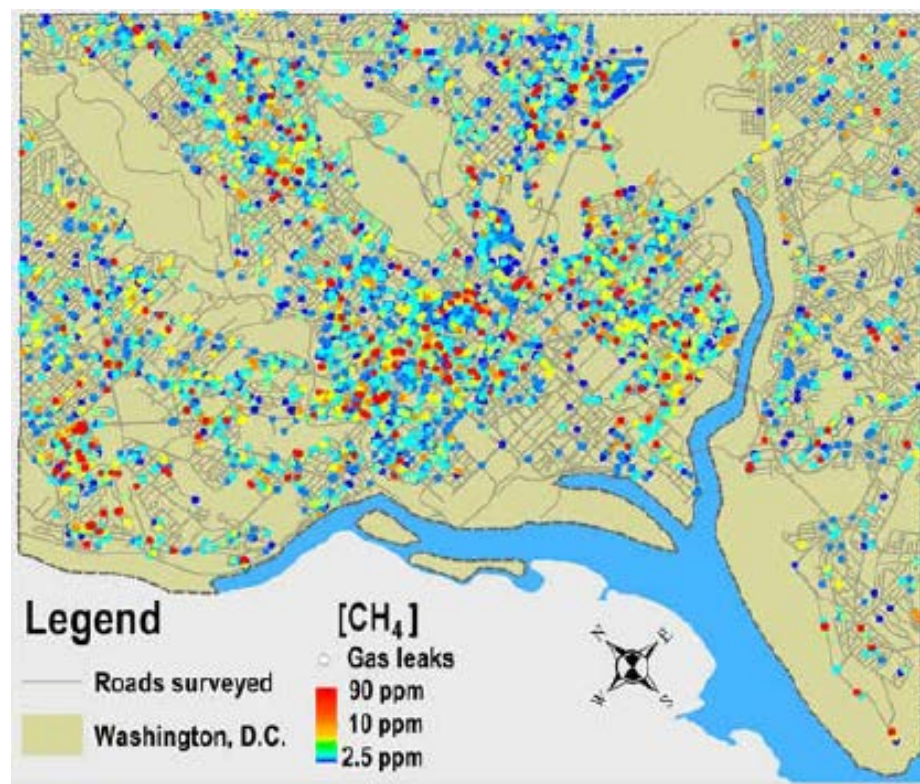
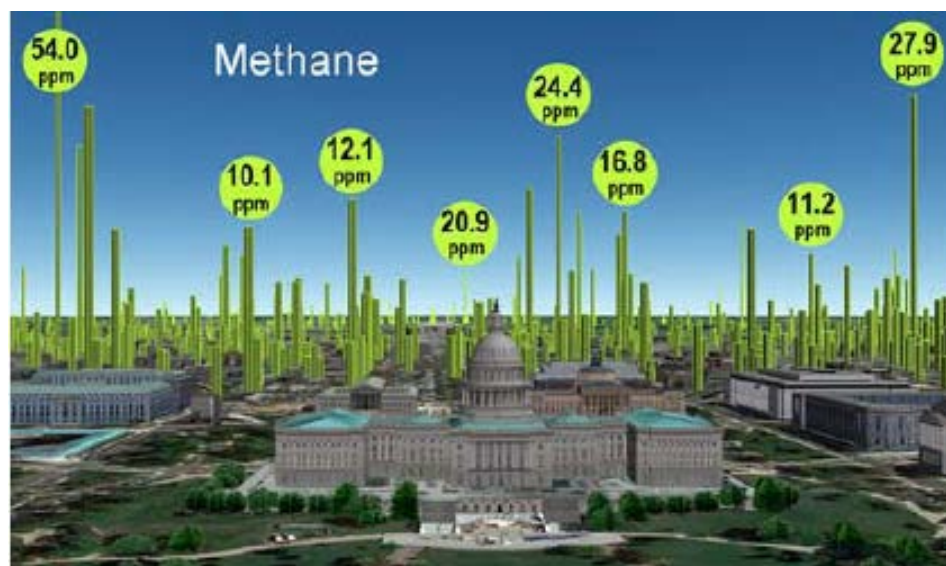




# Just Published in January: Map of ~6,000 Methane Leaks

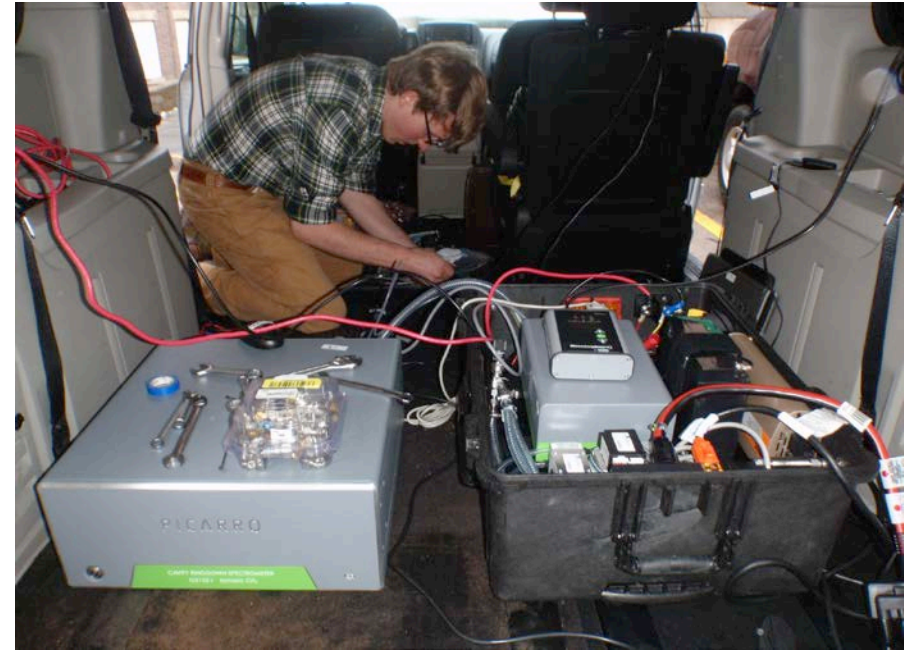
## Natural Gas Pipeline Leaks Across Washington, DC

Robert B. Jackson,<sup>†,‡,\*</sup> Adrian Down,<sup>†</sup> Nathan G. Phillips,<sup>§</sup> Robert C. Ackley,<sup>||</sup> Charles W. Cook,<sup>†</sup>  
Desiree L. Plata,<sup>⊥</sup> and Kaiguang Zhao<sup>†</sup>

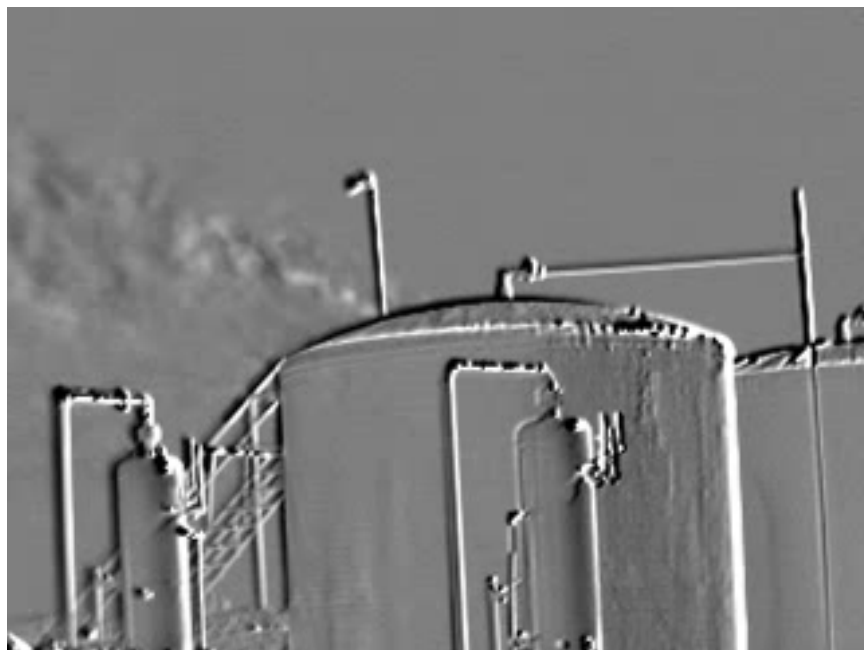




# Methane losses from pipelines and pads (w/ Boston Univ.)



# Wellpad Tank Leak (Pt 11)



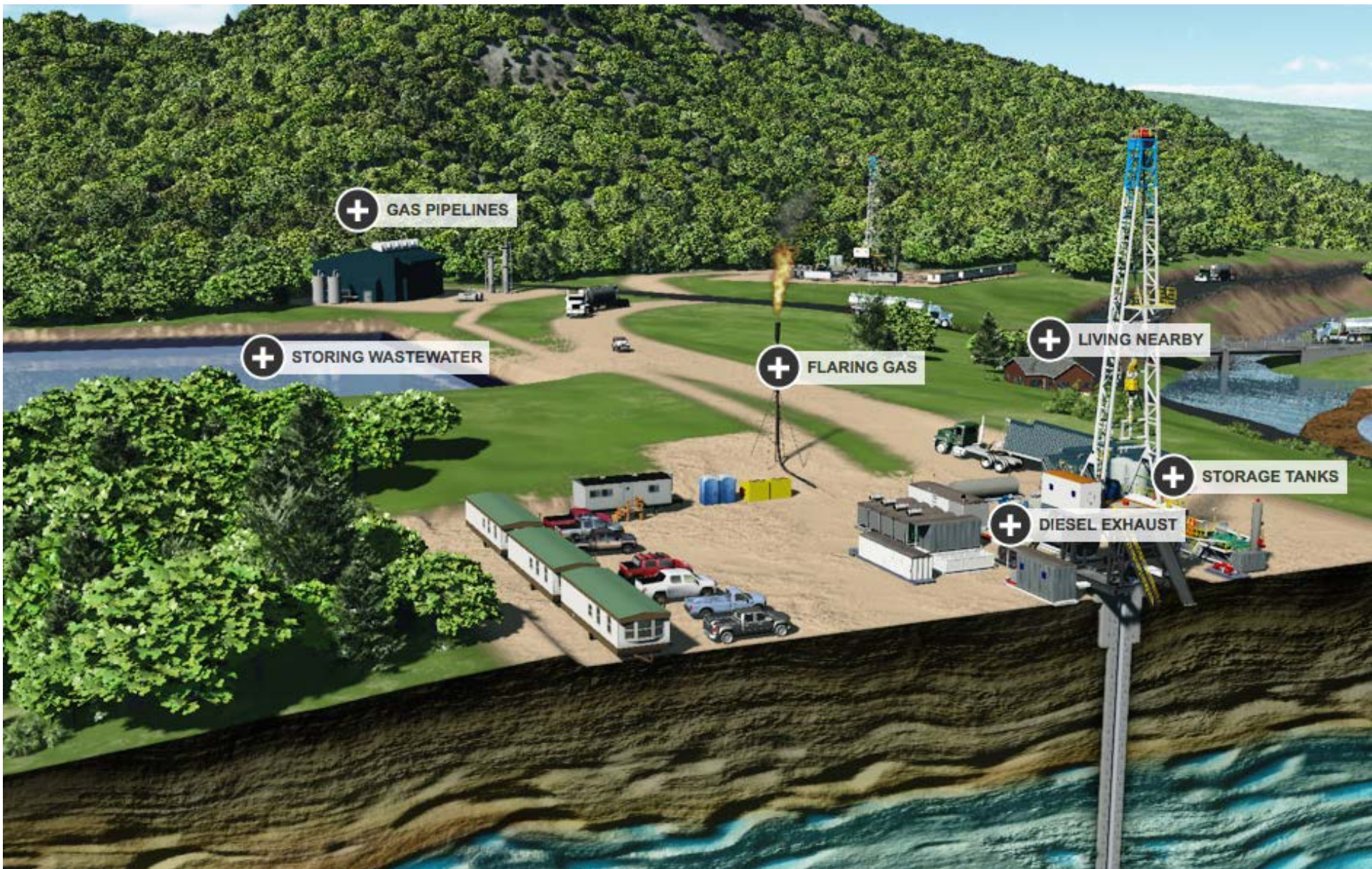
|                | Plume Scanner | Isotope Vehicle   |
|----------------|---------------|-------------------|
| Flux (L/min)   | 1311 L/min    |                   |
| d13C (per mil) |               | -<br>36.773±0.117 |

Oct. 20<sup>th</sup>, 2013; 15:21  
(32.424, -97.55)





# Possible Water Interactions





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## CHEMICALS USED IN HYDRAULIC FRACTURING

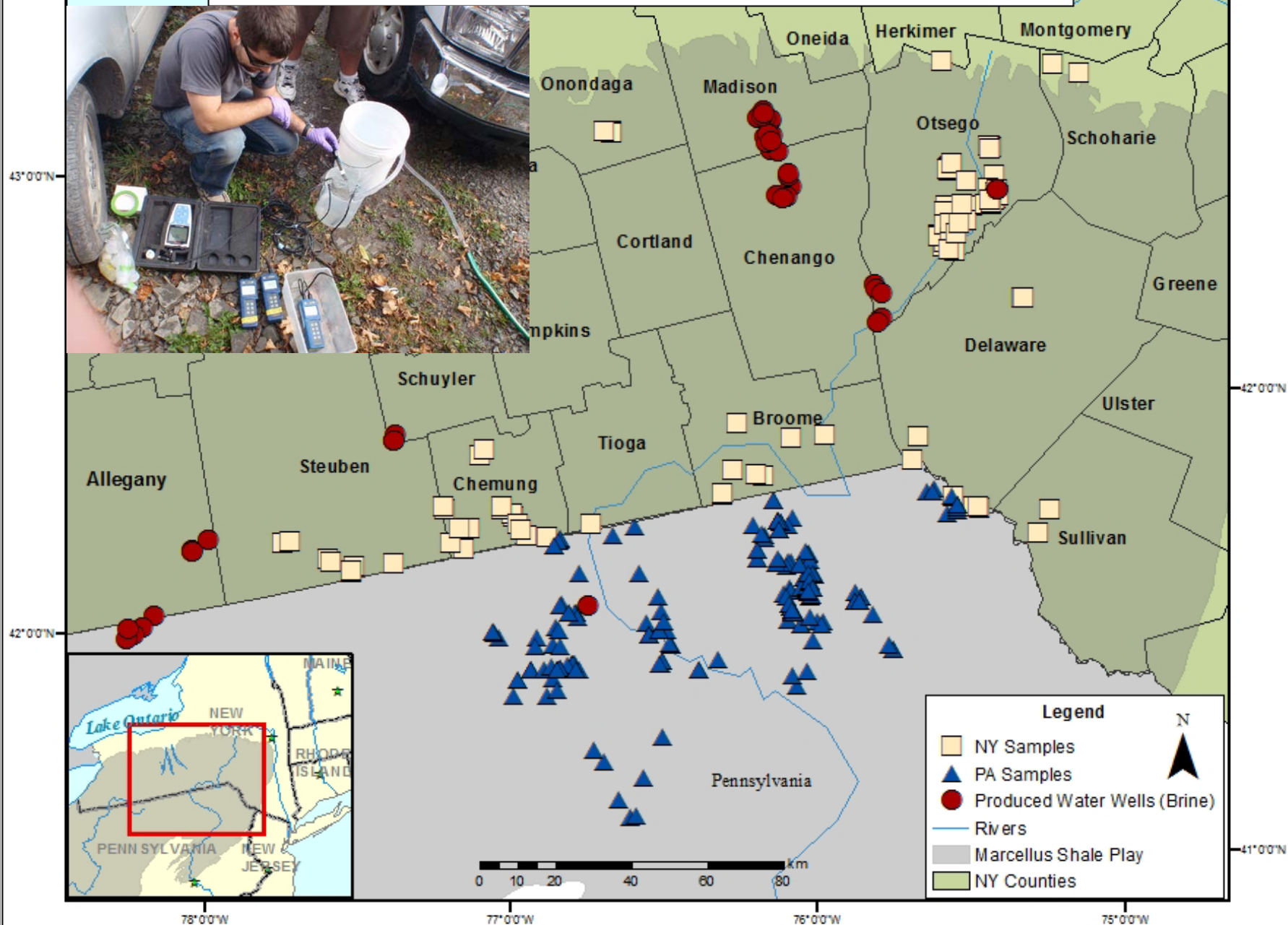
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- 780 million gallons of products used from 2005-2009 (not including water).
- 2,500 hydraulic fracturing products containing 750 chemicals and other components
- Some harmless (salt, citric acid, coffee, walnut shells)
- Some not: benzene, naphthalene, and diesel (carcinogens); toluene and hydrochloric acid (hazardous air pollutants); and many other chemicals, including 2-butoxyethanol, ethylene glycol, and lead.

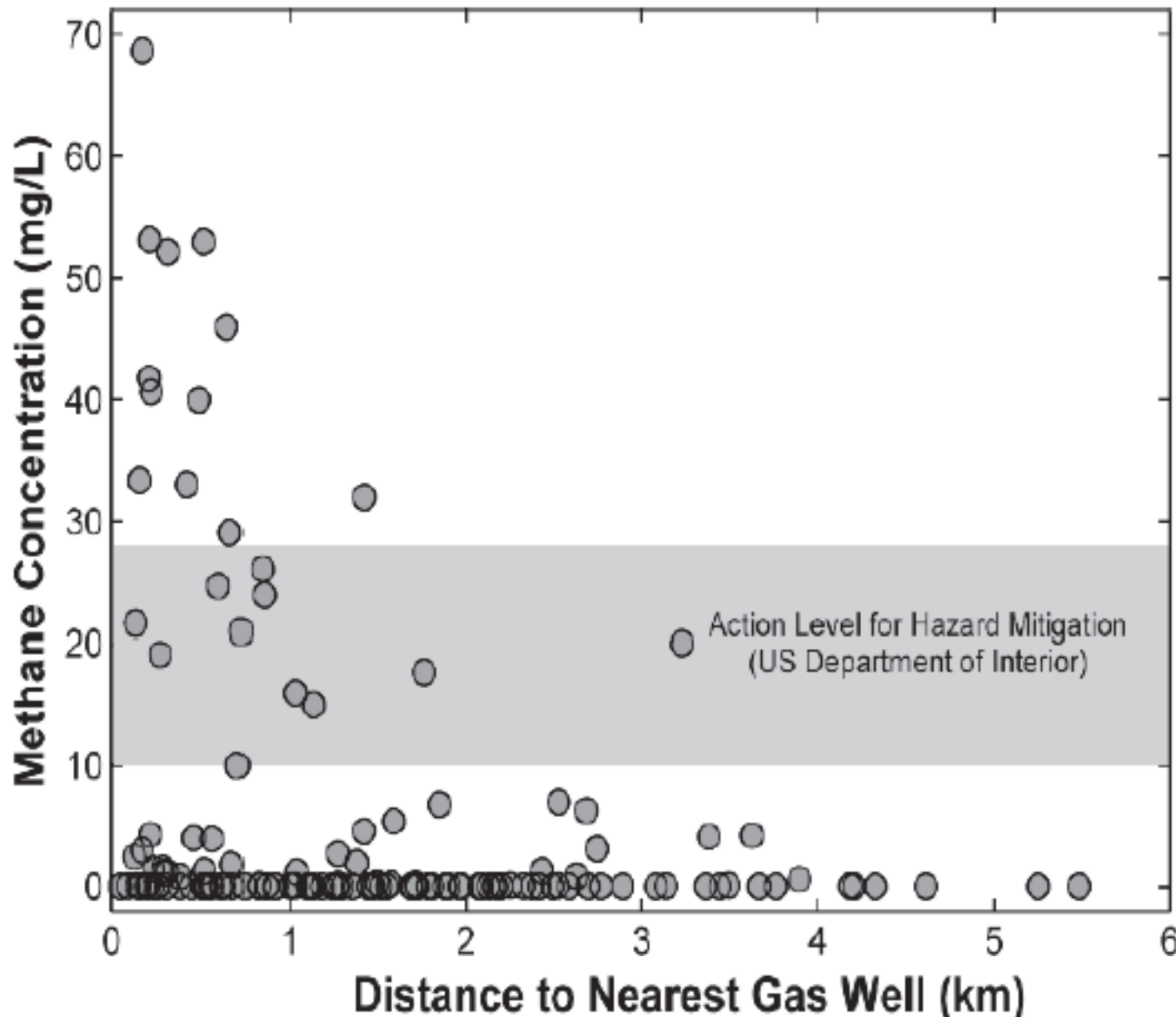
Colborn et al. (2011) documented the use of 632 chemicals.



## Water Sample Locations in the Marcellus Shale Region



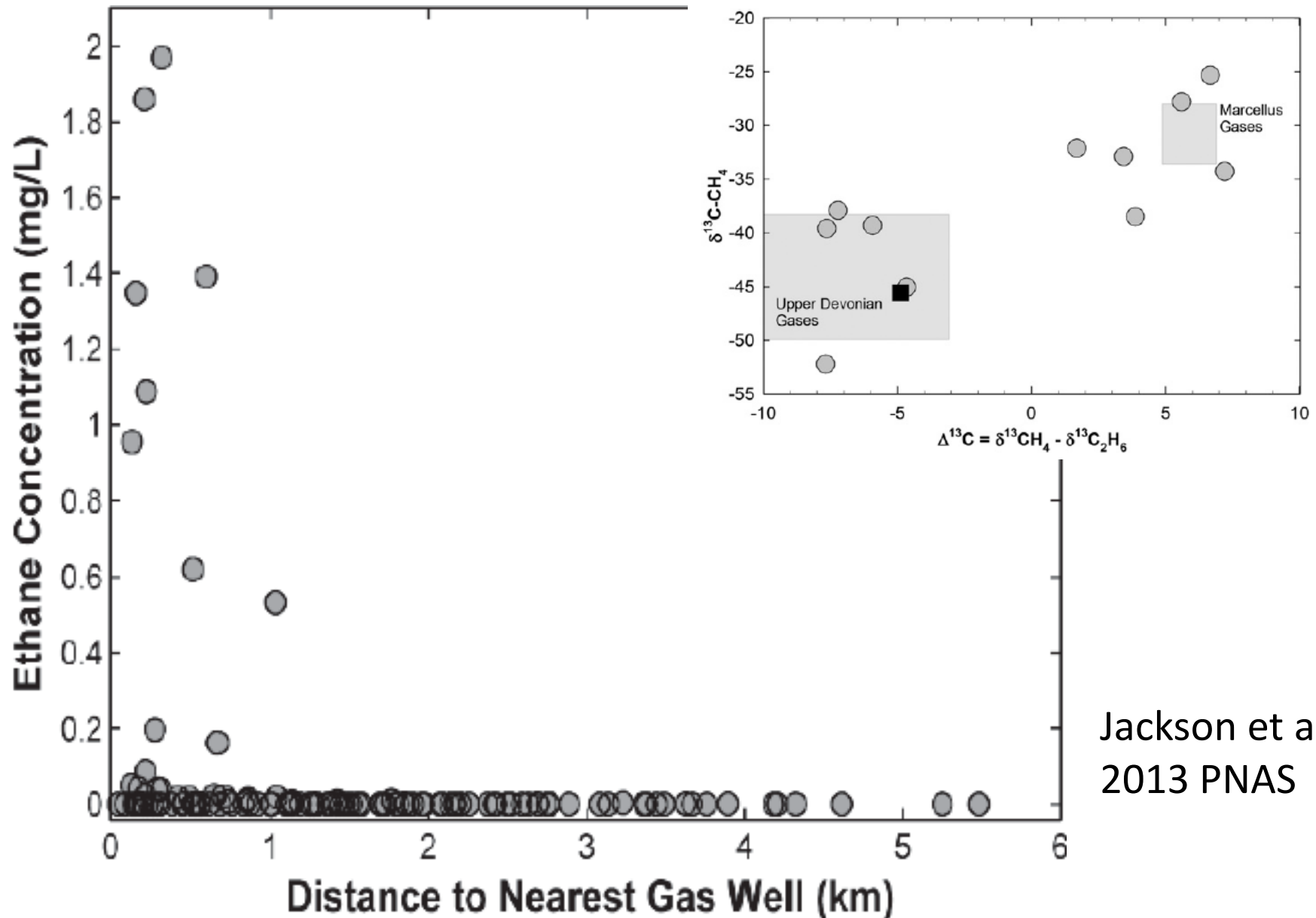
# No Evidence or Changes in Salts, Metals, or Radioactivity But Evidence for Gas Contamination in a Subset of Houses



Jackson et al.  
2013 PNAS



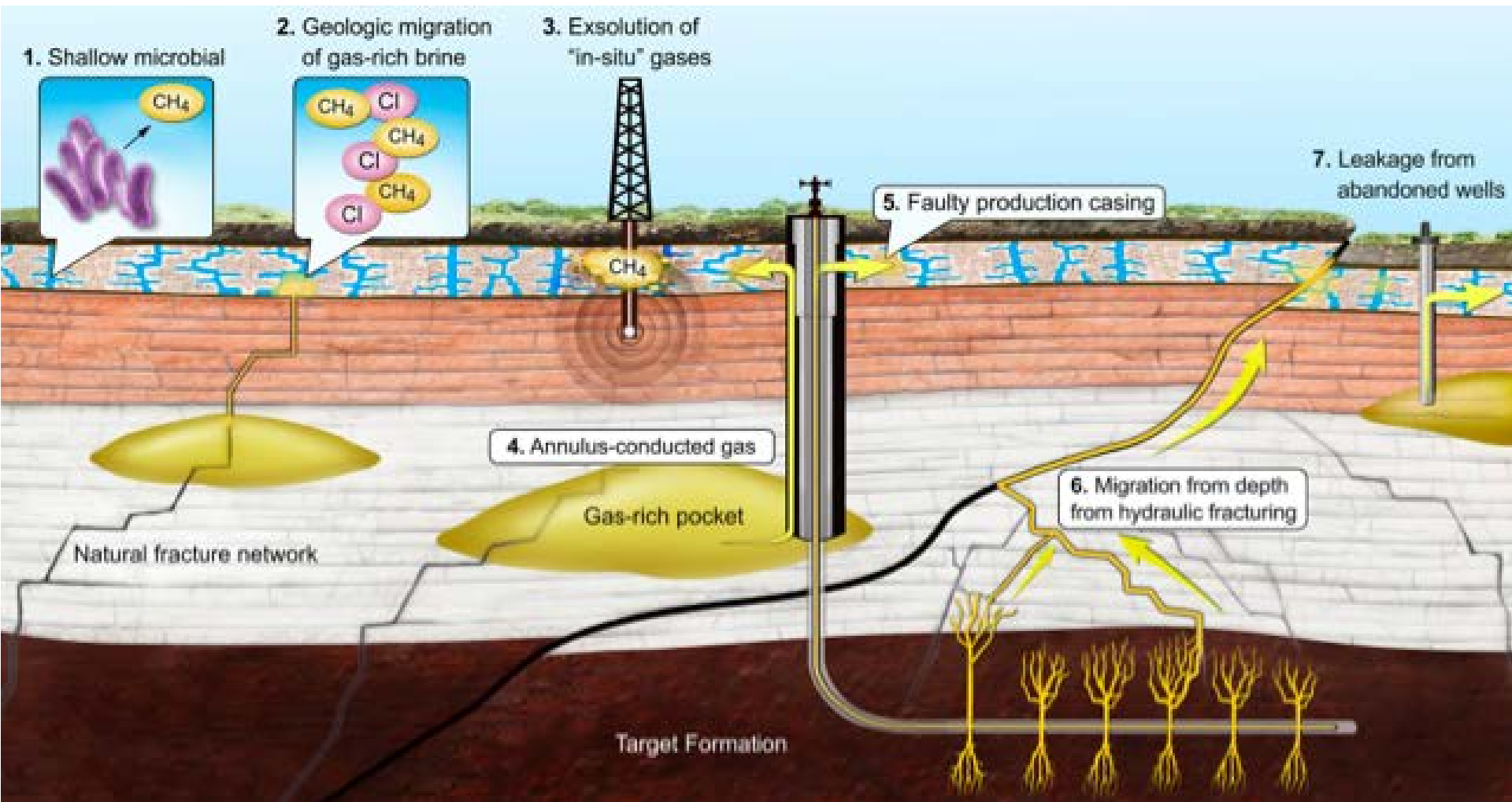
Higher ethane concentrations are even harder to explain, and hydrocarbon and noble gas isotopes identify sources.



Jackson et al.  
2013 PNAS

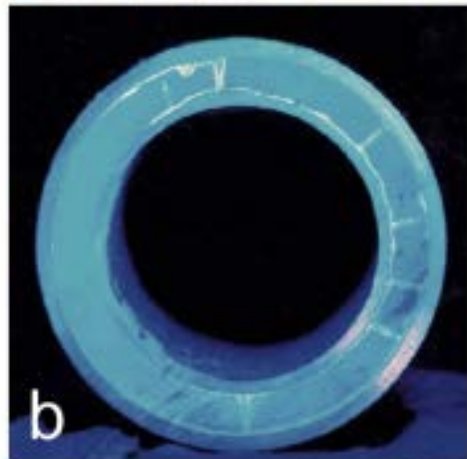
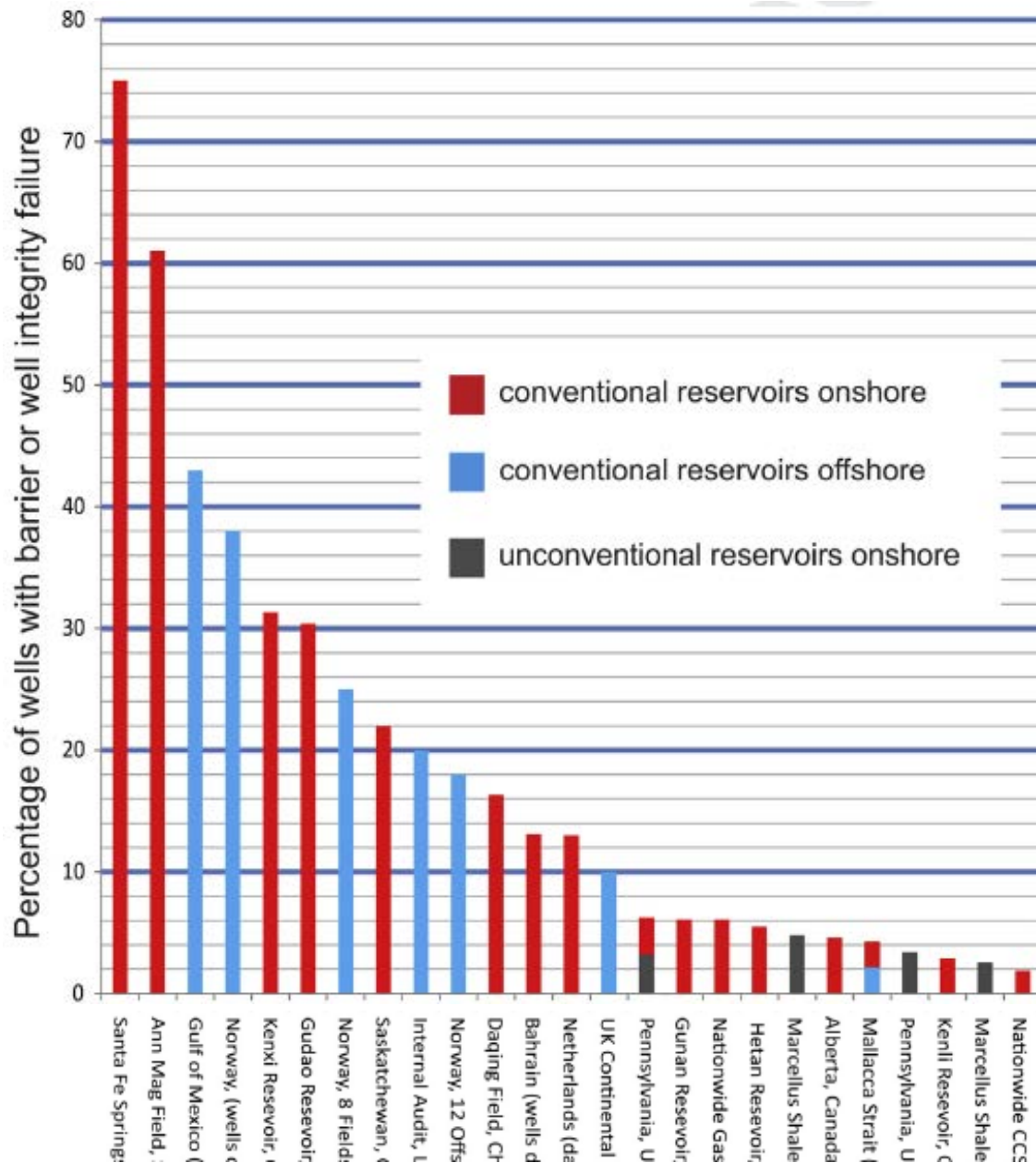
# What are the Likeliest Pathways of Contamination?

## Well Integrity is Key





# % Well Barrier & Integrity Failures (25 studies); Legacy Issues



Davies et al. 2014  
Mar. Petrol. Geol.

## Governor Corbett signs Marcellus Shale bill into law

February, 2012

Images




 Print Story

Published: 2/13 7:18 pm

 Share

Updated: 2/13 7:20 pm

 Recommend

 3 recommendations. [Sign Up](#) to see what your friends recommend.

 Tweet 6

Governor Tom Corbett Monday signed House Bill 1950, the Marcellus Shale bill, into law. The bill enhances protection of our natural resources through stronger environmental standards, authorizes counties to adopt an impact fee, and builds upon efforts to help move Pennsylvania toward energy independence.

Some of its changes (including recommendations from Jackson et al. 2011):

- 1) Restrict drilling within 1000 ft of a public water supply.
- 2) Double the distance from 250 feet to 500 feet to separate a gas well from a private water well,
- 3) Extend a well operator's presumptive liability for pollution or water loss from 1,000 feet to 2,500 feet.



New Report: No Evidence for Contamination in the Fayetteville

## **Shallow Groundwater Quality and Geochemistry in the Fayetteville Shale Gas-Production Area, North-Central Arkansas, 2011**



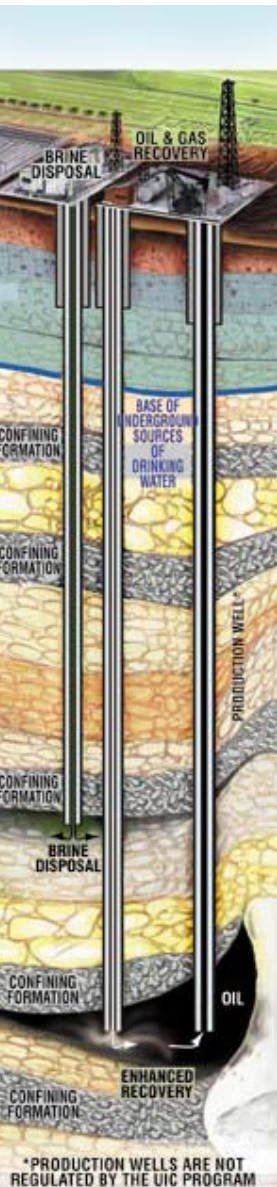
Scientific Investigations Report 2012–5273

By Timothy M. Kresse, Nathaniel R. Warner, Phillip D. Hays, Adrian Down,  
Avner Vengosh, Robert B. Jackson



# Management of produced water

- Deep inject for underground disposal (>95%)
- Spray on lands (some states permit this – bad idea)
- Haul to a municipal wastewater treatment plant (no)
- Haul to a commercial wastewater treatment facility
- Reuse for a future fracturing job w/ or w/o treatment.





Open Wastewater Pits are a Source of Spills and Air Emissions;  
77 surface spills (~0.5% of active wells) affecting ground water  
in one year for Weld County, CO (Gross et al. 2013).

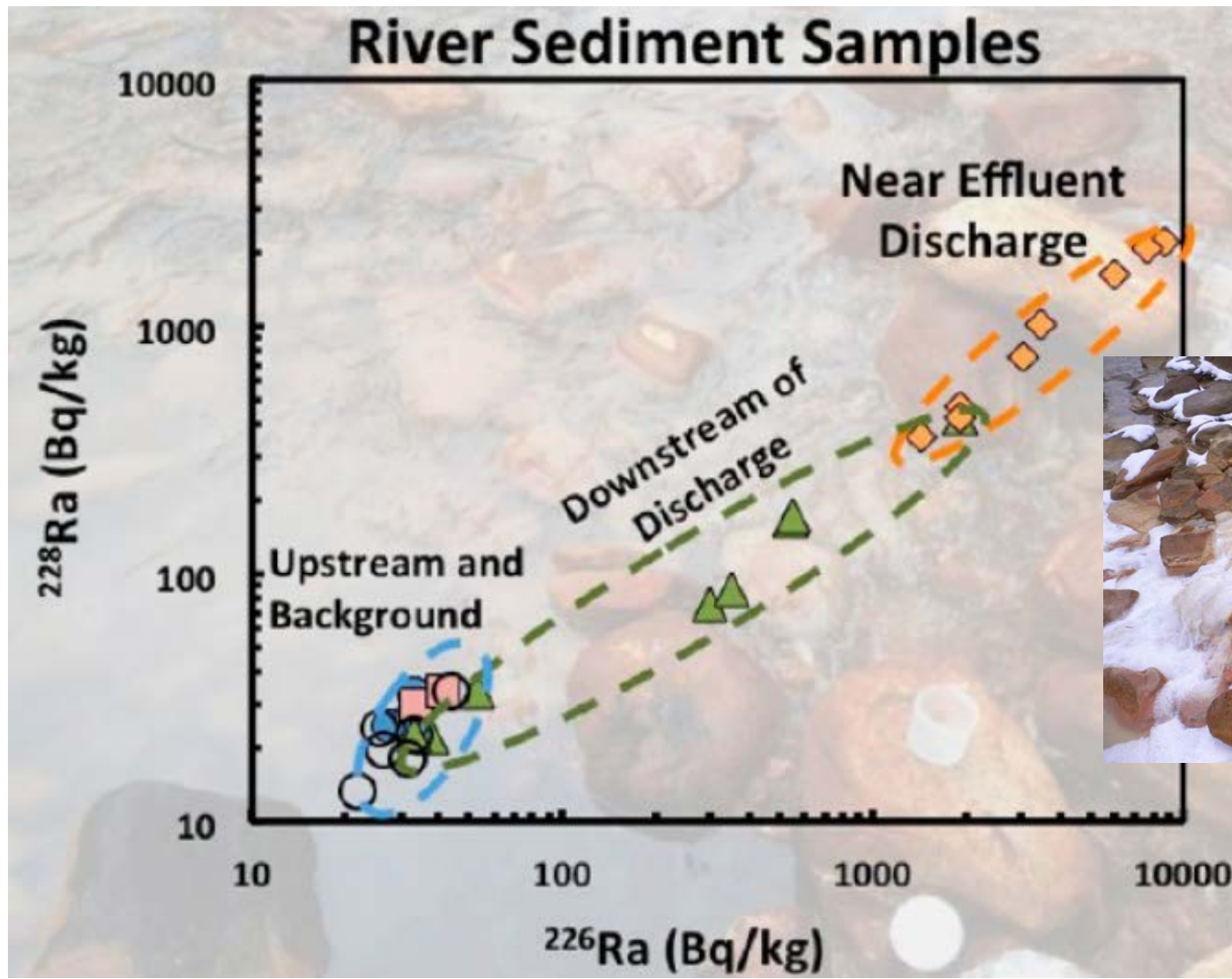




# Disposal of Produced Waters



# Streamwater and sediment effects: No radioactivity detected in drinking water, but a buildup occurred associated with wastewater effluent



Warner et al.  
2013 ES&T

# Positive Developments on the Water Front

- 1) Reuse of water for fracking (industry initiative);
- 2) Greater disclosure of the chemicals in fracking fluids (voluntary – [fracfocus.org](http://fracfocus.org); required - new state rules in WY, TX, and elsewhere). Transparency should lead to phase-outs of the most toxic chemicals;
- 3) Proposals to eliminate chemicals in fracturing fluids (e.g., Tamboran);
- 4) Green completions and elimination of open waste-water pits (e.g., enclosed tanks for handling waste).



New York – September 21<sup>st</sup>, 2012

**BloombergBusinessweek**  
**News From Bloomberg**



## **New York Delays Fracking Decision to Review Effect on Health**

- New York Governor Andrew Cuomo's administration is delaying a final decision on hydraulic fracturing to study its effects on human health.

# Where Will Our Energy Come From?

