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Overview of the Regional Groundwater Monitoring Program

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SB4 Regional Groundwater Monitoring Program - Water Quality in Areas of Oil and Gas Production

U.S. Department of the Interior
U.S. Geological Survey

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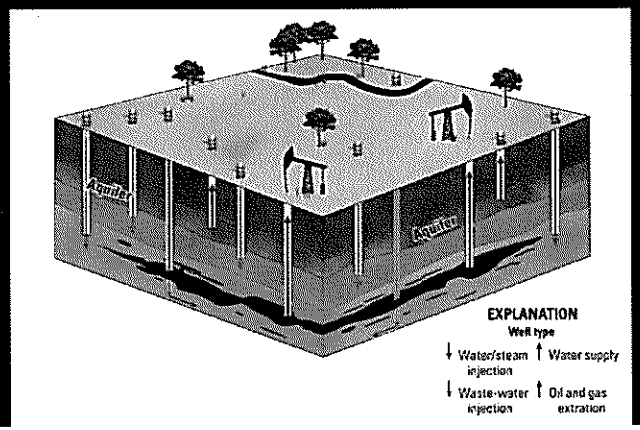
Regional Monitoring Program (RMP) Questions:

- Where are protected groundwater (GW) resources?
- How close are oil/gas operations and protected GW, and what geologic materials separate them?
- Where is there evidence of oil/gas fluids in protected GW? Where does evidence indicate no connections?
- When oil/gas fluids are present in protected GW, what pathways or processes are responsible?
- Have oil and gas operations as a whole contributed to water-quality changes in groundwater basins?



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https://ca.water.usgs.gov/projects/oil-gas-groundwater/index.html

RMP Status

- In oil-field study areas
  - Mapping groundwater < 10,000 mg/L dissolved solids
  - Oil-field fluid chemistry characterization
  - Groundwater quality monitoring & analysis
- Work on one or more of these tasks in progress in about 25 oil fields
- Study areas selected from high priority fields

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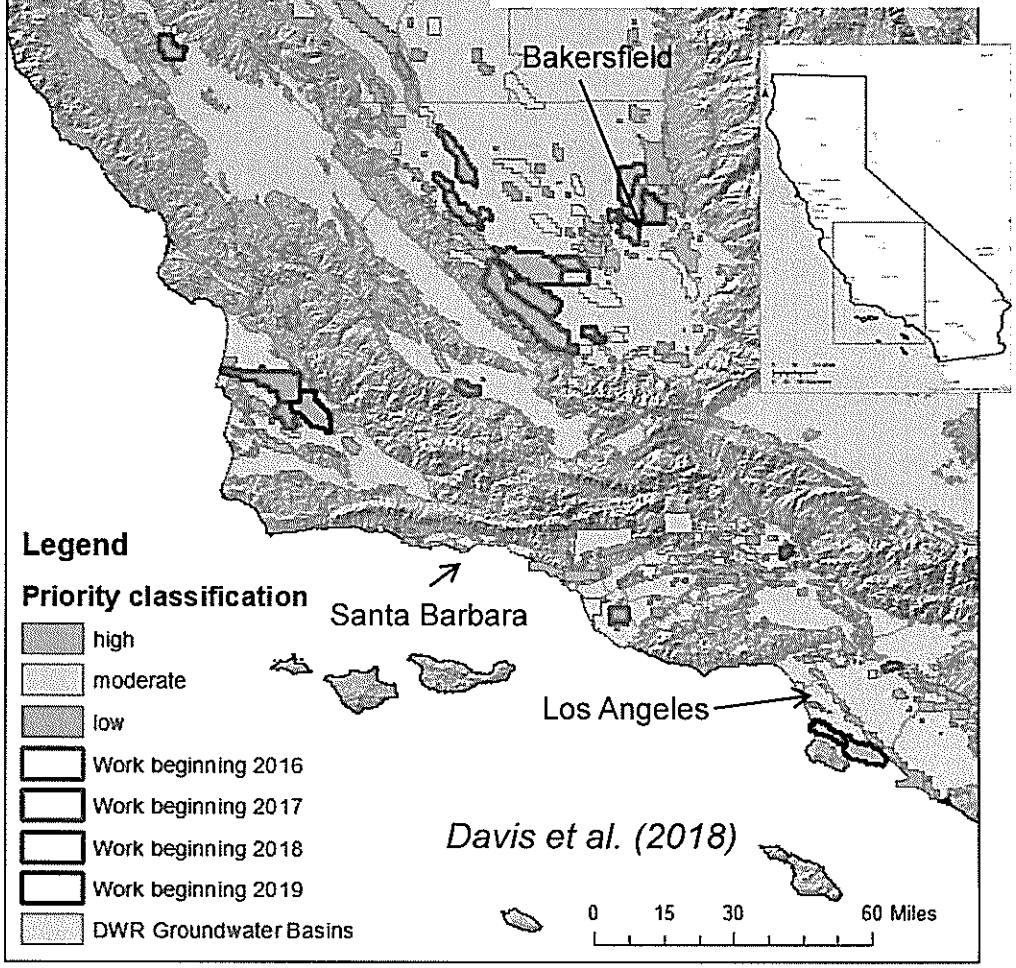
Relative Prioritization of Oil Fields for Regional Monitoring of Groundwater Based on Vertical Proximity, Well Density, & Injection Volumes



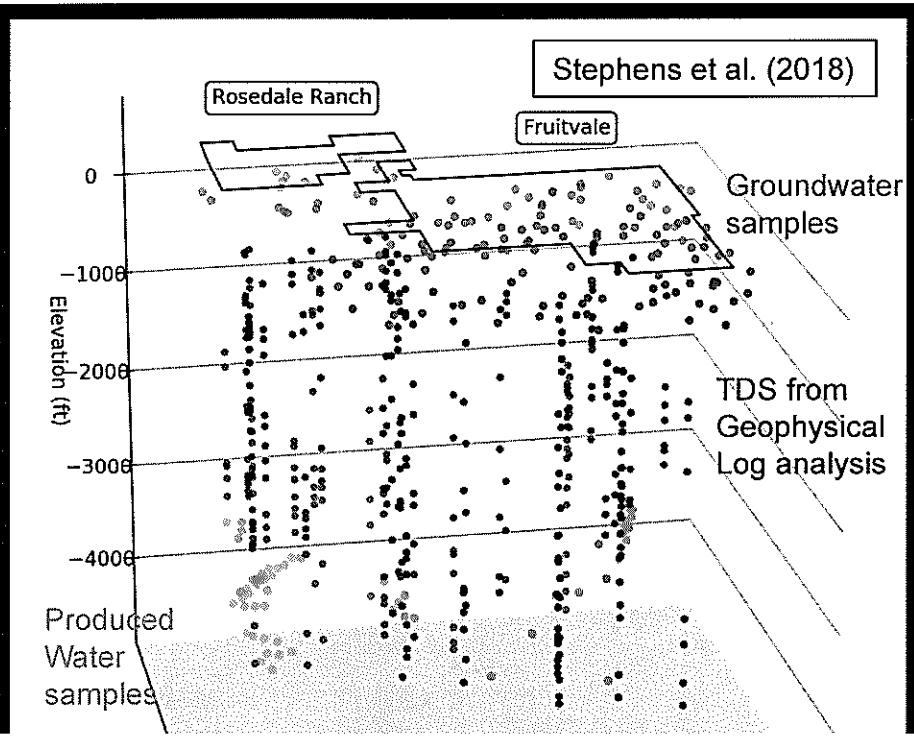
Davis et al. (2018)

Salinity Mapping

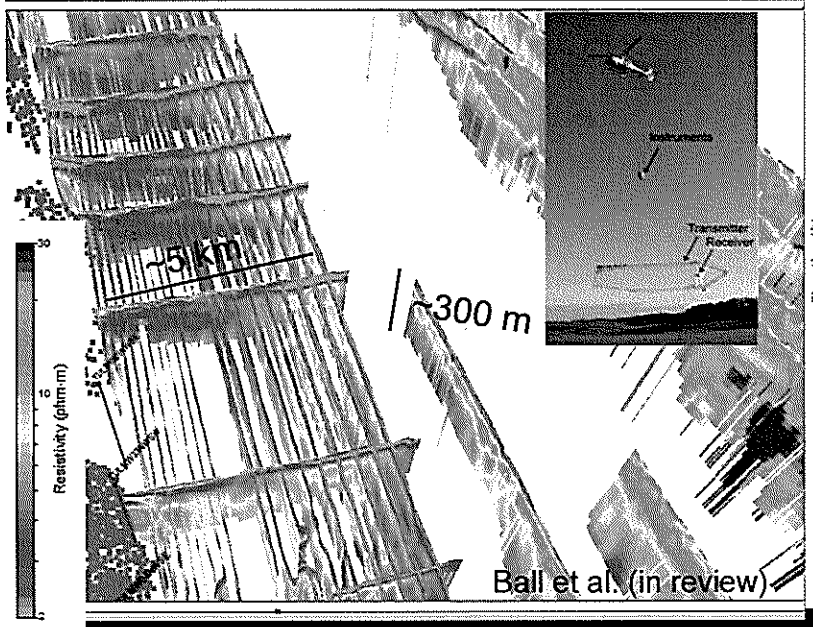
- Where are groundwater resources with <10,000 mg/L total dissolved solids [TDS] in relation to oil & gas development?

Collaborations:

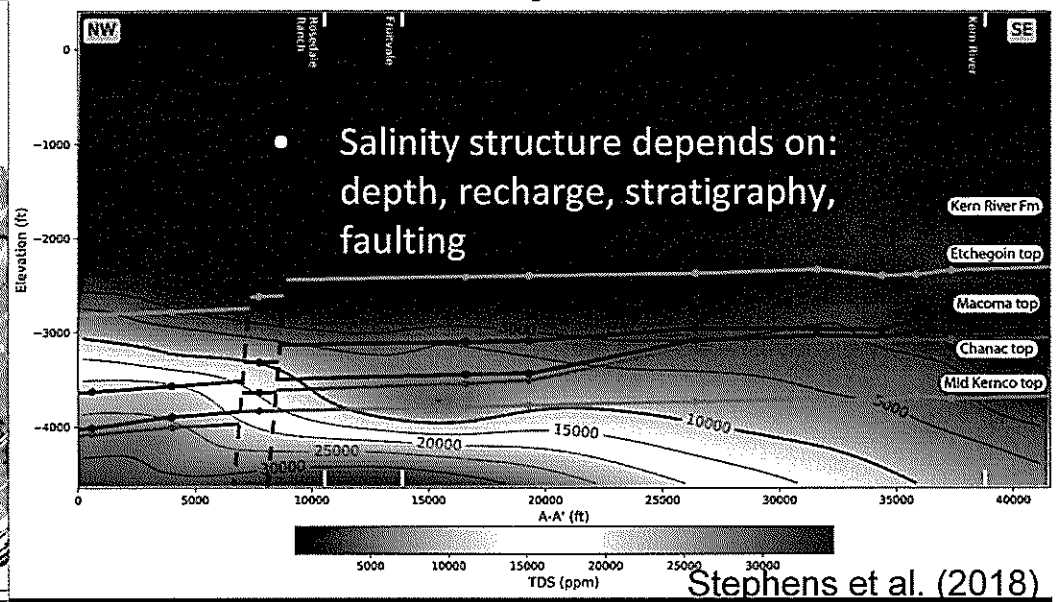
- CSUS (cooperative agreement)
- USGS Geology, Geophysics, & Geochemistry Center, Energy & Minerals Mission Area
- USGS Hydrogeophysics Branch, Water Mission Area



Fruitvale and Rosedale Ranch groundwater TDS cross section A-A'

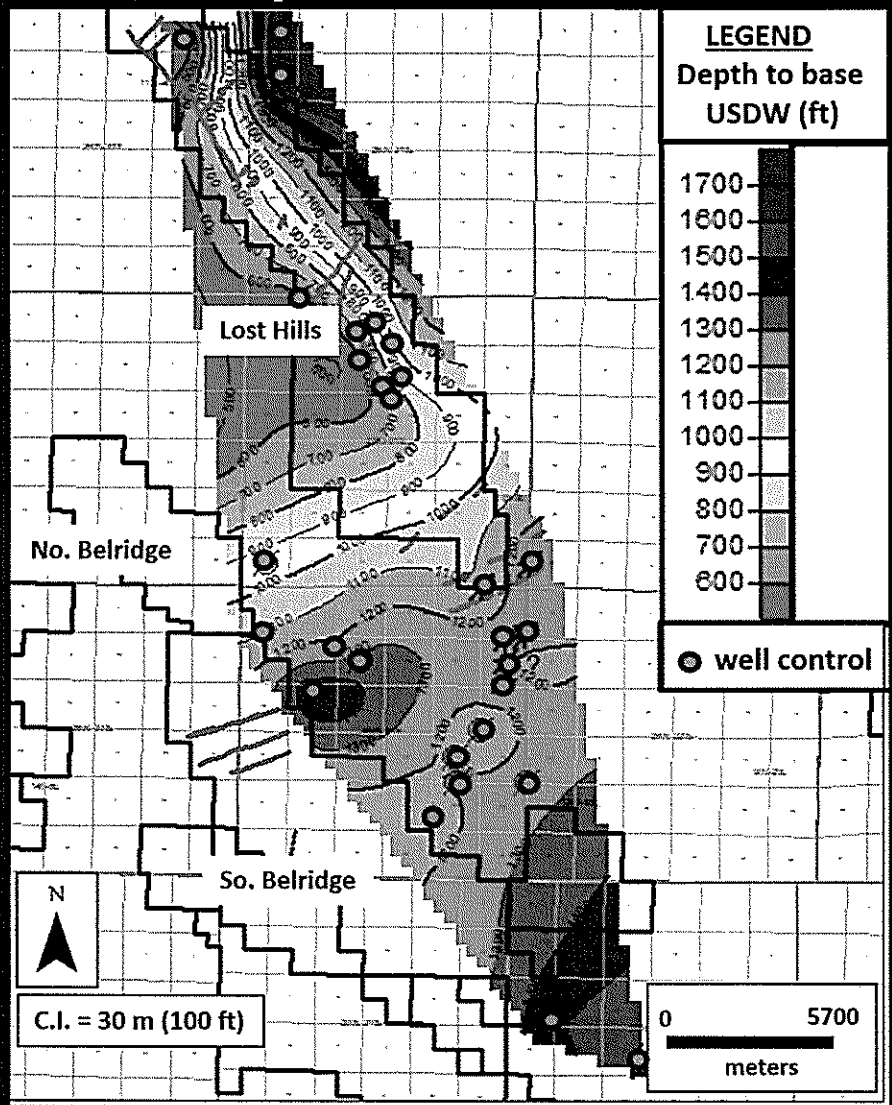


Ball et al. (in review)

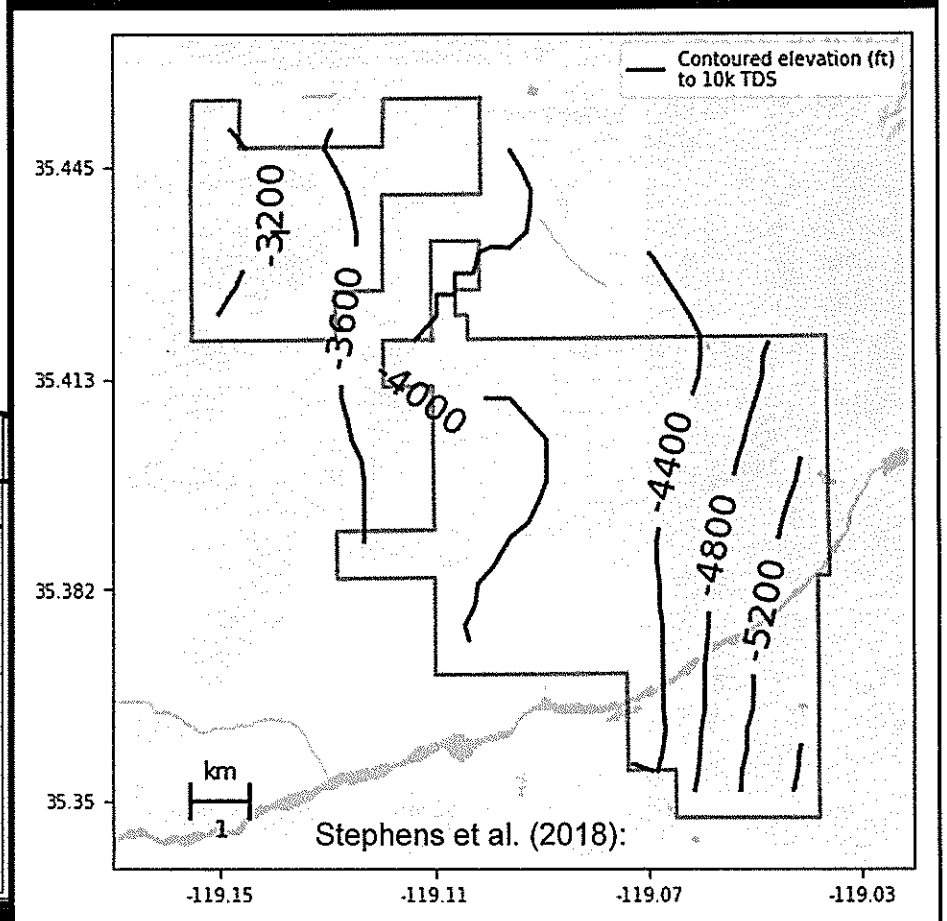


Stephens et al. (2018)

Depth to Base of Freshwater



- Varies by > 1,000 ft across oil-field areas



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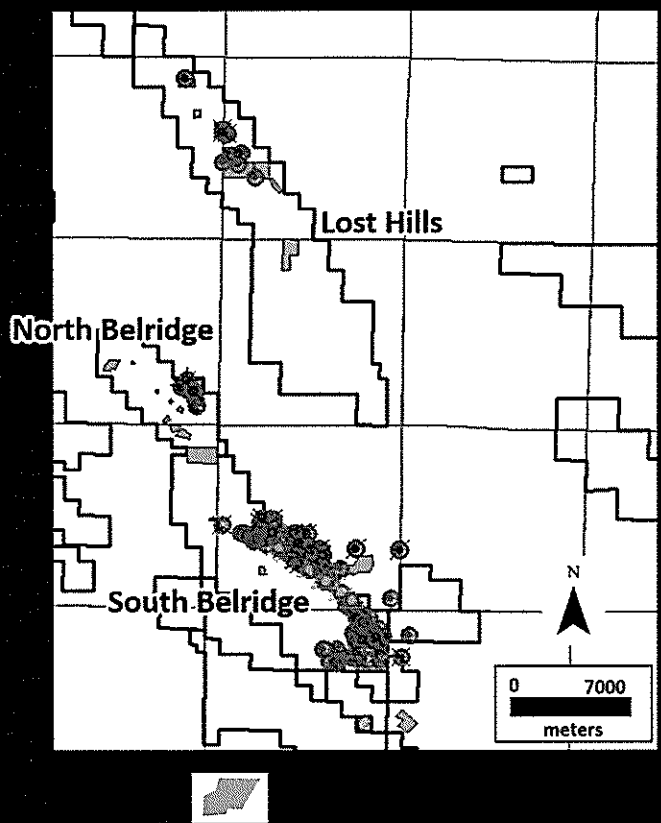
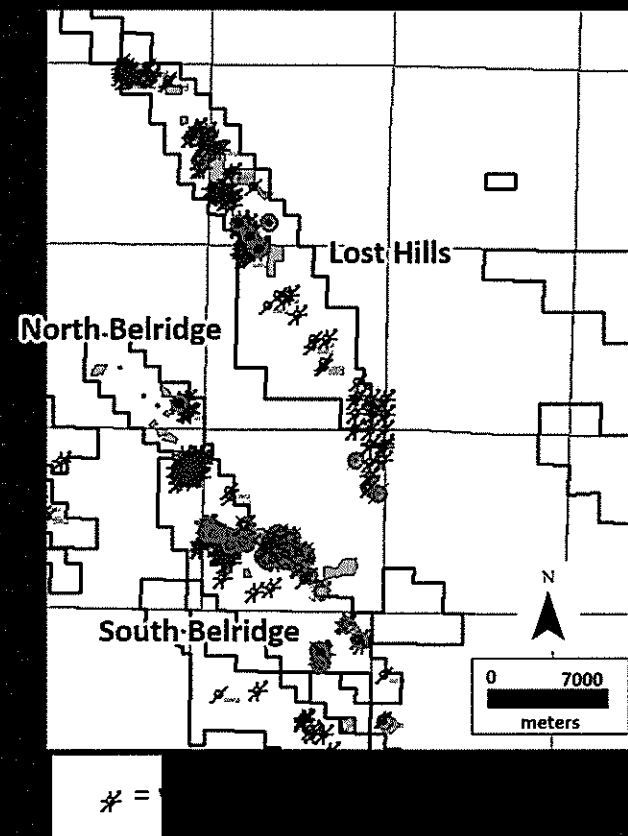
Gillespie et al. (2019): Depth to base of TDS = 10,000 mg/l) based on log analysis. Red lines, faults; Black lines, oilfield administrative boundaries; Logs used, blue dots.

Salinity Affects from Disposal – Geophysical Logs

Geophysical logs showing evidence of increased salinity from pond disposal



Geophysical logs showing evidence of increased salinity from disposal injection



- Well networks also monitor pond disposal in shallow groundwater
- Little data to assess potential lateral movement of disposal injection

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Gillespie et al. (2019)

Regional Monitoring Program – Sampled Areas By 2020

- 2016-19
  - Fruitvale
  - Lost Hills/N & S Belridge
- 2017-20
  - Elk Hills/North Coles Levee
  - Oxnard
  - Orcutt
  - Montebello
- 2018-21
  - Placerita
  - Santa Maria Valley
  - Midway Sunset/Buena Vista
  - San Ardo
  - Kern River
- 2019-22
  - Cat Canyon
  - Poso Creek
  - Wilmington/Torrance

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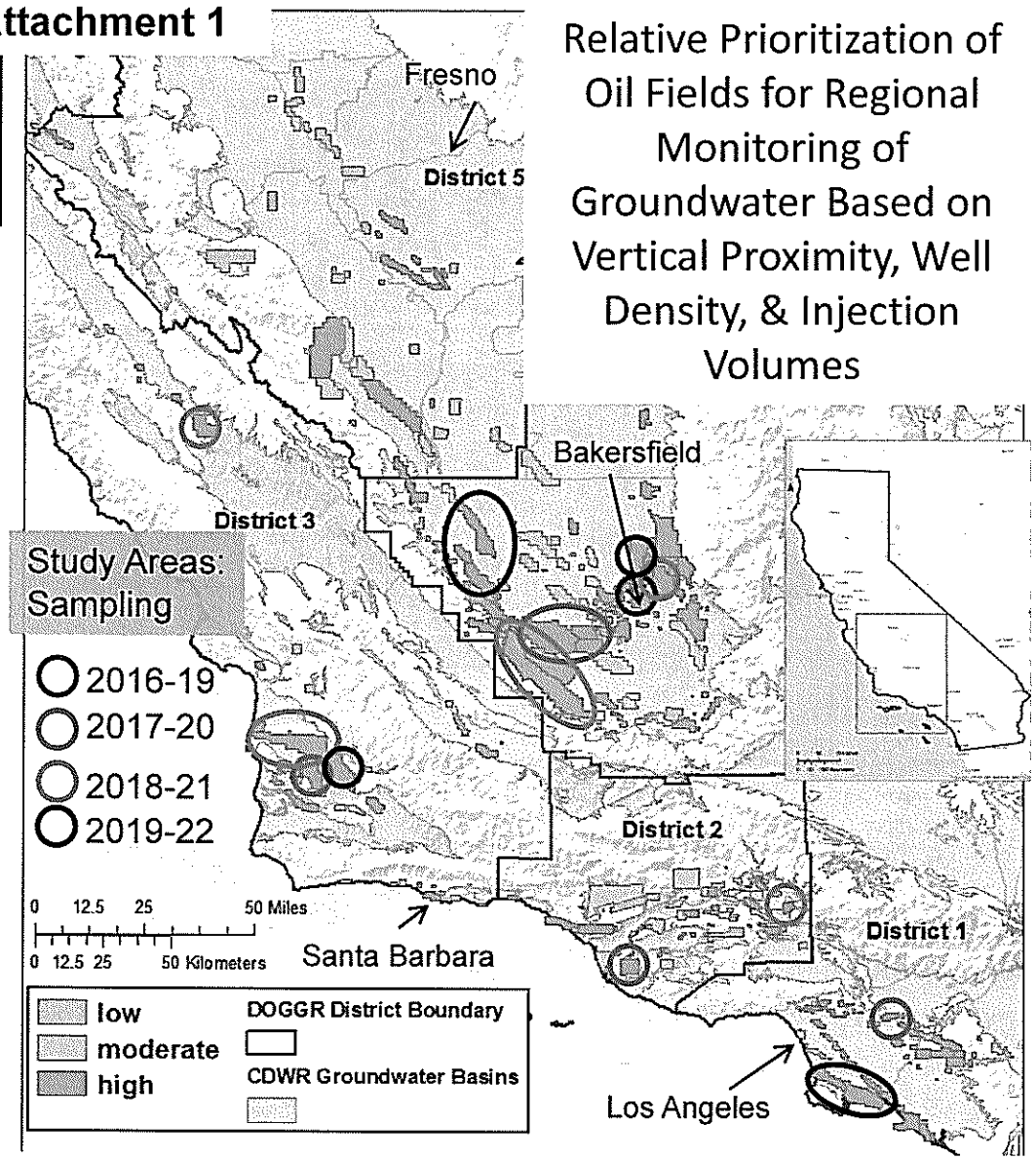
Attachment 1

Relative Prioritization of Oil Fields for Regional Monitoring of Groundwater Based on Vertical Proximity, Well Density, & Injection Volumes



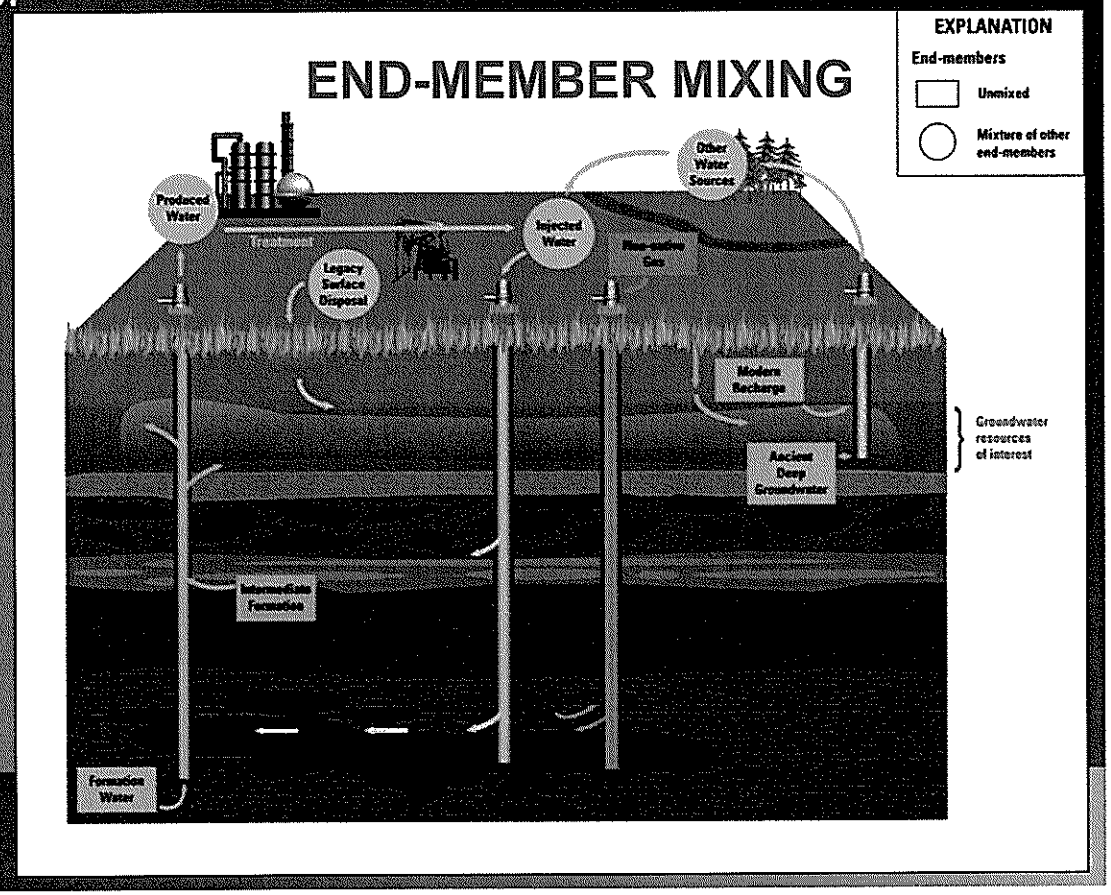
Prioritization categories for consideration in implementing regional groundwater monitoring adjacent to oil fields

Davis et al. (2018)

Sources: Esri, USGS, NOAA

Water-Quality Analysis Approach

- Compile/analyze existing groundwater and oil-field data (including historical water chemistry data)
- Select existing water wells (and oil-field sites) for sampling based on: hydrogeology, oilfield infrastructure, spatial coverage, well availability …
- Sample potential source waters:
  - upgradient groundwater
  - major recharge sources
  - Produced water/gas from:
    - Oil wells
    - Injectate (disposal, water flood)
    - Disposal ponds
- Install monitoring wells at selected locations to fill gaps
- Use multiple lines of evidence to support interpretations



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Chemical Constituents

Inorganic and Radionuclide Characterization

Field parameters (O2, pH, SC, alkalinity, temperature, H_2S)
Inorganics (major and minor ions, trace elements, nutrients),
Radionuclides (Ra-224, 226, 228)

Organic characterization

VOCs, DOC, DOC fluorescence & absorbance, organic acids,
hydrocarbon molecular and isotopic compositions

Fluid mixing, chemical sources, geochemical reactions, and age dating

Various combinations of constituents above plus
δ^2H and $\delta^{18}O$ in water, $\delta^{13}C$ in DIC, $\delta^{11}B$ in dissolved B, $^{87}Sr/^{86}Sr$ in dissolved Sr,
δ^7Li in dissolved Li, noble gases, atmospheric gases, *3H, SF6, 14C*

Similar analyses for produced water and groundwater samples
Italics – groundwater samples only
COGG analytes not part of regulatory monitoring programs

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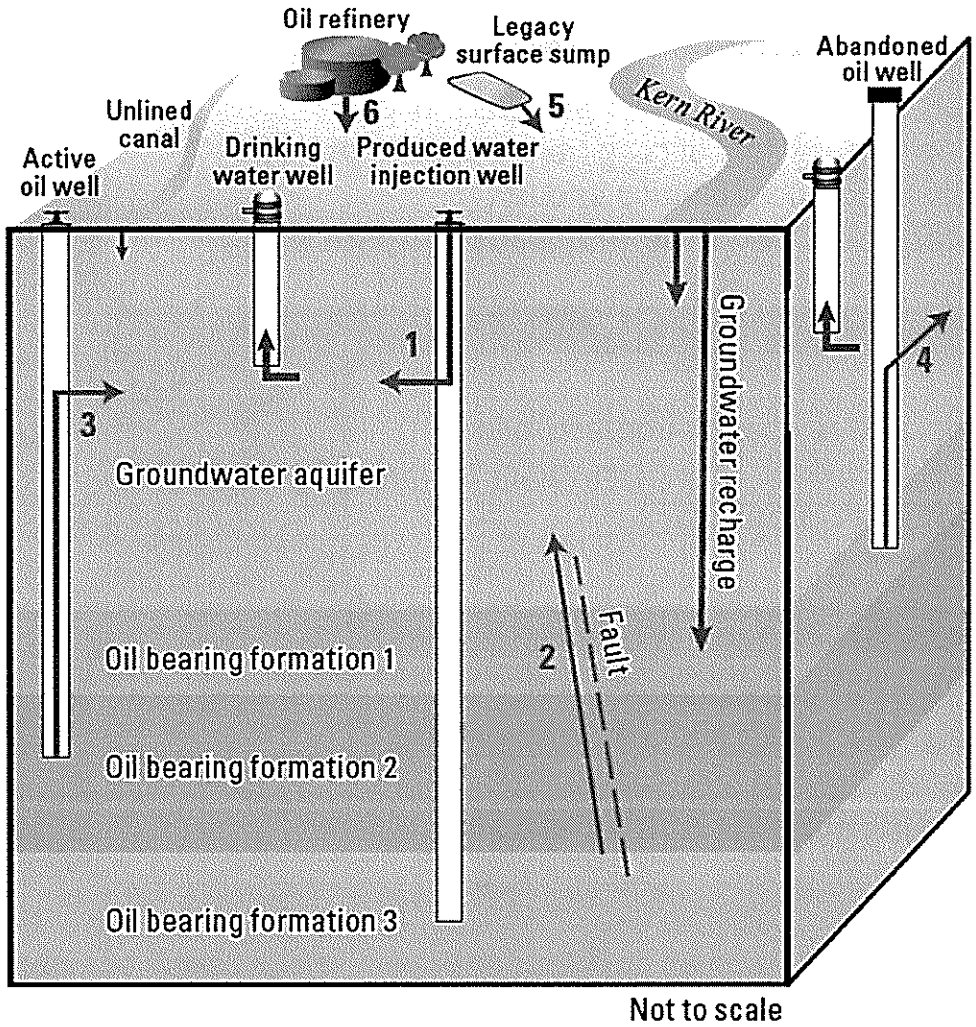
Fruitvale Groundwater Results



- Regional processes (Kern River recharge) controlling groundwater quality
- Thermogenic gas and/or deep formation brine indicators detected in a few wells at trace levels
- Pathways/sources could not be discerned, could include:
  - high injection volumes & oil-well density
  - Historic disposal ponds
  - Natural fluid migration

Wright et al. (2019)

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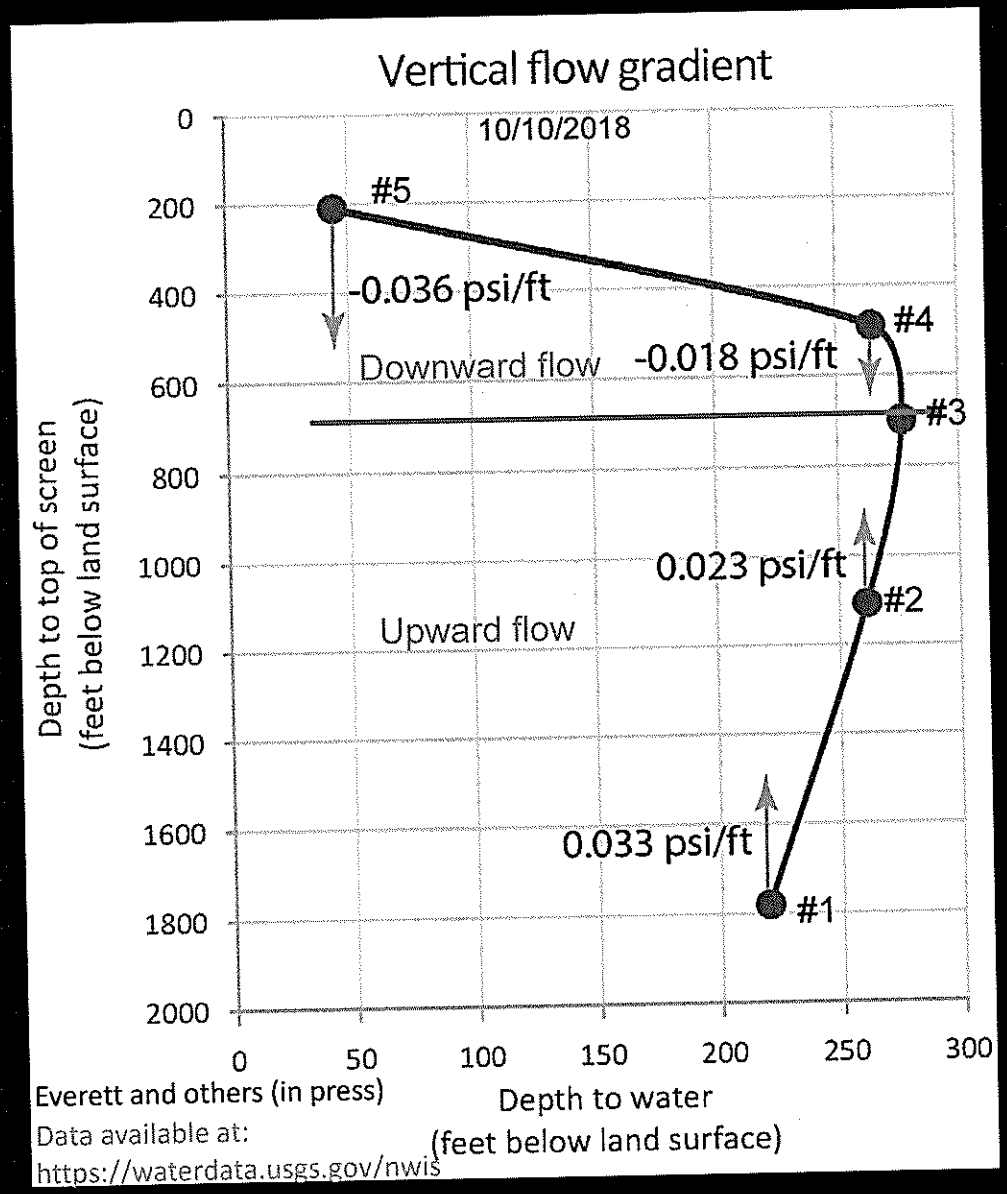
Oil-Field Fluid Sampling Findings

- Large variability in the chemistry of oil-field water exists between fields, with depth of production zones, and in relation to injection processes
- Variability is due to natural and human processes
- Variability indicates sampling in each field is warranted
- Using a diverse set of tracers improves our understanding of this variability & any potential mixing between groundwater and oil-field water
- A limited standard subset of tracers is likely to be insufficient to characterize variability & mixing

McMahon et al. (2018)

Monitoring: Water-Level/Pressure Data

- Needed to understand directions of potential water movement
- Gaps in vertical flow and chemical gradients common
- RMP includes limited well installation to address; 2 drilled so far, 2 in permitting
- Example: Multiple well monitoring site (5 wells) near Lost Hills oil field boundary
- Comparisons to pressure, temperature data in oil zones generally lacking



Everett and others (in press)
Data available at:
https://waterdata.usgs.gov/nwis

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RMP Publications and Documents

- USGS & California Water Board websites

  https://ca.water.usgs.gov/projects/oil-gas-groundwater/index.html

  https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/regional_monitoring/index.shtml

- Includes
  - Published manuscripts
  - Published data
  - Program descriptions
  - Sampling protocols, QA/QC procedures (etc.)

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