# Induced Seismicity Consortium (ISC)


# Water Contamination Mapping Tool for Hydraulic Fracturing Operations in California

Nima Jabbari

Los Angeles, CA
July 23, 2015

# Outline

- Research statement.
- Recent Studies on Water Contamination from Hydraulic Fracturing (CCST/LBNL and EPA).
- Spatial analysis of oil and gas wells with respect to the groundwater basins.

# Research Statement

- Groundwater contamination potential in hydraulic fracturing operations

This research includes two sections:

- Reviewing literature published on contamination evidence in California and elsewhere.

- Spatial analysis of information and data as a tool to help finding correlations between chemicals and groundwater contamination.

# CCST Study – SB4

California LEGISLATIVE INFORMATION


(CCST,LBNL)

- **Vol. I:** Past, Present, and Future of Well Stimulation in CA (*January 14, 2015*)
- **Vol. II:** Potential ENE Impacts (*July1, 2015*)
- **Vol. III:** Case-studies on ENE and Public Health Risk (*July1, 2015*)

# CCST Study – Vol. II

## Potential EnE Impacts of Hydraulic Fracturing and Acid Stimulations

### Conclusions

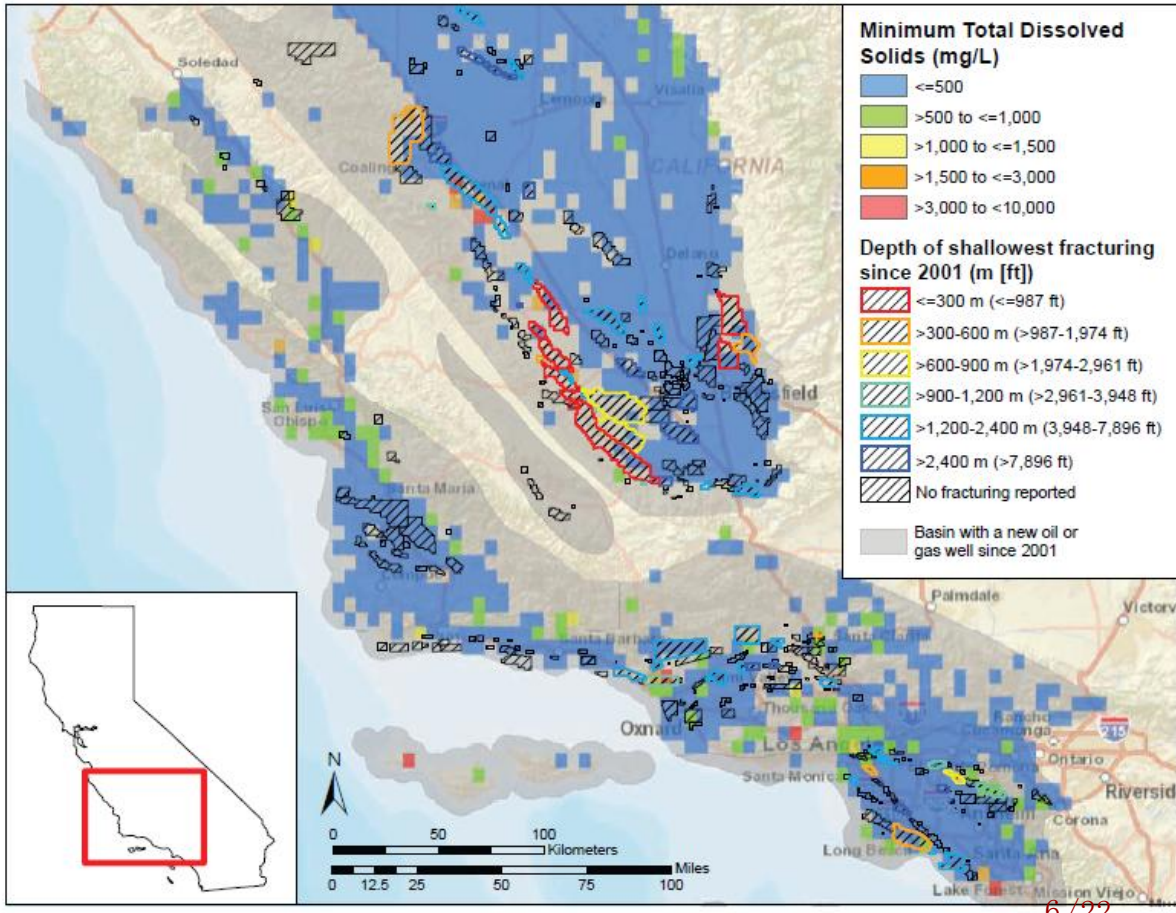
- Direct impacts appear small (**not** investigated, though).
- Operators have unrestricted use of uncharacterized chemicals.
- Majority of impacts are indirect.
- Produced water disposed of in percolation basins: could contain chemicals/ chemistry has not been measured/may use for irrigation(need for advanced tests).

# CCST Study – Vol. II

## Impacts on water resources:

- Potential GW contamination: raised by shallow fracturing (3/4th of the CA operations are in shallow wells - < 600 m or 2,000 ft).

*Groundwater quality in the San Joaquin and Los Angeles Basins. Some high quality water exists in fields that have shallow fractured wells.*




- Protected aquifers:

Historically: <u>TDS < 3,000 mg/l</u>

SB4: <u>TDS < 10,000 mg/l</u>

# CCST Study – Vol. II

**Impacts on water resources:**

- Leakage of chemicals can happen through existing wells (old reservoirs with high well density).
- TDS thresholds: 3,000 mg/l vs. 10,000 mg/l.
- Old wells may not protect aquifer zones with TDS in the range of 3,000 to 10,000 mg/l (it was not mandated at that time).
- Need to evaluate the effectiveness of the fracturing job design to make sure aquifer is protected.

# CCST Study – Vol. II

**Studies on potential contamination near stimulation sites:**

Studies that Found Evidence of Potential Water Contamination:

- *Kern County, 2013*: discharge to unlined pits – Saline water, formation fluids, HF fluid.
- Hard to draw correlations between stimulation operations and contamination incidents in general.

Studies that Found **No** Evidence of Potential Water Contamination:

- *Inglewood, CA* (Cardno ENTRIX, 2012): the only sampling study in CA.
- Studies outside of California **the Marcellus Shale, Pennsylvania** (e.g., Boyer et al., 2011; Brantley et al., 2014 and references therein; Siegel et al., 2015), **the Fayetteville Shale, Arkansas** (Warner et al., 2013b), **the Barnett Shale, Texas** (Fontenot et al., 2013), and **the Bakken Shale** (McMahon et al., 2015).

# EPA Study

***Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources (2015)***

Above and below ground mechanisms with the potential to impact drinking water resources

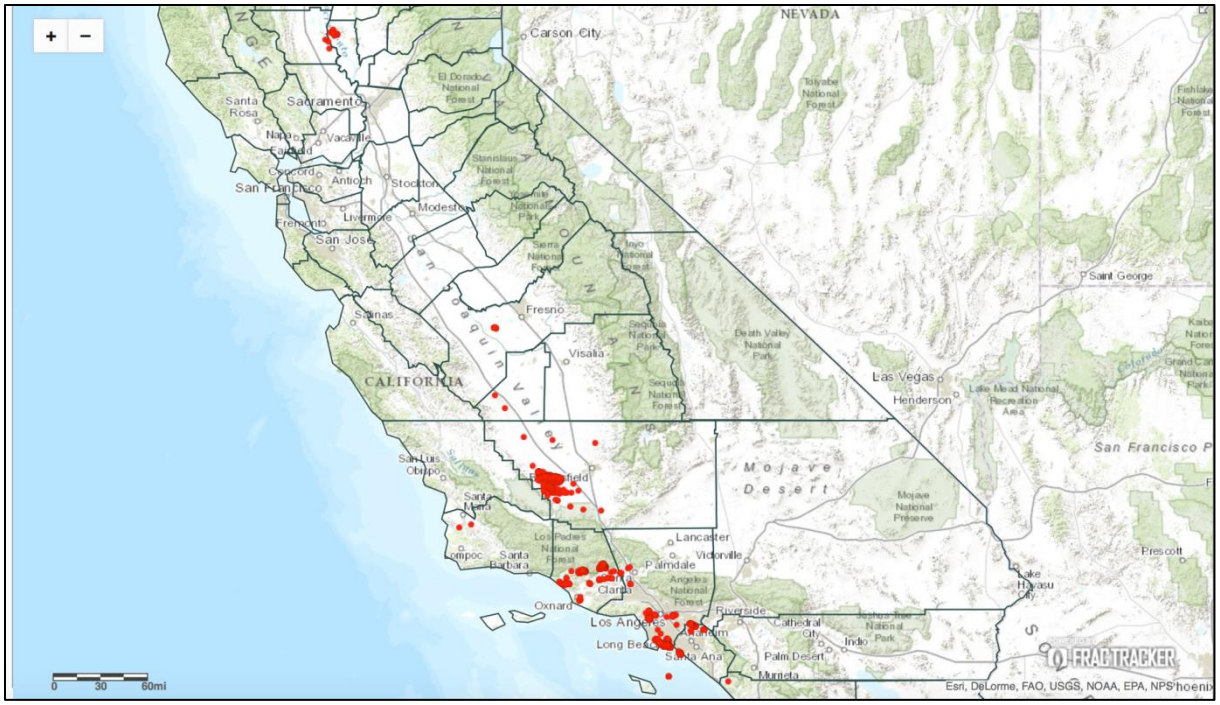
- Low water availability and water withdrawals
- Spills  of HF fluids and produced water
- Fracturing directly into underground drinking water resources
- Below ground migration of liquids and gases
- Improper treatment of waste

- No evidence of widespread systematic impacts on drinking water resources in the US.
- Small number of contamination of water wells.

# Spatial Analysis

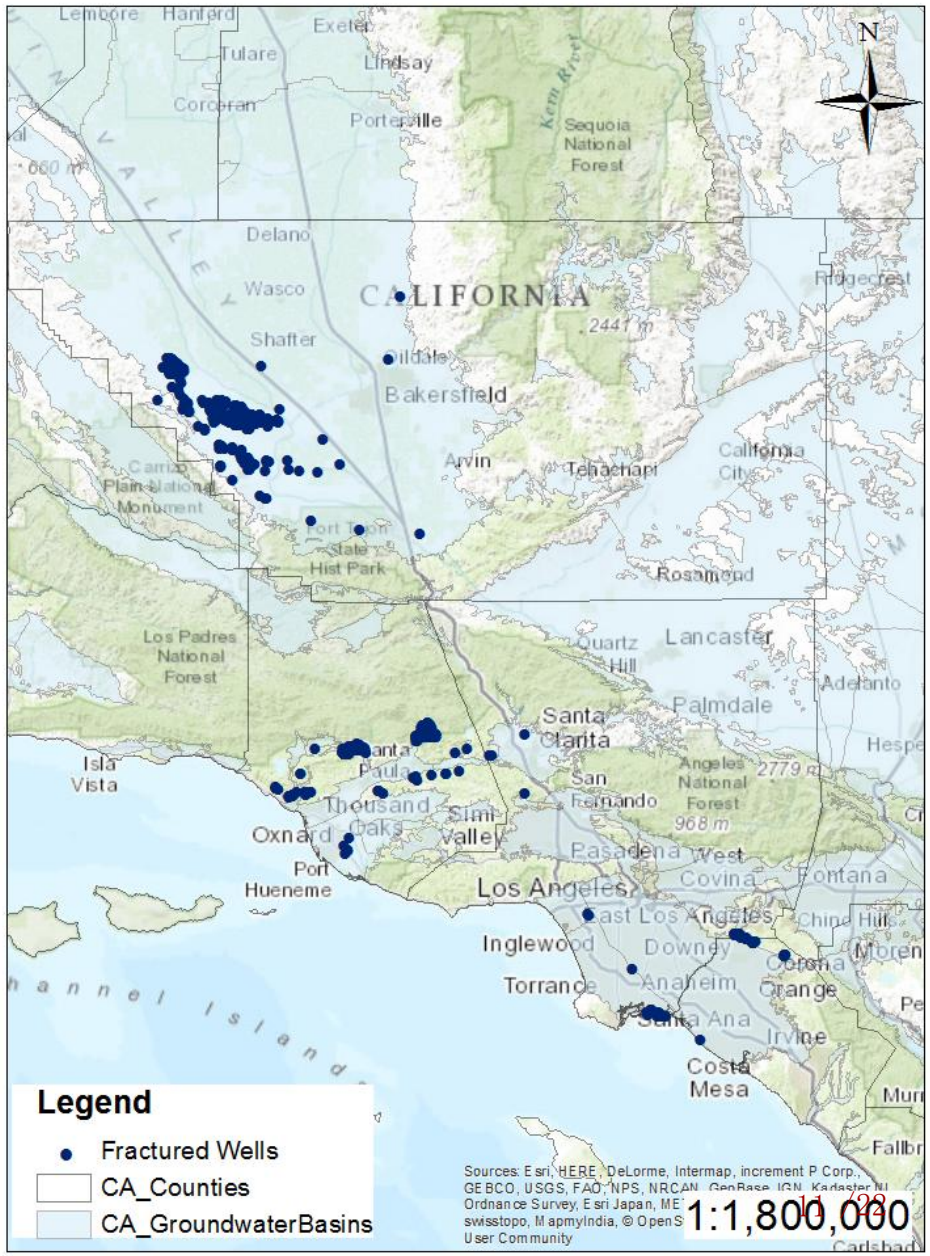
- Total of 1000 fractured wells in CA.
- 982 (98%) in 4 counties:

- Kern: 459
- Ventura: 456
- Los Angeles: 40
- Orange: 27




http://maps.fractracker.org/latest/?appid=57ecf5feeba8428f80a749ec50921ad6

# Spatial Analysis

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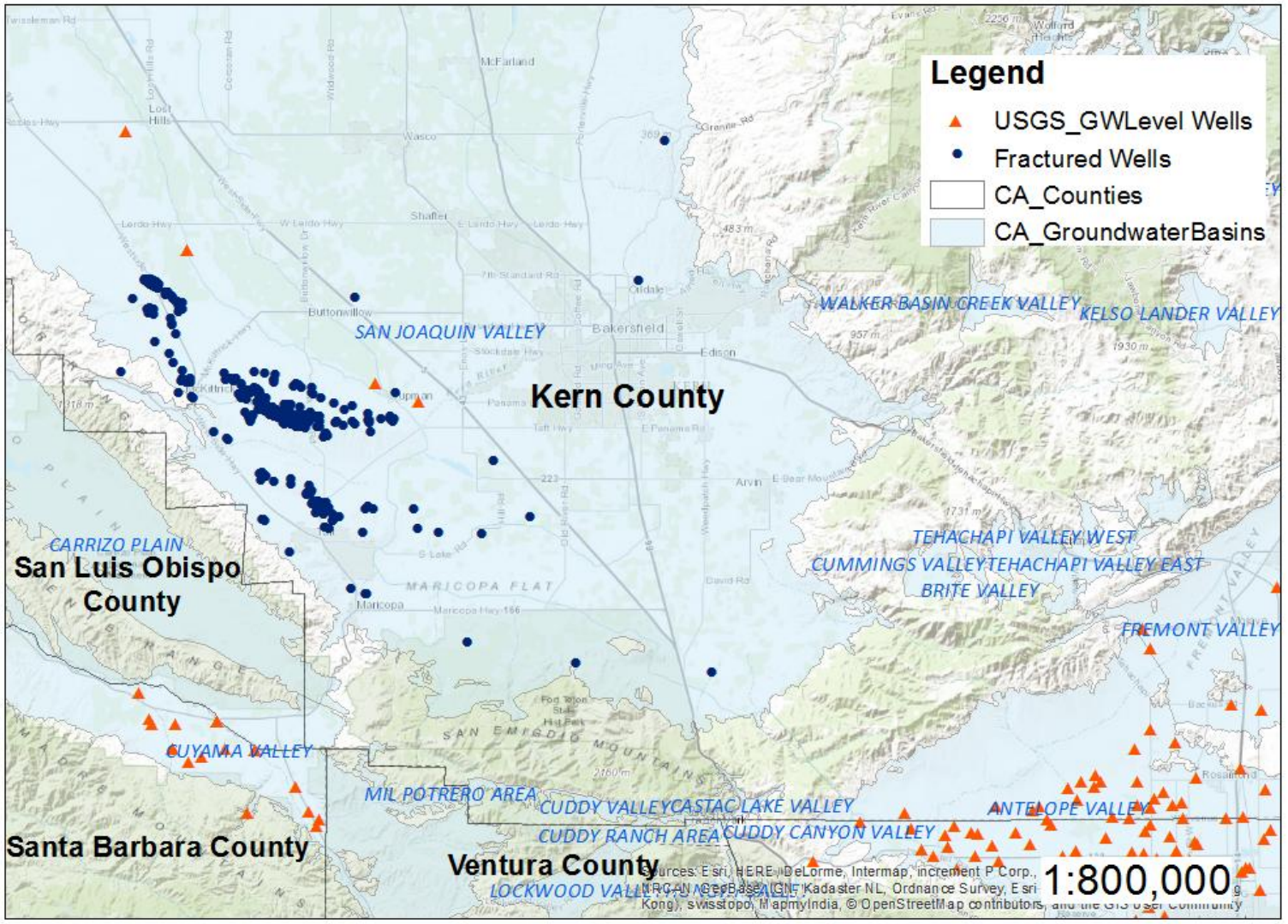

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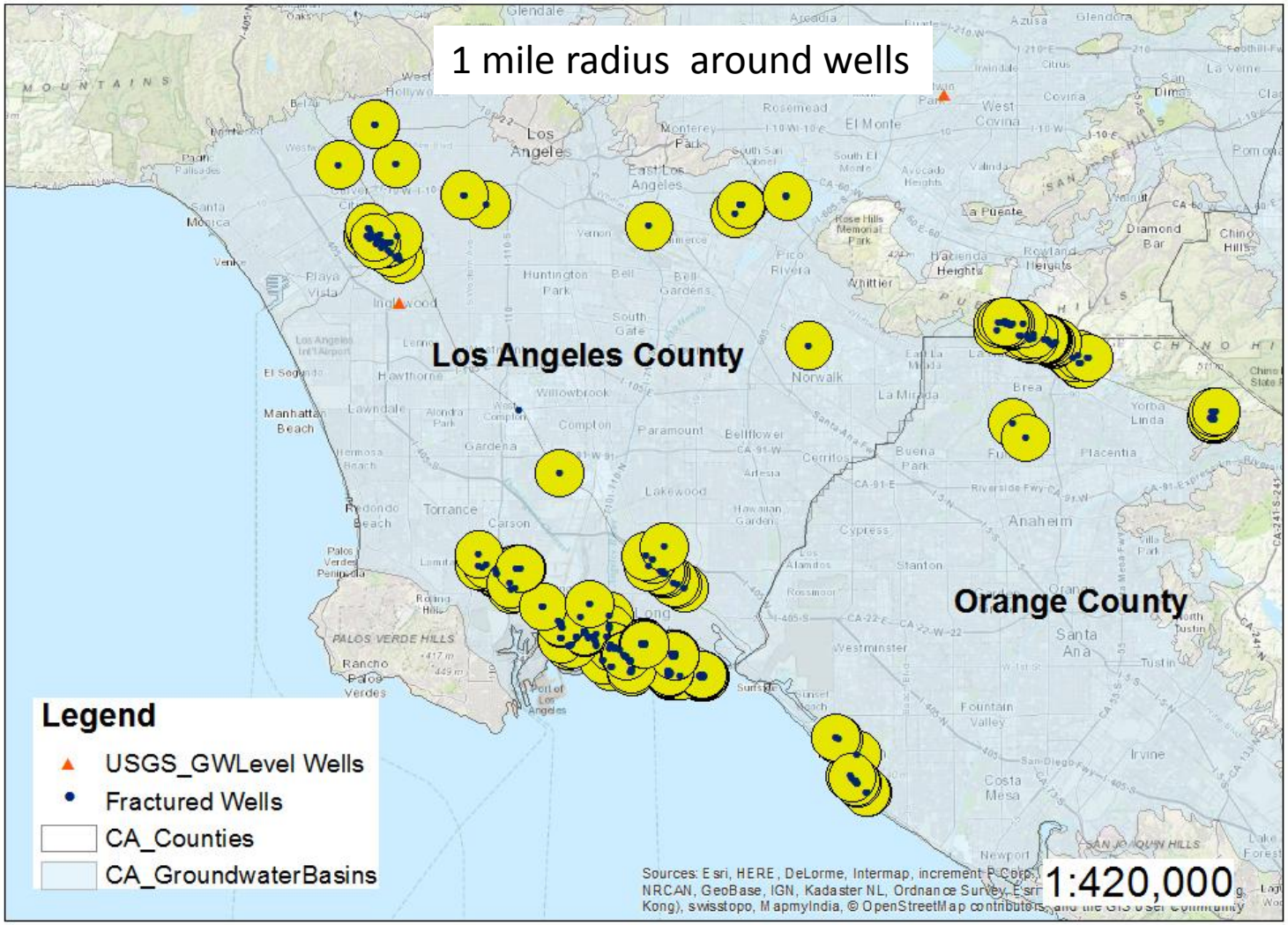

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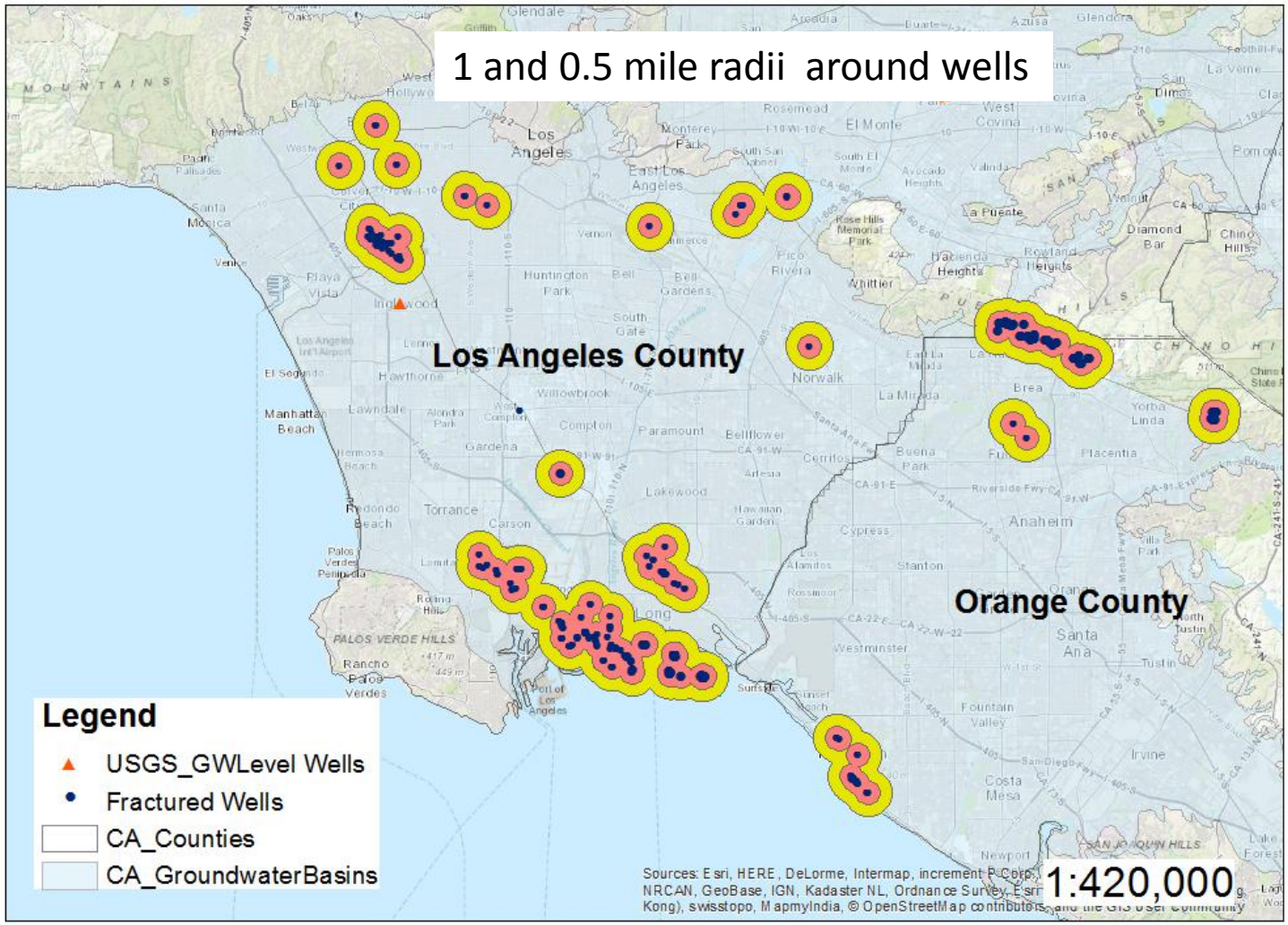

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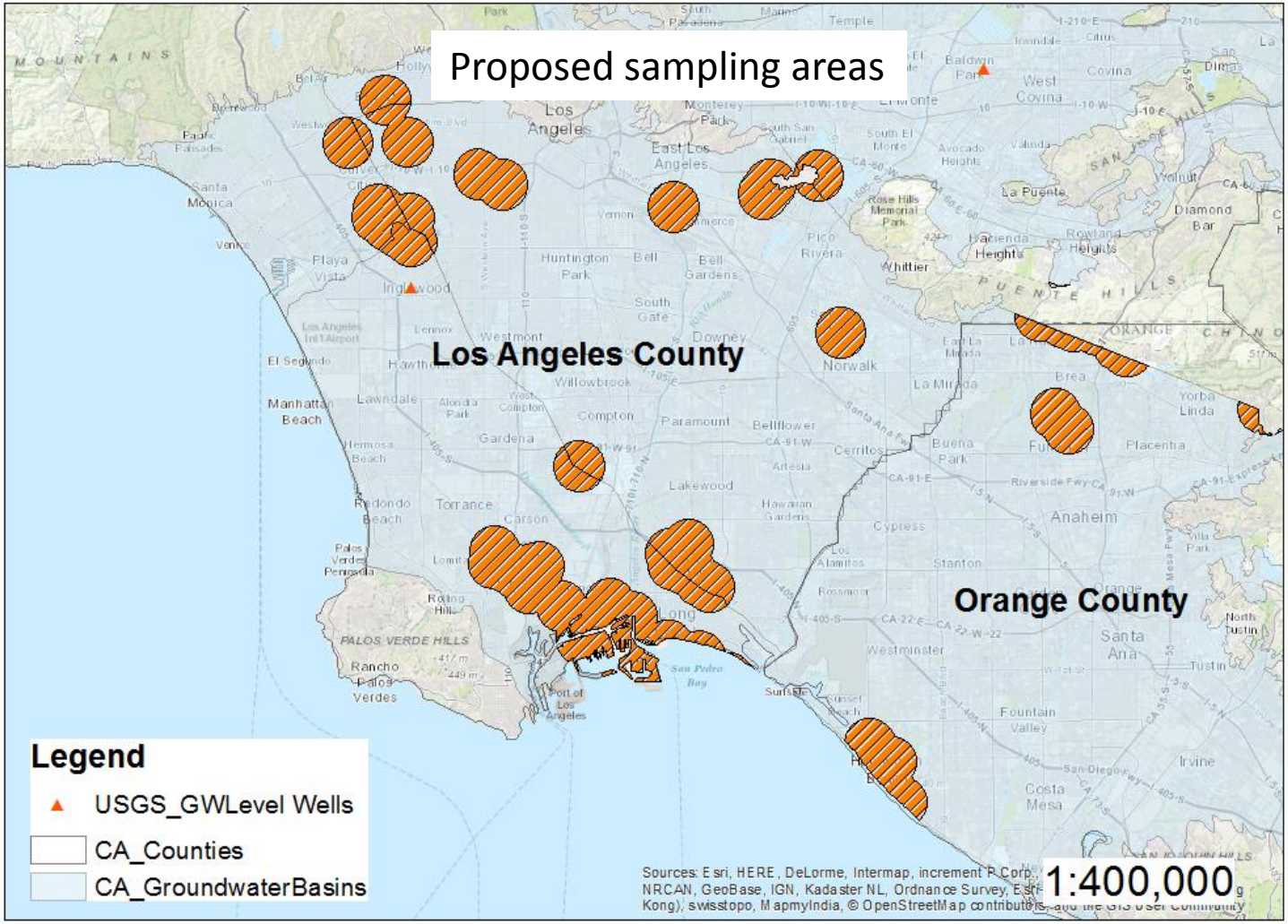

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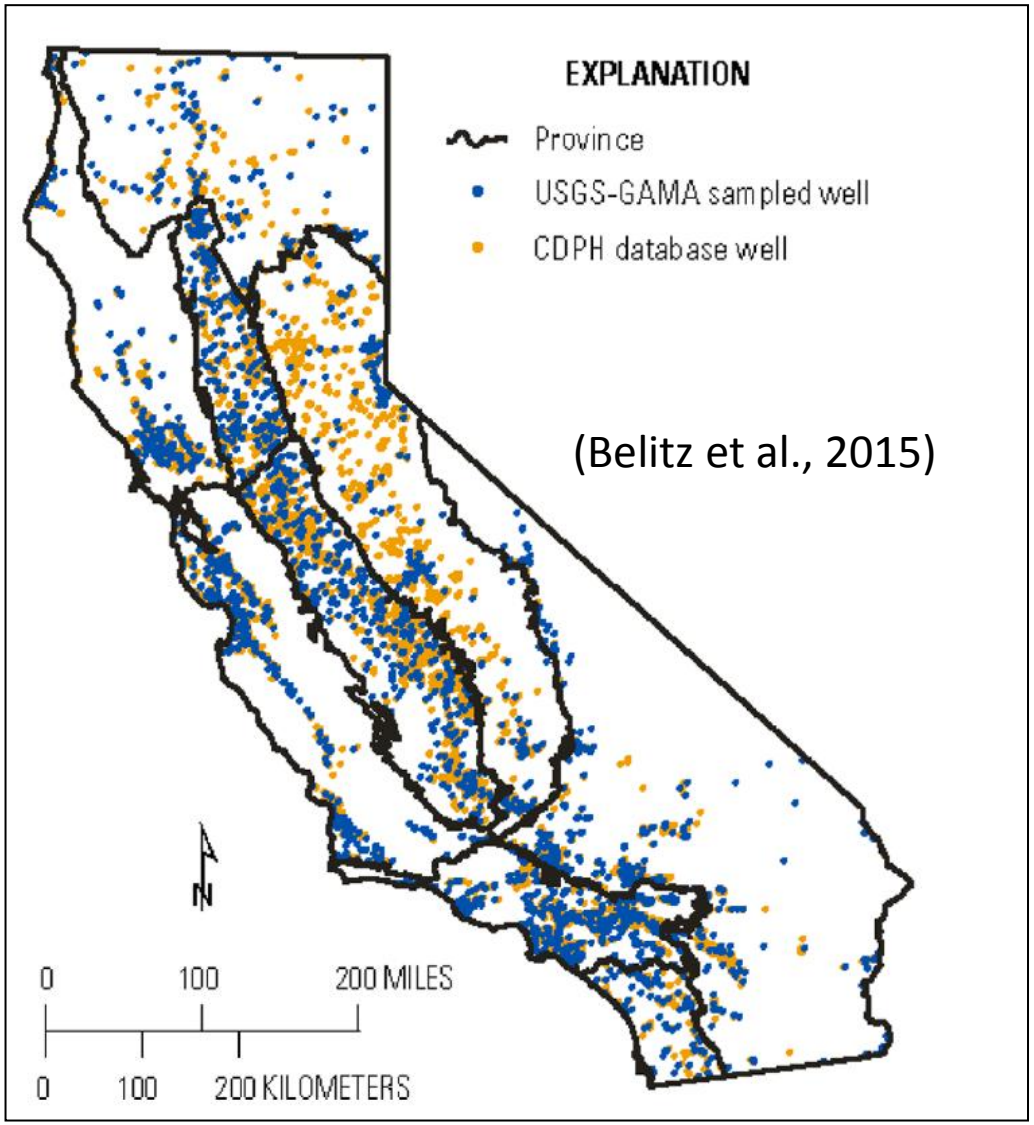


(Belitz et al., 2015)

# Analysis of Chemical Usage in CA Fracturing Wells

- Using data from Skytruth: 436 wells through 2013

- 161 unique chemical agents excluding the proppant, water, proprietary, confidential business, and trade secret agents.

| CumFreqPerc | Frequency | Purpose | Ingredients | CAS Number |
|---|---|---|---|---|
| 99.5% | 434 | Gelling Agent | Guar gum | 9000-30-0 |
| 87.2% | 380 | Breaker | Ammonium Phosphate | 7727-54-0 |
| 86.5% | 377 | pH Control Additive | Sodium hydroxide | 1310-73-2 |
| 84.2% | 367 | Breaker | Hemicellulase Enzyme Concentrate | 9025-56-3 |
| 83.5% | 364 | | Petroleum Distillates | 64742-47-8 |
| 82.6% | 360 | | Fatty alcohol polyglycol ether surfactant | 9043-30-5 |
| 80.7% | 352 | | Paraffinic Petroleum Distillate | 64742-55-8 |
| 78.9% | 344 | | 2-Butoxy-1-Propanol | 15821-83-7 |
| 78.9% | 344 | Gelling Agent | 1-Butoxy-2-Propanol | 5131-66-8 |
| 78.9% | 344 | | Diatomaceous Earth, Calcined | 91053-39-3 |

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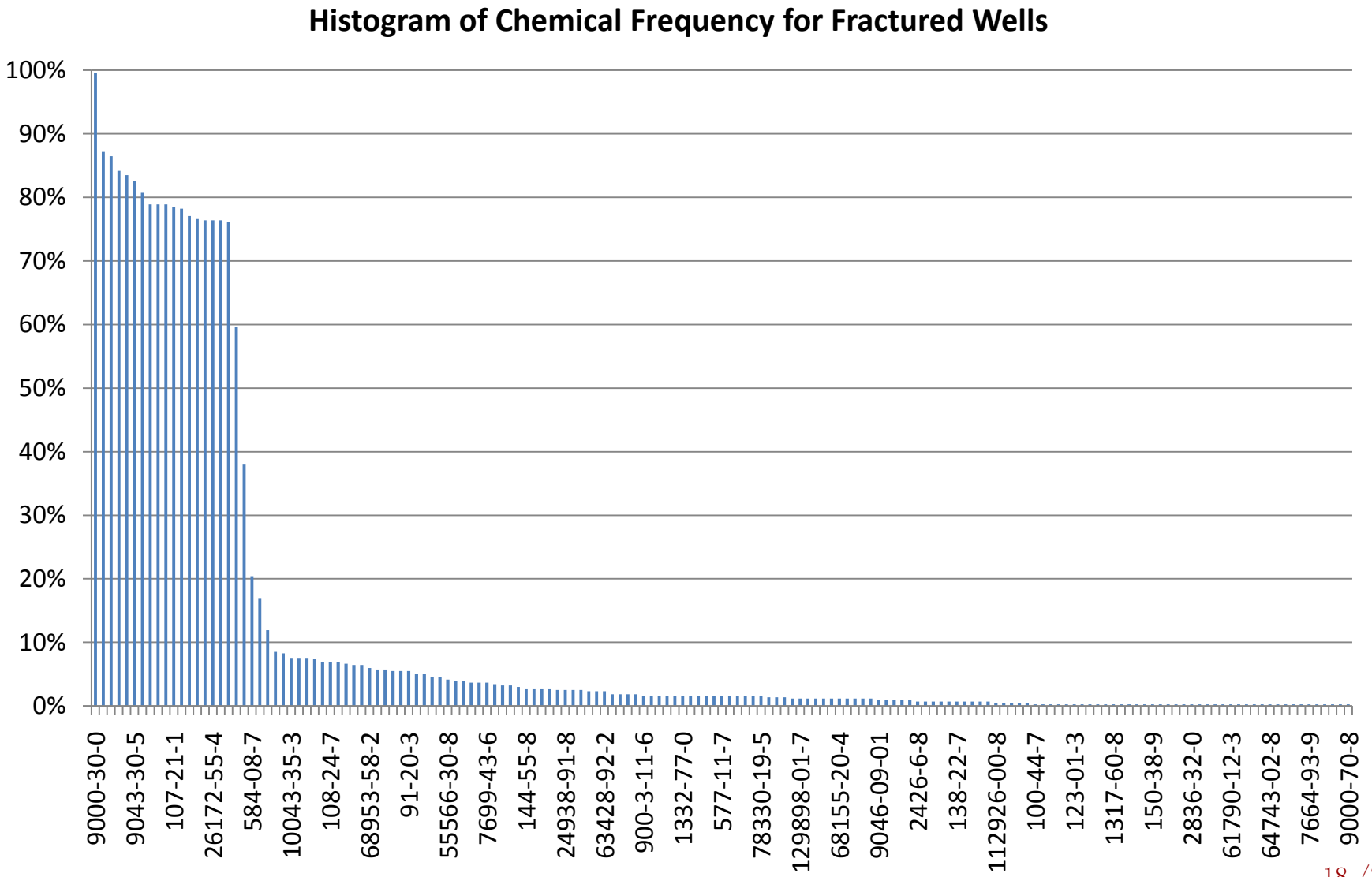

# Analysis of Chemical Usage in CA Fracturing Wells

- List of 12 chemicals recognized by EPA's drinking water standards:

| | | | | | | 10kg Child | | |
|---|---|---|---|---|---|---|---|---|
| No. | Chemical | CASRN # | Frequency of usage | Purpose | MCL (mg/L) | One-day (mg/L) | Ten-day (mg/L) | Life-time (mg/L) |
| 1 | Ethylbenzene | 100-41-4 | 4 | Acidizing | 0.7 | 30 | 3 | 0.7 |
| 2 | Ethylene glycol | 107-21-1 | 342 | Crosslinker | - | 20 | 6 | - |
| 3 | Formaldehyde | 50-00-0 | 4 | **Biocide? | - | 10 | 5 | 1 |
| 4 | Isopropylbenzene (cumene) | 98-82-8 | 3 | ** | - | 11 | 11 | - |
| 5 | Naphthalene | 91-20-3 | 24 | Surfactant, Carrier fluid for the active surfactant ingredients | | 0.5 | 0.5 | - |
| 6 | Trimethylbenzene (1,2,4-) | 95-63-6 | 11 | | - | - | - | - |
| 7 | Trimethylbenzene (1,3,5-) | 108-67-8 | 3 | | - | 10 | - | - |
| 8 | Xylenes | 1330-20-7 | 3 | Acidizing / Solvent | 10 | 40 | 40 | - |
| 9 | Chlorite | 7758-19-2 | 7 | | 1 | 0.8 | 0.8 | 0.8 |
| 10 | Chloride | 7647-14-5 | 32 | | 250 | | | |
| 11 | Sulfate | 7757-82-6 | 8 | | 250 | | | |
| 12 | Bromate | 7789-38-0 | 1 | | 0.01 | 0.2 | | - |

# Spatial Analysis

- Answering two questions:

- Has the groundwater quality in the search radius been affected?

(TDS ? Good measure but is not enough).

- If yes, can we make reasonable correlations between the change in quality and the chemical used/produced in the fracturing operations?

(not easy to answer /need for more stringent sampling programs + further analysis of samples).

# Future Research Direction

- Continuing the spatial analysis.

- Including water quality (USGS and CDPH) data to observe correlations between monitored chemicals and the ones used in injectant.

- Compiling data for the entire state and expand the ISM software to include chemical injection data and contamination of groundwater resources if any.

# Thanks for your attention!