



Department of
Conservation



San Joaquin Valley Aquifer Exemptions, UIC Reviews and Produced Water Use

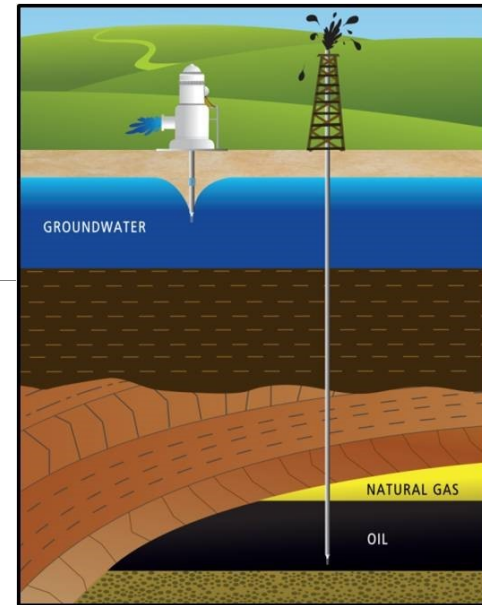
GRA California Oil, Gas & Groundwater 2016

BILL BARTLING – INLAND DISTRICT DEPUTY

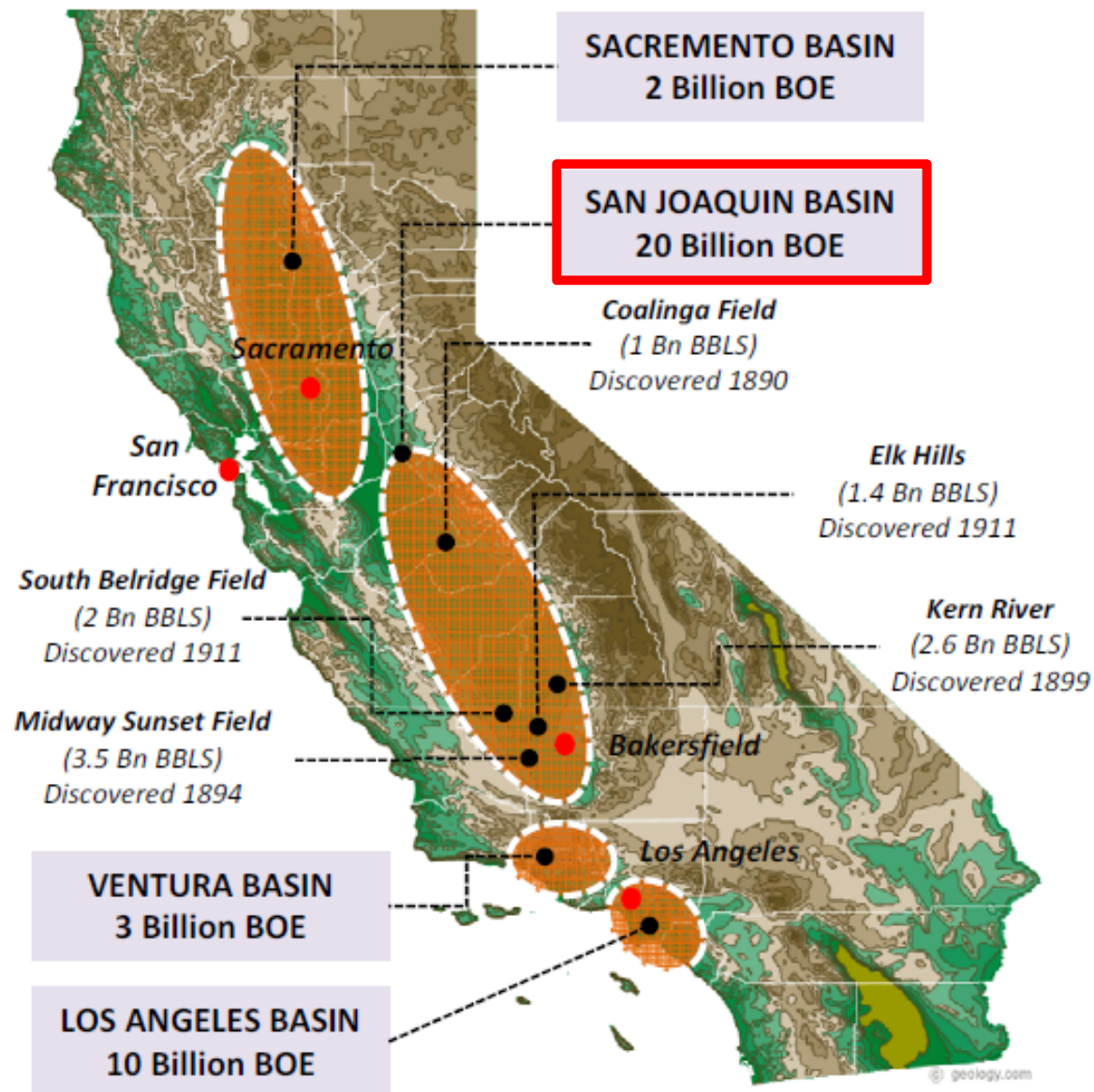
DEPARTMENT OF CONSERVATION

DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

NOVEMBER 2, 2016 – BAKERSFIELD, CA



Oil in California



DOGGR mission

Three elements form the foundation for DOGGR operations.

The Aquifer Exemption and UIC technical analyses have an emphasis on protection of waters with beneficial use. Beneficial uses of water include:

- Public drinking water supplies
- Residential use
- Agriculture and livestock
- Industrial
- Enhanced oil recovery



The Division supervises the drilling, operation, maintenance, and P&A of oil, gas, and geothermal wells, to prevent damage to:

1. life, health, property, and natural resources
2. ***underground and surface waters suitable for irrigation or domestic use***
3. oil, gas, and geothermal reservoirs



questions

oil and gas production provides broad economic and social benefits, but it also comes with risks that must be effectively addressed

Water Quality

- aquifer exemption process and UIC reviews protect Underground Sources of Drinking Water (USDW)

Hydraulic Fracturing

- first two permits issued under SB4 law - process was rigorous – took over a year

Earthquakes

- State Geologist has concluded that unlike in Oklahoma, there is no evidence for historic seismicity in California induced by oilfield activities
- California oilfields are operationally different from Oklahoma and the geology here is not conducive to generating earthquakes from oilfield activities
- nevertheless, we continue to monitor and study earthquakes

Fugitive emissions

- Aliso Canyon illuminated the issue
- many studies underway, new legislation under consideration



significant legislation and regulations

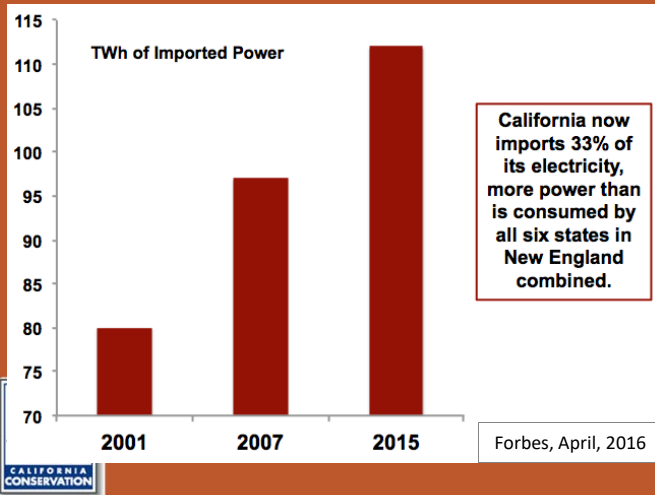
- **Legislation**
 - Idle and orphan wells
 - Gas storage
- **Regulations**
 - Idle and orphan wells
 - Gas storage
 - Steam operations
 - Surface expressions
 - UIC updates
 - Facilities



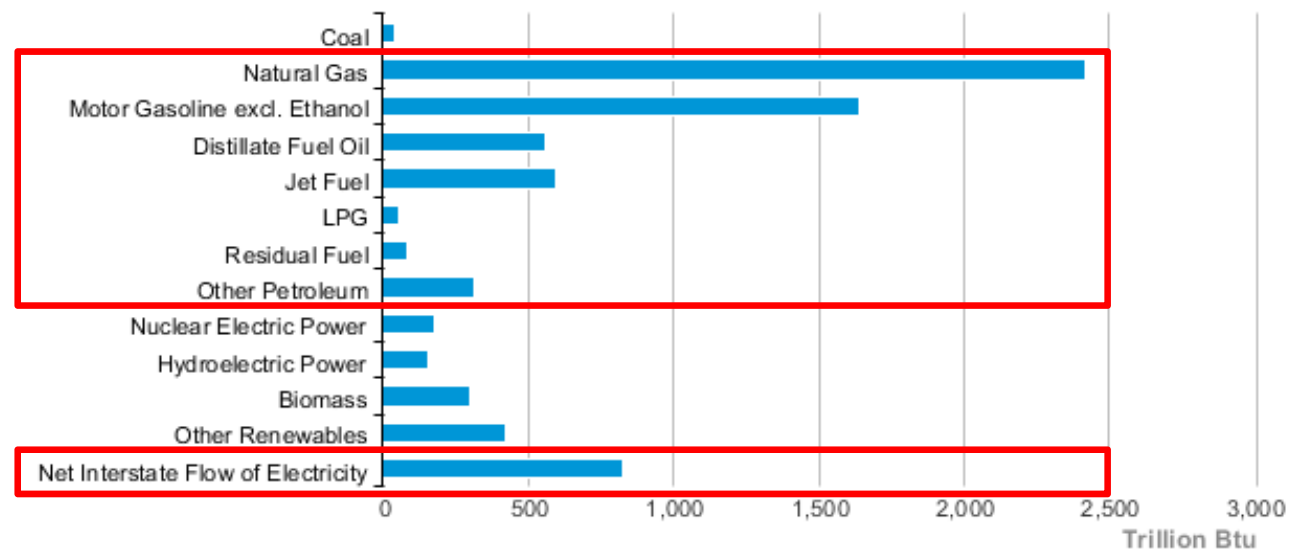
petroleum remains the overwhelmingly dominant source of energy in California

In 2016, California imported 33% of electricity used

This is up from 25% in 2010.



California Energy Consumption Estimates, 2014



Source: Energy Information Administration, State Energy Data System

annual petroleum commerce in California

there is more to a barrel of oil than
gasoline

nearly \$60 billion in annual taxes from
California oil operations

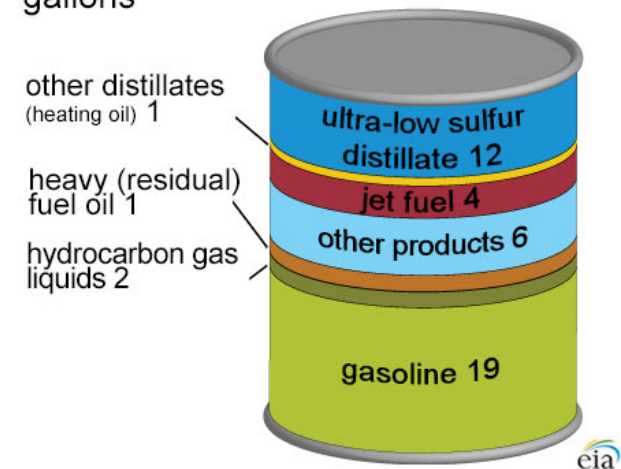
Total Economic Contribution

- 455,940 direct, indirect and induced jobs
- \$38 billion in total labor income
- \$72 billion in value added, accounting for 3.4 percent of state GDP
- \$204 billion in output, accounting for 5.7 percent of California total.

Total Fiscal Contribution

- \$21.2 billion in state and local tax revenues
- \$12.8 billion in federal taxes
- \$18.9 billion in sales and excise taxes
- \$2.1 billion in corporate income taxes

Petroleum made from a barrel of crude oil, 2015 gallons

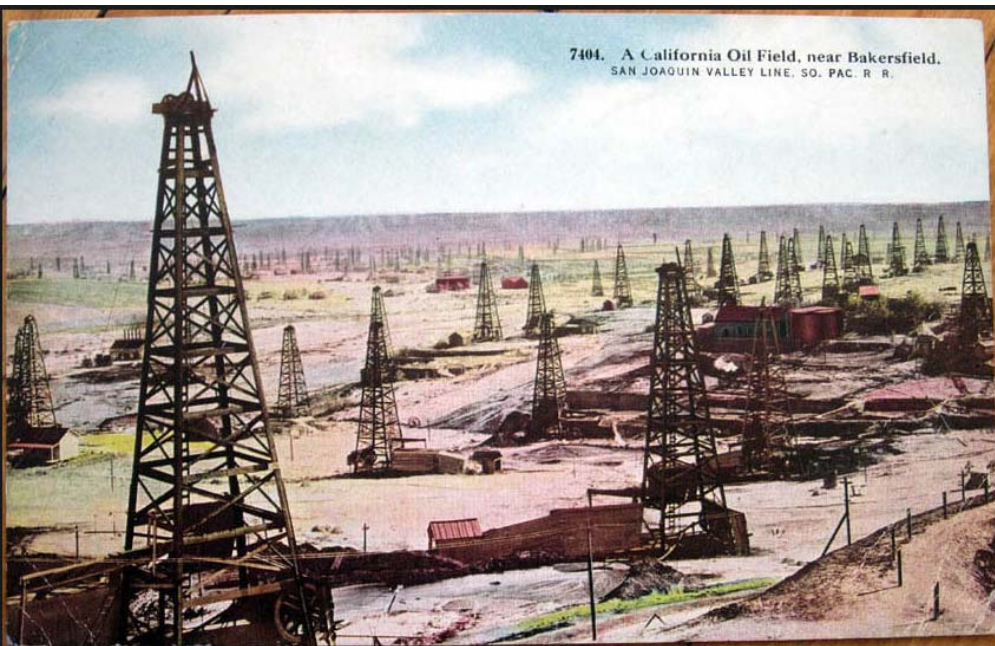


Note: A 42-gallon (U.S.) barrel of crude oil yields about 45 gallons of petroleum products because of refinery processing gain. The sum of the product amounts in the image may not equal 45 because of independent rounding.

Source: U.S. Energy Information Administration, *Petroleum Supply Monthly*, February 2016, preliminary data for 2015

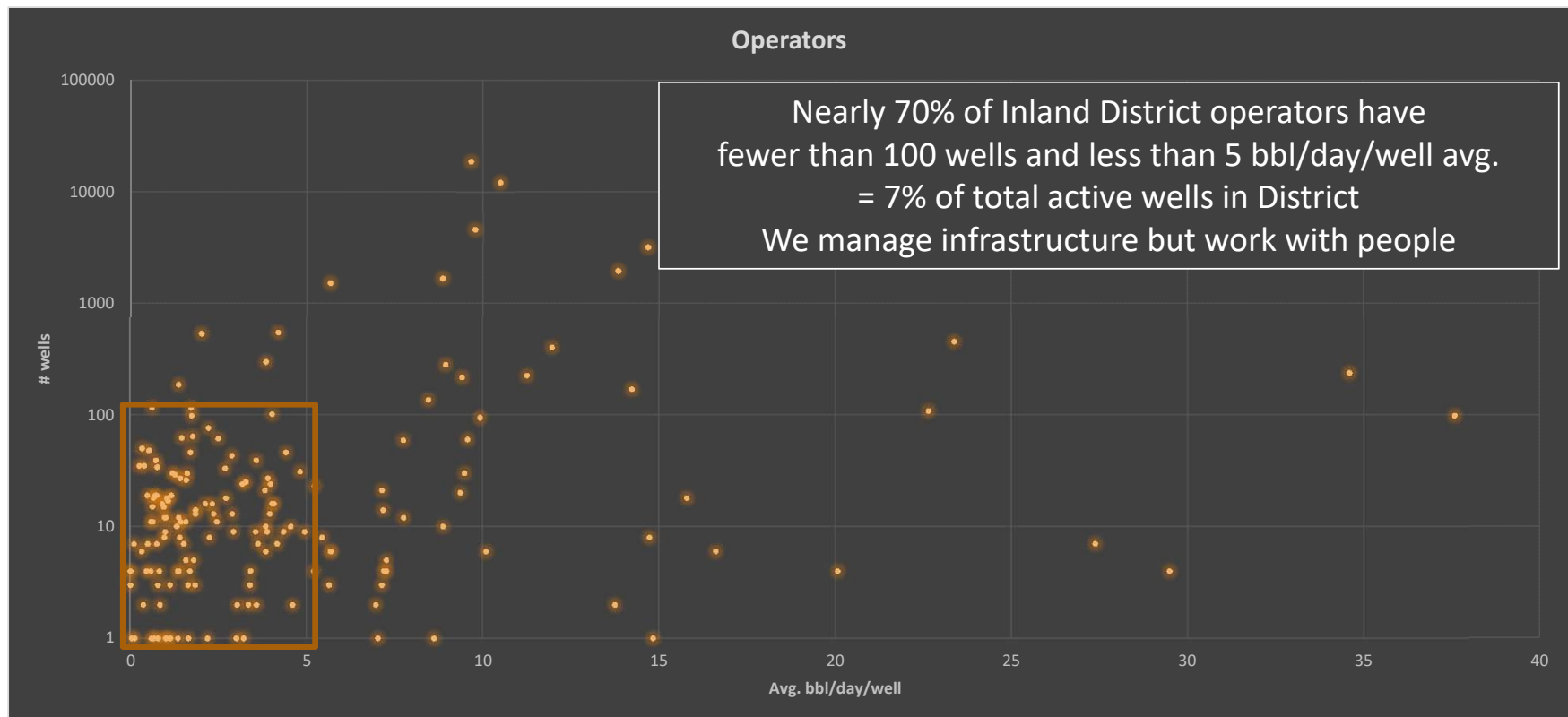


DOGGR through time 1915 - 2016

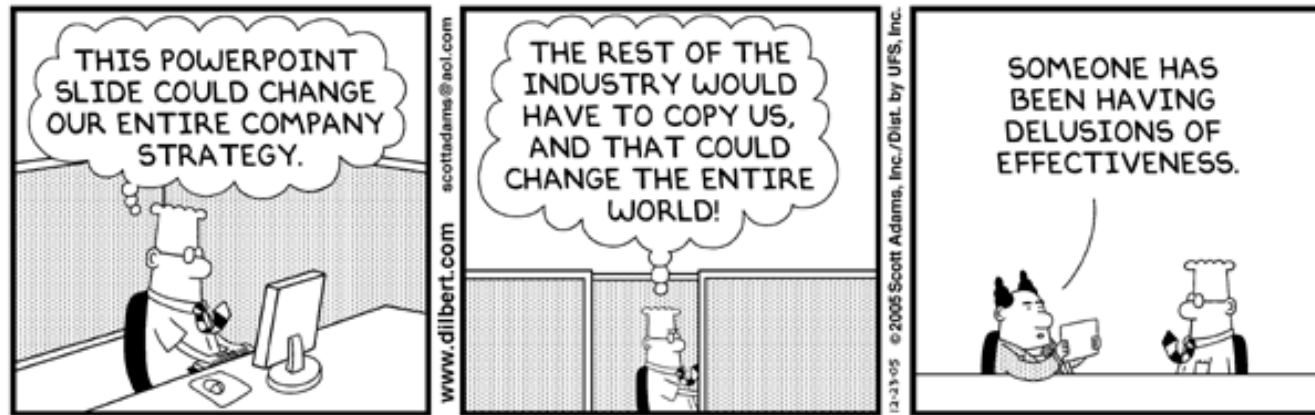


2015 – DOGGR Renewal Plan authored

inland district operator population profile



changes at DOGGR



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- new organizational model to meet aggressive goals
- new management and professional levels
- new people at each level
- hiring experience into all levels
- adopting new technologies to support our efforts
- new mapping of areas of responsibility
- new ways of working together
- new ways of working with stakeholders



avoiding trouble

FROM REACTIVE AND PUNITIVE



TO PREDICTIVE AND PREVENTATIVE



Recognizing and intervening in impacting events and practices



renewal plan

Four areas of improvement – turning the page on the past

Regulatory Overhaul

- **Injection Projects** Review to be completed by October 2018
- **Aquifer Exemption** Review Under way – finalized DOGGR processing of 23 applications, most with multiple aquifers

New Regulations

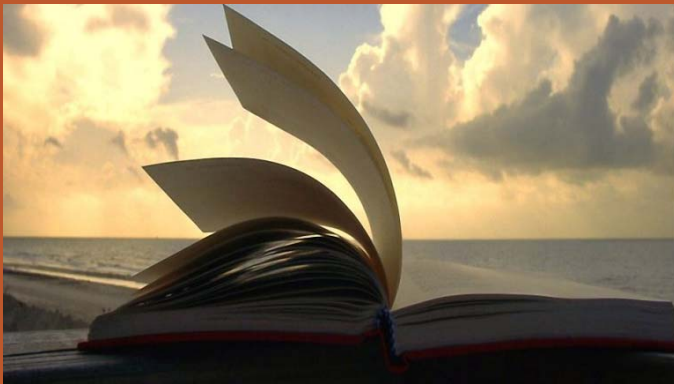
- **Well Stimulation** - First SB4 permits have recently been issued
- **Underground Injection** Controls - New draft regulations under review
- **Gas Storage** - Aliso Canyon has spawned new legislation and new regs. New regs have been issued with wide-ranging application to other state storage sites.
- **Idle Wells** – new rules for managing and abandoning

Modernize Data Management

- **New database** and modern analytical and modeling software
- **Research projects** with the National Laboratories

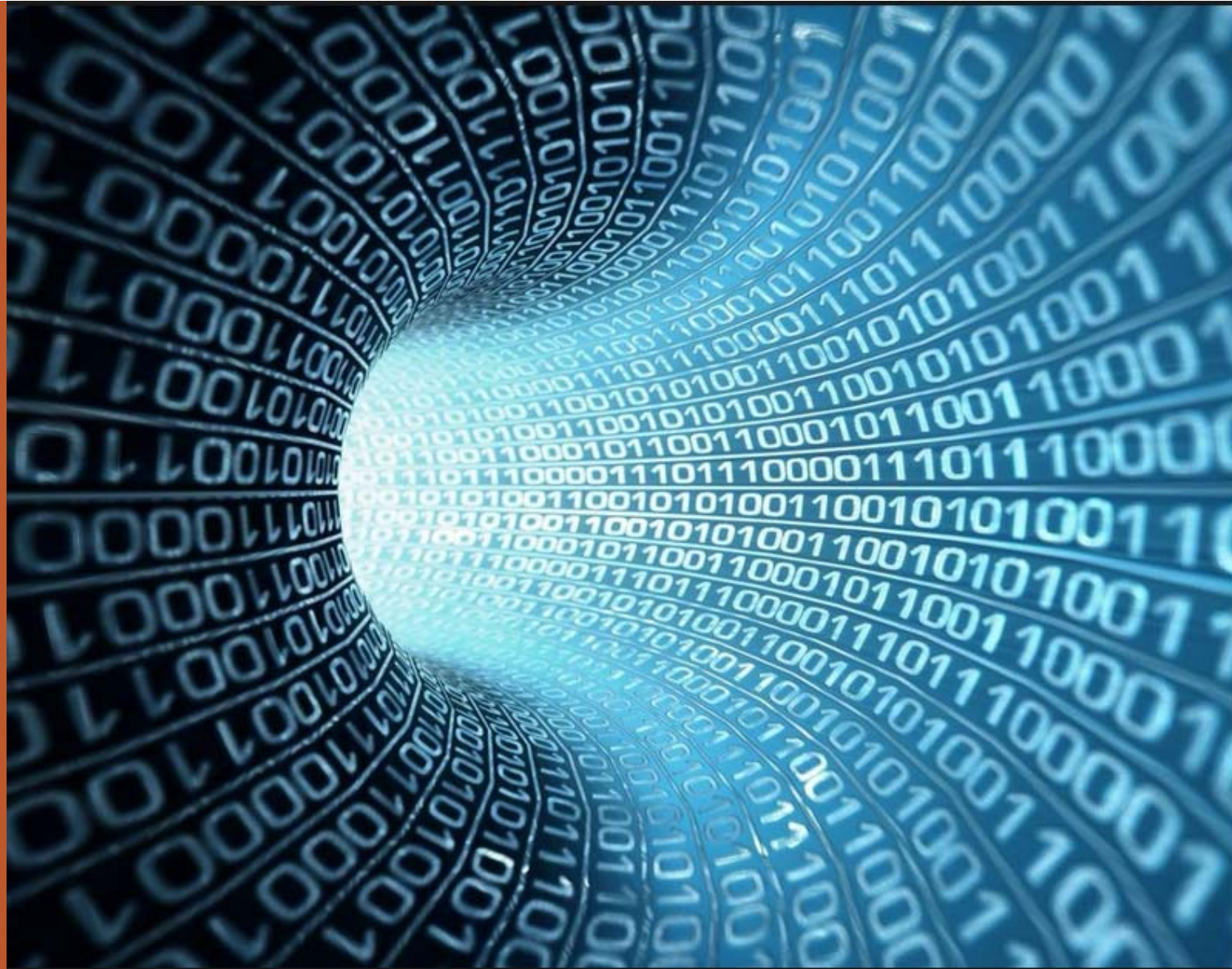
Ensure a High Quality Work Force

- Hiring highly skilled people from industry, instituted new technical training program for the entire workforce



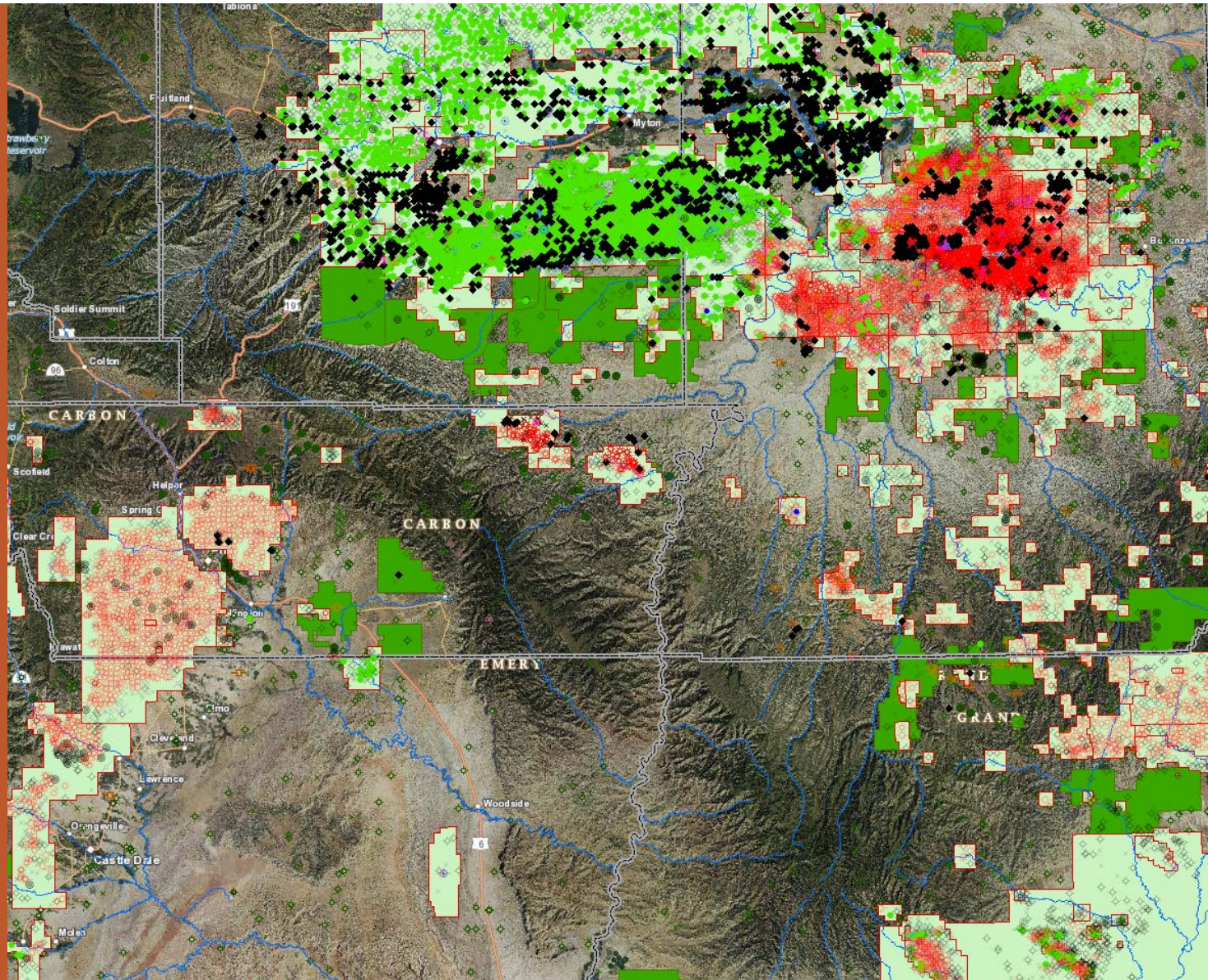
modernizing data management

paper to digits



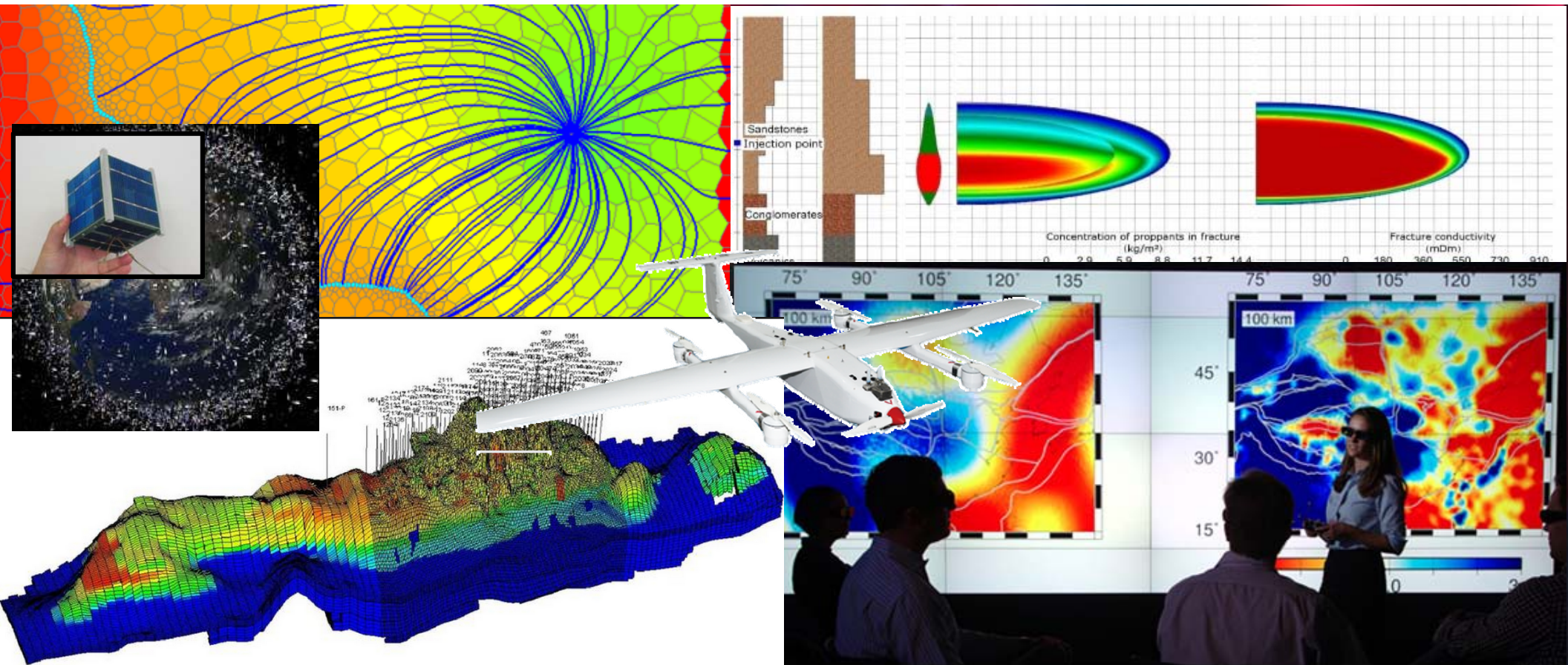
new database

based on multi-state implemented
RBDMS from GWPC



new technologies

The collage illustrates various geoscientific technologies. It features a 3D visualization of fluid flow in a porous medium, a photograph of a small blue cube-shaped device, a 3D model of a geological structure, a 3D model of a fracture network, a 3D model of a fracture conductivity distribution, a 3D model of a fracture conductivity distribution, a 3D model of a fracture conductivity distribution, and a photograph of a person presenting a large screen displaying a 3D model of a fracture network.



research

expanding our scope and breadth of understanding, and advancing our renewal plan goal of operating a data and science-based organization through academic collaboration and partnerships



- **Earth Observatory (LLNL)** – hydraulic fracture behavior including extent and density via geomechanical modeling and simulation
- **Gas storage (LLNL)** – Natural gas storage integrity, wellbore integrity and improvement of blowout kill methods
- **Induced seismicity (LBNL)** – monitoring and modeling oilfield activities and seismicity
- **Training (LLNL)** - Hydraulic Fracturing geomechanics
- **Remote sensing and data processing** – InSAR, LiDAR, nearIR, RGB, etc
- **Surface/subsurface integration (Stanford)** – understanding reservoir systems
- **Multi-variate statistical analysis (Stanford)** – risk analysis and portfolio prioritization
- **Predictive analytics** – trend analysis, optimization of resources



stages of approving a class II injection well

requires multi-agency reviews and
approvals

■ Aquifer Exemption

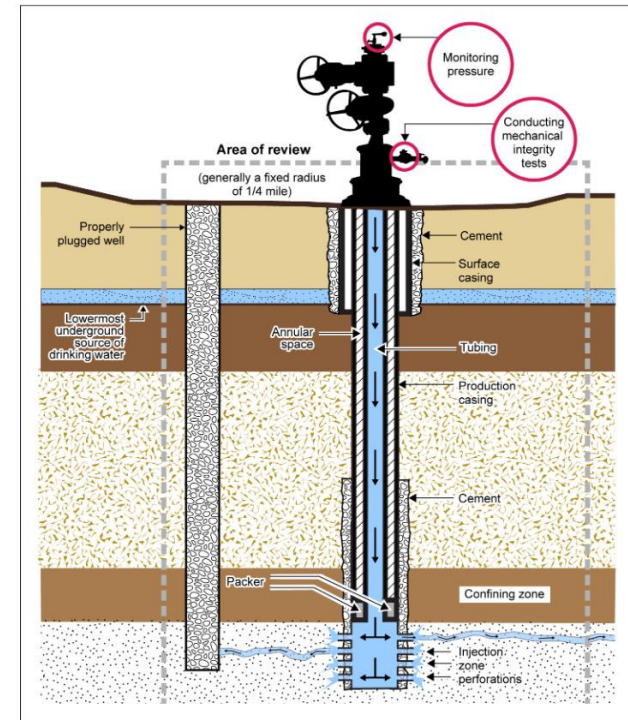
- Defines an underground geological formation as exempt from protection under the US Safe Drinking Water Act
- State and Federal criteria must be met to qualify

■ UIC Project Approval

- AOR / ZEI determination
- Well integrity for all wells in AOR
- Volume and pressure analysis

■ Permit to inject

- Well construction
- Monitoring
- Testing



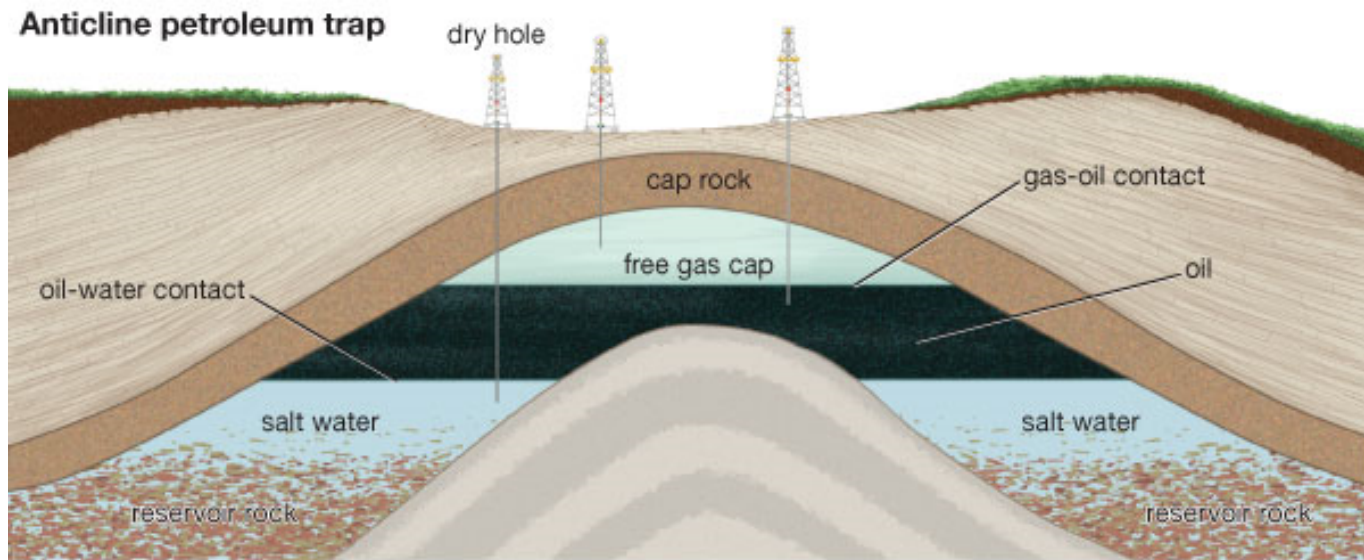
Sources: GAO analysis of EPA and Ohio's information. | GAO-14-555



aquifer exemptions

Authorized under the federal safe drinking water act.

Only the US EPA can exempt an aquifer. The State agencies apply and enforce Federal and State laws, and after passing rigorous technical evaluation submit recommendations for exemption to US EPA.

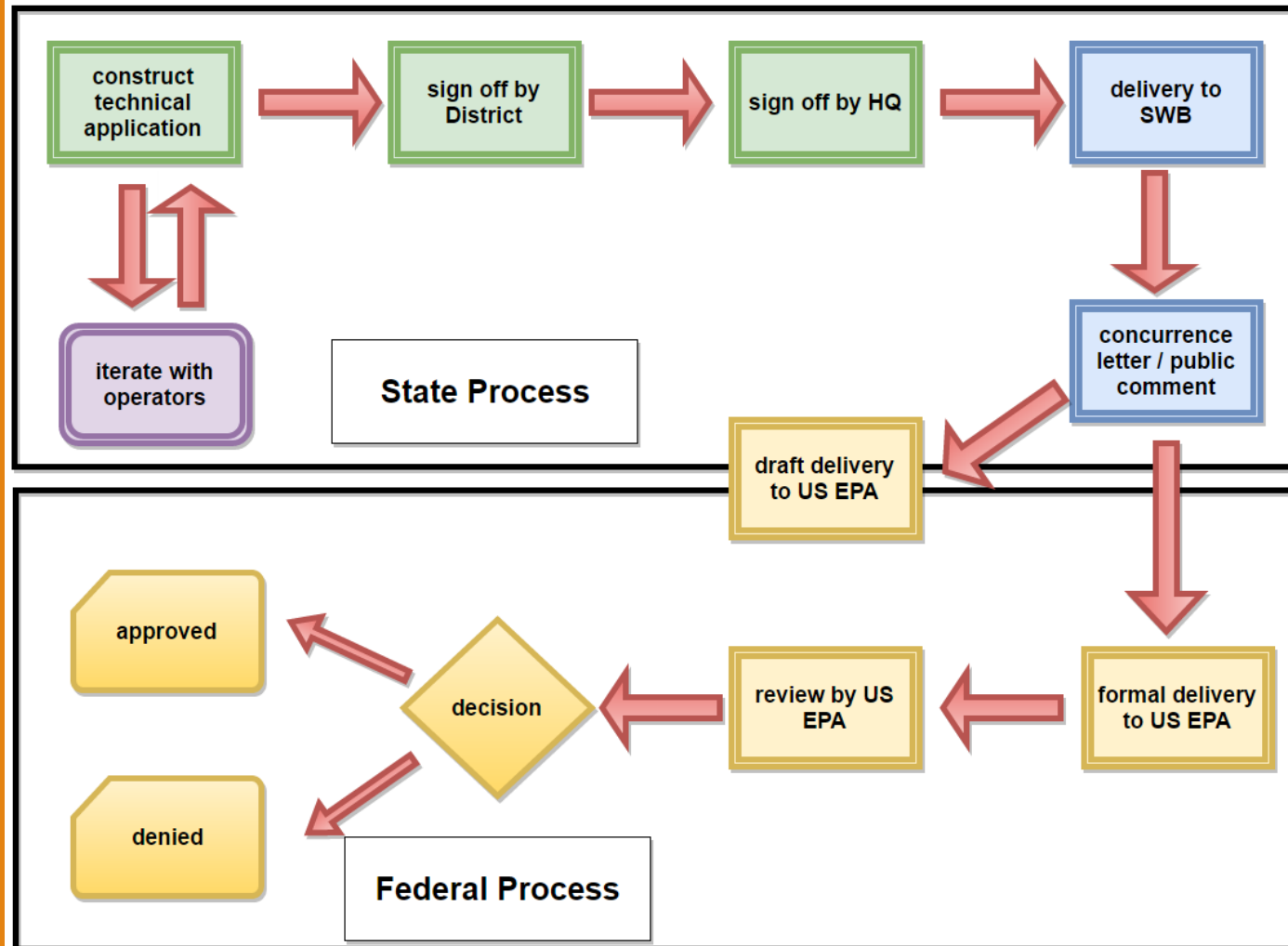


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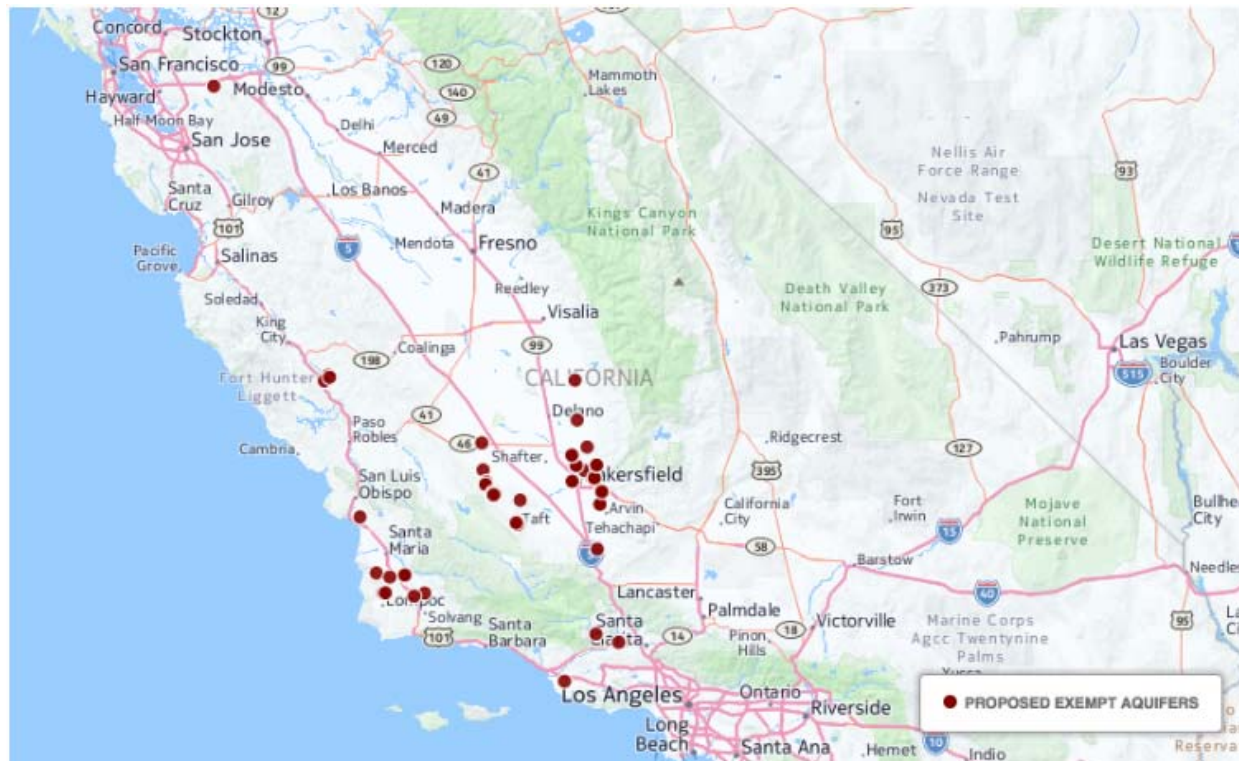
- collect and analyze scientific and engineering data to document areas of hydrocarbon concentrations
- define the geological features that contain the hydrocarbons and associated water
- sub-surface geological formations must meet specific Federal and State criteria to be classified as exempt
- these are designed to ensure that underground sources of drinking water (USDW's) remain protected in oilfields.

aquifer exemption analysis, proposal and approval process

State and Federal agencies must review the applications. DOGGR and SWB are charged with conducting the technical analysis for the State and passing it along to US EPA.



exemption proposals



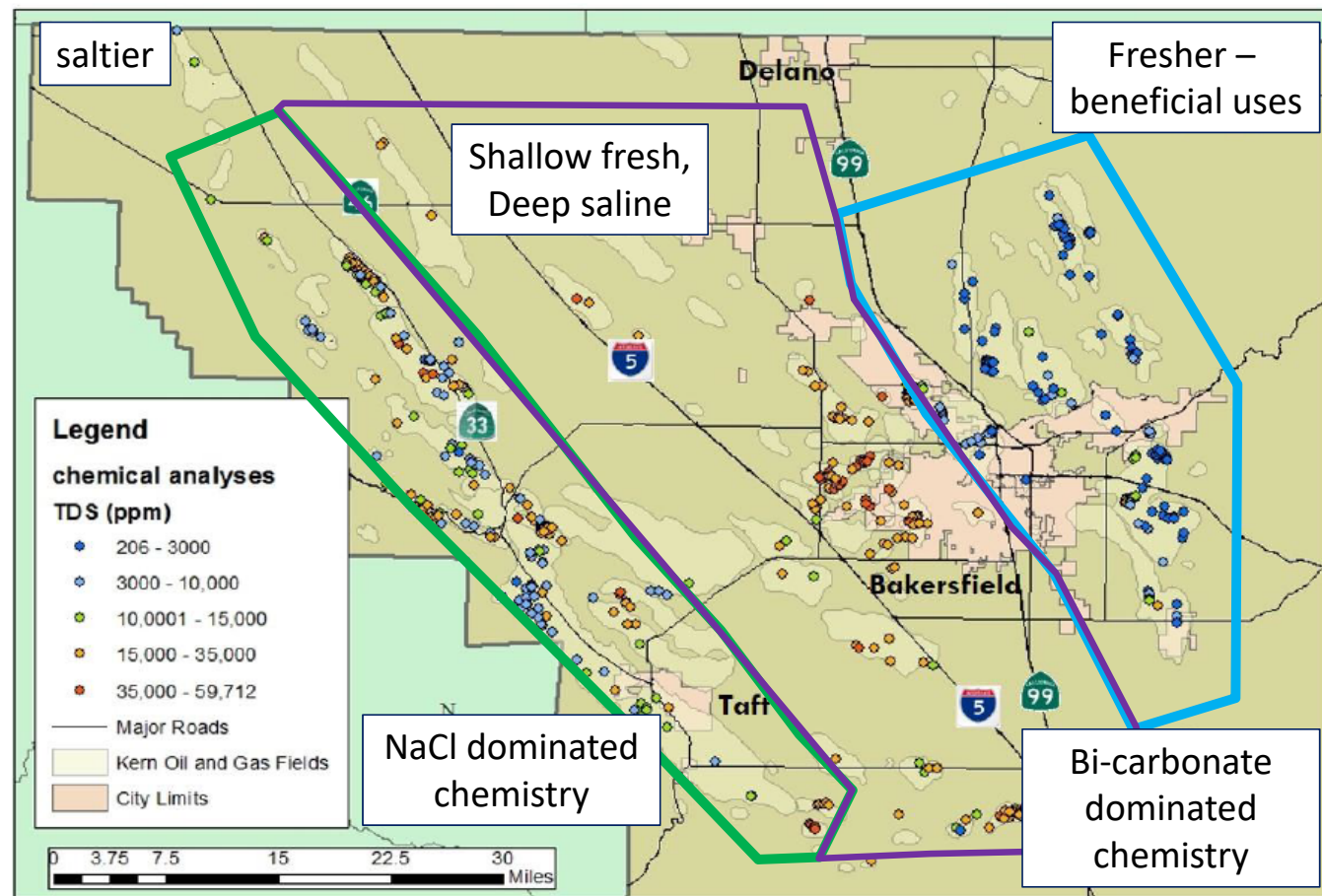
water salinity generally increases east to west

This is due to:

fresh water recharge from the Sierra Nevada range to the east

sparse rainfall in the west to dilute naturally saline formation waters

differences in sedimentary source rocks, granitic on the east, ultramafic metamorphic on the west affect salt chemistries



From Gillespie, Kong and Anderson, 2016



water salinity generally increases with depth

deeper water is relic from the original marine deposition, shallower formations above confining shales are exposed to rainwater recharge

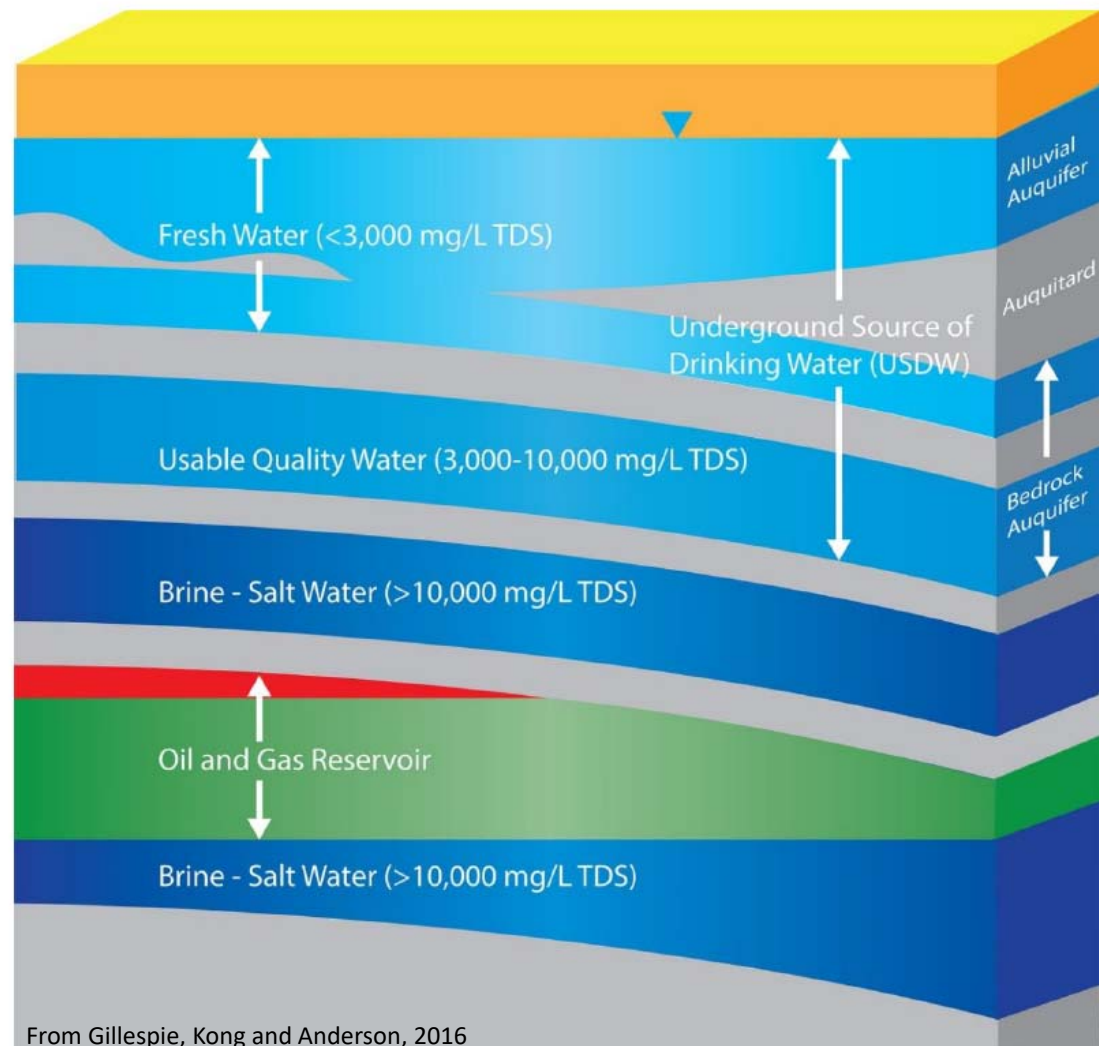


Figure 2. Salinity typically increases with depth in underground aquifers (US EPA, 2002)



federal exemption criteria



Exemption criteria as specified in 40 CFR 146.4

a) The aquifer does not currently serve as a source of drinking water

b) The aquifer cannot now, and will not in the future, serve as a source of drinking water because:

1) It is mineral, hydrocarbon, or geothermal energy producing, or can be demonstrated by a permit application for a Class II operation to contain hydrocarbons that considering their quantity and location are expected to be commercially producible

OR

2) The aquifer is situated at a depth or location that makes the recovery of water for drinking water purposes economically or technologically impractical

OR

3) The aquifer is so contaminated by natural or unnatural sources that it would be economically or technologically impractical to render that water fit for human consumption

OR

c) TDS is more than 3,000 and less than 10,000 and it is not reasonably expected to supply a public water system.

state exemption criteria



Exemption criteria as specified in PRC 3131(a)

1. Criteria set forth in Section 146.4 of Title 40 of the Code of Federal Regulations have been met
2. The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use
3. The injected fluid will remain in the aquifer or portion of the aquifer that would be exempted

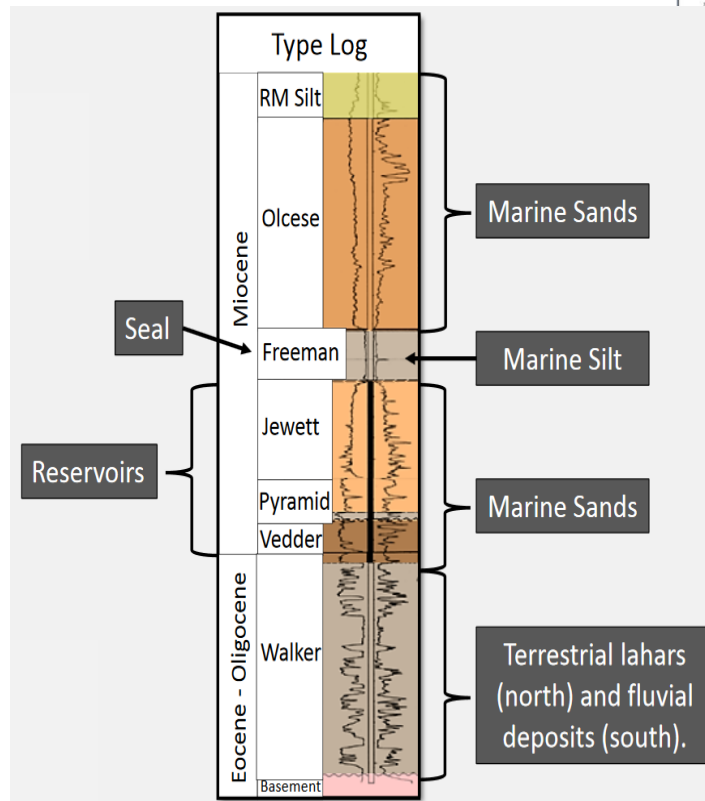
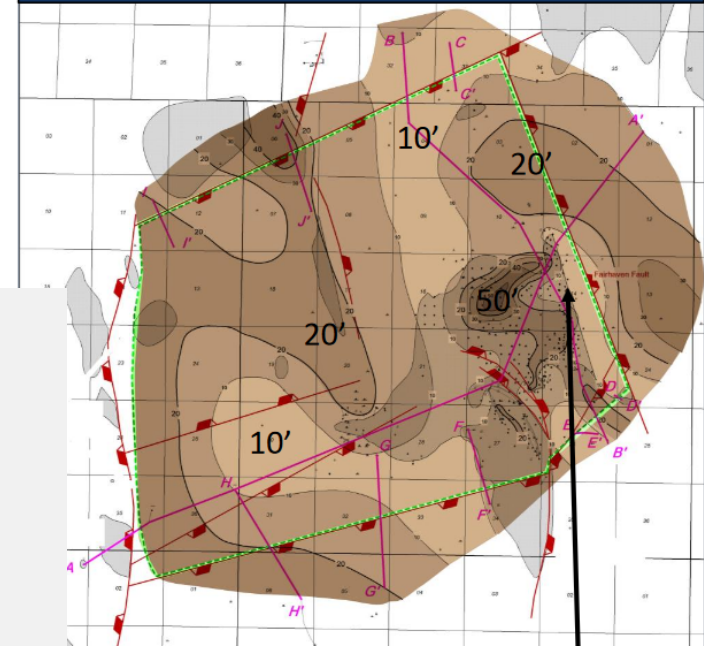
vertical confinement example

zones proposed for exemption must be stratigraphically isolated from zones containing waters with beneficial use.

vertical permeability and the lateral extents and thickness of stratigraphic confining layers must be documented

the distribution and thickness of stratigraphic confining layers are defined and mapped from well and geophysical data

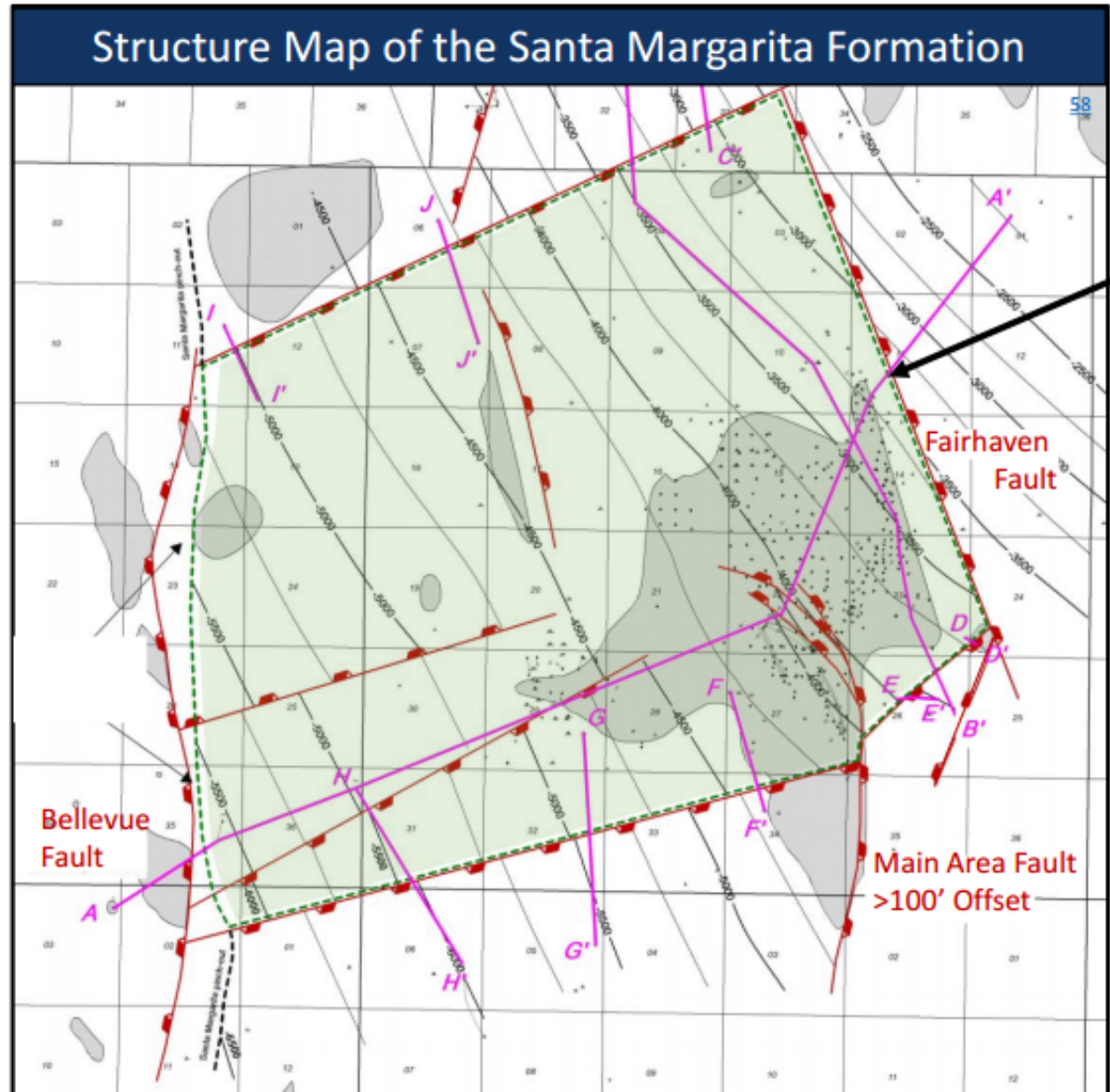
Isopach Map of the Overlying Confining Shale



lateral confinement example

Maps, cross sections and associated data document sealing faults, stratigraphic edges

- no productive wells on hanging wall of the Fairhaven Fault
- sealing faults along the north, east and southern boundaries
- proposed AE does not extend to the Bellevue fault due to stratigraphic pinch out against the McClure Shale

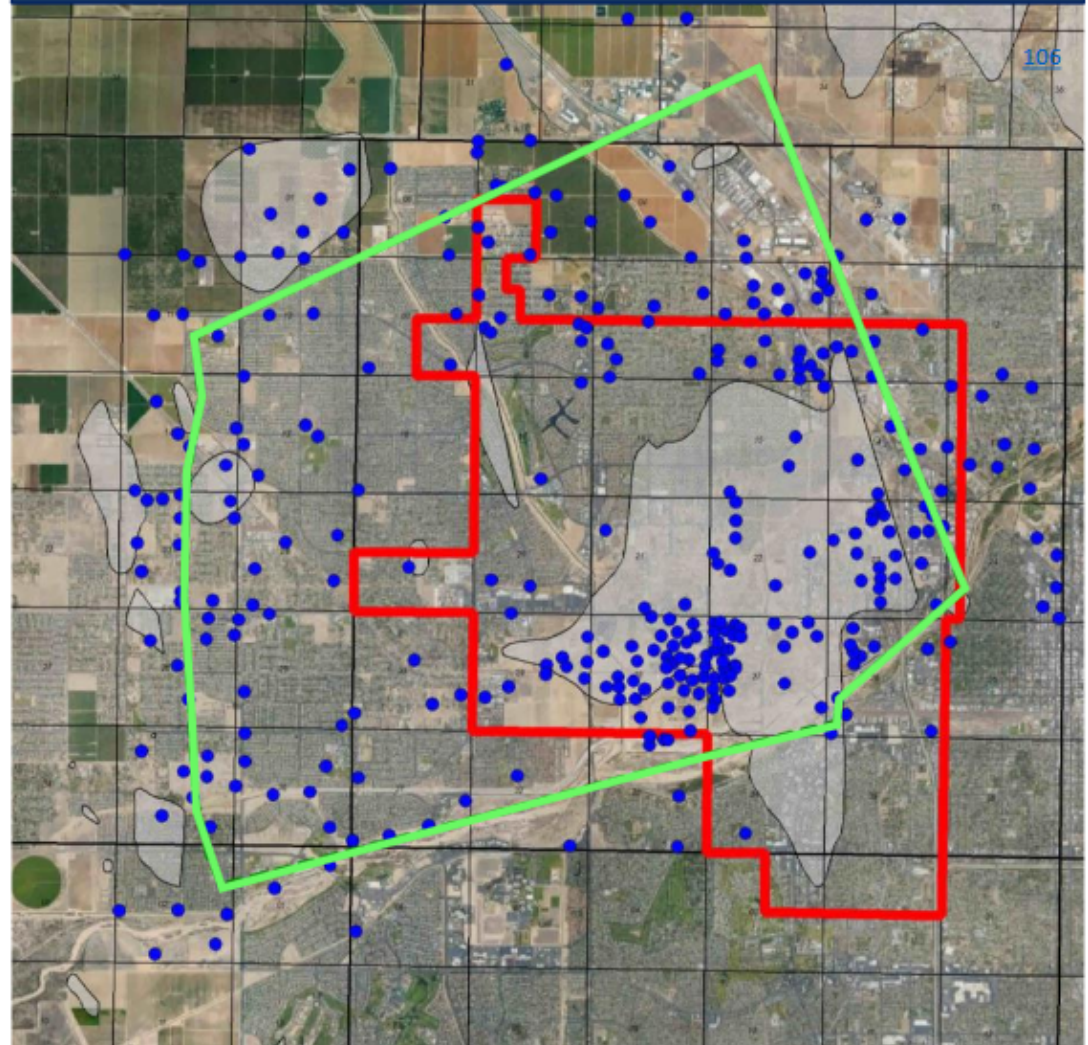


water wells

All water wells which produce for beneficial use within and for an effective distance beyond the proposed exemption area are mapped and analyzed to determine if there is hydrologic connectivity to the zone being proposed for injection.



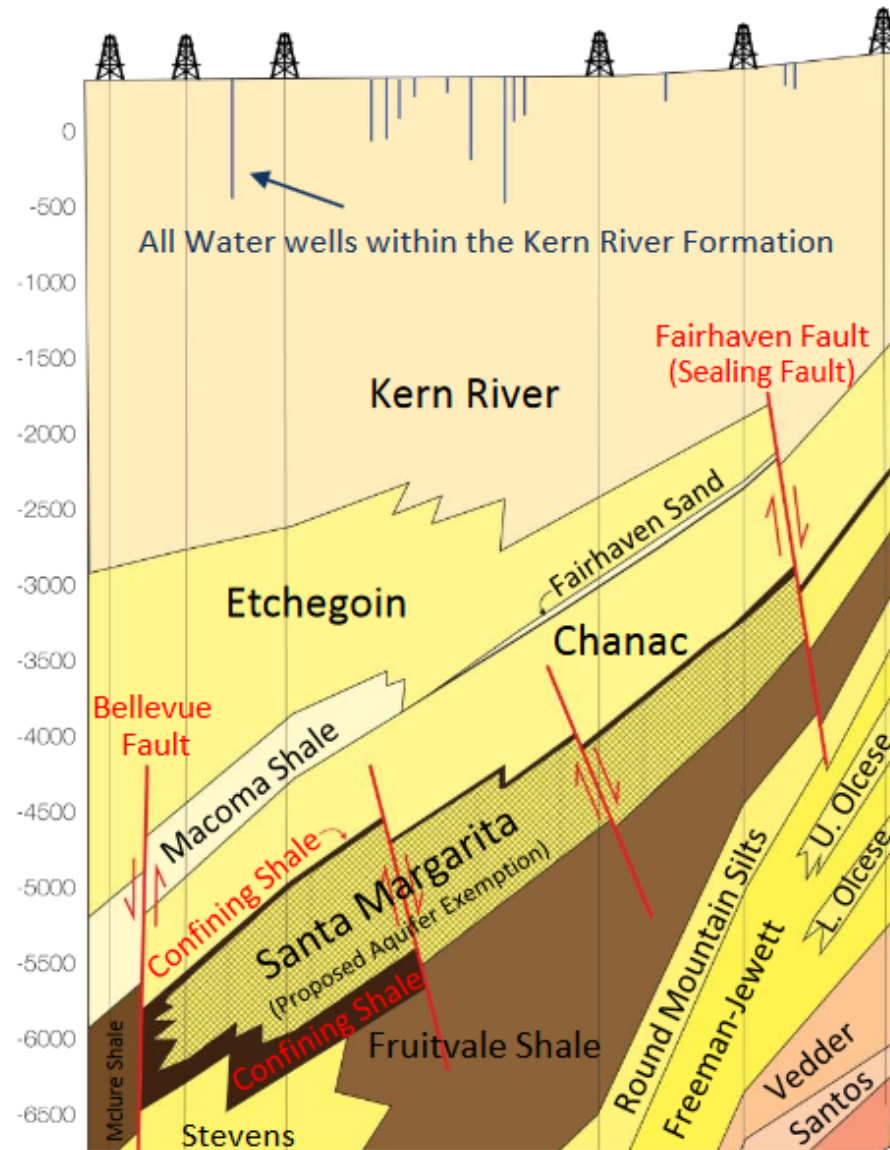
Active Water wells in the project area



isolation of water wells from injection zone

it must be demonstrated that the proposed exempted zones have containment boundaries, such as impermeable shales, faults or stratigraphic pinchouts to ensure that injected fluids remain in the exempted zone.

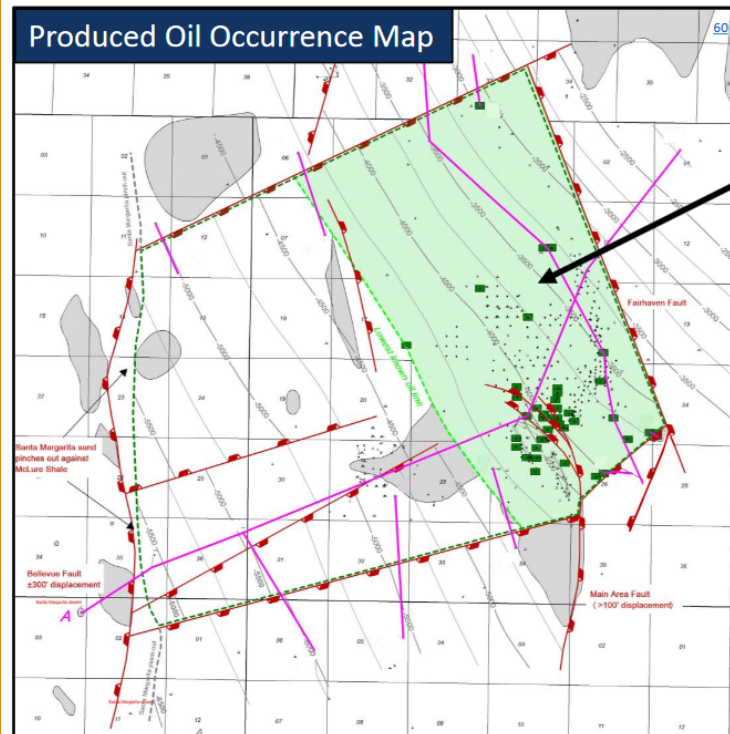
this cross section shows a proposed exempted zone and the water wells in the area, completed several thousand feet above and separated from the proposed exempted zone.




hydrocarbon producing


a key criteria for exemption is the presence of hydrocarbons in the aquifer. documentation is cataloged from producing wells, subsurface samples and well logs to map the extent of these hydrocarbons.

The waters in oil-bearing aquifers often have high salinities and can contain naturally entrained components of the hydrocarbons making the water unfit for beneficial use without treatment.



- Historically producible oil in the Santa Margarita Formation
- Up to 55% pore space oil saturation

 Hydrocarbon Producing Area

 Well with oil occurrence and/or historical production



water chemistry analysis example

water chemistry analysis includes drinking water standards, proposed exempted aquifer water chemistry and proposed injectate water chemistry.

note that in this case, the quality of the injectate is better than the native formation waters.

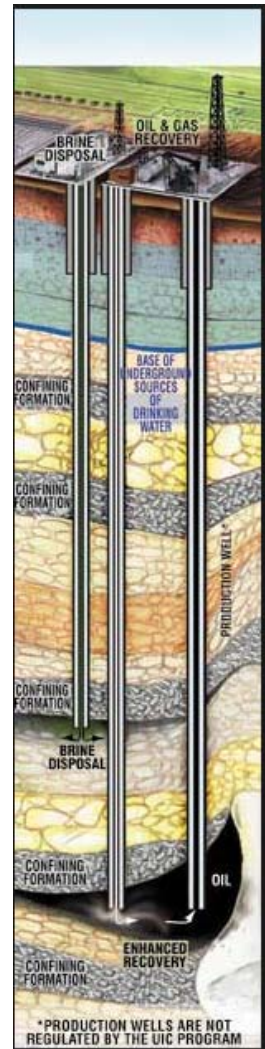
CA Title 22 Drinking Water Standards		Avg. Santa Margarita Fm.	Proposed Injectate	
Constituent	Max. Contaminant Level (mg/l)	Measured Contaminant Level (mg/l)	Measured Contaminant Level (mg/l)	
Total Dissolved Solids*	1,000	7,179	1,800	Meets drinking water standards. ¹²
Chloride	500	3,818	140	
Iron	0.3	2,864	0.61	
pH	8.5 Units	9	7.85	
Sulfate	500	322	23	Exceeds drinking water standards.
Specific Conductance	1,600 Micromohs	14,493	2,700	
Boron	1	7	.47	Exceeds drinking water standards but is less than existing formation contaminants.
Calcium	120	369	120	
Magnesium	120	43	39	
Potassium	-	77	13	
Sodium	100	2,005	310	Proposed injectate does not degrade aquifer quality
Benzene (µg/l)	1	2,705	-	
Ethylbenzene (µg/l)	680	2,696	-	
Toluene (µg/l)	100	2,043	-	
Xylene (µg/l)	1,750	2,656	-	



re-certifying underground injection projects

applying thorough technical review
and advanced analysis to document
that injected fluids currently are in,
and will remain in the zone intended
and permitted

- in excess of 900 active injection projects in the inventory State-wide
- projects have been prioritized to first evaluate those with greatest potential risks to drinking water
- new databases, analytical technologies and reservoir evaluation methods are used to complete these tasks quickly, consistently and with the highest quality
- includes detailed analysis of the injector and all other wells in the area to assess them for mechanical integrity
- conducted in close interaction with operators and Water Boards



beneficial use of produced water

in some cases, produced water has high enough quality for beneficial use such as at the Cawelo Water District Produced Water Project

for more than 2 decades, ~29 million gallons of filtered and treated water per day, 10.4 billion gallons per year, have been delivered to agricultural uses from the Kern River oilfield

- water quality analysis reported the levels of ***acetone in Cawelo's produced water were 280 times below*** the maximum concentration considered safe for drinking water;
- ***petroleum hydrocarbons in Cawelo's produced water were 750 times below*** the maximum concentration considered safe for drinking water
- crops irrigated with Cawelo's produced water had the ***same chemical composition as crops irrigated with other water supplies.***
- other fields also provide water to agricultural districts



summary

- oil and gas production delivers significant social and financial benefits but is not without risk
- DOGGR regulates all activities associated with drilling, producing and abandoning wells associated with oil and gas production
- DOGGR's role is to enforce the laws and regulations with the goal of optimizing the value of the underground resource while ensuring maximum protection of safety, health, life and the environment
- the local office is growing quickly and embracing modern technologies to improve our ability to meet these goals





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