

Protecting surface and groundwater from drilling and hydraulic fracturing activities



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Universidad de Los Andes , December 1st, 2014

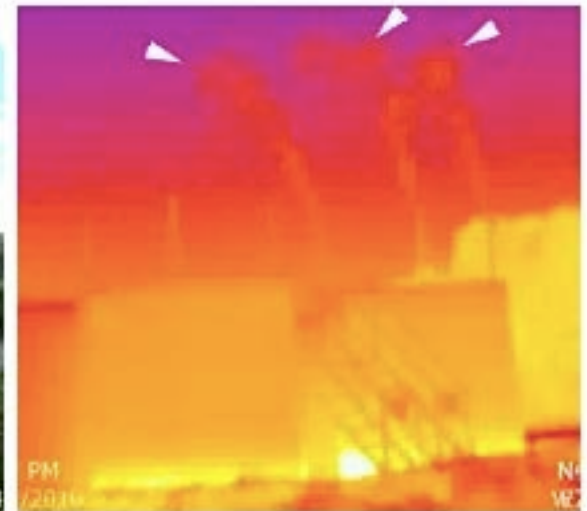
Principles for Protecting People and the Environment

- 1) Gather as much pre- and post-drilling data as possible for water, air, natural gas, and human health, and *make the data publicly available*.
- 2) Keep track of everything – what's used in fracturing fluids, where the water used for drilling comes from, how wells are cased and cemented, how wastewater is disposed (a registry), the locations of old and abandoned wells, how wells are plugged, etc.
- 3) Protect people through best management practices, strong rules and regulations, and sufficient fees.

Above all – don't rush.

Public Concerns for Unconventional Shale Extraction

- Water for hydraulic fracturing, 12-20 MM liters per well
- Contamination of drinking water
- Wastewater disposal (salinity – 10-times sea water, bromide, arsenic, barium, radioactivity)
- Air quality interactions
- Induced earthquakes
- Social and community issues
- Land footprint of wellpads, roads, and pipelines



View of Water Use (12-20 MM liters/well) Depends on Place and Scale



AP Photo



In Texas, water use for shale gas is $\sim 1\%$ of state water withdrawals. However, locally the groundwater use is 11% in Barnett, 38% in Tx-Haynesville, and 18% in Eagle Ford.

Hydraulic fracturing is water intensive (15 million L per well) and generates 7.8 million L of wastewater

Resource play (data source)	Frack water per well ^a	EUR (GJ, Bcf)	Water intensity for fracking (L/GJ)
Bakken (166)	8,700,000 2,300,000	NA	NA
Barnett (20, 27, 29, 40)	10,600,000 2,800,000	2.0, 1.9	5.2
Denver (37, 41)	10,600,000 2,800,000	1.2, 1.1	9.1
Fayetteville (42)	19,700,000 5,200,000	2.3, 2.1	8.7
Haynesville (20, 43)	21,500,000 5,670,000	2.6, 2.5	8.2
Marcellus (37, 39, 44)	14,800,000 3,900,000	1.9, 1.8	7.8
Woodford (45, 46)	15,700,000 4,160,000	2.3, 2.2	6.8
Average	14,500,000 3,800,000	2.1, 1.9	7.6

Jackson et al. 2014
Ann Rev Env Resour

Appendix 3, Columbia's Rules for Water Supply:

“The measures for the monitoring related to the use of water, that should be reported in the Environmental Compliance Reports, shall include:

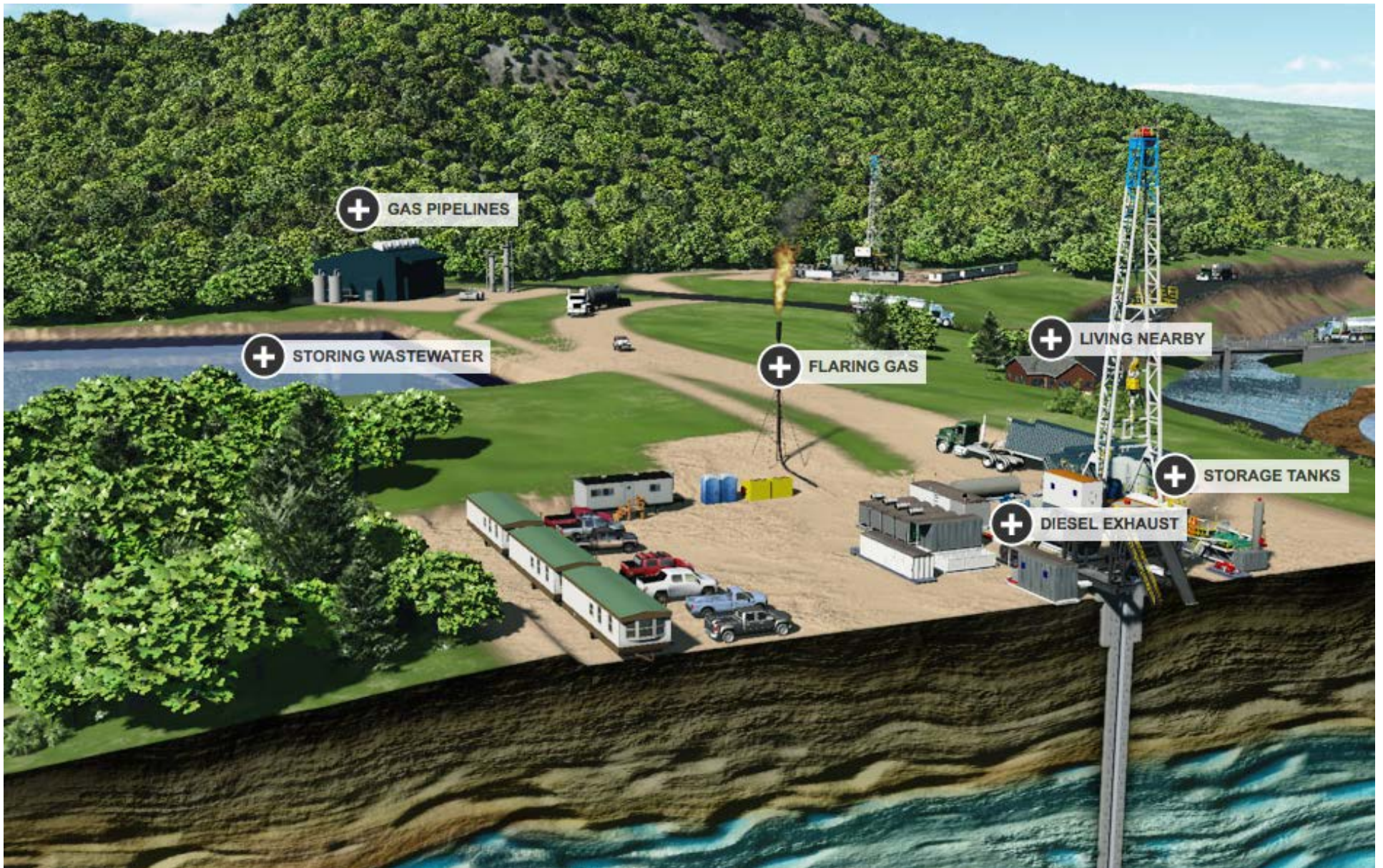
- Volume and type of water used for drilling.
- Volume and type of water used for hydraulic stimulation.
- Volume of water reused in hydraulic stimulation”

Is this information to be made public? Where did the water come from?

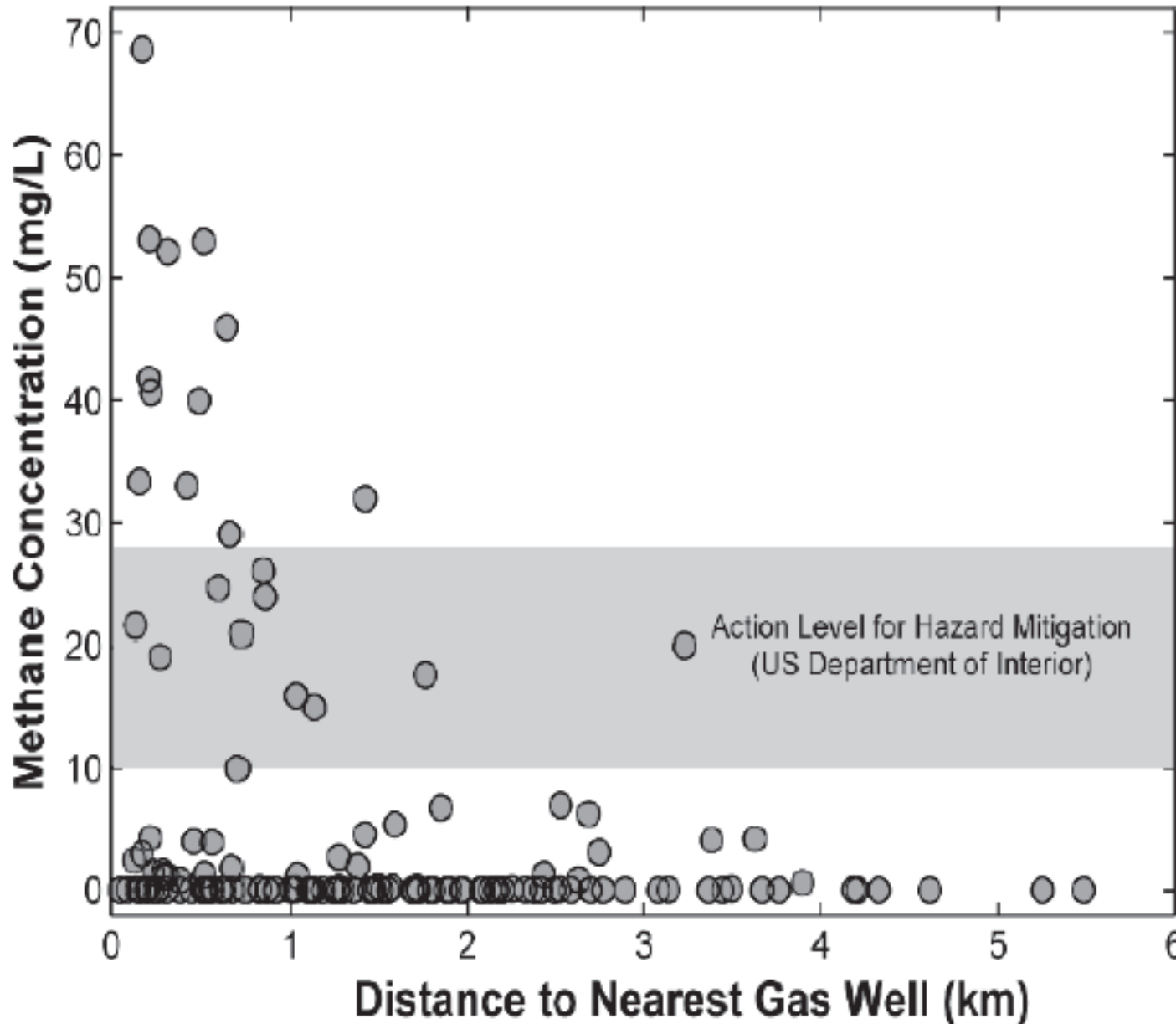
Two good attributes (though weakly applied):

- “• Use of waste or non drinking water for hydraulic stimulation (if possible).
- Reuse of water for hydraulic stimulation (if possible).”

Possible Water Quality Interactions

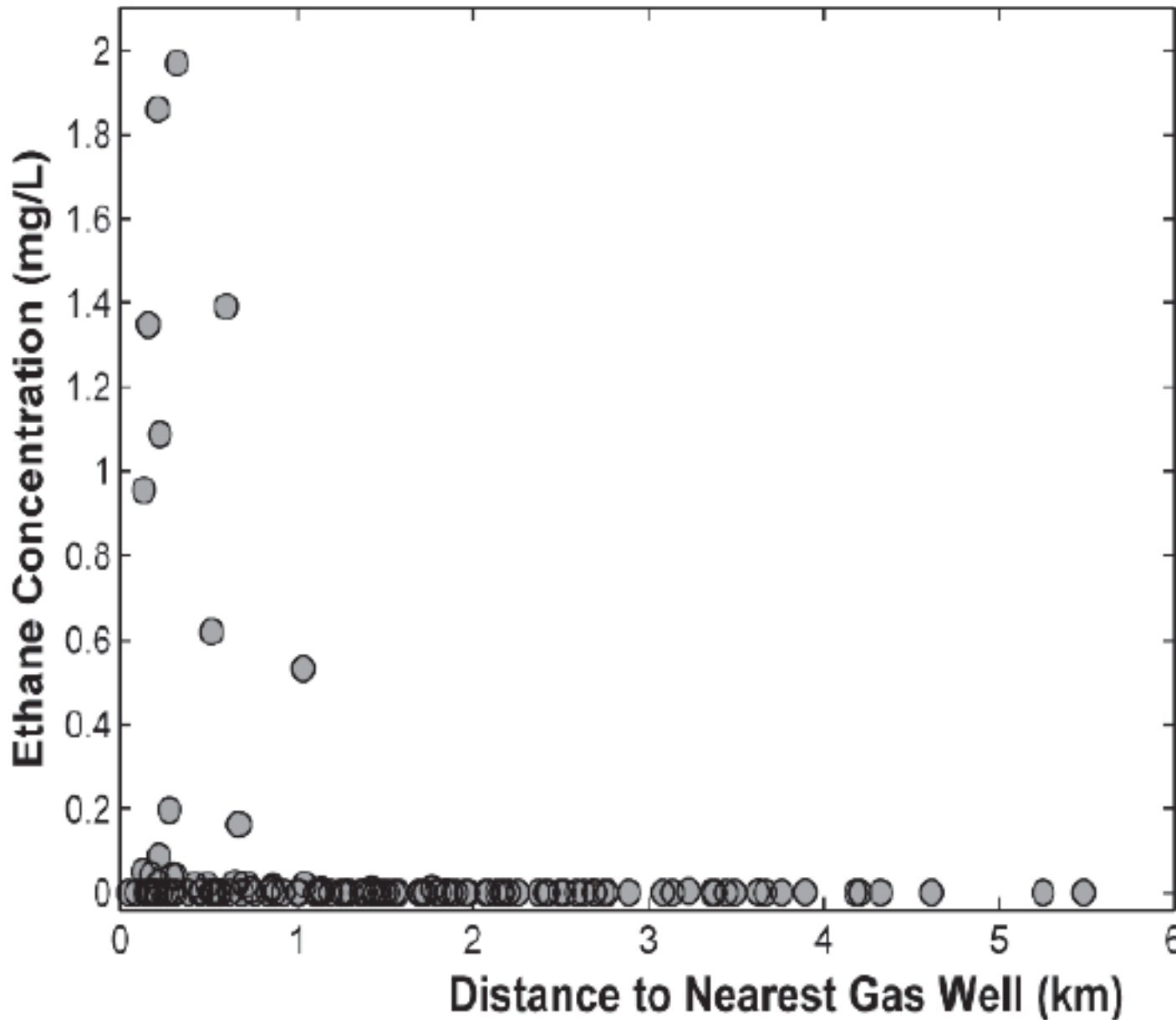


No Evidence of Changes in Salts, Metals, or Radioactivity But Stray Gas Contamination in Some Houses Near Drilling



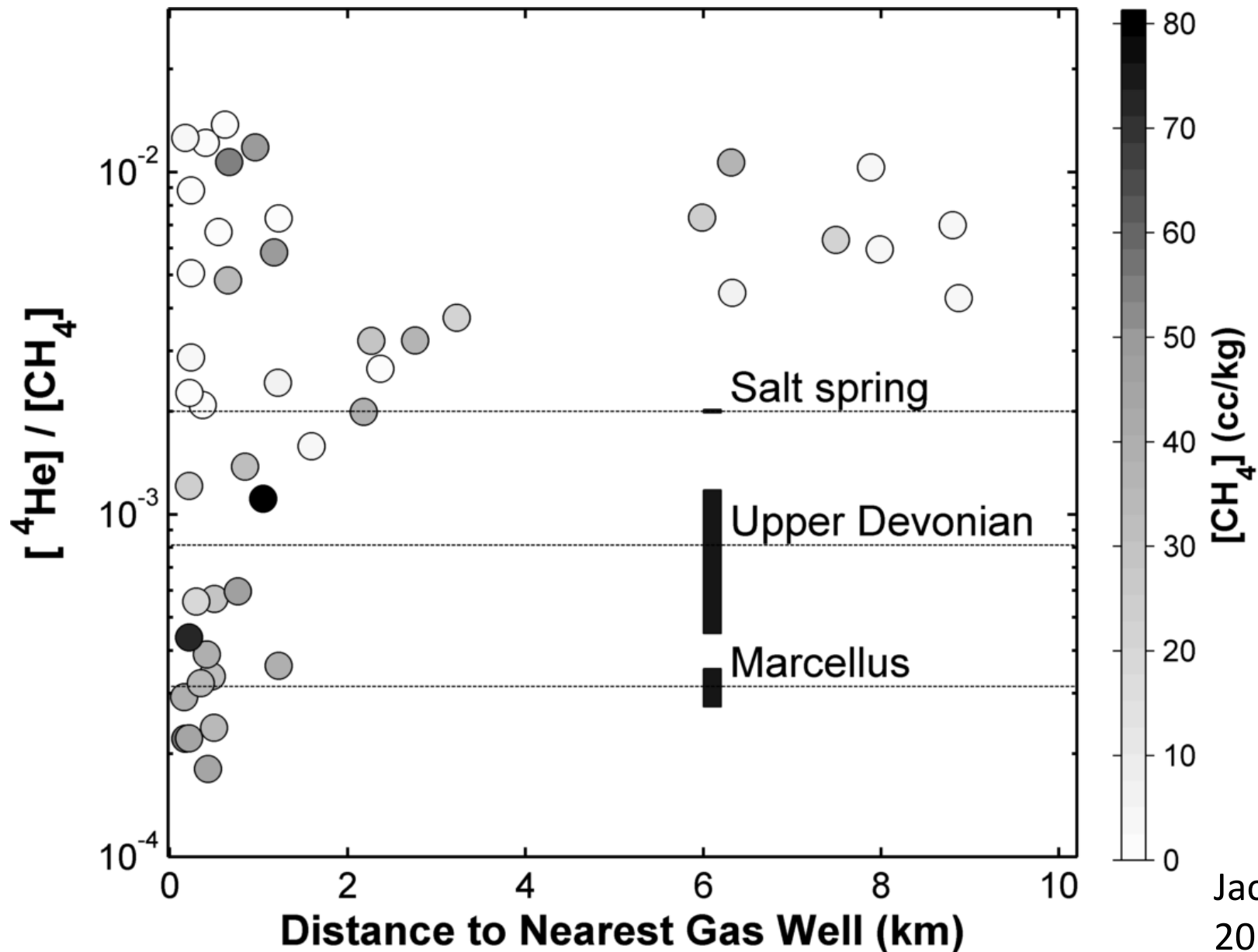
Osborn et al. 2011;
Jackson et al. 2013
PNAS

Higher ethane concentrations are even harder to explain...



Jackson et al.
2013 , PNAS

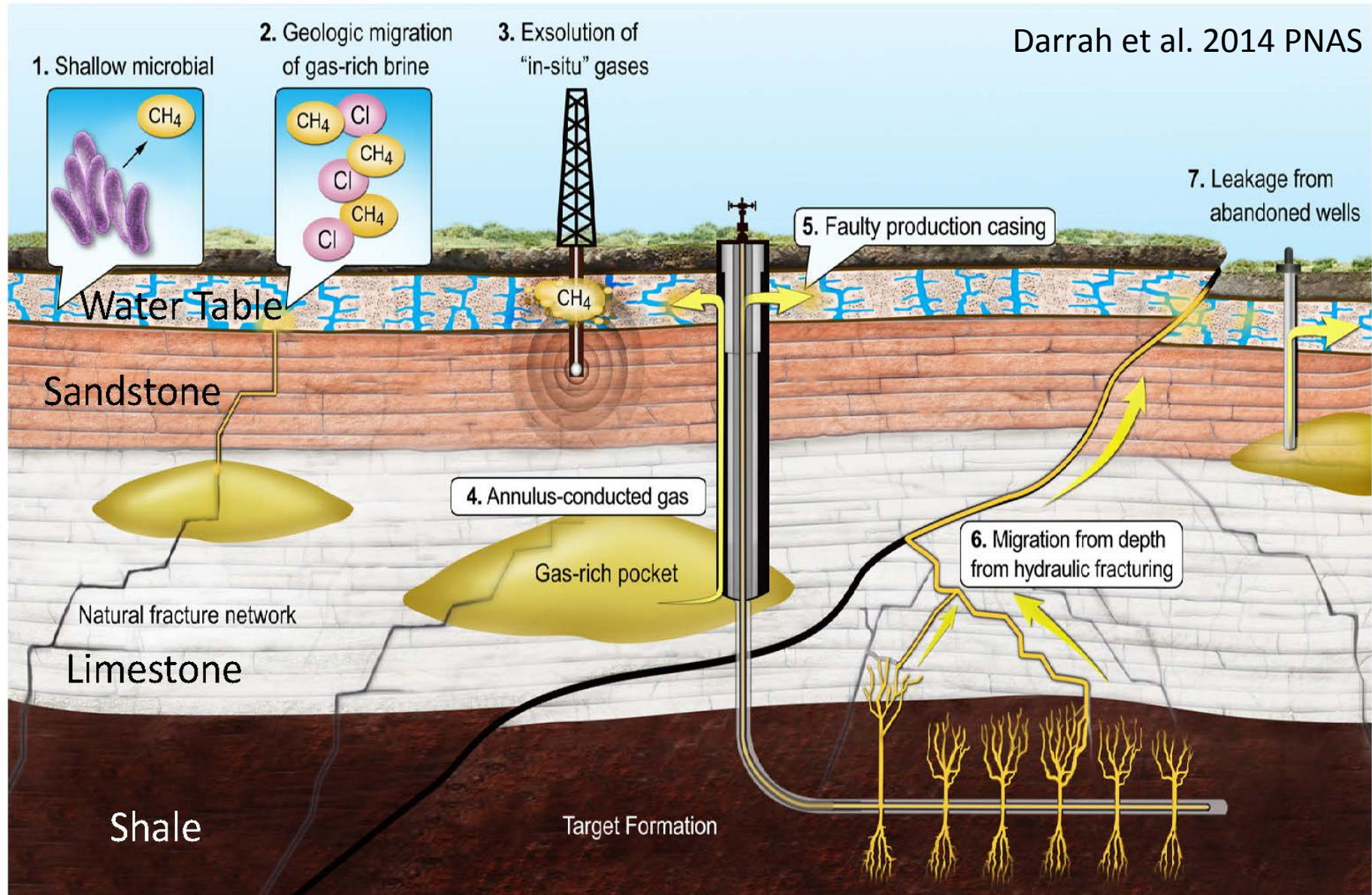
Noble gases (e.g., He, Ar, and Ne) help identify sources



Jackson et al.
2013 PNAS

Well Integrity is Key to Protecting Drinking Water (Cement and Casing Standards)

Darrah et al. 2014 PNAS



A new analysis suggests that a few % of wells to tens of % of wells have problems over long time scales



Contents lists available at [ScienceDirect](#)

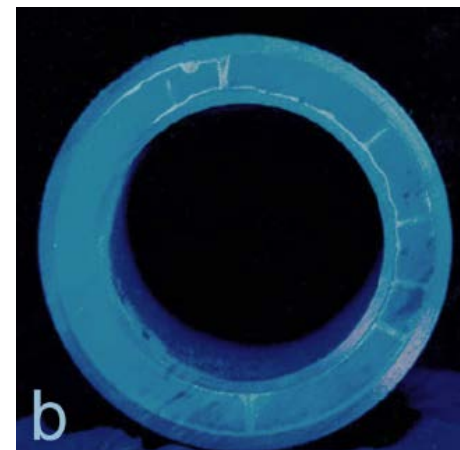
Marine and Petroleum Geology

journal homepage: www.elsevier.com/locate/marpetgeo

Review article

Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation

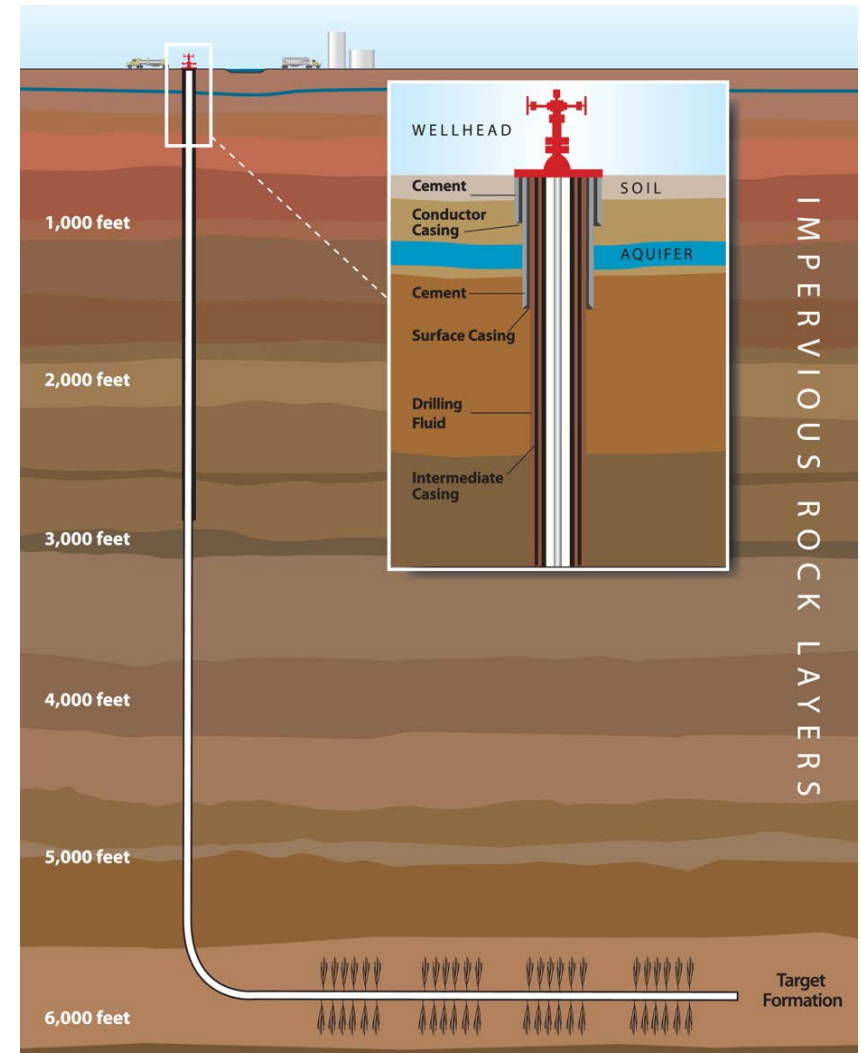
Richard J. Davies^{a,*}, Sam Almond^a, Robert S. Ward^b, Robert B. Jackson^{c,d},
Charlotte Adams^a, Fred Worrall^a, Liam G. Herringshaw^a, Jon G. Gluyas^a,
Mark A. Whitehead^e



What if no cement is used for 1000 m or more?
Or the hydraulic fracturing is only 100s of feet deep?
(Best practices differ across companies.)

In Parker County, TX,
Butler and Teal 1H Wells:
Surface casing and cement to
400 feet; estimated top of
cement at 4,700 feet
(TX RRC 2014).

At Pavillion, WY, fracking as
shallow as 699 ft; domestic
water wells as deep as 750 ft.



Colombia's Rules on Minimum Depths and Setbacks

RESOLUTION NUMBER 90341

“The distance between a hydraulic stimulation and an aquifer usable for human consumption cannot be shorter than five (5) times the hydraulic stimulation radius calculated on the basis of a geomechanical model taking into account the horizontal and vertical efforts of the area being stimulated.” **Whose model? Based on what data inputs? This statute is unclear to me.**

“Hydraulic stimulation operations shall not be carried out in wells at less than two hundred (200) meters of distance in surface from a water well supply built for consumption, irrigation, agricultural use or other subsistence activities.” **Based on data, a distance of 250 or 300 m is even better.**

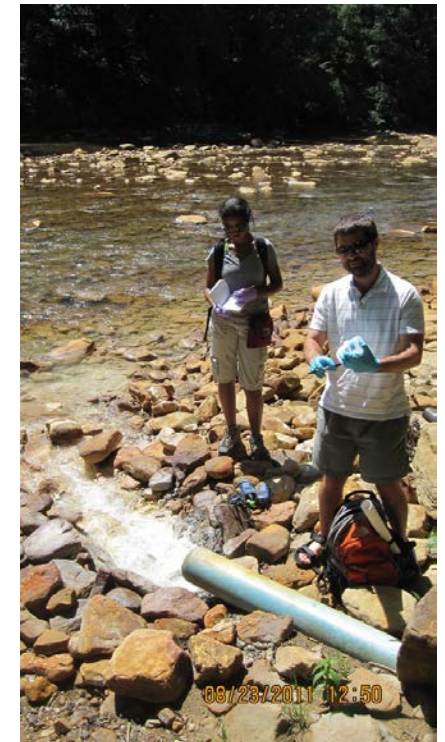
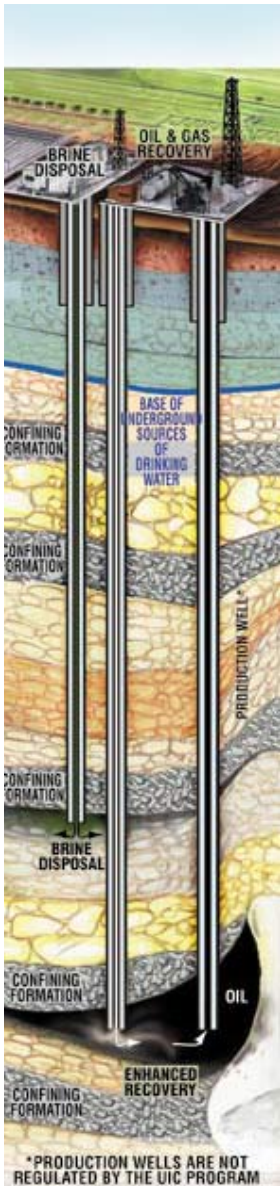
Wastewater: What's in Produced Waters?

- Salinity (Marcellus brine – 250,000 mg/L; 10 fold seawater);
- High bromide, which can form carcinogenic disinfection by-products (e.g., trihalomethanes) when chlorinated;
- High concentrations of toxic elements (Ba., As, Se, Pb);
- Naturally occurring radioactive materials; (5000 pCi/L, drinking water standard=5 pCi/L)
- Hydrocarbon residuals, oil, organics



Management of wastewater

- 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

No Open Wastewater Pits Allowed in Colombia – Good!

Appendix 3: “Note: no flowback or produced water shall be stored in outdoor pits, but only in closed tanks (frac tanks or other similar tanks) with cap and safety ventilation, or in open tanks, with the measures established in section 7.7 of this appendix and while it is ensured that the levels of Volatile Organic Compounds do not exceed the limits set forth in the regulations in force.

Closed tanks are safer than open tanks; why not require them?



Do Colombia's Statutes Allow Wastewater Disposal by Spraying Wastewater on Land?

Appendix 3: "The applicant should present in the EIS an approximate general description of wastewaters, both before and after the treatment that shall be disposed of in the proposed disposal area.

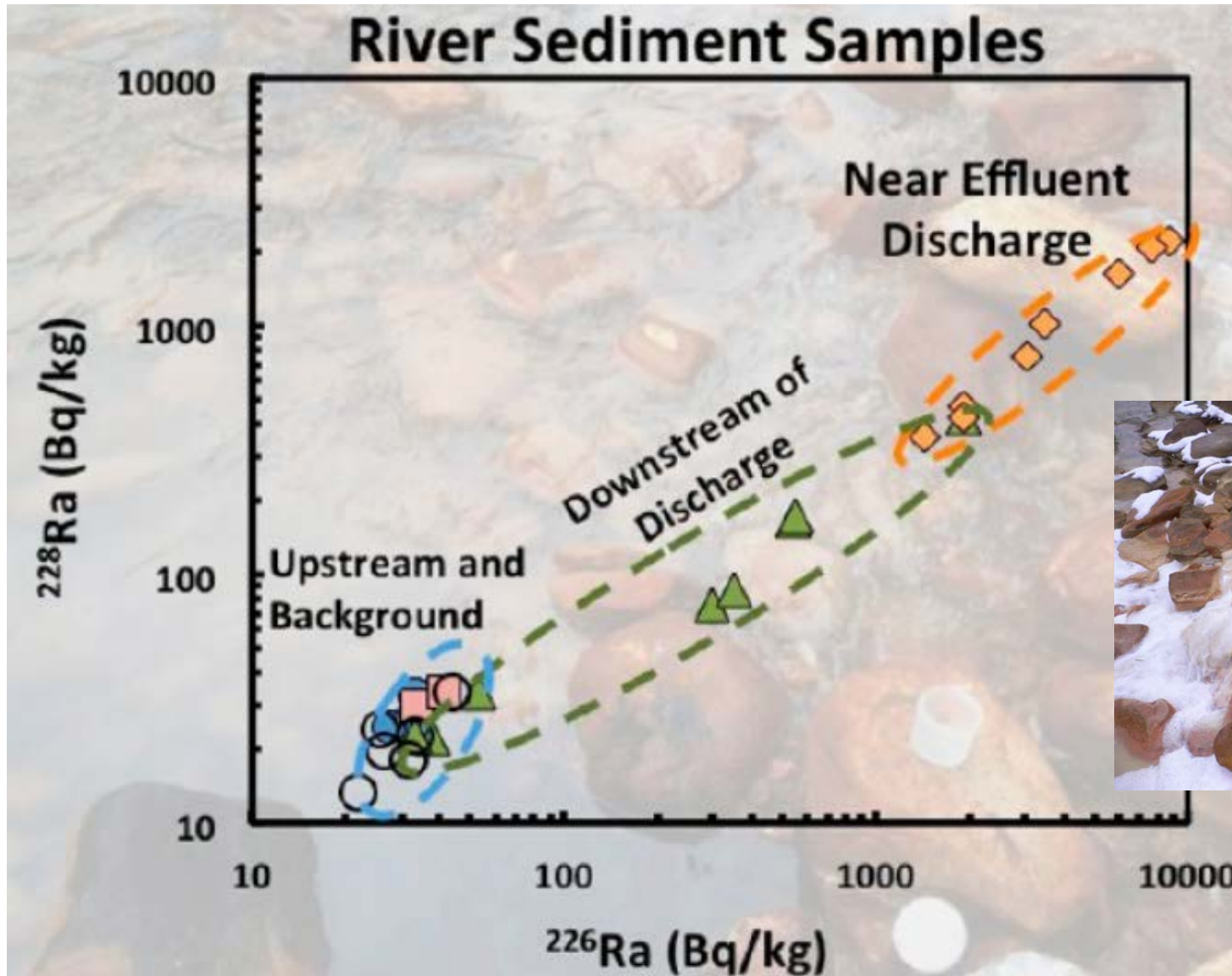
This description shall include the following:

- The projected volume and the estimated rate of wastewater that may be applied to each soil unit present in the area to be licensed.

The fixed rate shall be included in the specific EMP.

I can't tell from the current wording, but I'm assuming not...

Monitor Wastewater Treatment Plants Carefully For Radioactivity and Other Factors



Warner et al.
2013 ES&T

Legacy Wells : What Happens in 25 or 50 Years?



How Will Colombia Plan for Plugging & Abandoning Wells?

1. Will there be a permanent, public registry of well locations and status?



2. How will Colombia pay for plugging and abandonment? (Bonds, impact fees, severance taxes, etc.?)

3. This is the only mention I could find of any plan:

“7.11 Dismantling and Abandonment Plan. The dismantling and abandonment plan shall include the following measures:

- Study of background radiation on the surface in the exploration areas and of the equipment used during exploration.
- In case tubing or residues containing NORM exceeding the dispensation levels contained in Resolution 180005.... shall be applied for its handling and disposal.”

Just Published Online : Annual Review of Environment and Resources
:



The Environmental Costs and Benefits of Fracking

Robert B. Jackson,^{1,2} Avner Vengosh,²
J. William Carey,³ Richard J. Davies,⁴
Thomas H. Darrah,⁵ Francis O'Sullivan,⁶
and Gabrielle Pétron⁷



Our Air Studies Upstream at Wellpads and Downstream to City Streets

