Overview of USGS study results in Northeastern San Joaquin Groundwater subbasin: Implications for water quality and groundwater recharge

By: John A. Izbicki, Loren F. Metzger, and David R. O'Leary

In cooperation with: The Northeastern San Joaquin Groundwater Banking Authority, Calaveras County Water District, and California Department of Water Resources

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Scope of presentation

- Overview 2003-2012
- Source and movement of high-chloride water
- Arsenic
- Groundwater recharge

U.S. Geological Survey drill rig, Sept. 2006, Victory Park, Stockton, CA

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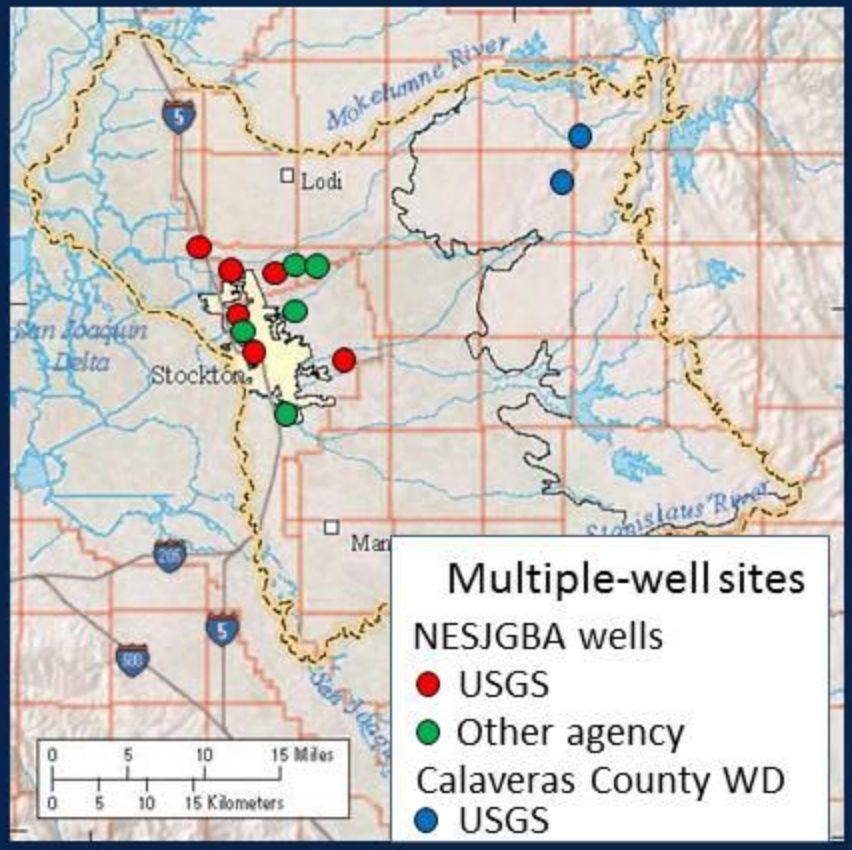
Overview: 2003 to 2012

- 8 USGS multiple-well monitoring sites, total 13 sites with 41 wells
- Almost 40 electromagnetic (EM) induction logs coupled with more than 100 chloride samples
- Continuous water-level data collected from 35 wells
- Almost than 200 water samples collected from almost 100 wells



- Coupled well-bore flow and depth-dependent water-quality data collected from 12 production wells under unpumped and pumped conditions

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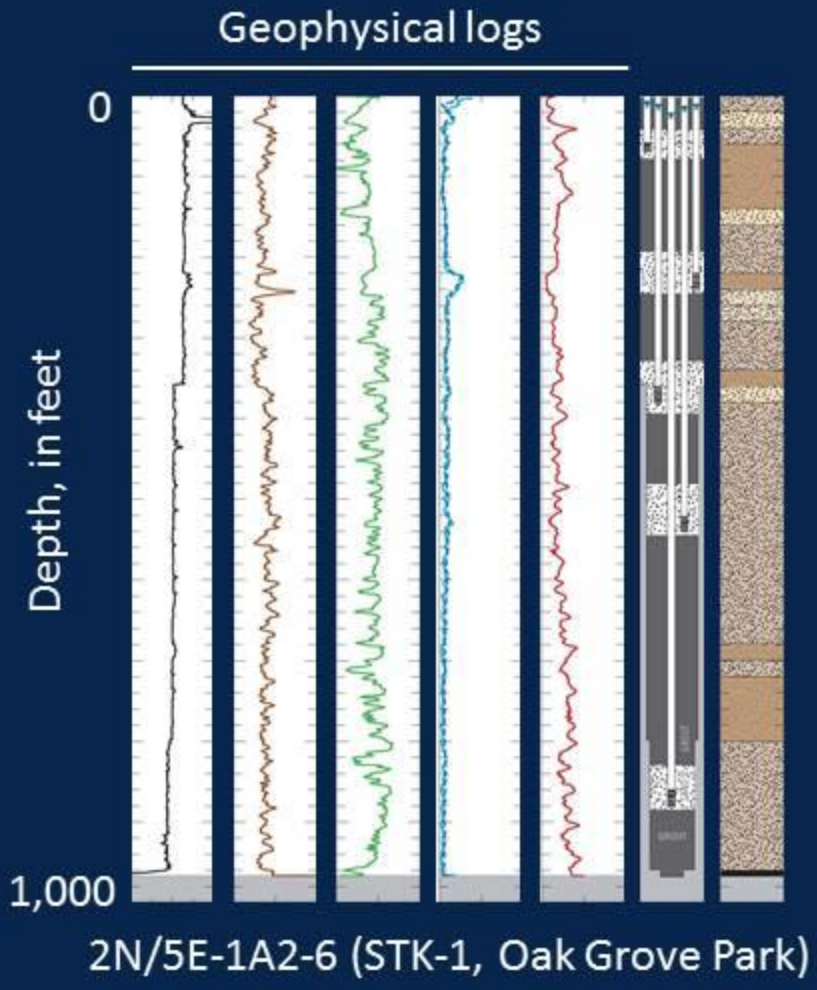

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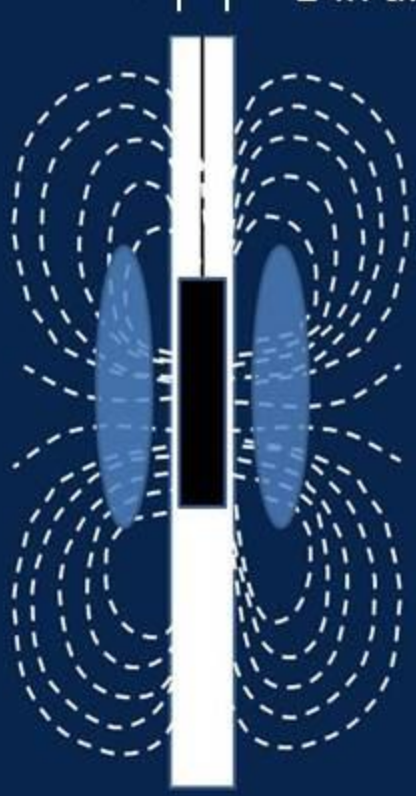

EM induction logging

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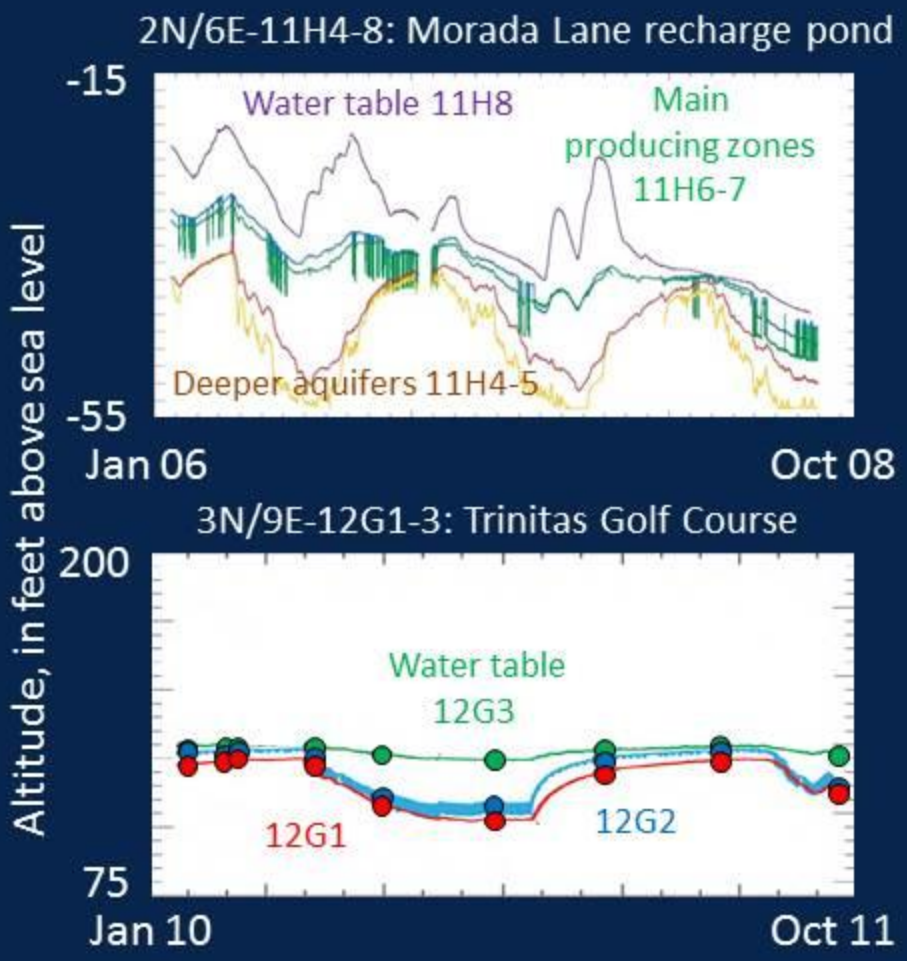

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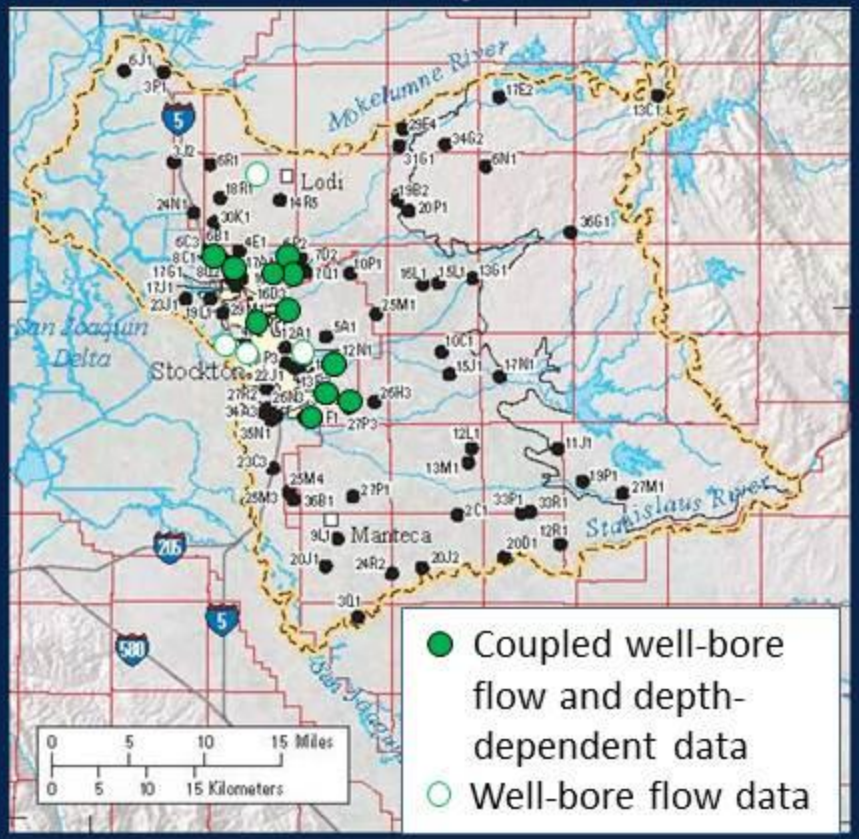
USGS sampled wells



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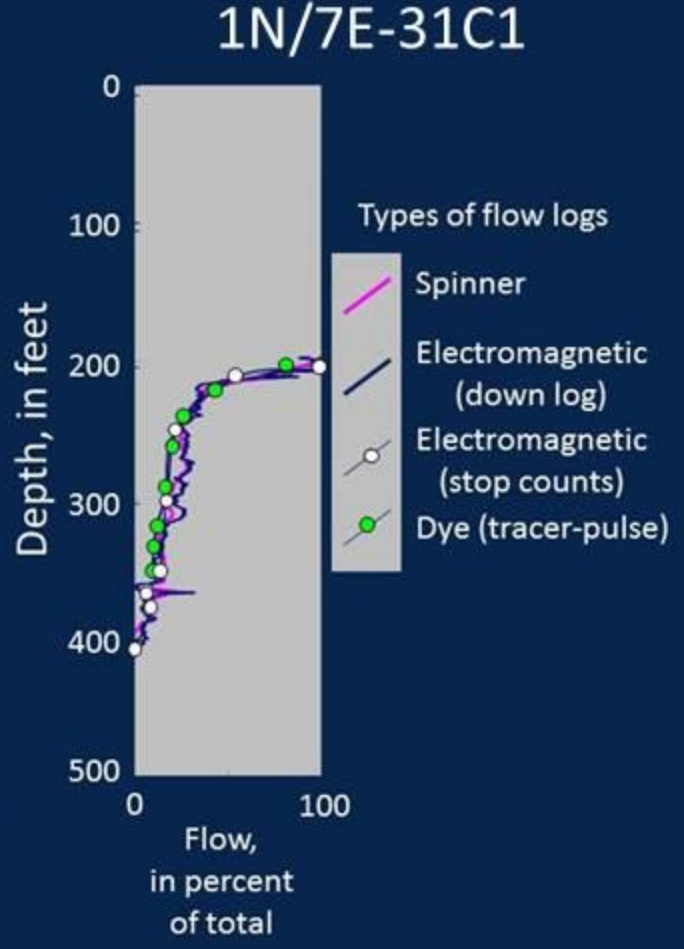

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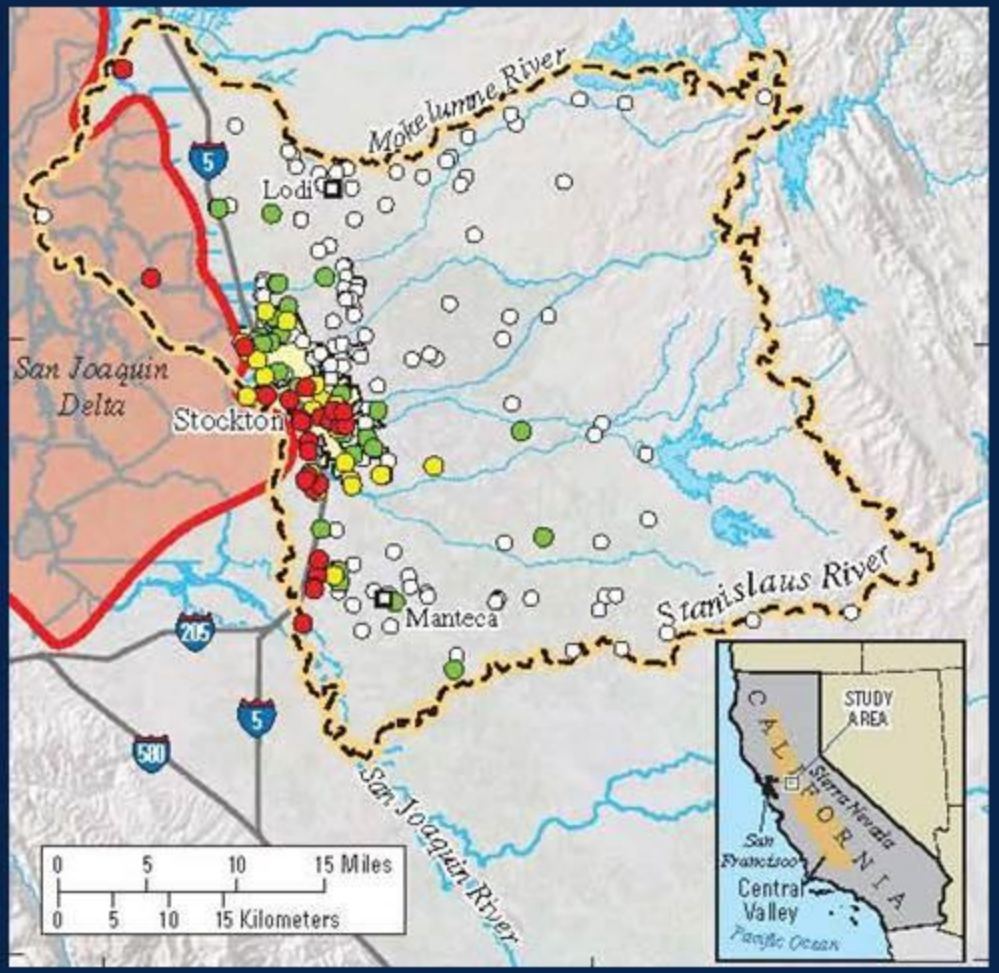
Sources of high-chloride water

- Potential sources
  - Irrigation return
  - Delta sediments
  - Deeper deposits
- Movement of high-chloride water through alluvial deposits



1931 extent of chloride greater than 1,000 mg/L in Delta surface water (Piper and others, 1939)

Chloride, in milligrams per liter

- Less than 50
- 50 to 100
- 100 to 250
- Greater than 250

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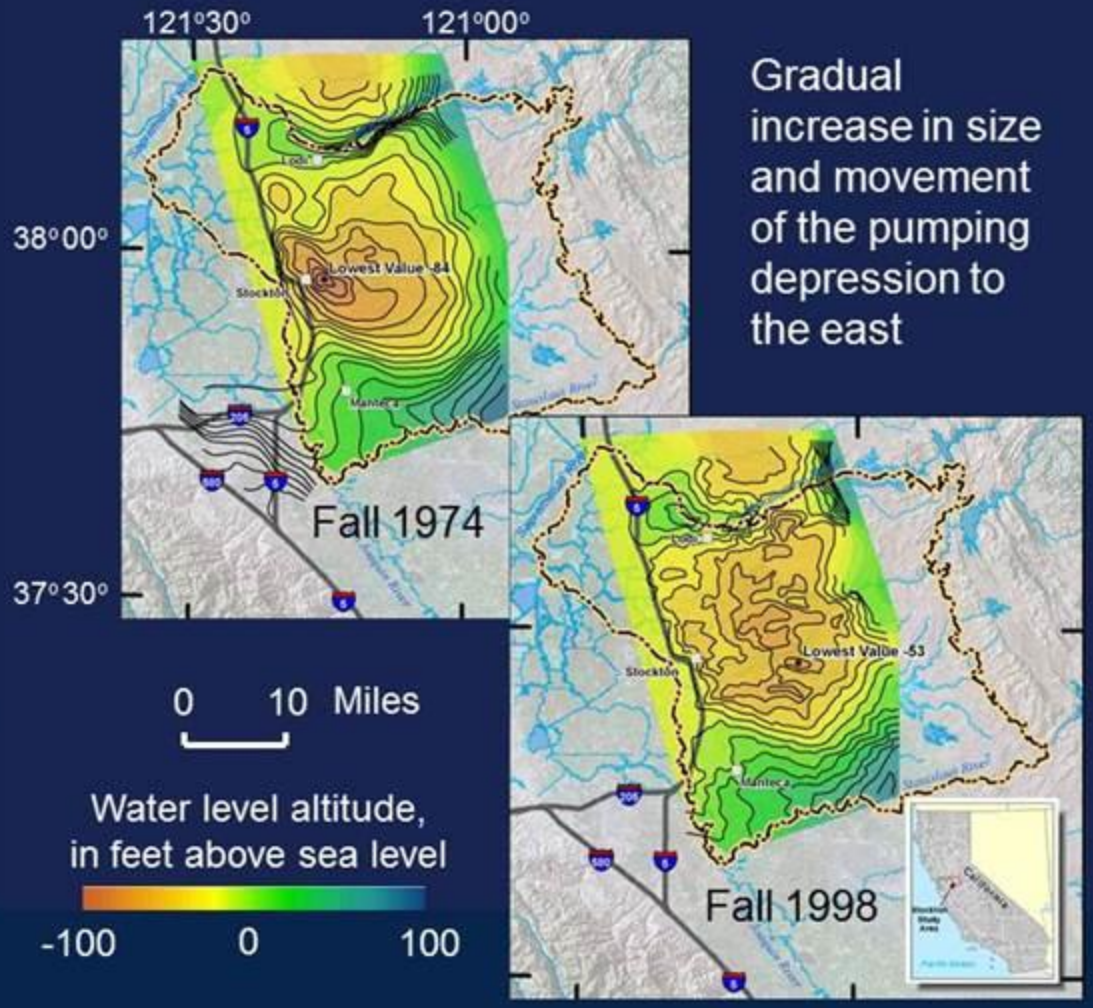

Gradual increase in size and movement of the pumping depression to the east

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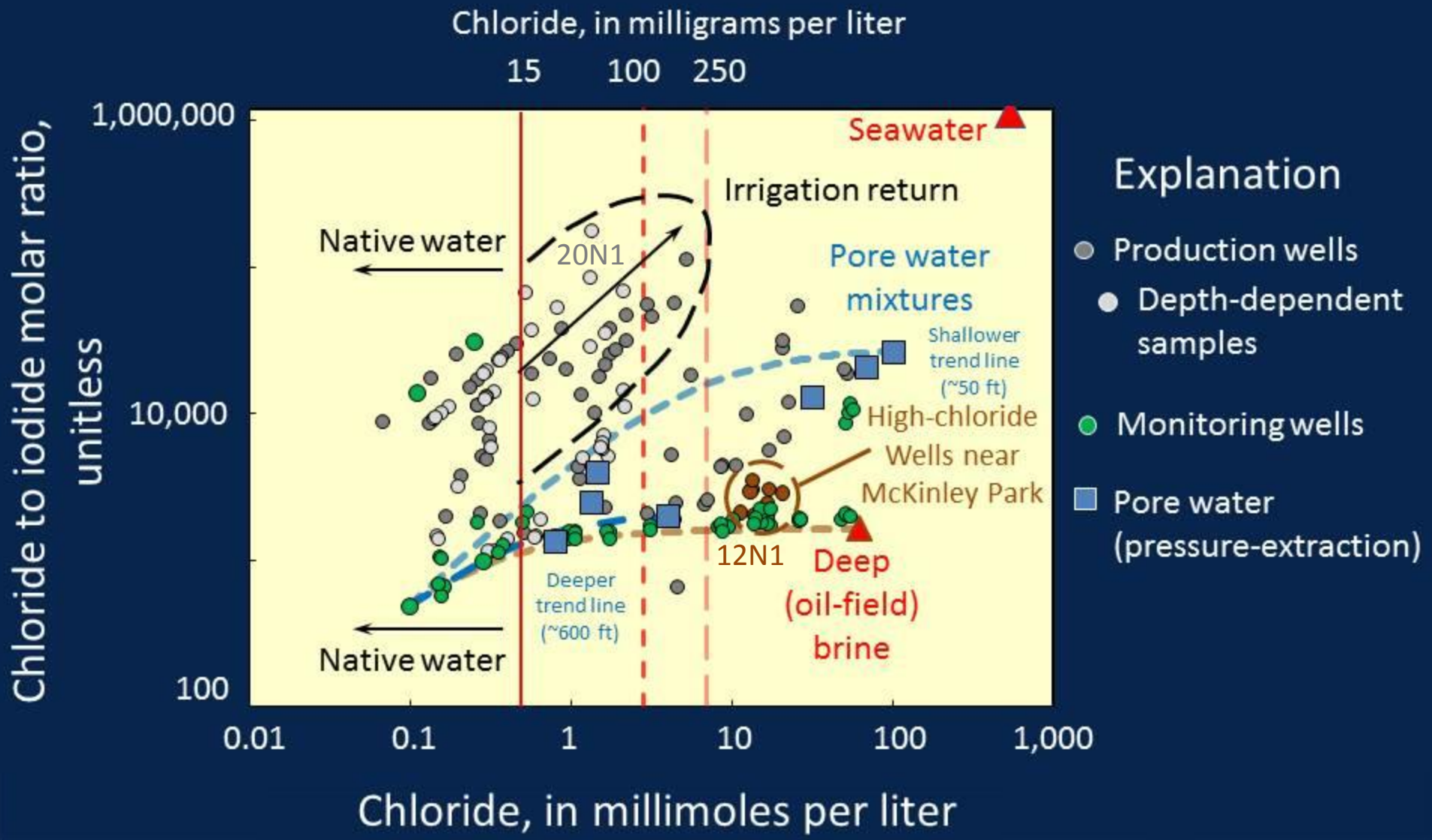
Sources of high-chloride water



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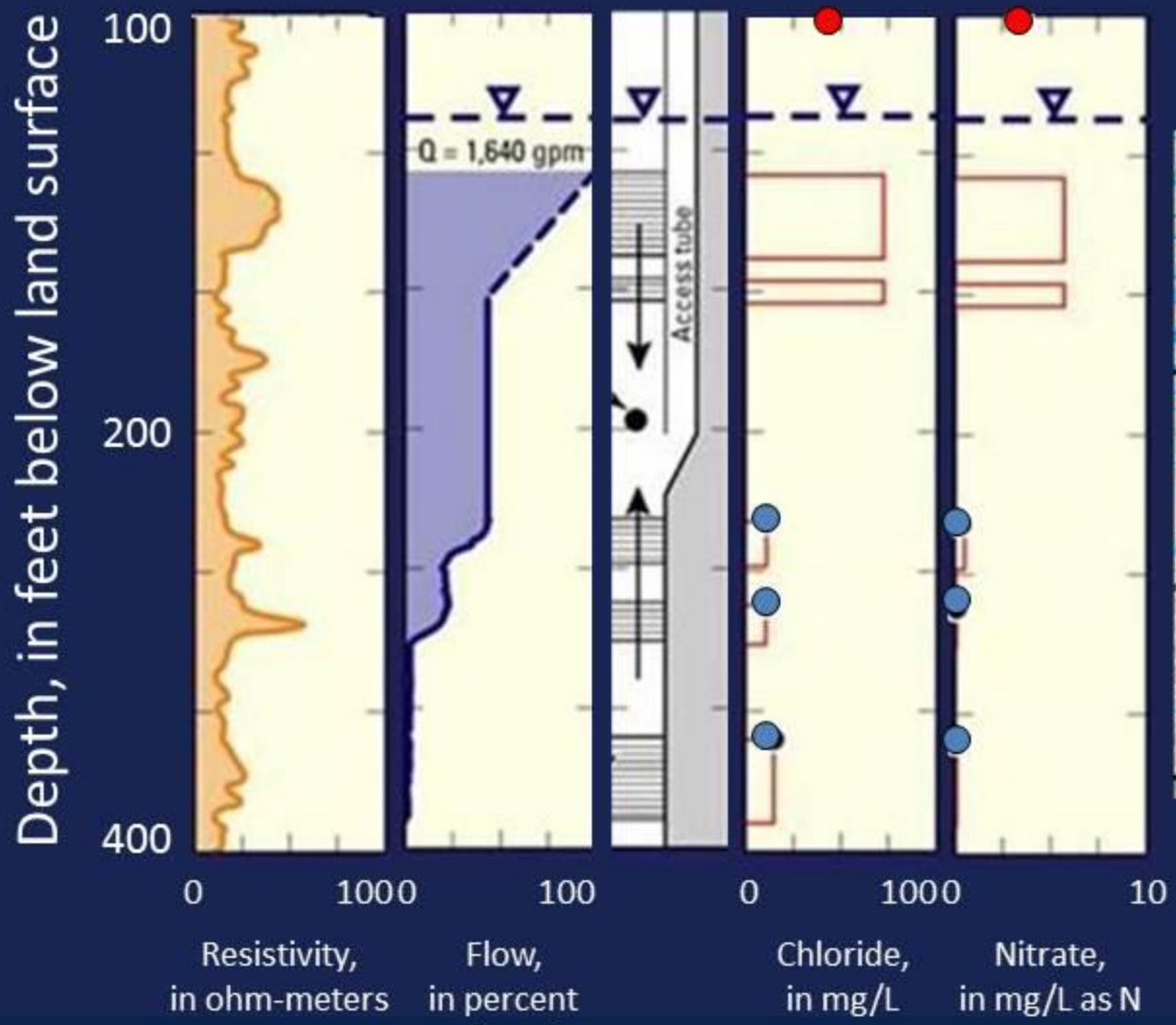
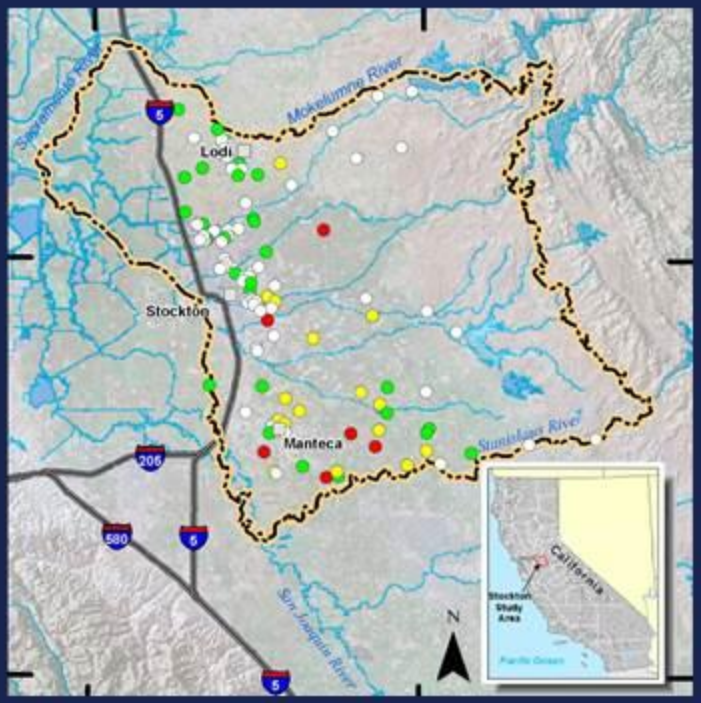
Chloride and nitrate data from well 1N/7E-20N1

Surface discharge samples



Nitrate concentrations in NESJG subbasin, 2008



Nitrate as nitrogen, in milligrams per liter

Less than 5
5 to 10
10 to 15
Greater than 15

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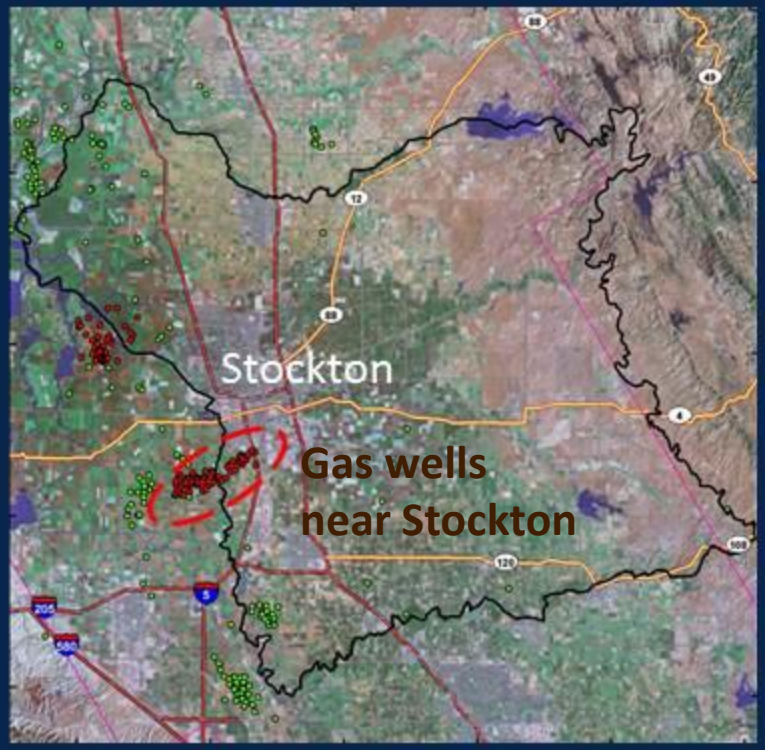
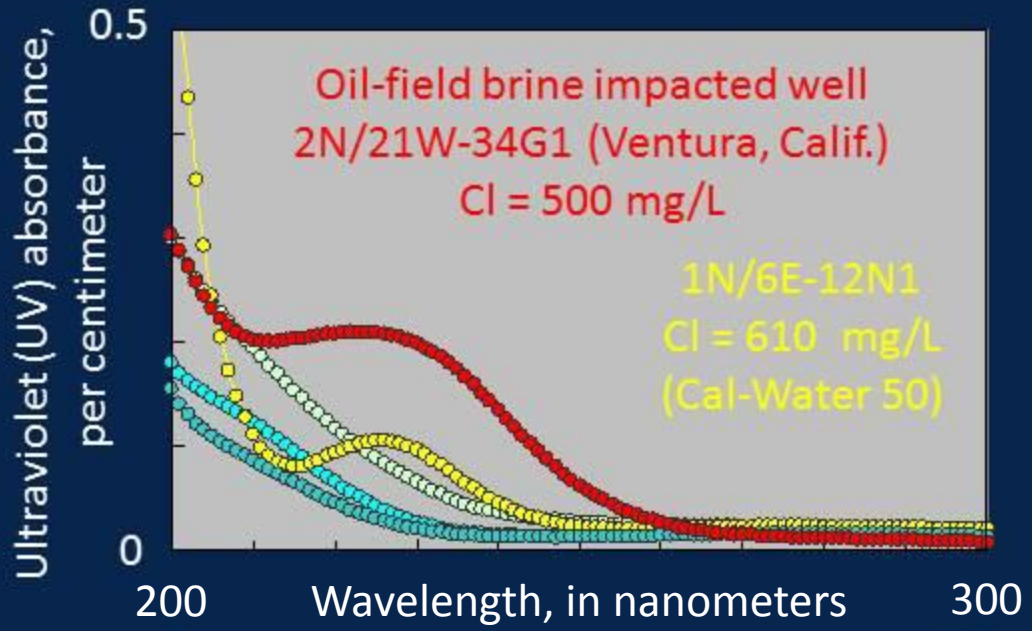
Sources of high-chloride water

San Joaquin County



California Department of Conservation,
Division of Oil and Gas



McKinley Park, Stockton , Calif. circa 1912

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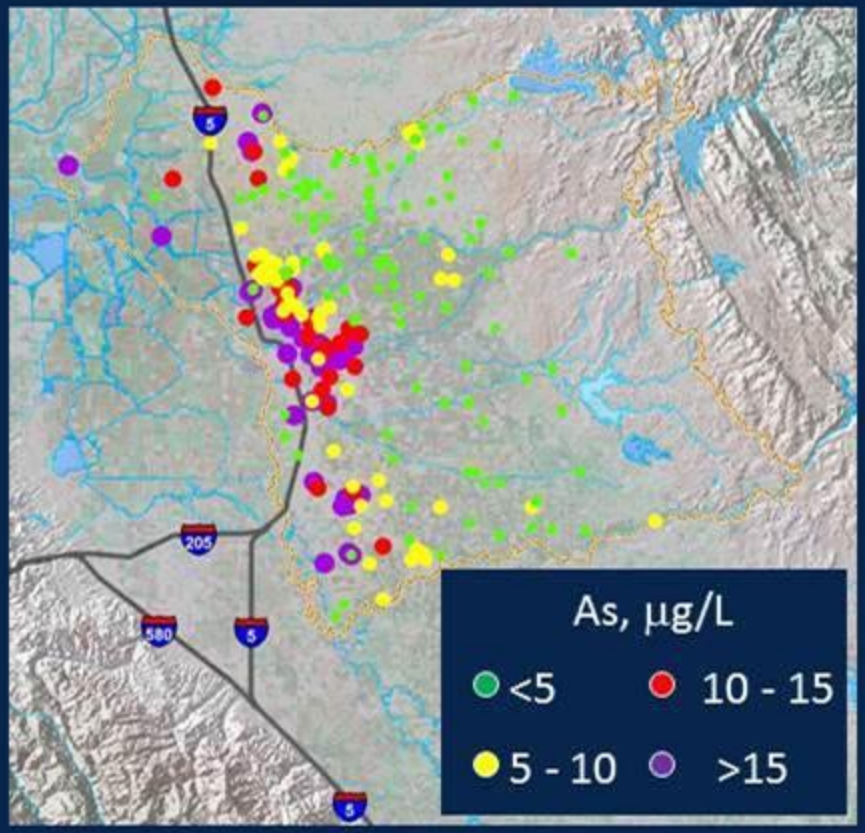
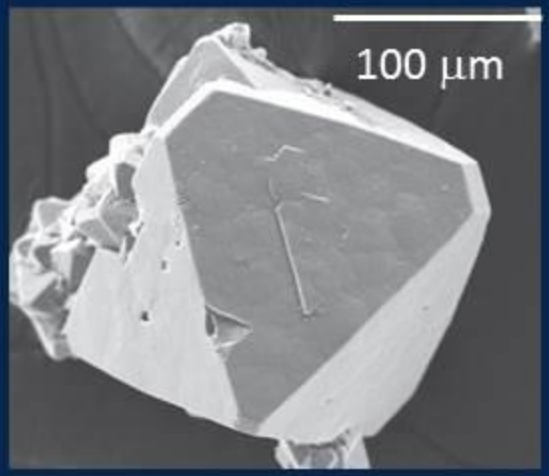
Geologic sources of arsenic

Northeastern San Joaquin Groundwater Subbasin

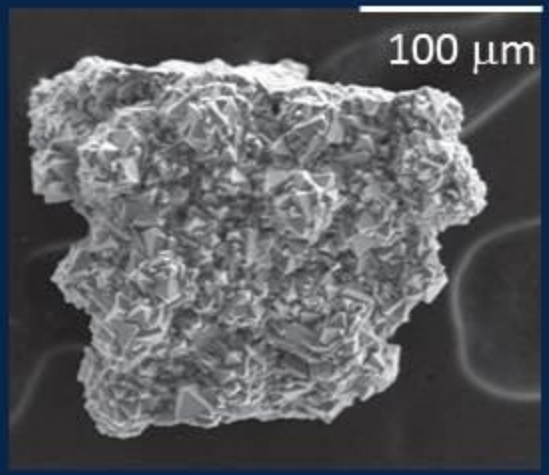


Changes in dissolved oxygen and redox affect spatial and depth distribution of trace elements

Arsenic in pyrite



Primary octahedral crystal
4 percent arsenic



Secondary twinned-pyritohedron crystal
0 percent arsenic

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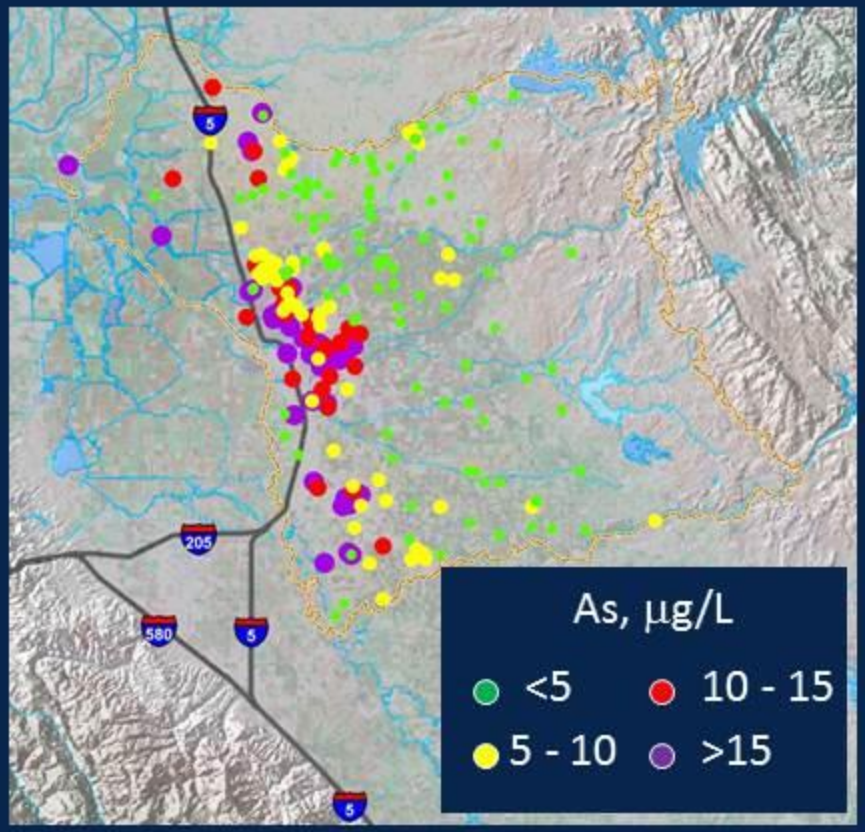
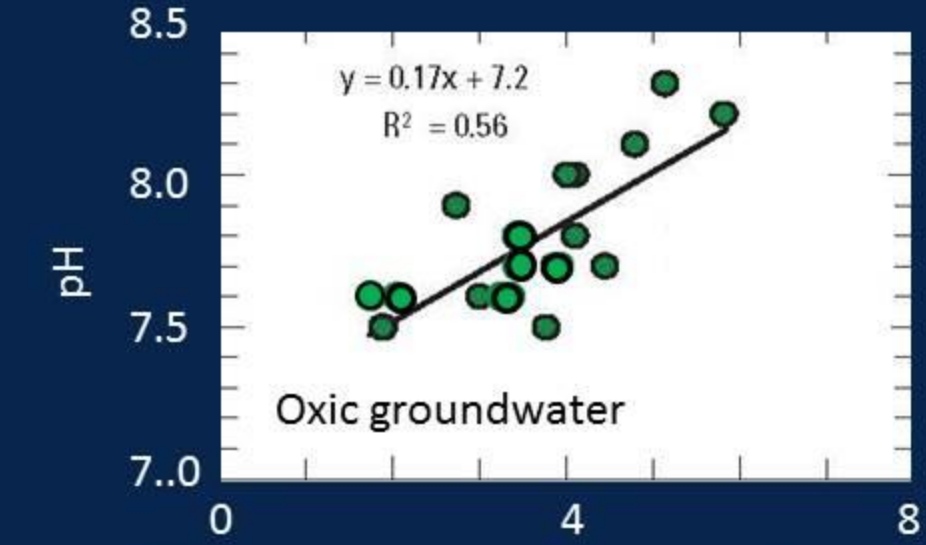
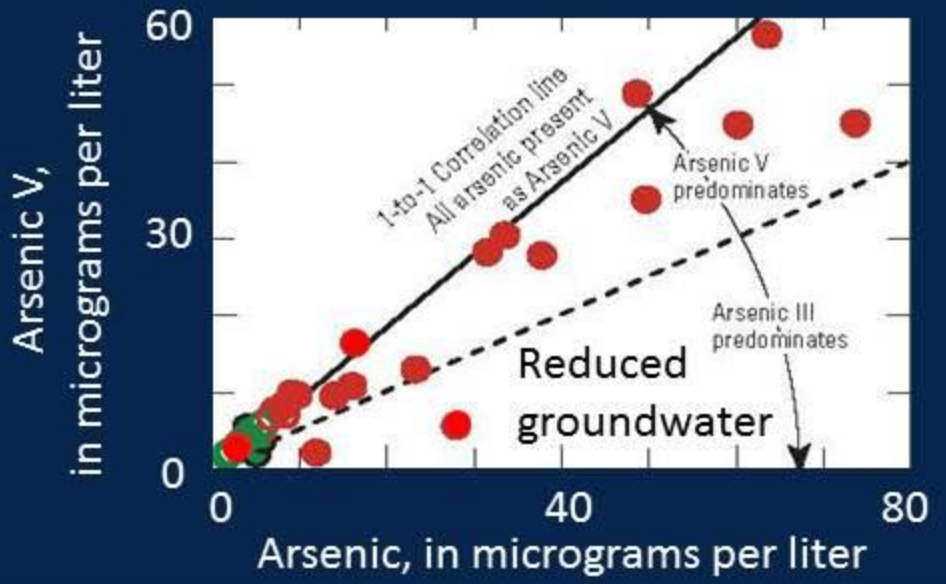
Groundwater flow, redox, and pH

Northeastern San Joaquin Groundwater Subbasin







Changes in dissolved oxygen and redox affect spatial and depth distribution of trace elements

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Groundwater flow, redox, and pH

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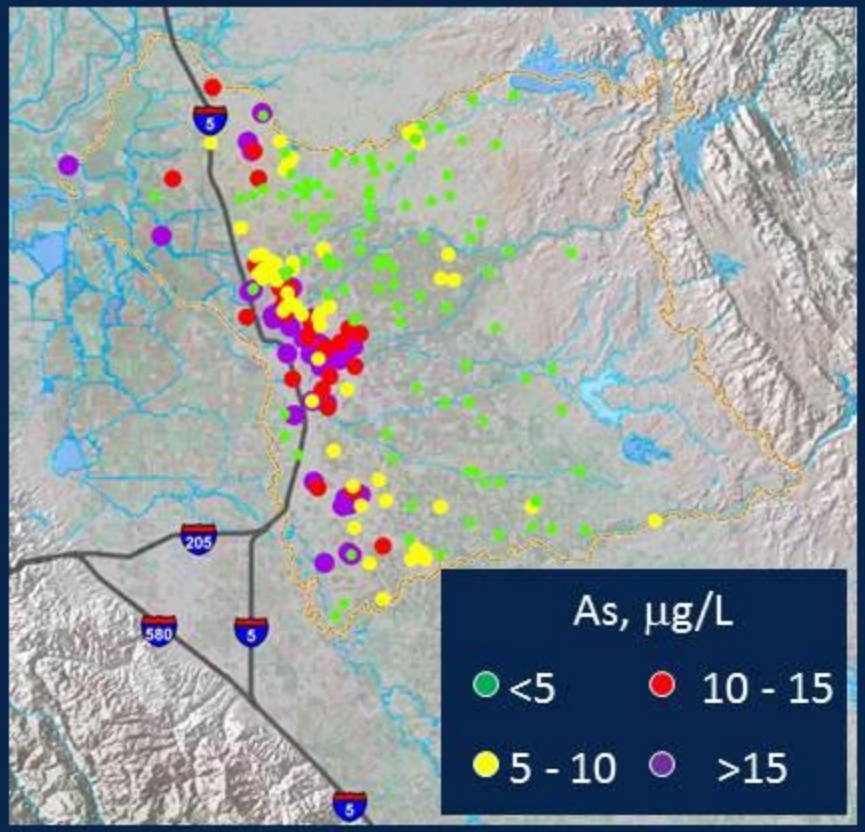
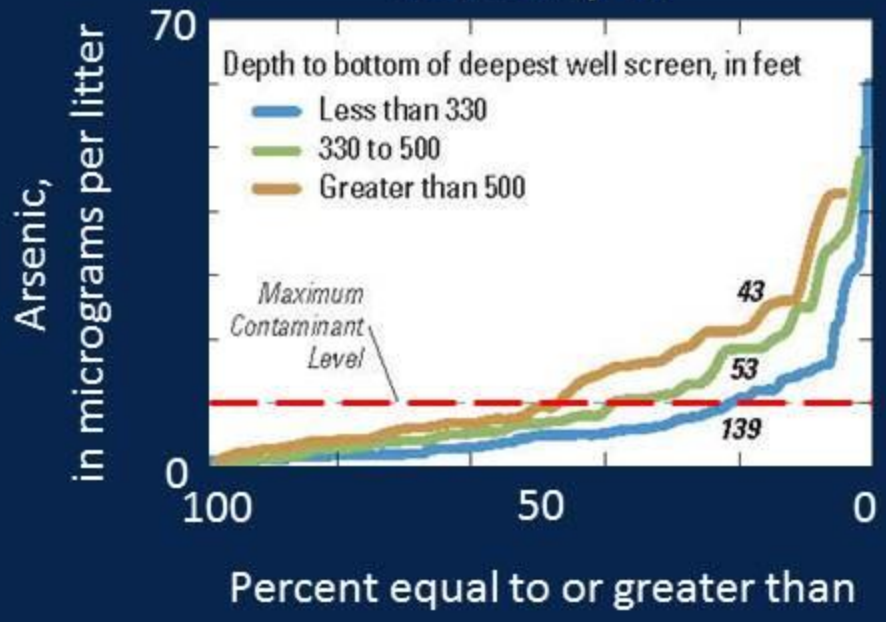


Arsenic concentrations with depth



Changes in dissolved oxygen and redox affect spatial and depth distribution of trace elements

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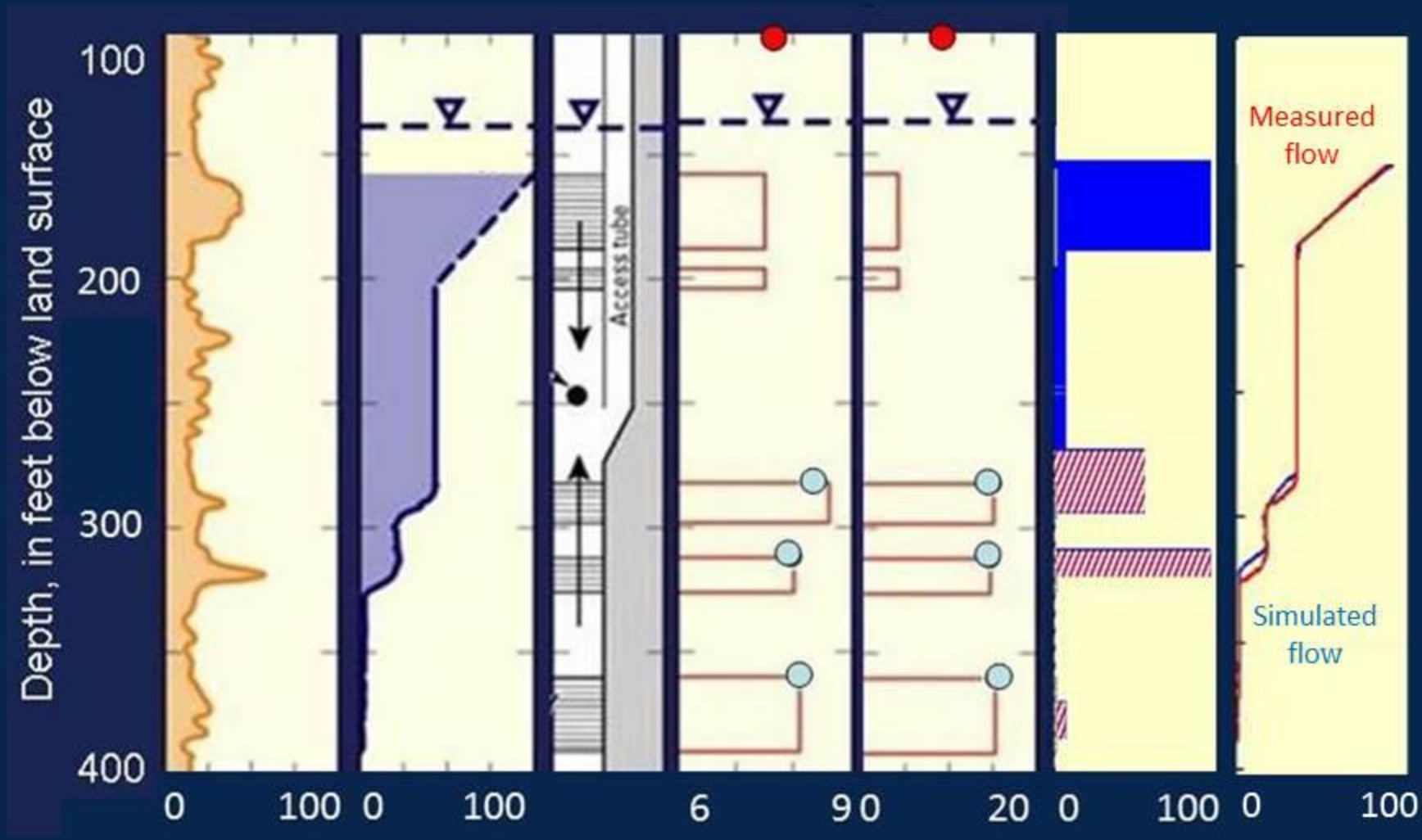
Well-bore flow and arsenic in well 1N/7E-20N1



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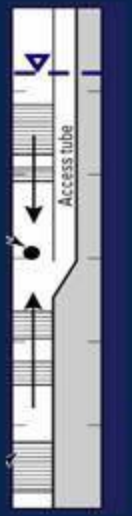
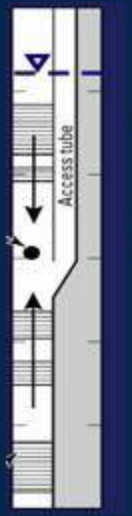
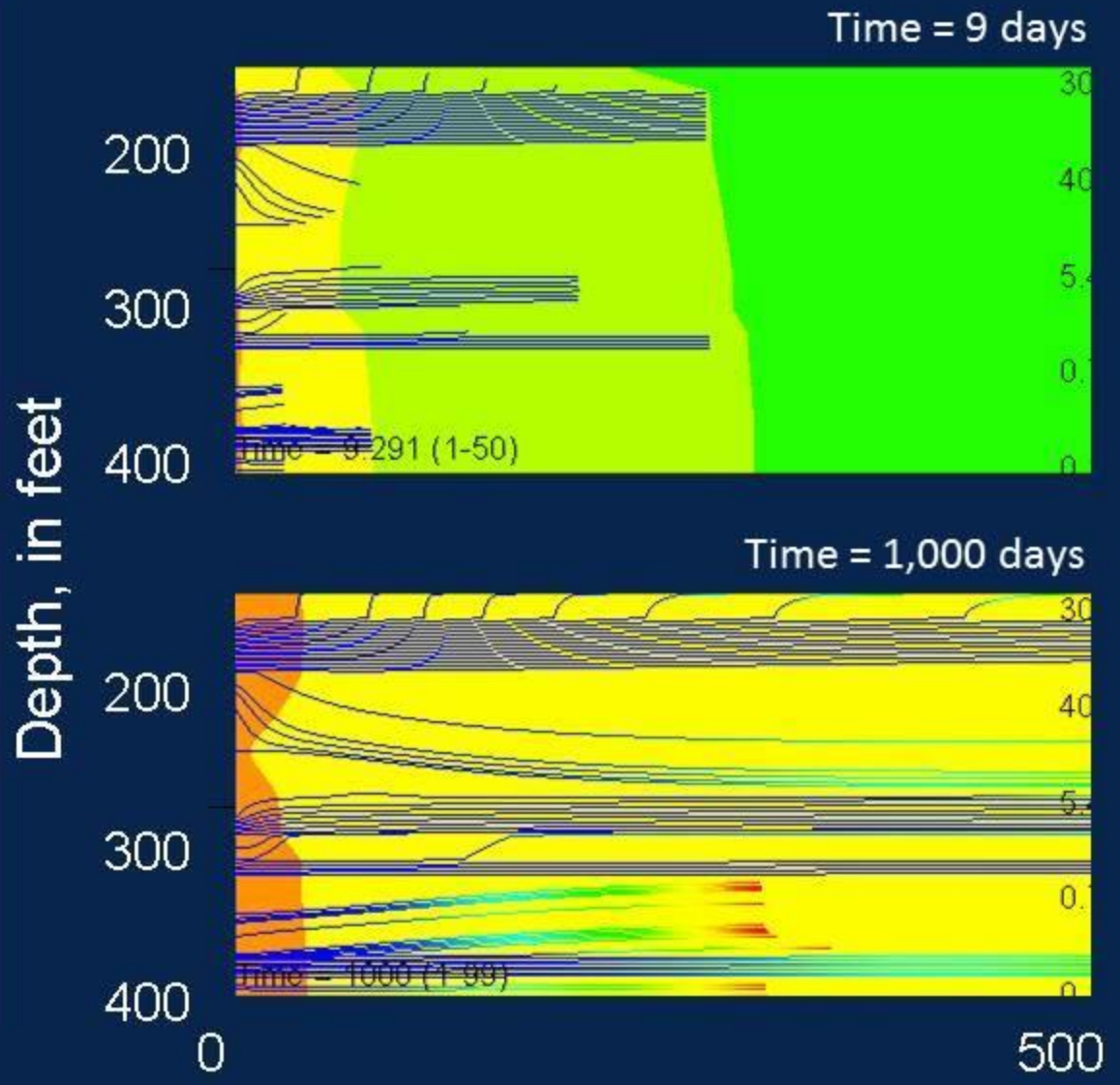
Drawdown and particle movement to well 1N/7E-20N1







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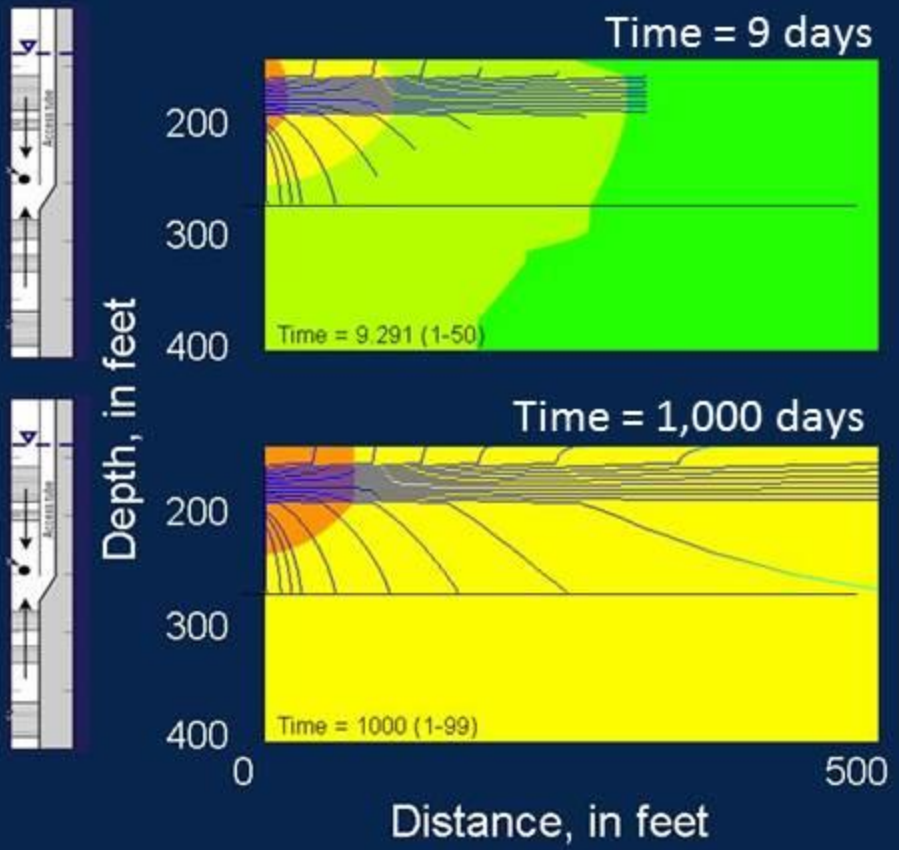
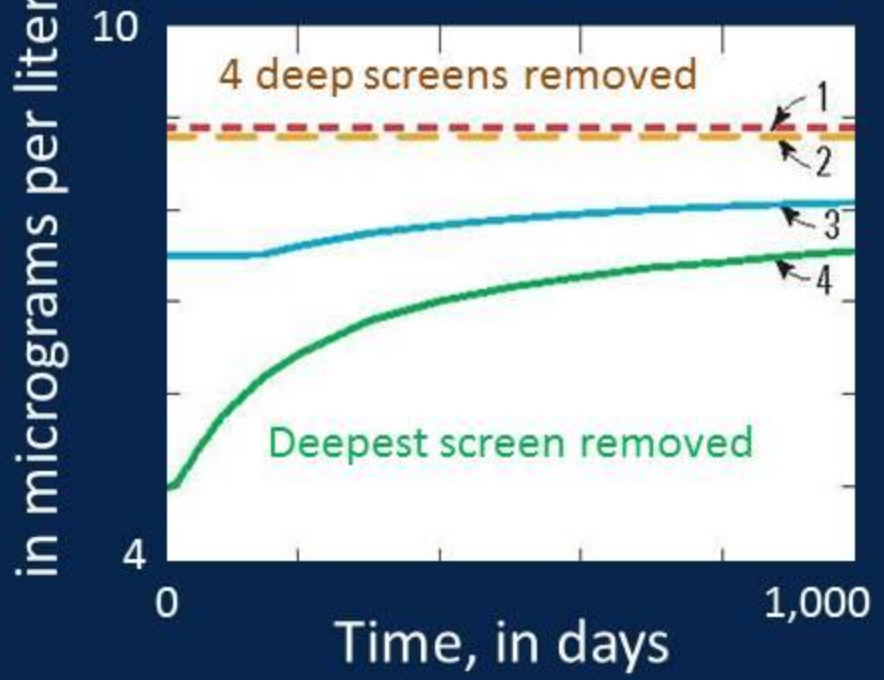
Drawdown and particle movement to modified well 1N/7E-20N1



Drawdown, in feet

< 0.1
0.5
1.0
5.0
> 10

Simulated arsenic concentration from well after modification



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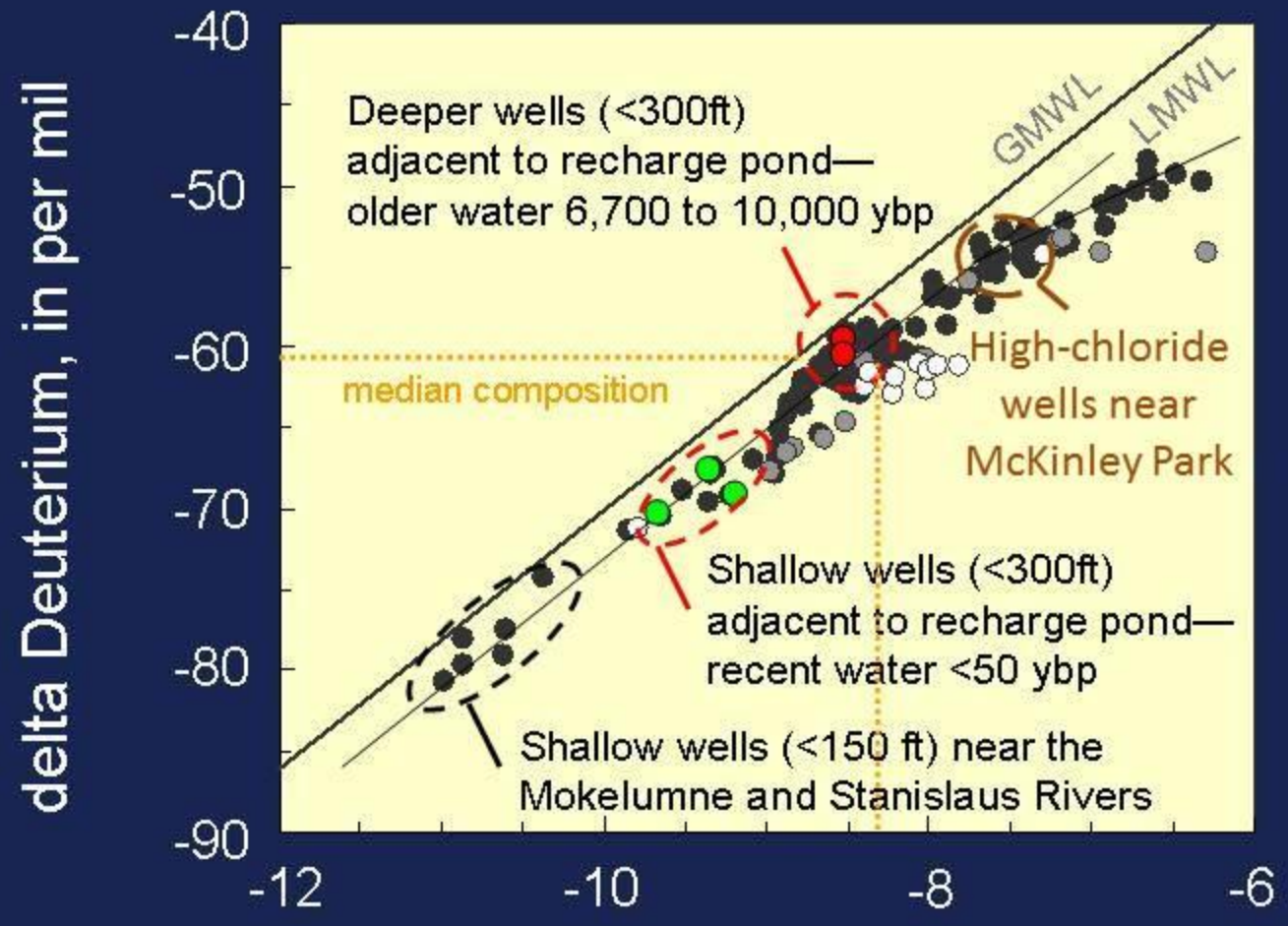
Stable oxygen and hydrogen isotopic composition of water from wells



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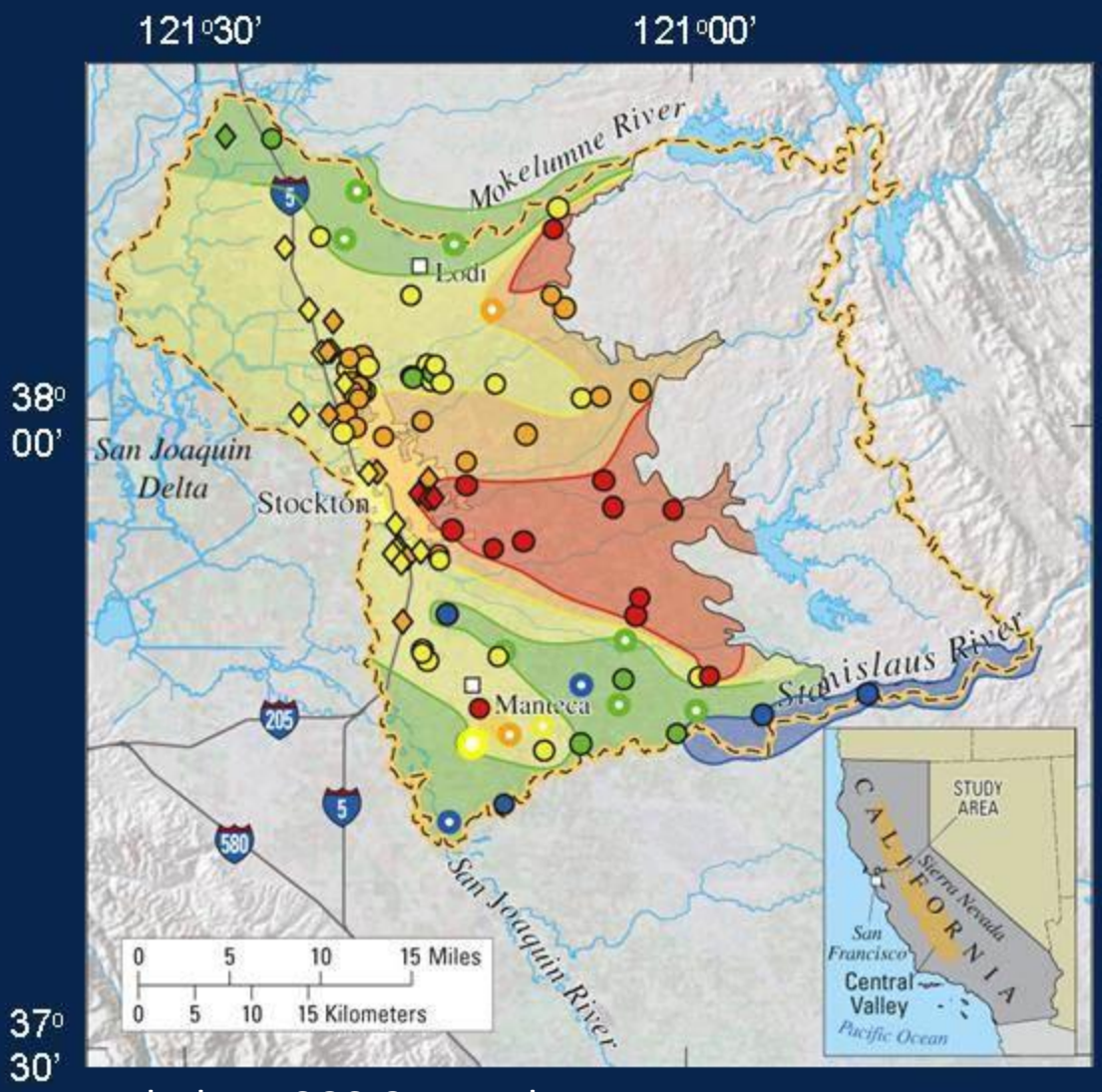
Distribution of delta Deuterium data



delta Deuterium, in per mil

2004-2007

- Greater than -55
- -60 to -55
- -70 to -60
- Less than -70
- Less than -80

- Chloride greater than 100 mg/L
- Previous data

Includes USGS GAMA data

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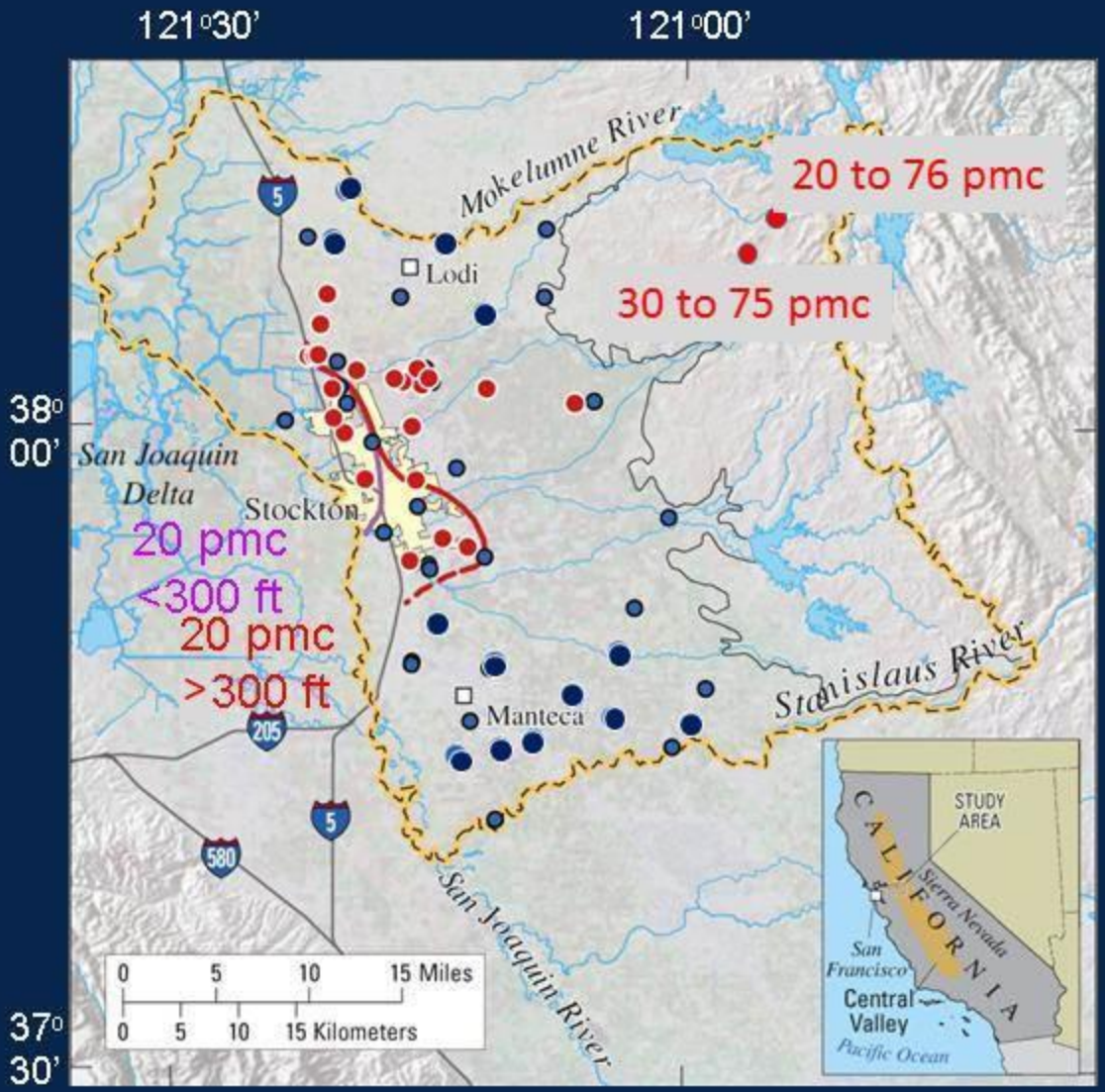
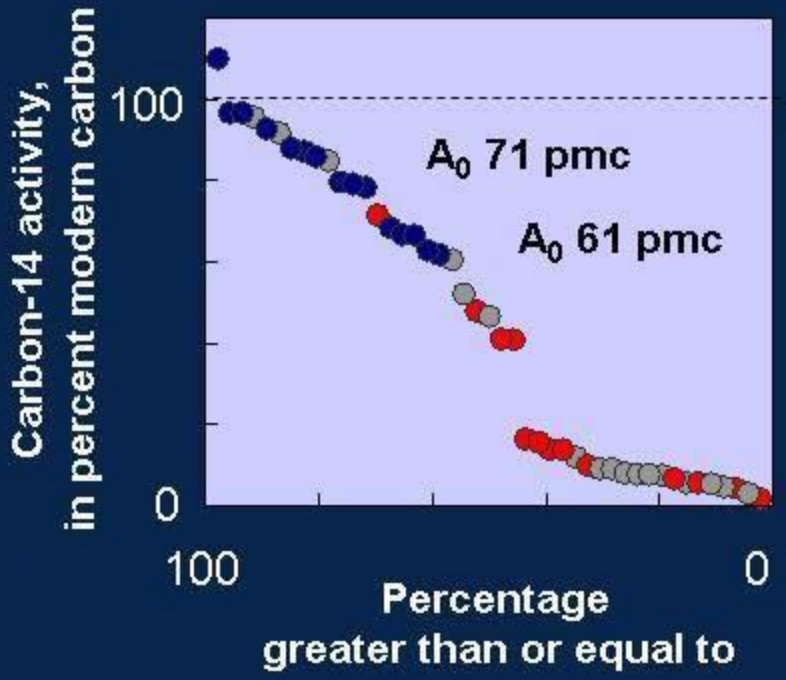
Distribution of Tritium and Carbon-14 data





- Post-1952 water
- Pre-1952 water

Includes USGS GAMA data

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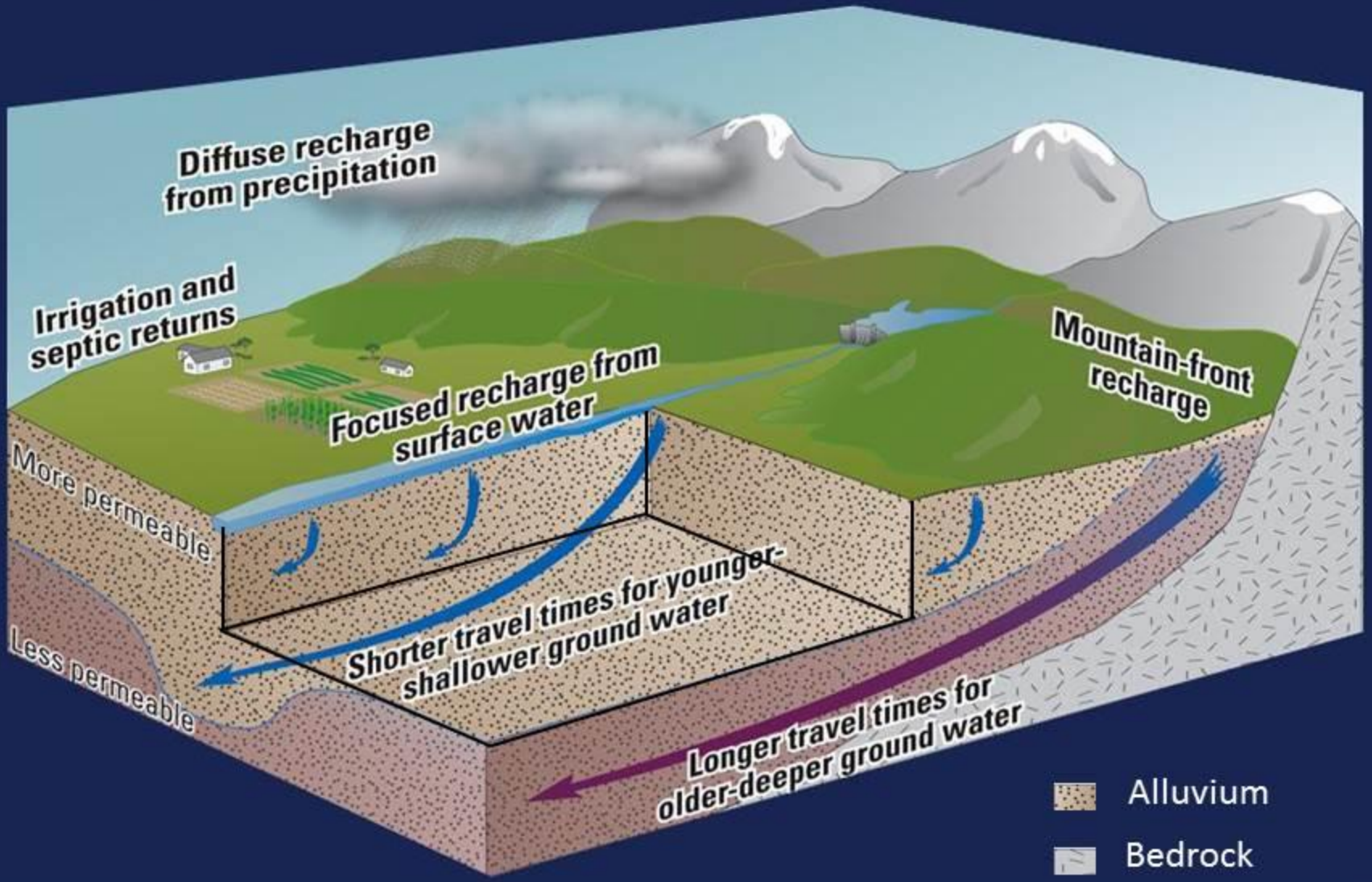
Recharge sources and movement



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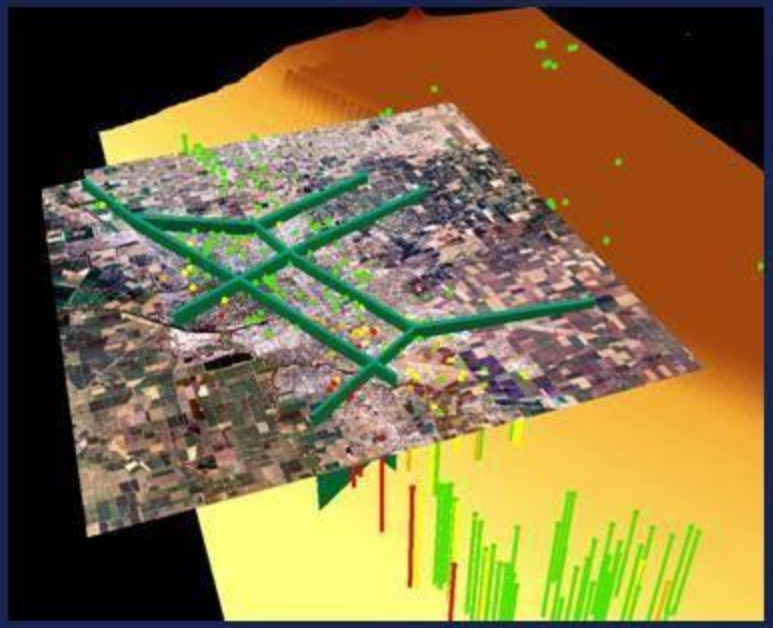
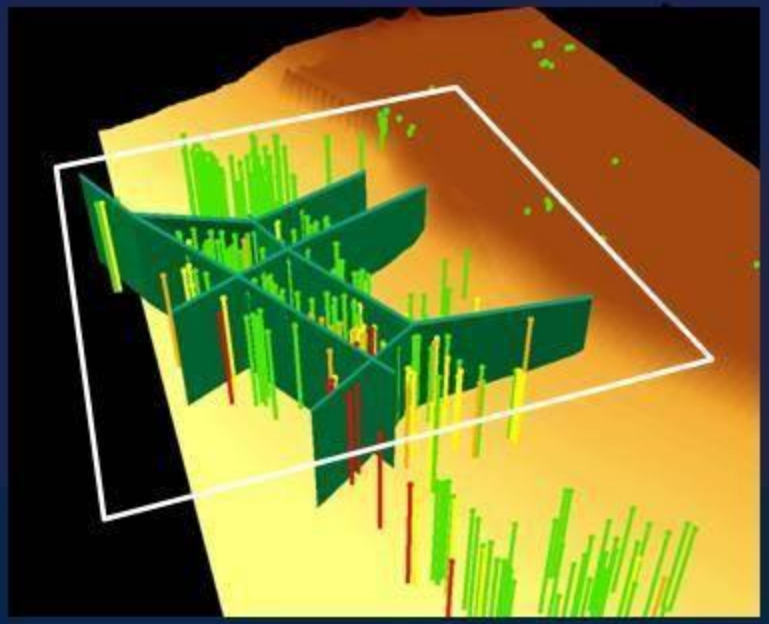
ARC-Scene and Earth-Vision Modeling



- Tool to assemble geologic, geophysical, and geochemical data
- Framework to use these data as tools to interpret layers and develop concepts and water movement



Wells and chloride concentration, in mg/L

Less than 100

100 to 250

250 to 500

Greater than 500

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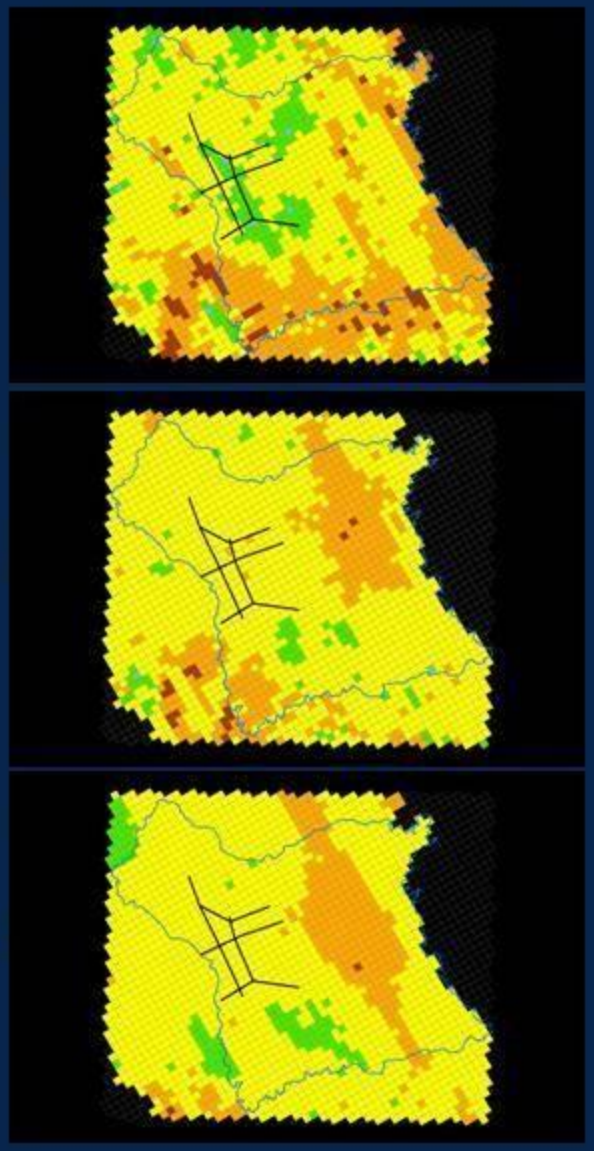
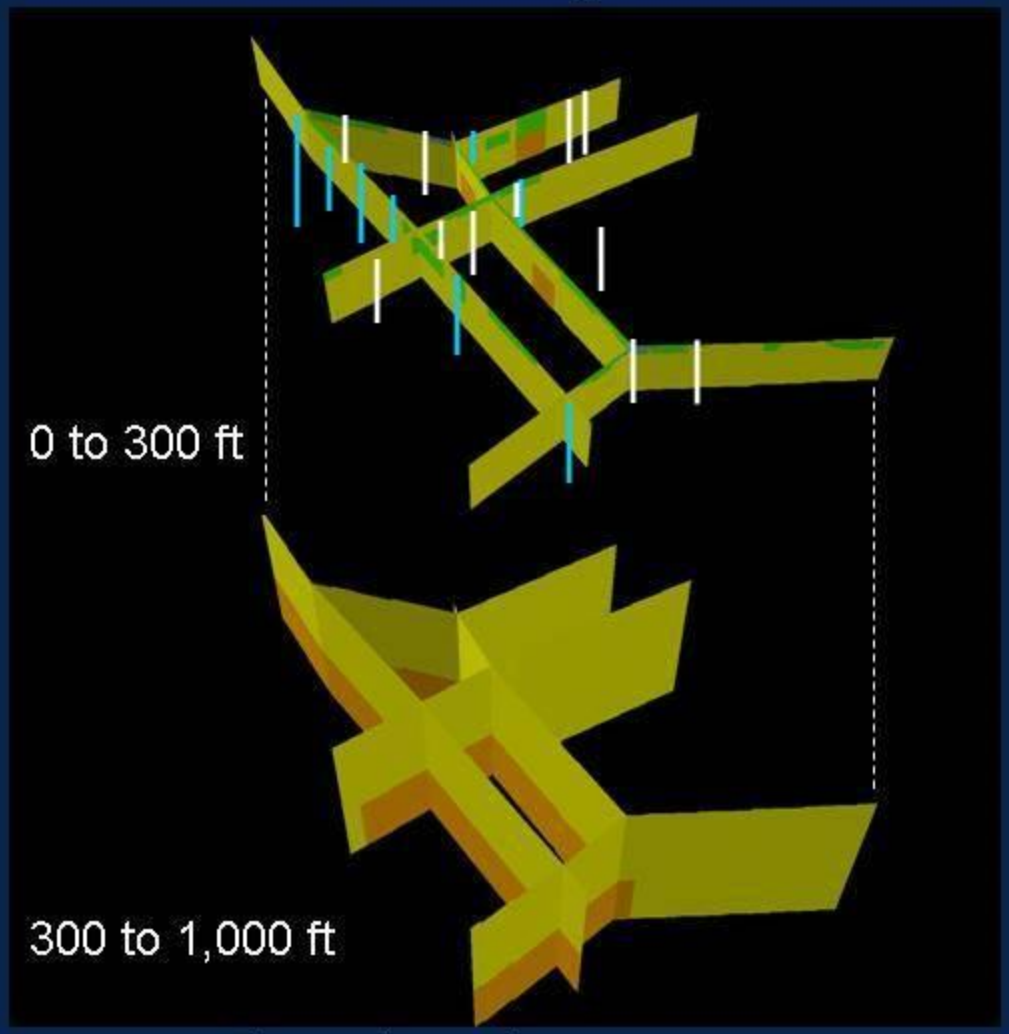
3-D Visualization of Aquifer Lithology (Texture) Data

Assemble selected slices → Fence diagram





Percent sand or coarser

- Less than 20
- 20 to 40
- 40 to 60
- Greater than 60

Conclusions

- Chloride from delta sediments and deeper deposits driven by groundwater pumping
  - Lower chloride but high nitrate from irrigation return
  - Higher chloride from delta sediments and deeper deposits

Continued need for high-quality, basic hydrologic data collection

- Deeper groundwater contains arsenic at greater than the Maximum Contaminant Level of 10 micrograms per liter
- Groundwater recharge can circulate to deeper depths within aquifers

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Reports (data available on-line at http://waterdata.usgs.gov/nwis)

- Clark, D.A., Izbicki, J.A., Metzger, L.F., Everett, R.R., Smith, G.A., O'Leary, David, Teague, N.F., and Burgess, M.K., 2012, Groundwater Data for Selected Wells within the Eastern San Joaquin Groundwater Subbasin, California, 2003–8: U.S. Geological Survey Data Series 696, 154 p.

- Izbicki, J.A., Stamos, C.L., Metzger, L.F., Halford, K.J., Kulp, T.R., Bennett, G.L., 2008, Source, Distribution, and Management of Arsenic in Water from Wells, Eastern San Joaquin Ground-Water Subbasin, California. USGS Open-File Report: 2008-1272, 8 p.

- Izbicki, J.A., Metzger, L.F., McPherson, K.R., Everett, R.R., Bennett, G.L., V., 2006, Sources of High-Chloride Water to Wells, Eastern San Joaquin Ground-Water Subbasin, California. USGS Open-File Report: 2006-1309, 8 p.

- Metzger, L.F., Izbicki, J.A., and Nawikas, J.M., 2012, Test drilling and data collection in the Calaveras County portion of the Eastern San Joaquin Groundwater Subbasin, California, December 2009–June 2011: U.S. Geological Survey Open-File Report 2012-1049, 26 p.

- Metzger, L.F., and Izbicki, J.A., 2012, Electromagnetic-induction logging to monitor changing chloride concentrations. Ground Water, Vol. 5, no. 1 pp. 108-121. doi: 10.1111/j.1745-6584.2012.00944.x

- O'Leary, D.R., Izbicki, J.A., Moran, J.E., Meeth, T., Nakagawa, B., Metzger, L.F., Bonds, C.; Singleton, M.J., 2012, Movement of water infiltrated from a recharge basin to wells. Ground Water, Vol. 50, pp. 242 – 255.

- O'Leary, D.R., Izbicki, J.A., and Metzger, L.F., in review, An updated assessment of sources of high-chloride water to wells, Eastern San Joaquin Groundwater Subbasin, California.

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