The Public Health Dimensions of Oil and Gas Development in California

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Disclaimer

The ideas in this presentation are my own and do not necessarily reflect those of the Central Valley Regional Water Quality Control Board, The State Water Board, or the Food Safety Expert Panel.

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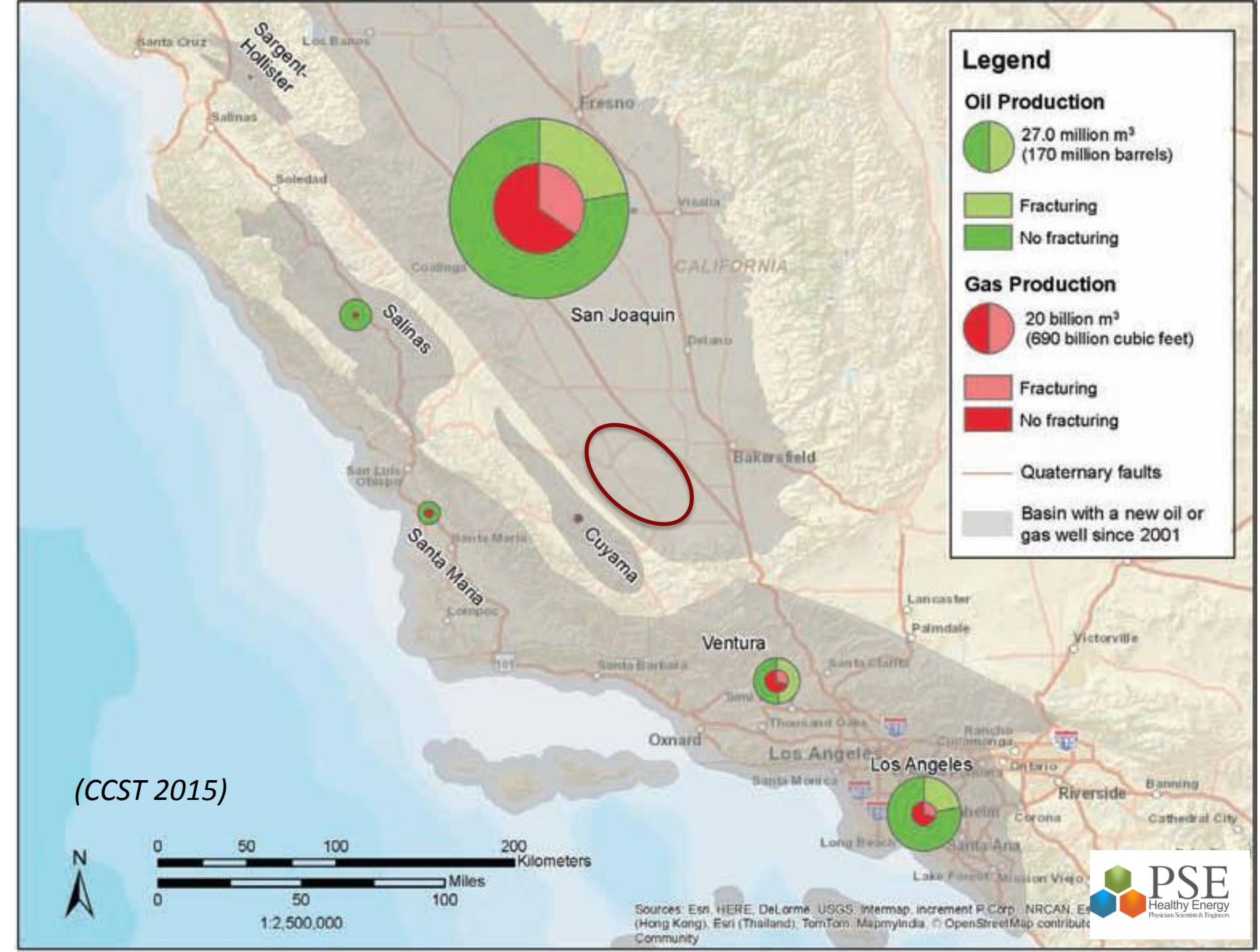
Legend
Oil Production
27.0 million m³
(170 million barrels)
Fracturing
No fracturing
Gas Production
20 billion m³
(690 billion cubic feet)
Fracturing
No fracturing
Quaternary faults
Basin with a new oil or gas well since 2001
Sargent-Hollister
Salinas
San Joaquin
Cuyama
Santa Maria
Ventura
Los Angeles
Bakersfield
Fresno
CALIFORNIA
0 50 100 200 Kilometers
0 50 100 Miles
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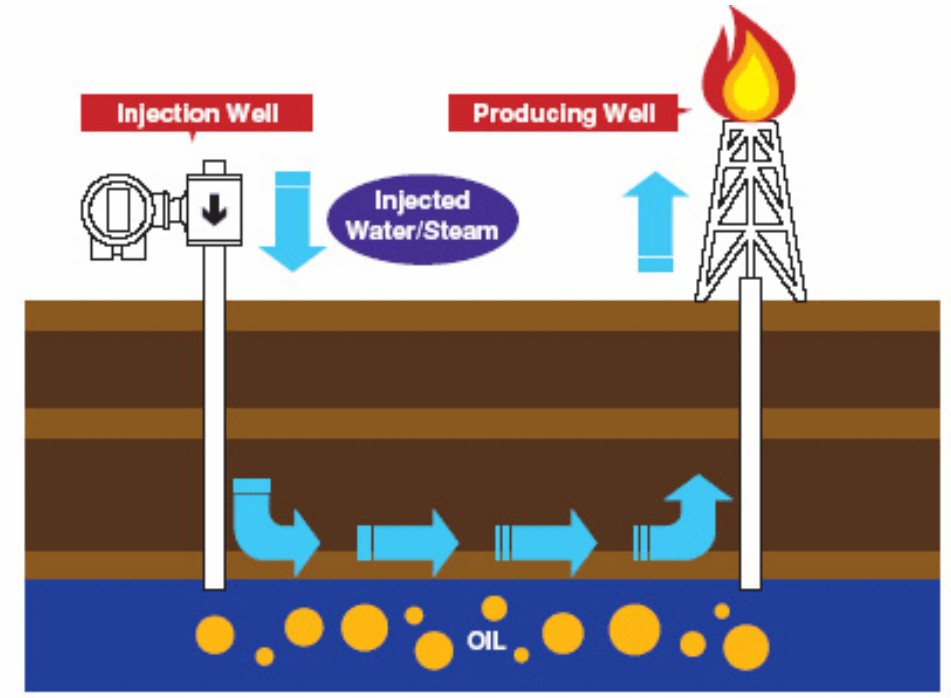
(CCST 2015)

Enhanced Oil Recovery

Steam Cogeneration Plant, Midway-Sunset Field



Source: Yokogawa Corporation of America

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Carbon-Intensity of California Oil

NOTE: Average global oil score is between 5 and 13

California oil scores (steam injection-enabled oil production):

- Midway-Sunset = 21.18
- Coalinga = 25.36
- San Ardo = 28.82

Alberta Tar Sands:

- Albian Heavy Synthetic = 21.02
- Suncor Synthetic = 24.49

187,080 BOPD (31% of current CA oil production) is 19.9 gCO2e/MJ or greater (on par with Alberta tar sands)

CARB (2012); Brandt (2011)

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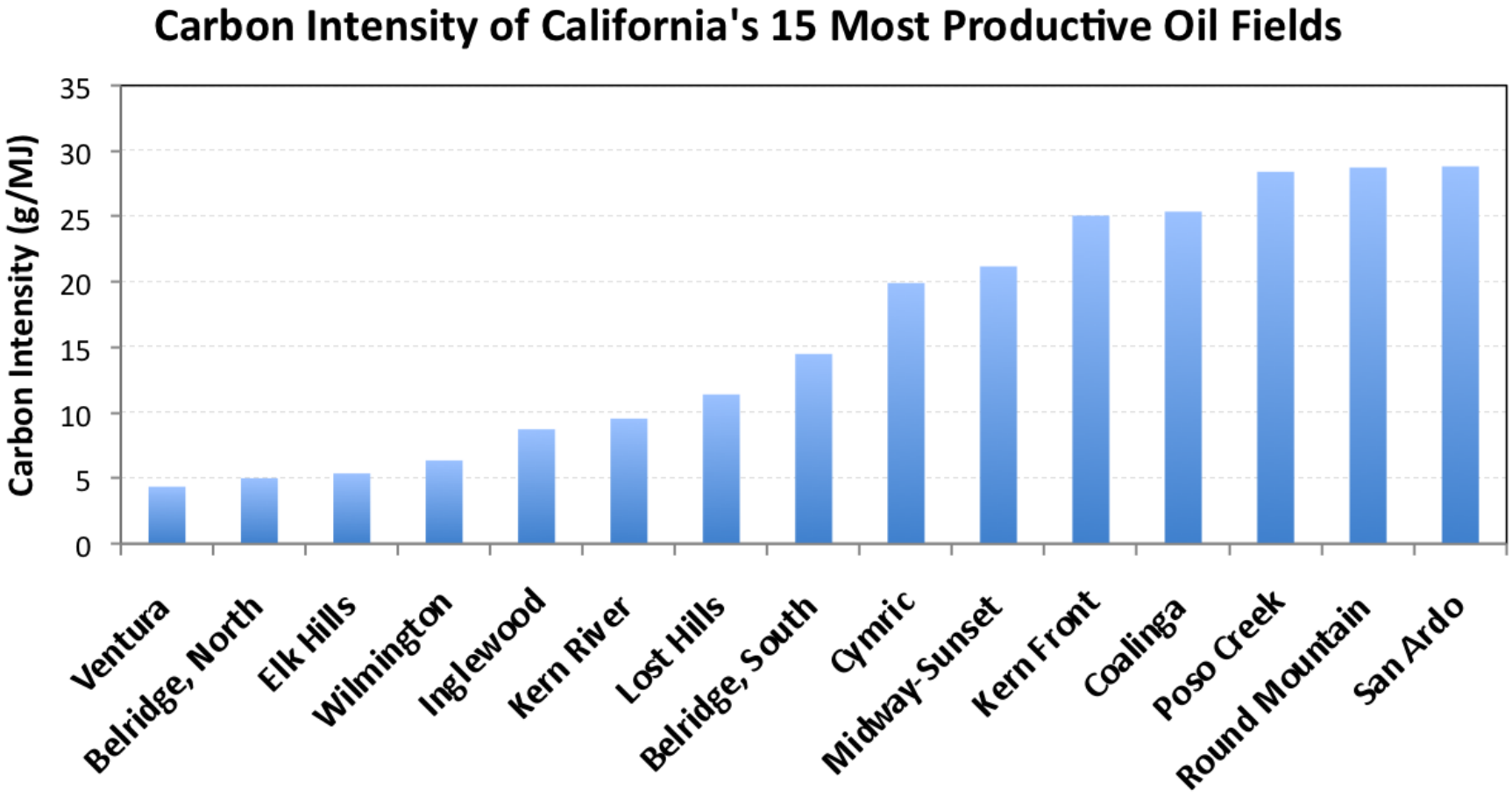
15 Most productive oil fields by carbon intensity



California Air Resources Board (2012)

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An Independent Scientific Assessment of Well Stimulation in California

Chapter Six

Potential Impacts of Well Stimulation on Human Health in California

Seth B. C. Shonkoff[1,2,3], Randy L. Maddalena[3], Jake Hays[1,4], William Stringfellow[3,5], Zachary S. Wettstein[6], Robert Harrison[6], Whitney Sandelin[5], Thomas E. McKone[3,7]

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6.1. Abstract

This chapter addresses environmental public health and occupational health hazards that are directly attributable to well stimulation or indirectly associated with oil and gas development facilitated by well stimulation in California. Hazards that are directly attributable to well stimulation primarily consist of human exposures to well stimulation chemicals through inadvertent or intentional release to water, air, or soil followed by environmental fate and transport processes. Hazards that are indirectly associated with well-stimulation-enabled oil and gas development also include chemicals and environmental releases. Such hazards may not be directly related to well stimulation, but rather could result from expanded development that is enabled by well stimulation.

The risk factors directly attributable to well stimulation stem largely from the use of a very large number and quantity of stimulation chemicals. The number and toxicity of chemicals used in well stimulation fluids make it impossible to quantify risk to the environment and to human health. To gain insight on the potential of chemicals used in stimulation to harm human health, we used a ranking scheme that is based on toxic hazards of chemicals and reported quantities used in well stimulation operations. The ranking includes both acute and chronic toxicity. (Note that these same chemicals were ranked for aquatic toxicity in Volume II Chapter 2.)

Chapter Four

A Case Study of the Petroleum Geological Potential and Potential Public Health Risks Associated with Hydraulic Fracturing and Oil and Gas Development in The Los Angeles Basin

Seth B. C. Shonkoff[1,2,3], Donald Gautier[4]

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[2]Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA
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4.1. Introduction to the Los Angeles Basin Case Study

The Los Angeles Basin is unique in its exceptional natural concentration of oil directly beneath a dense urban population. In few other places in the world has simultaneous petroleum development and urbanization occurred to such an extent. Conflicts of oil and city life are not new to Los Angeles, but recent reports suggesting the possibility of additional large-scale oil production enabled by hydraulic fracturing, coupled with the ever increasing encroachment of urbanization on the existing oil fields, lends a particular urgency to the need to understand the public health implications of having millions of people who live, work, play, and learn in close proximity to billions of barrels of crude oil.

The Los Angeles Basin Case Study contains two components. In Section 4.2, Gautier reviews the history and current trends of oil production in the Los Angeles Basin combined with a geology-based analysis of the potential for additional petroleum development. We conclude in this section that oil production in the Los Angeles Basin has been in decline for years, and that continued oil development is likely to be within existing oil fields rather than widespread development of previously undeveloped source-rock (shale tight oil) resources outside of these boundaries. Based on this scenario of future oil development, in the second part of the Los Angeles Basin Case Study, Section 4.3, Shonkoff and colleagues

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Public Health Risk Factors of Hydraulic Fracturing and O&G Development in CA

1. Oil and gas development and elevated toxic air contaminant concentrations **near human populations**
2. Large numbers of **chemicals** and lack of information
3. Use of produced water for **irrigation of crops** without appropriate testing and treatment
4. Disposal of produced water with chemicals in **percolation pits**, especially near quality water aquifers that are or could be used for human consumption
5. **Shallow hydraulic fracturing** near protected aquifers that are or could be used for human consumption
6. **Disposal of produced water into aquifers** that are or could be used for human consumption
7. Elevated VOC and silica exposures in **occupational** settings

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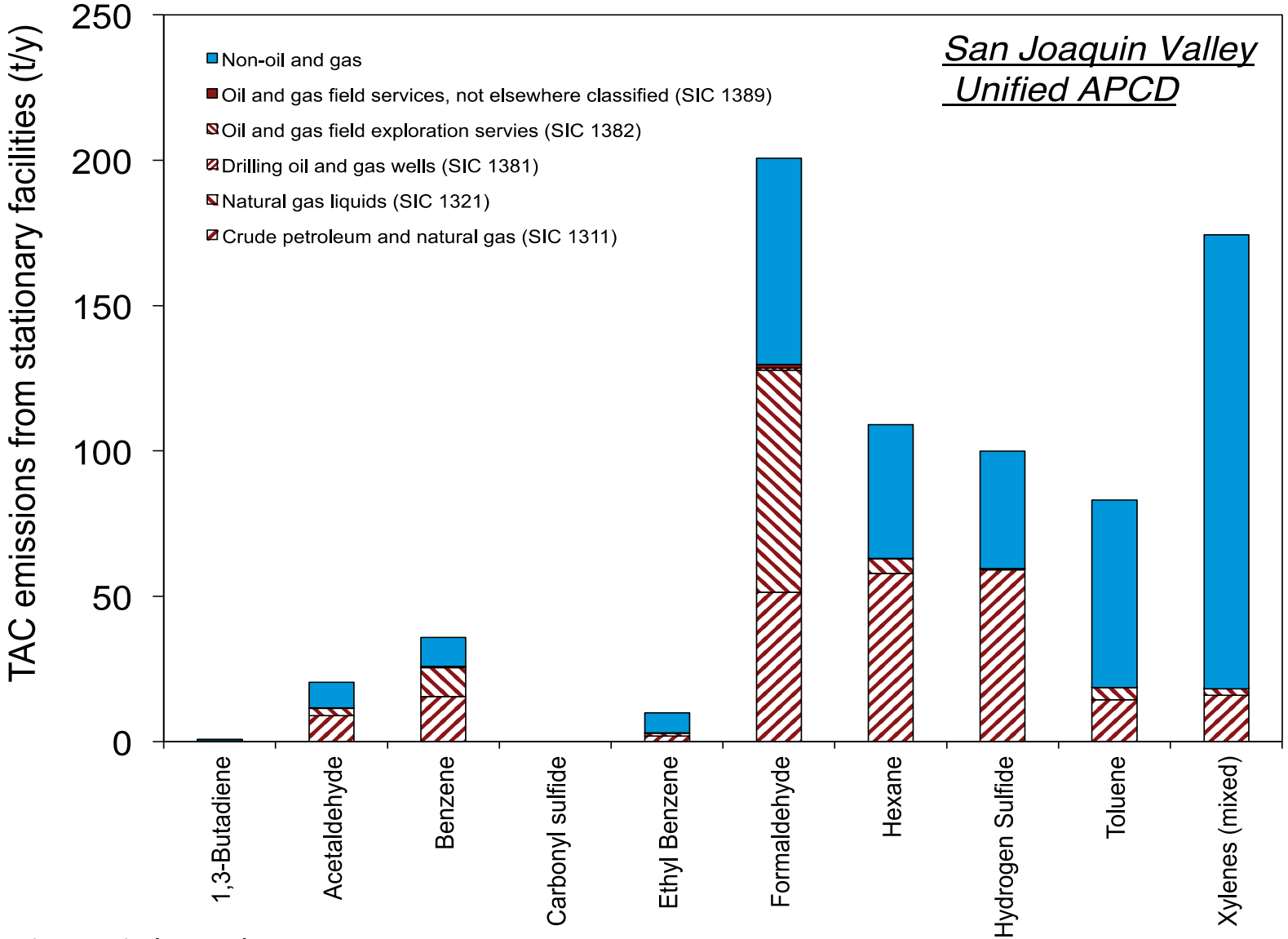
Summed facility-level toxic air contaminant (TAC) emissions in San Joaquin Valley



Brandt et al. (2015)

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Increased incidence of Birth Defects with increased *Density* of Gas Development

Neural Tube Defects:
Highest tertile of exposure
OR = 2.0, 95% CI: 1.0, 3.9

Congenital Heart Disease:
Highest Tertile of Exposure
OR = 1.3 for the highest tertile
(95% CI: 1.2, 1.5)

McKenzie et al. (2014)

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Increase Risk of Preterm Births

Association between UNGD activity and preterm birth that increased across quartiles, with a fourth quartile odds ratio of 1.4 (95% conf. int.= 1.0, 1.9).

Casey et al. (2015)

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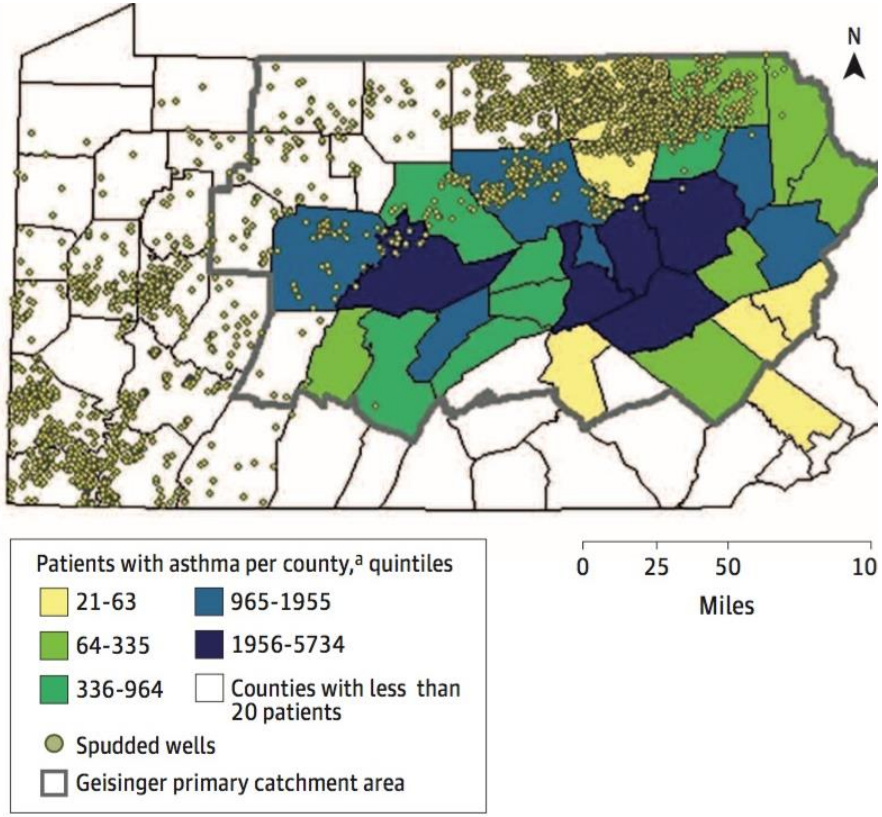
Exacerbation of Asthma

- 35,508 asthma patients in Geisinger electronic health records (Northeast PA)
- Odds ratios (ORs) – high vs. low gas development activities (stimulation, production,
  - **1.5** (95% CI, 1.2-1.7) for the association of the pad metric with **severe** exacerbations
  - **4.4** (95% CI, 3.8-5.2) for the association of the production metric with **mild** exacerbations.



Rasmussen, et al. 2016.

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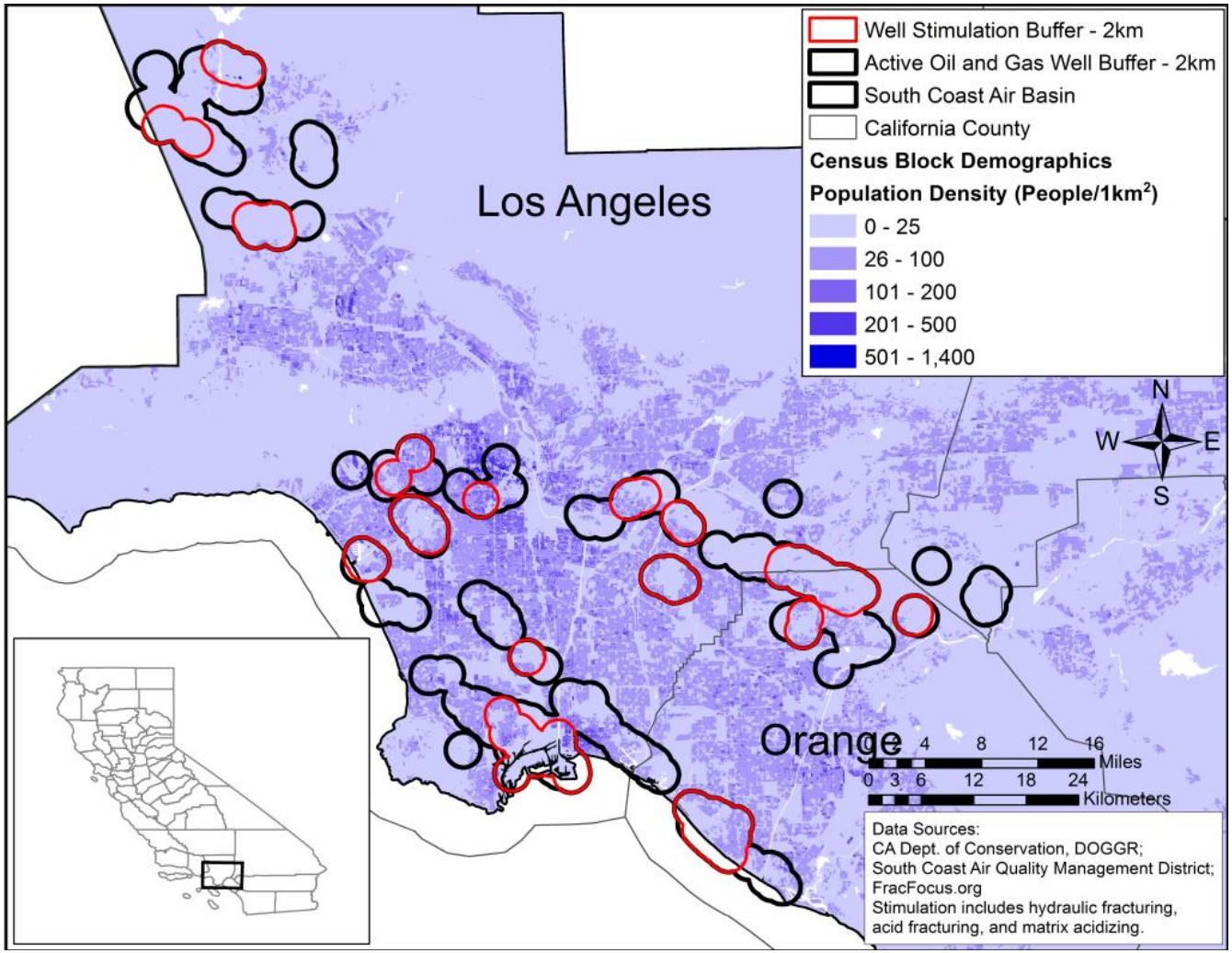
Population density within 2000 meters of currently active oil production wells



Shonkoff, et al. (2015)

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Proximity of human populations and sensitive receptors to active oil wells in the South Coast Air Basin

Buffer Distance (m)	Number of Residents	Number of Schools	Number of Children Attending Schools	Number of Elderly Facilities	Number of Daycare Facilities	Under 5	Over 75
100	32,071	4	3,290	12	5	2,295	1,664
400	233,102	50	34,819	94	72	16,685	14,005
800	627,546	130	89,241	213	184	45,050	35,189
1,000	866,299	180	135,797	258	262	62,547	47,759
1,600	1,677,594	348	242,833	429	524	122,321	91,452
2,000	2,257,933	470	332,855	582	718	164,992	122,737

Shonkoff, et al. (2015)

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Air Pollution and Human Health Recommendations

Research:

- Initiate studies in California to assess air pollutant exposures as a function of distance *(and density)* for all types of oil and gas development, not just stimulated wells

Policy:

- Develop science-based surface setbacks to limit exposures.
- Require the application of air pollutant emission control technologies for all relevant oil and gas infrastructure

Long et al., CCST Steering Committee (2015)

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Aquifer Recharge with Oilfield Produced Water

Photo Credit: Todd D'Addario

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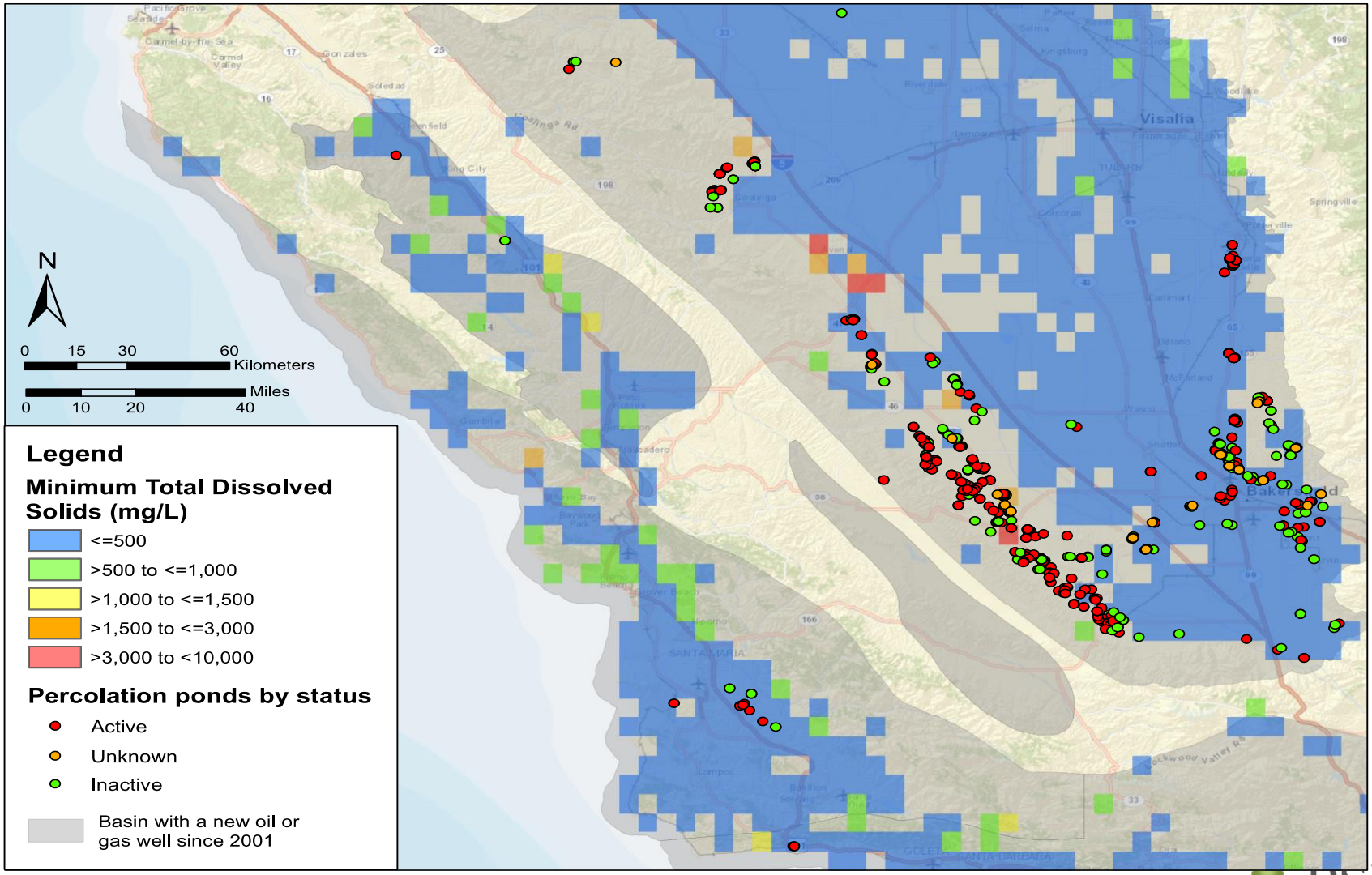
Location of percolation pits used for produced water disposal and the location of groundwater of varying quality

Data from Central Valley Regional Water Quality Board



Long et al., CCST Steering Committee (2015)

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Disposal of Produced Water in Percolation Pits

- Produced water disposed in percolation pits likely contains hydraulic fracturing chemicals, associated breakdown products, and health-damaging naturally occurring constituents
- **"Unregulated percolation pits present an unjustified risk to water supply, wildlife, vegetation, and human health"**

- ***Recommendation:*** *Ensure safe disposal of produced water in percolation pits with appropriate testing and treatment or phase out this practice.*

Long et al., CCST Steering Committee (2015)

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Produced Water Reused For Food Crop Irrigation, Livestock Watering and Aquifer Recharge

Photo credits: Lauren Sommer/KQED

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Risks of Reuse of Produced Water for Food Crop Irrigation

Conclusions:

- The majority of well stimulation chemicals are unlikely to be removed using typical or common water treatment systems (Oil-water separators)
- Nothing to prevent chemical additives from entering the food system or coming into contact with workers
- ***Recommendation:*** *Produced water should not be used for irrigation or groundwater re-charge until or unless appropriate testing shows non-hazardous chemical concentrations, or required water treatment reduces concentrations to non-hazardous levels.*

Long et al., CCST Steering Committee (2015)

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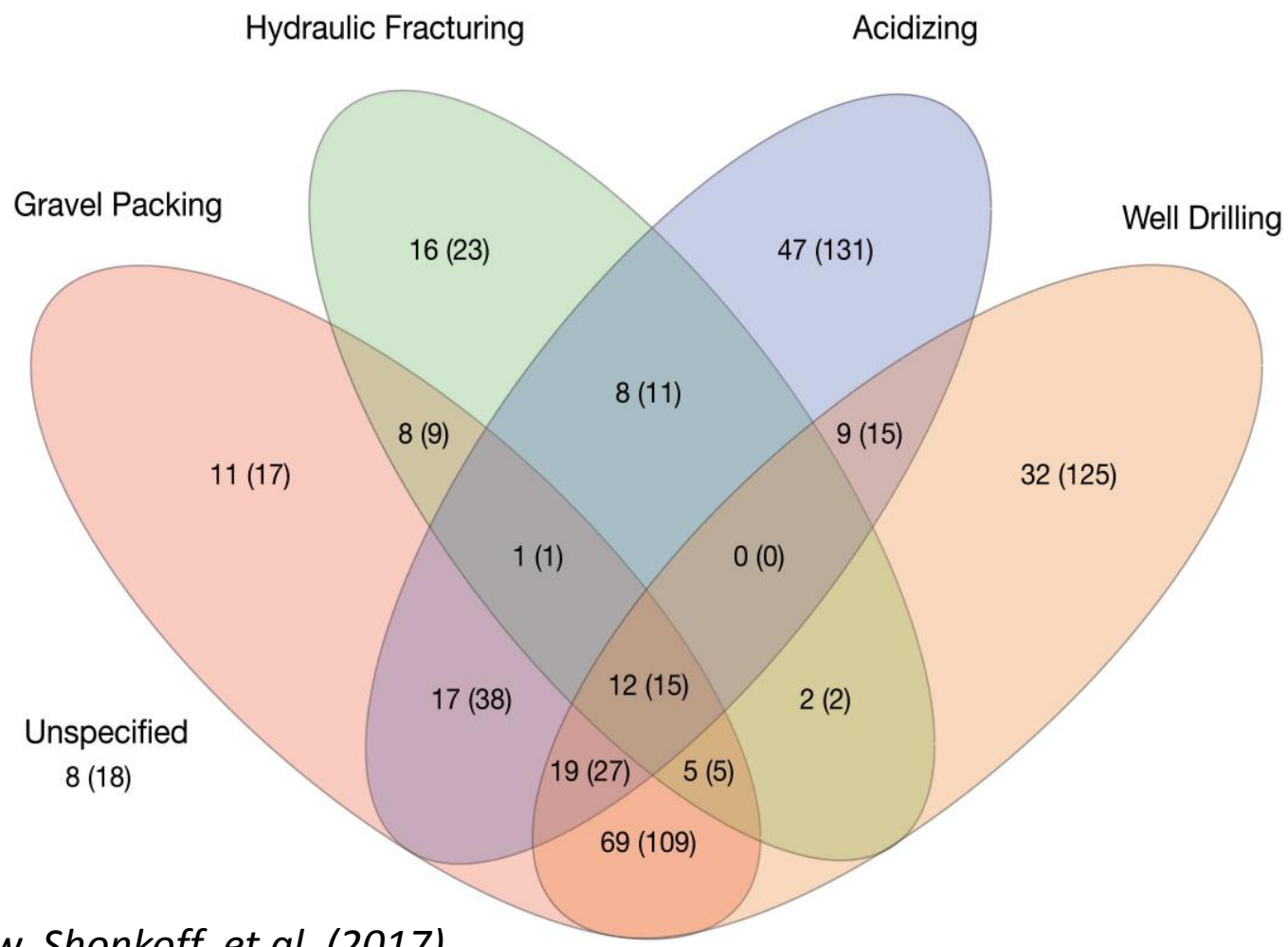
Overlap of Chemical Usage According to Activity (SCAQMD)



Stringfellow, Shonkoff, et al. (2017)

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Summary of Available Chemical data for Routine O&G Operations (Drilling, Routine Maintenance, etc.)

Number of chemicals	Proportion of all Chemicals	Identified by unique CASRN	Toxicity	Quantity of use
151	30%	Available	Available	Available
1	0%	Available	Available	Unavailable
97	18%	Available	Unavailable	Available
43	8%	Unavailable	Unavailable	Available
233	44%	Unavailable	Unavailable	Unavailable

Note: These data do **NOT** include chemicals from hydraulic fracturing or matrix acidizing events

Stringfellow, Shonkoff, et al. (2017)

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Additional Considerations

- 8 chemical additives are on the **California Proposition 65 List**
- 8 chemical additives are on the list of **U.S. EPA National Primary Drinking Water Standard and Health Advisory chemicals**
- 10 chemical additives are classified by the **International Agency for Research on Cancer** as carcinogenic or possibly carcinogenic in humans
- Bioconcentration factor data available for 86 chemicals, of which only 1 was considered **bioaccumulative**
- 11 chemical additives are considered hazardous air pollutants according to the **Clean Air Act**
- 5 chemical additives are categorized as "category 1 and 2" in the Globally Harmonized System (GHS) for **mammalian toxicity**
- 39 chemical additives are categorized as "category 1 and 2" in the Globally Harmonized System (GHS) for **ecotoxicity**

Shonkoff et al. (2016)

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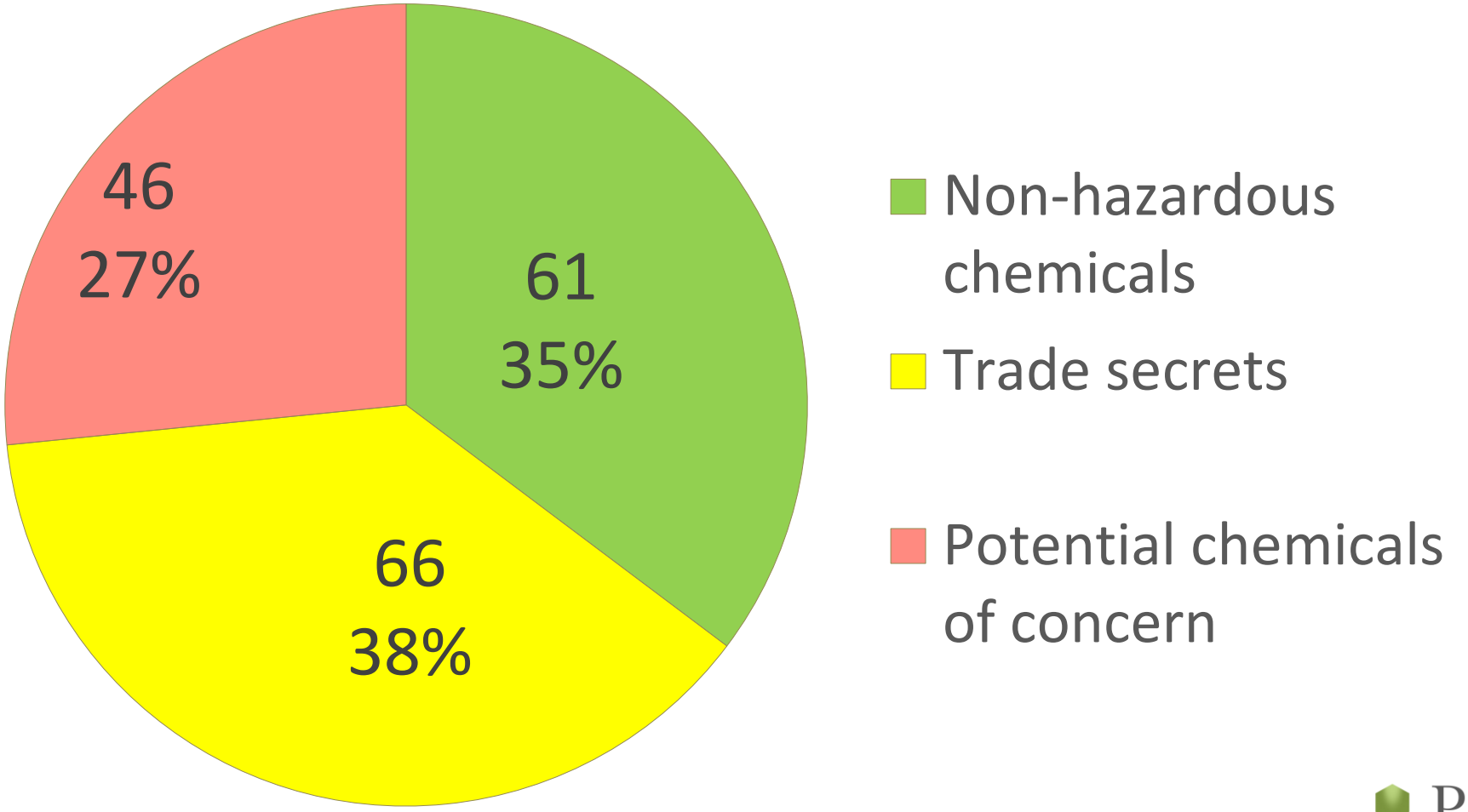
Oilfield Chemicals Results Summary - SJV

173 total chemical additives were disclosed



Shonkoff et al. (2016)

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Parallels with Regulation of Municipal Wastewater Reuse (Title 22 of the CA Code of Regulations)

- Municipal wastewater recycling in California is regulated by Title 22 of the California Code of Regulations, which establishes water quality standards specific for different uses.
- Comprehensive policy for water reuse, including uniform statewide rules, developed in 2008 by the State Water Board and the Department of Public Health.
- Guidelines include detailed treatment, testing protocols matching water quality to use:
  - Fodder crops, non food-bearing trees, sod farms, etc.
  - Crops where the edible portion is above ground and does not contact the recycled water, pasture for animals producing milk
  - Food crops where the recycled water comes into contact with the edible portion of a food crop eaten raw).

Adapted from Heberger & Donnely (2015)

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Policy Recommendations

- All chemicals used in oil and gas development ***from all activities*** should be publicly disclosed in a manner analogous to Senate Bill 4 in California.
- Conduct an independent scientific study of the environmental public health dimensions of "beneficial reuse" of oil field produced water, especially for irrigation of food crops, watering livestock and recharging aquifers to inform state-level policies on this issue.
- Implement the recommendations from SB 4 CCST Independent Scientific Study *with updated information on chemical additives.*
- Follow procedural precedent for development of Title 22 rules – regulations for municipal wastewater reuse

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Thank you

Questions?

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