



# Examining Cases of Environmental Contamination Potentially Attributed to Unconventional Oil and Gas Extraction

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# What is unconventional drilling?



## Hydraulic Fracturing

large amounts of water, sand and chemicals

## Shale Acidization

Hydrochloric and Hydrofluoric acids

## Underground Injection Wells

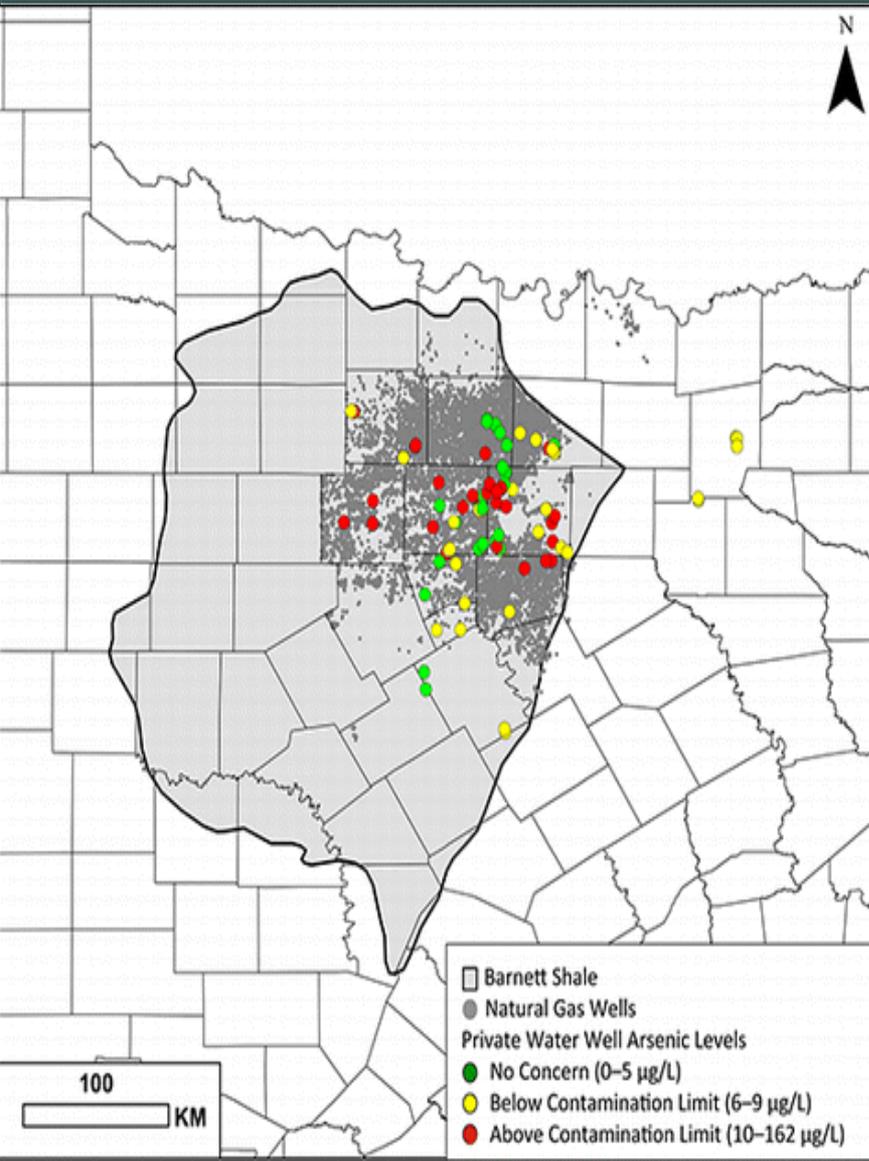
(Salt Water Disposal)

# Environmental Concerns



- Air
- Human Health
- Soil
- Groundwater
- Surface Water
- Industrial Fluids
- Chemical contamination
- Gases

# Elevated Levels of Arsenic



29 of the 91 samples collected with active extraction areas contained elevated levels of arsenic ( $>10 \mu\text{g/L}$ )

Drinking water with arsenic levels above  $10 \mu\text{g/L}$  has been shown to increase the risk for bladder cancer (Chu et al., *Int. J. Environ. Res. Public Health*, 2006)

Highest concentration that was detected was  $161 \mu\text{g/L}$

Arsenic was not found to be elevated in any of the control sites

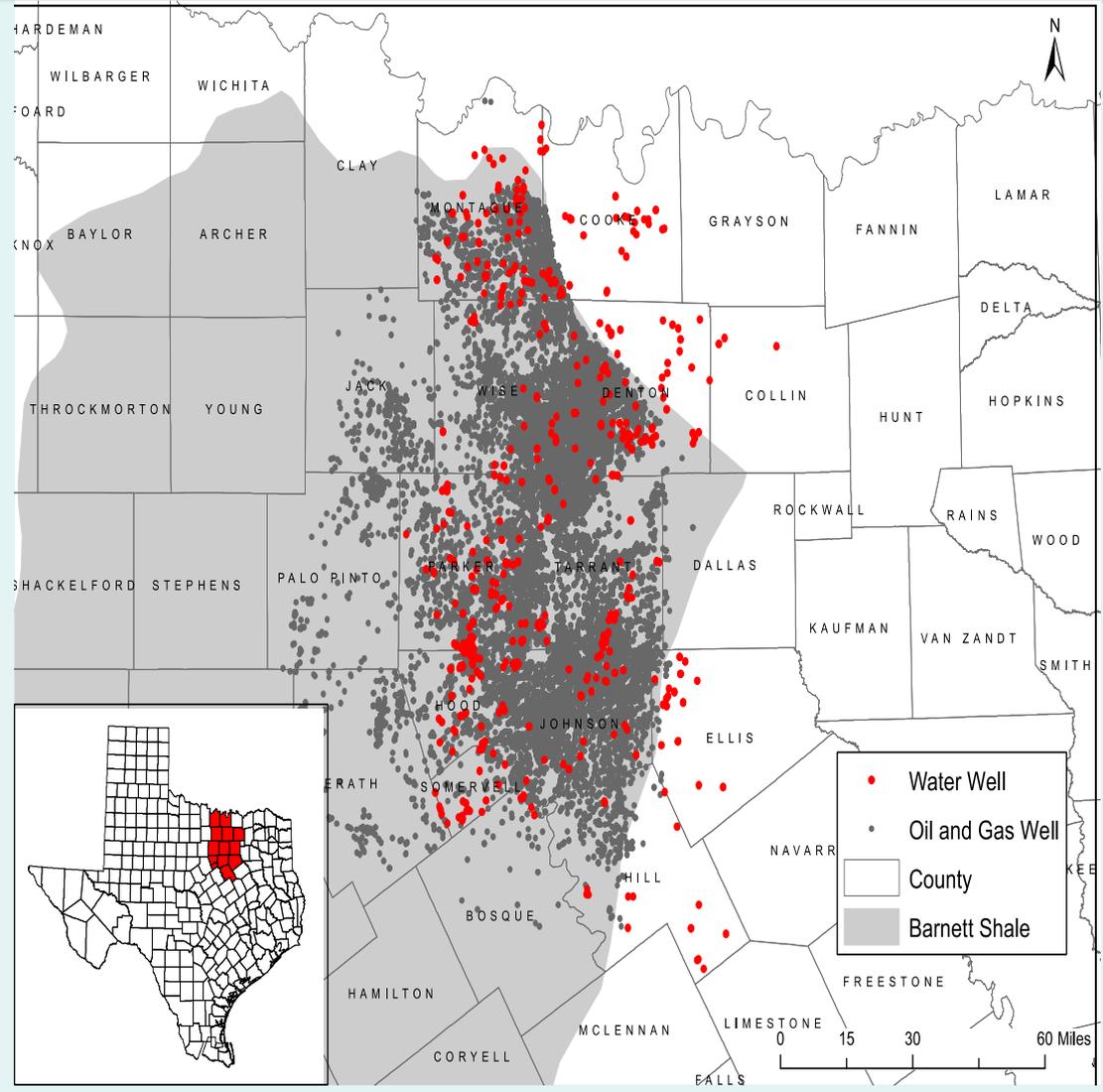
B.E. Fontenot, et al. *Environ. Sci. Tech.* **2013**, *47*, 10032-10040.

D.D. Carlton, Jr., et al. *Inter. J. Environ. Sci. Tech.* **2015**.

# 2014 Study

#Data points	550
Collin	4
Cooke	40
Dallas	1
Denton	82
Ellis	25
Hill	14
Hood	60
Johnson	43
Montague	66
Parker	108
Somervell	19
Tarrant	47
Wise	41

#Residential wells	350
#Municipal/Public Water supply wells	141
#Agricultural wells	59



# Detected Abnormalities

Methanol (35)

Ethanol (240)

n-propanol

Isopropanol (8)

n-Butanol

2-Ethylhexanol

2-Butoxy Ethanol

Propargyl Alcohol (155)

Benzene (34)

Toluene (240)

Phenol

Benzylchloride

Trichloroethylene (14)

Ethylbenzene (22)

0-, m-, & p-Xylenes (183)

1,2,4-Trimethyl Benzene

1,3,5-Trimethyl Benzene

Isopropyl Benzene

d-Limonene

Naphthalene

1-Methyl Naphthalene

2-Methyl Naphthalene

1-Naphthol

2-Naphthol

Ethylene Glycol

Polyethylene Glycol

Propylene Glycol

Dichloromethane (121)

PEG 200

Glycerol

Acetophenone

Dimethylformamide

Glutaraldehyde

Acetaldehyde (35)

Di(2-Ethylhexyl) Phthalate

Pthalic Anhydride

Bisphenol A

Chloroform (296)

Cyclohexane (221)

Detections above respective EPA Maximum Contaminant Limit (MCL)

Detections at levels below MCL—need to monitor as these can fluctuate with gas well stimulation

Detections, no MCL value established

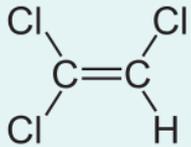
No Detections

# Contaminants of Extreme Concern



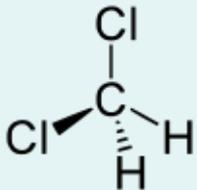
**Benzene** (34 detections above the 0.005 mg/L MCL, 91.2% within Barnett shale region)

Highly carcinogenic, induces acute lymphoblastic leukemia (ALL), chronic myeloid leukemia (CML) (Smith, Ann. Rev. Pub. Health, 2010) and a number of spinal and cranial birth defects (Lupo et al., Environ. Health Perspect., 2010)



**Trichloroethylene** (14 detections, no MCL, 100% within the Barnett shale region)

Exposure through drinking water has been found to increase the chances of developing non-Hodgkin's lymphoma (New Jersey Department of Health) and neurodegenerative diseases such as Parkinson's Disease (Kasarskis et al. Amy. Later. Scler., 2009).



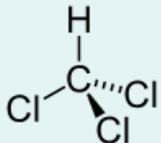
**Dichloromethane** (121 detections above the 0.005 mg/L MCL, 92.6% within Barnett shale region)

Inhalation hazard, acute exposure has resulted in optic neuropathy (Kobayashi et al., J. Ocul. Pharmacol. And Ther., 2008) and hepatitis (Cordes et al., West L. Med., 1988). Dichloromethane exposure has also been linked to lung, liver and pancreatic cancers in laboratory animals (US Department of Health and Human Services)



**Cyclohexane** (221 detections, no MCL, 74/7% within the Barnett shale region)

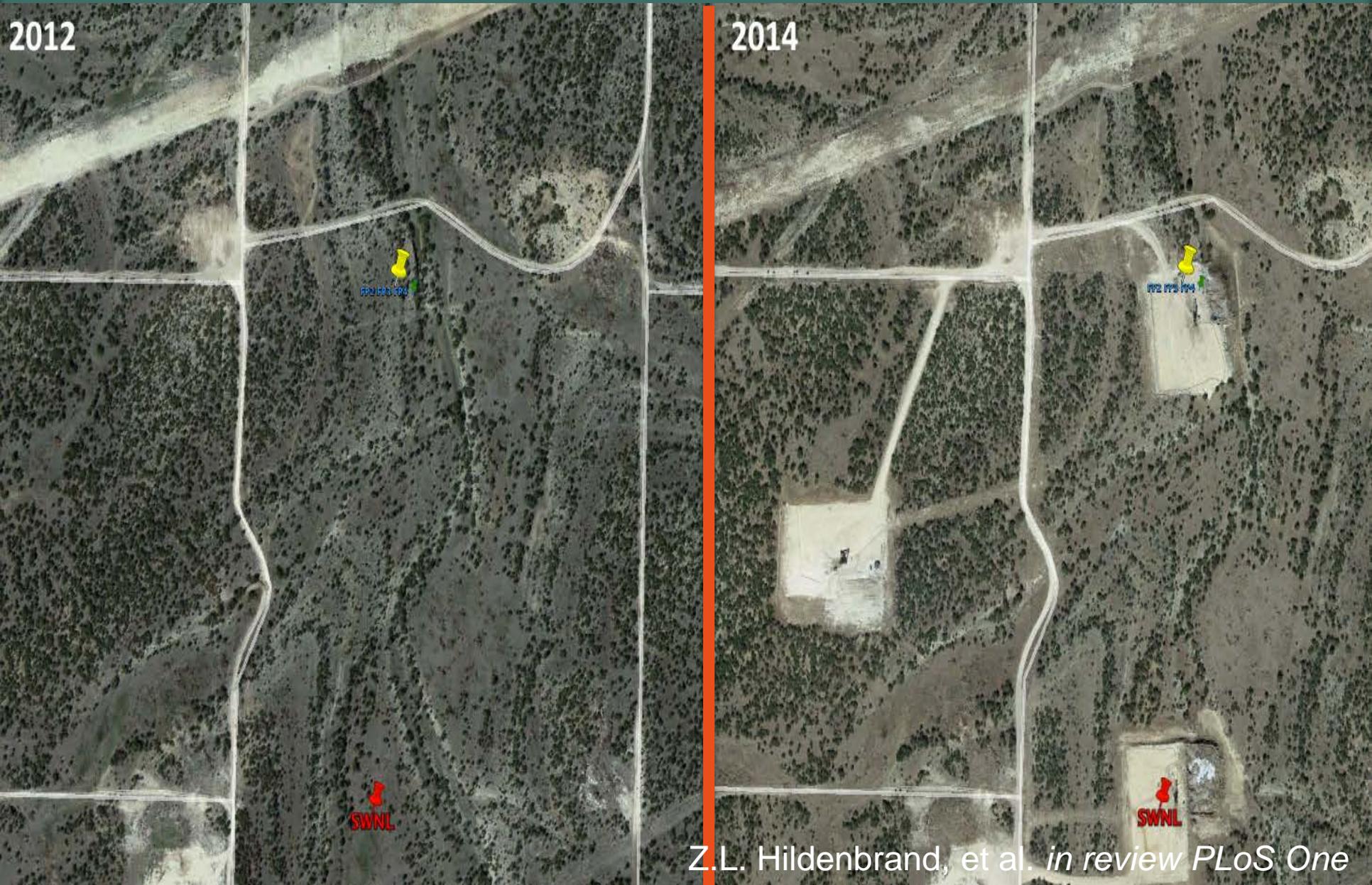
Exposure can induce headaches, tremors and convulsions (US Environmental Protection Agency, 1994)



**Chloroform** (296 detections, no MCL, 89.5% within the Barnett shale region)

Ingestion has been shown to induce kidney tumors in laboratory animals (WHO, 2004)

# Similar findings in time-series analysis





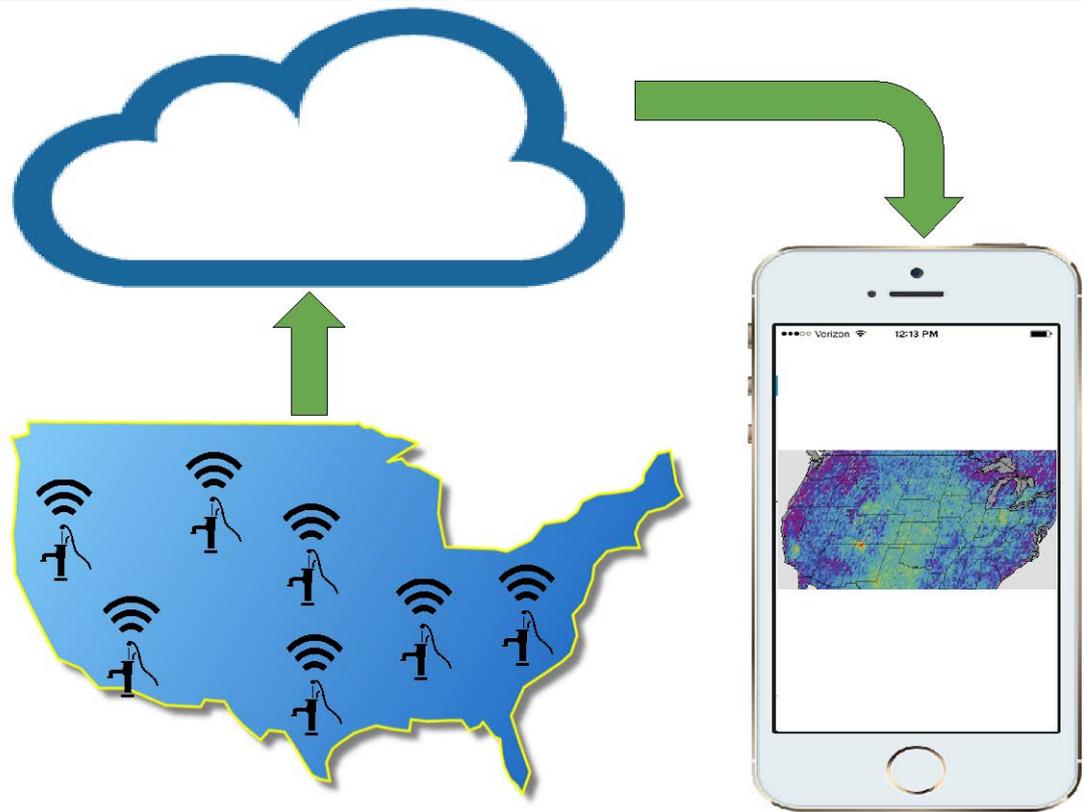
# A time-series analysis of compromised sub-region within the Barnett shale

L. Bai, et al. *J. Chromat. A*, 2015, 1388, 244-250.

Z.L. Hildenbrand, et al. *In Progress*.

- Volatile Organic Carbons
- Explosive levels of gases
- Compositional and isotopic matches with nearby gas wells

# On site detection of methane





# C.L.E.A.R.

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