

Assessment of Water Quality in the Northern San Joaquin Basin

Groundwater Ambient Monitoring and Assessment Program – Priority Basin Project (GAMA-PBP)

March 26th, 2014

<http://ca.water.usgs.gov/gama/>

Outline

- GAMA Priority Basin Project (GAMA-PBP) Design
- Status of groundwater quality in the Northern San Joaquin Basin study unit.
- Factors affecting groundwater quality
- Other GAMA-PBP work

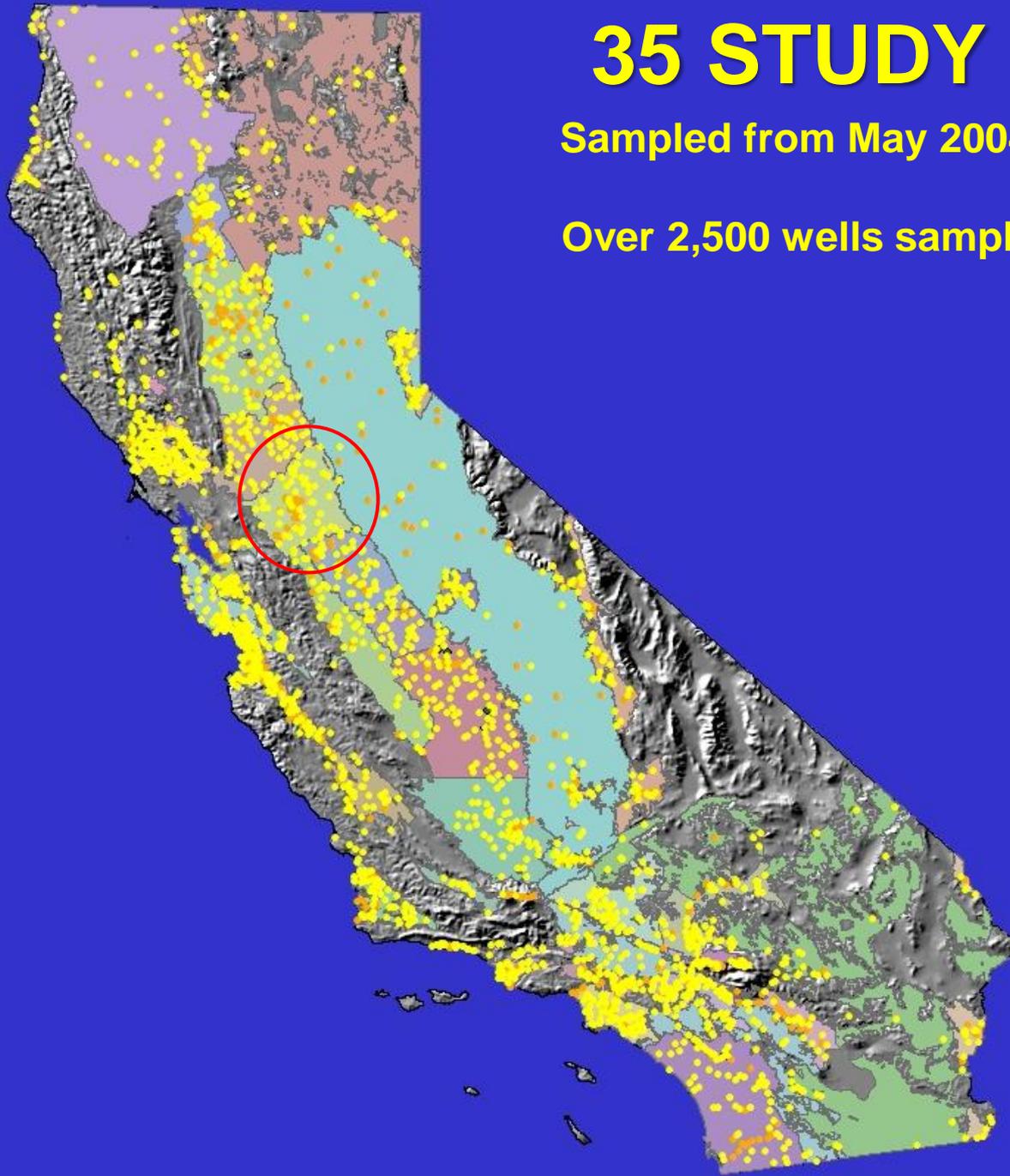
Goals of GAMA-PBP

- Comprehensive assessment of statewide groundwater quality in primary aquifer systems.
- Focus on identifying and understanding risks to groundwater and increasing the availability of that information to the public.
- GAMA-PBP assesses groundwater quality through direct sampling of groundwater using a statistically reliable sampling approach.
- Goal is to produce three types of assessments in each study units.
 1. **Status:** assessment of current quality of groundwater resource
 2. **Understanding:** identification of the natural and human factors affecting groundwater quality and explanation of relations between water quality and selected explanatory factors
 3. **Trends:** detection of changes in groundwater quality.

35 STUDY UNITS

Sampled from May 2004 – Dec. 2011

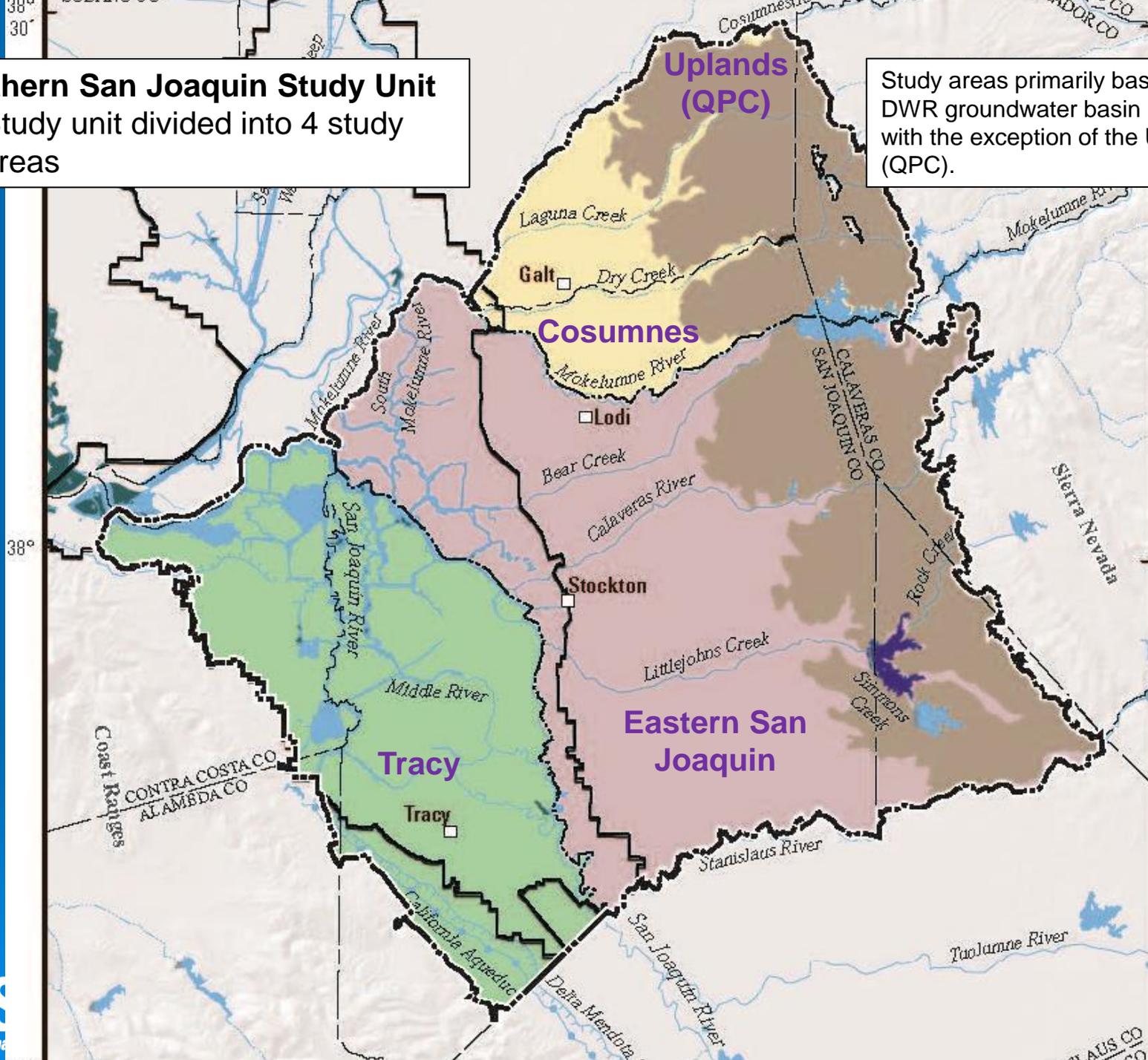
Over 2,500 wells sampled statewide



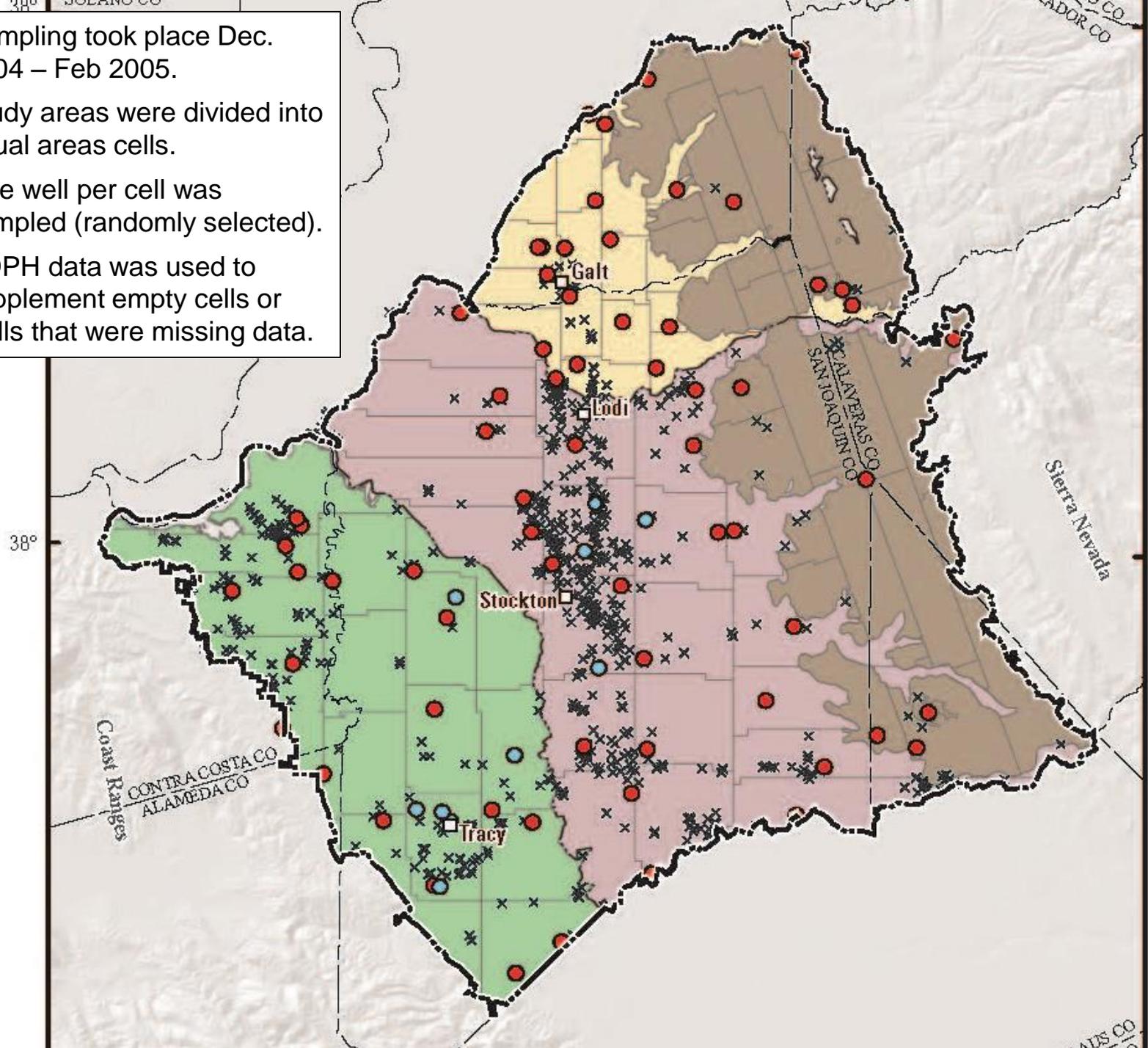
Northern San Joaquin Study Unit

- Study unit divided into 4 study areas

Study areas primarily based on DWR groundwater basin boundaries with the exception of the Uplands (QPC).



- Sampling took place Dec. 2004 – Feb 2005.
- Study areas were divided into equal areas cells.
- One well per cell was sampled (randomly selected).
- CDPH data was used to supplement empty cells or wells that were missing data.





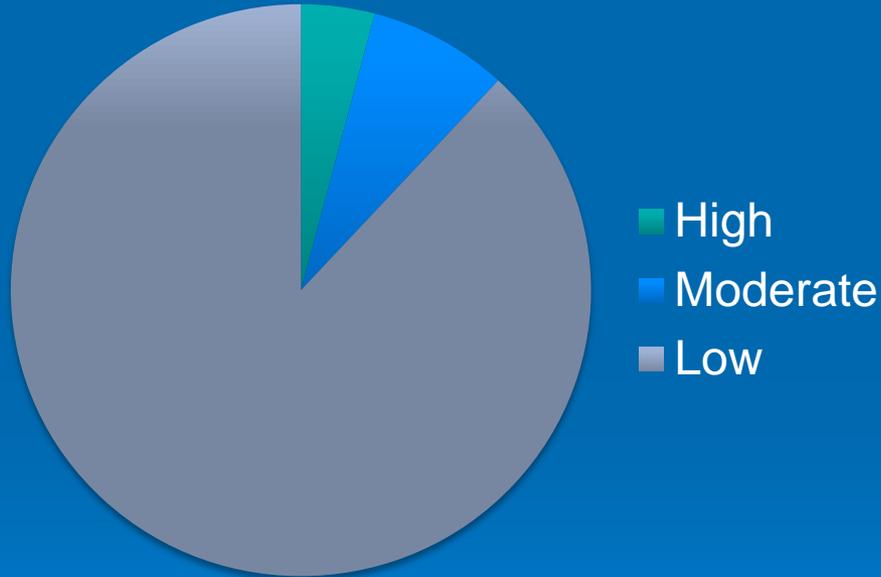
➤ Constituents sampled:

- Numerous organic compounds including volatile organic compounds (VOCs) and pesticide and pesticide degradates
- Waste-water indicators
- Nutrients and dissolved organic carbon
- Major and minor ions
- Trace elements
- Microbial constituents
- Radioactive constituents (radon, radium, gross-alpha and beta)
- Tracers of age and source
 - Tritium, carbon-14, noble gases, stable isotopes of water

*Not all constituents
were sampled at all well.

Benchmarks for evaluating groundwater quality

Constituent concentrations



GAMA-PBP used benchmarks for drinking water to provide context to results.

Benchmarks included Federal and California regulatory thresholds as well as non-regulatory health-based and aesthetic-based benchmarks.

- High = greater than benchmark.
- Moderate = greater than one-tenth of benchmark for organic constituents and greater than one-half of benchmark for inorganic constituents.

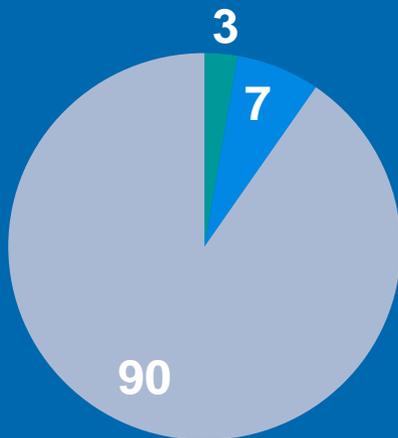
Status assessment overview

Health-based benchmarks (HBB)

Aesthetic benchmarks

Any organic constituent

■ High ■ Moderate ■ Low

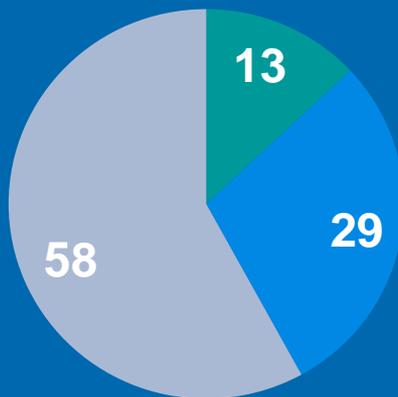


Organic constituents at high concentrations:

DBCP
PCE
Vinyl Chloride

Any inorganic constituent

■ High ■ Moderate ■ Low

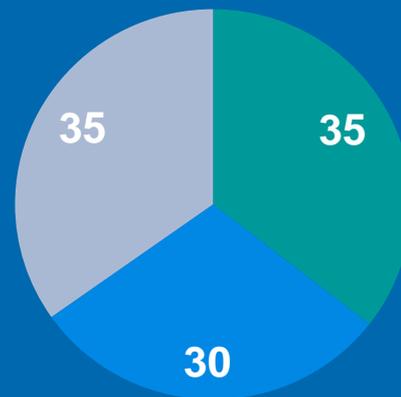


Inorganic constituents at high concentrations:

Arsenic
Boron
Nitrate

Any inorganic constituent

■ High ■ Moderate ■ Low

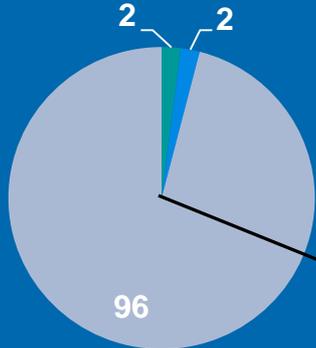


Constituents at high and moderate concentrations:

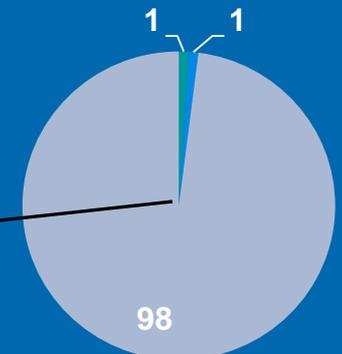
Iron
Manganese
Chloride
Sulfate
Total dissolved solids

Fumigants by study area

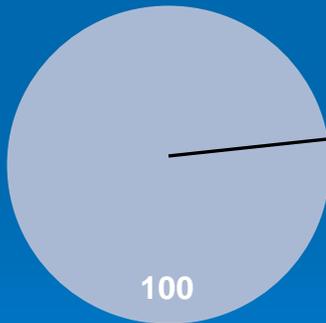
Eastern San Joaquin



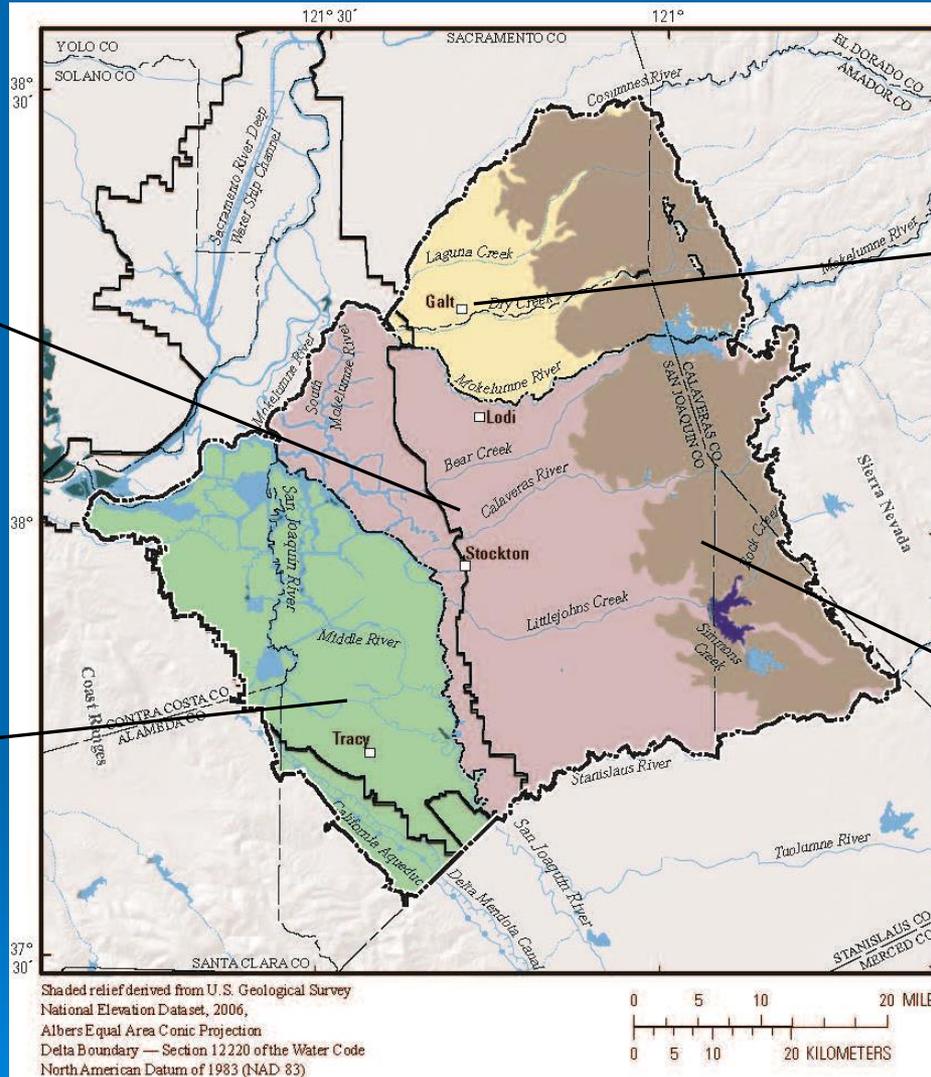
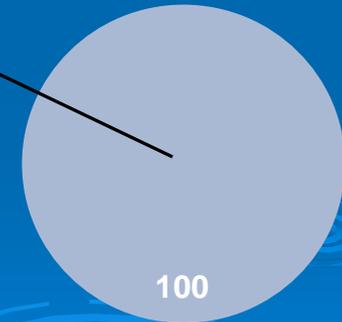
Cosumnes



Tracy



Uplands

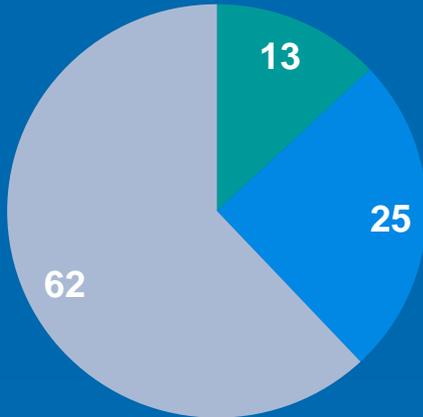


DBCP at high and moderate concentrations in both study areas.

Inorganic constituents classes (HBB)

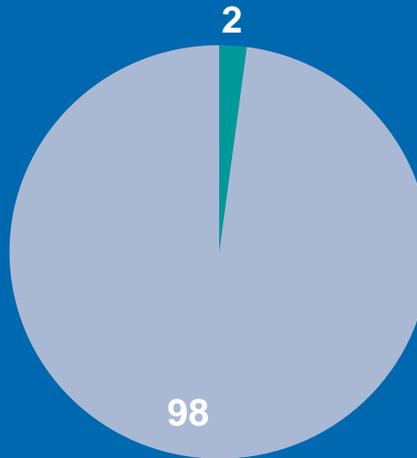
Trace Elements

■ High ■ Moderate ■ Low



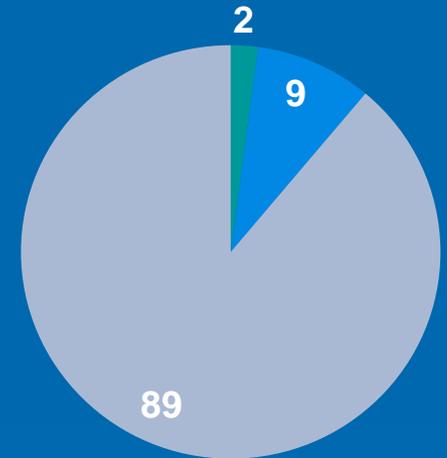
Radioactive Constituents

■ High ■ Moderate ■ Low



Nitrate

■ High ■ Moderate ■ Low

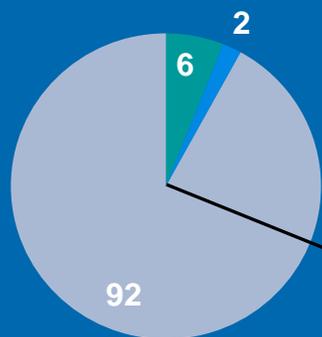


Trace elements at high and moderate concentrations:

Arsenic
Boron
Vanadium

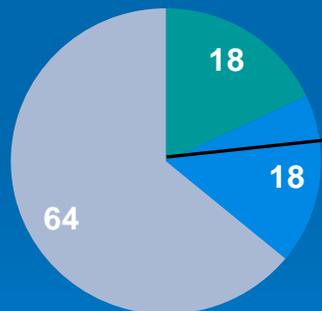
Inorganics with SMCLs by study area

Eastern San Joaquin

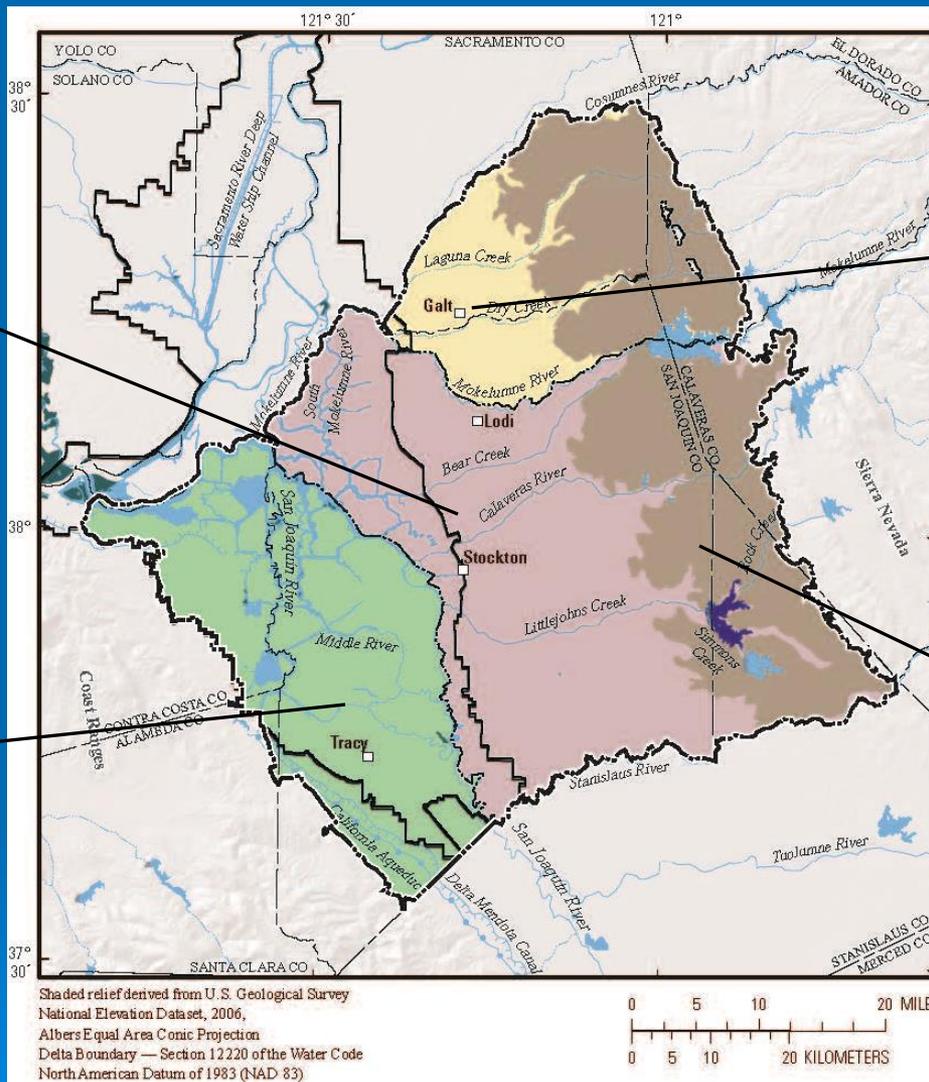


High - Mn
Moderate - Mn

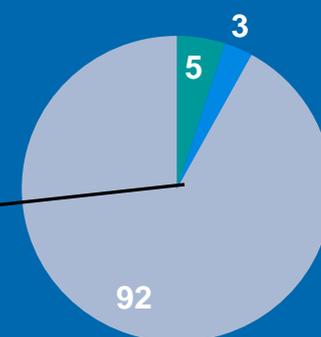
Tracy



High - Cl, Fe, Mn, SO₄ TDS
Moderate - Cl, Fe, Mn, SO₄ TDS

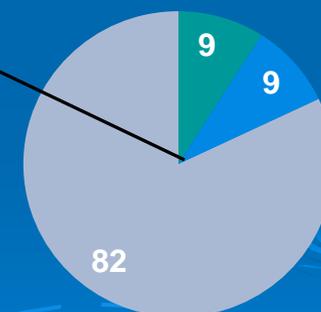


Cosumnes



High - Mn
Moderate - Fe

Uplands



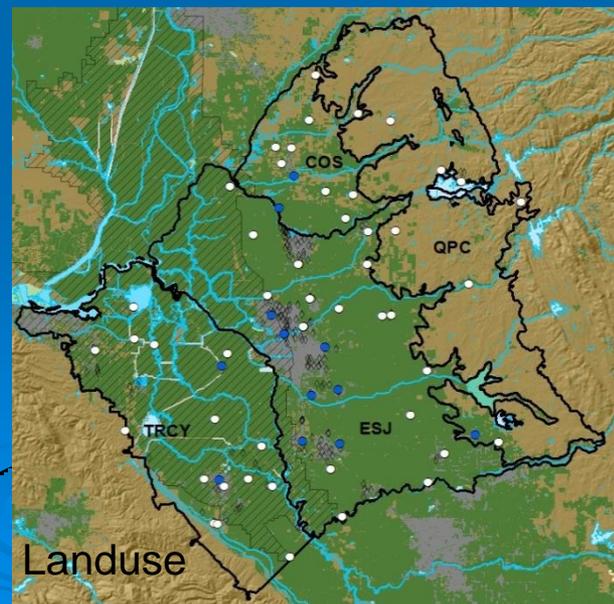
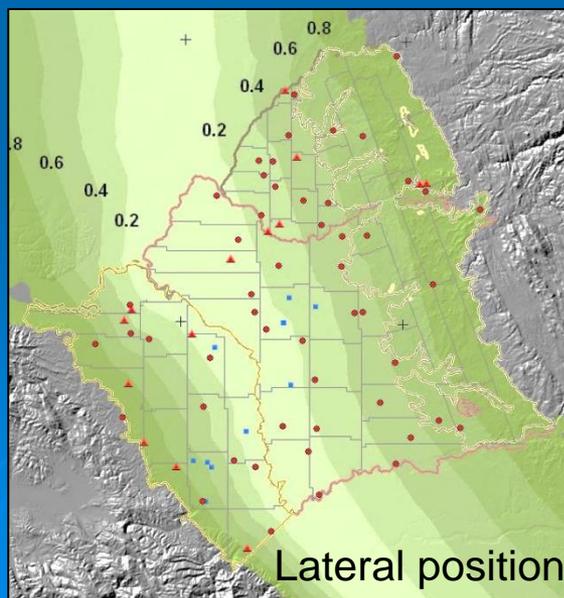
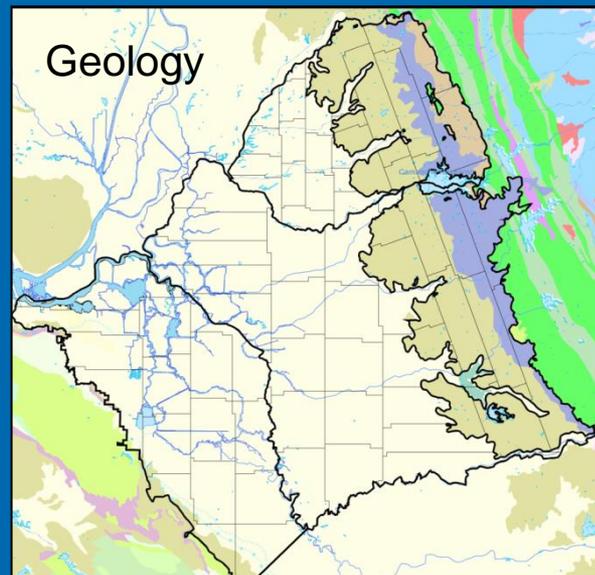
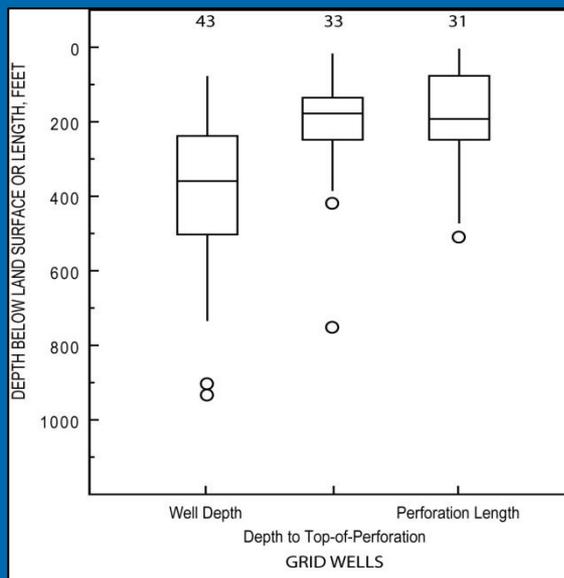
High - Fe, Mn
Moderate - Fe, Mn

Explanatory factors

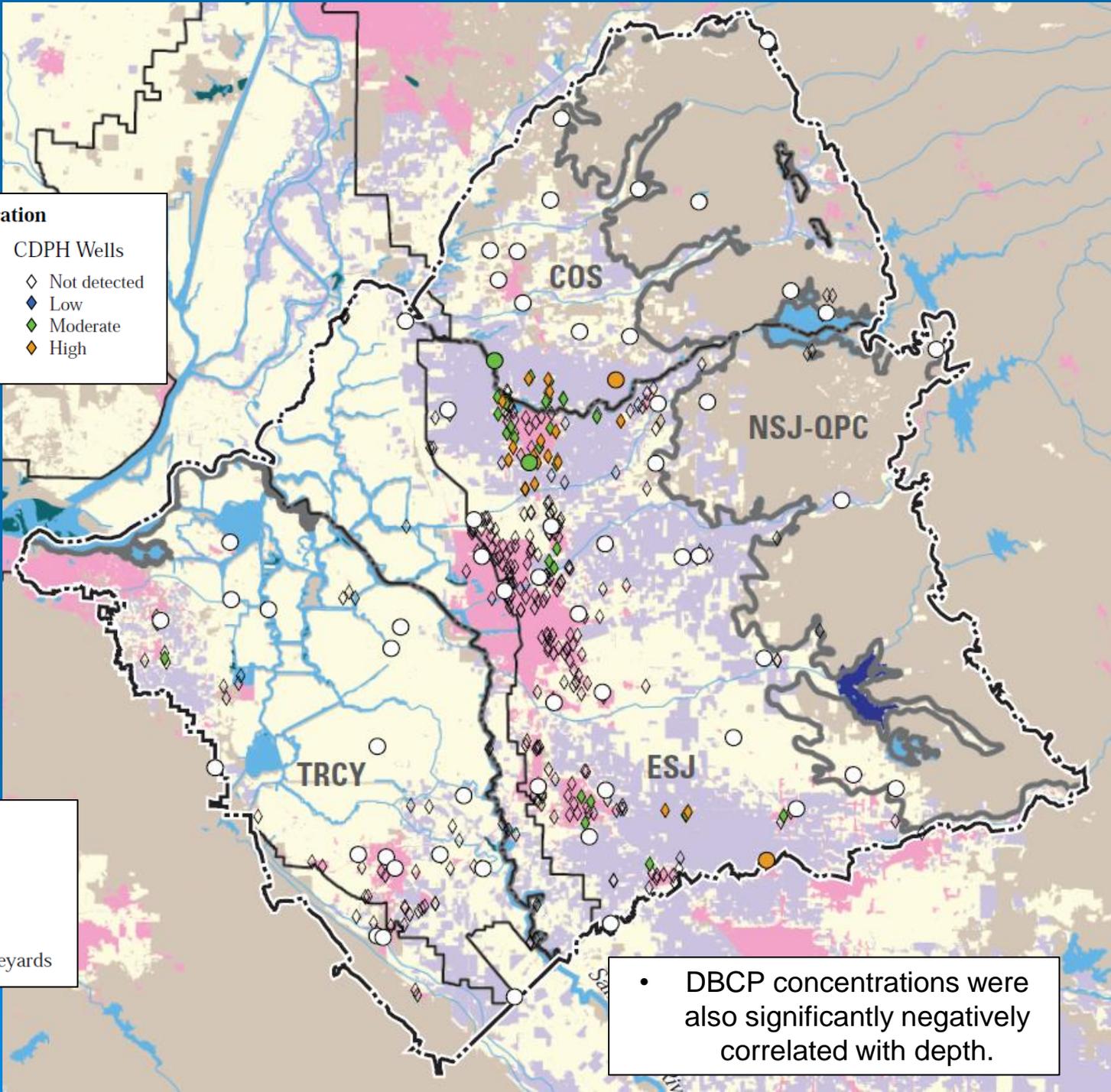
Potential explanatory factors assigned to wells.

Water quality information is compared to the explanatory factors.

- Depth
- Geology
- Ground-Water Age
- Land Use
- Lateral Position
- Redox



DBCP and land use



Relative-Concentration

Grid and Understanding Wells

- Not detected
- Low
- Moderate
- High

CDPH Wells

- ◇ Not detected
- ◇ Low
- ◇ Moderate
- ◇ High

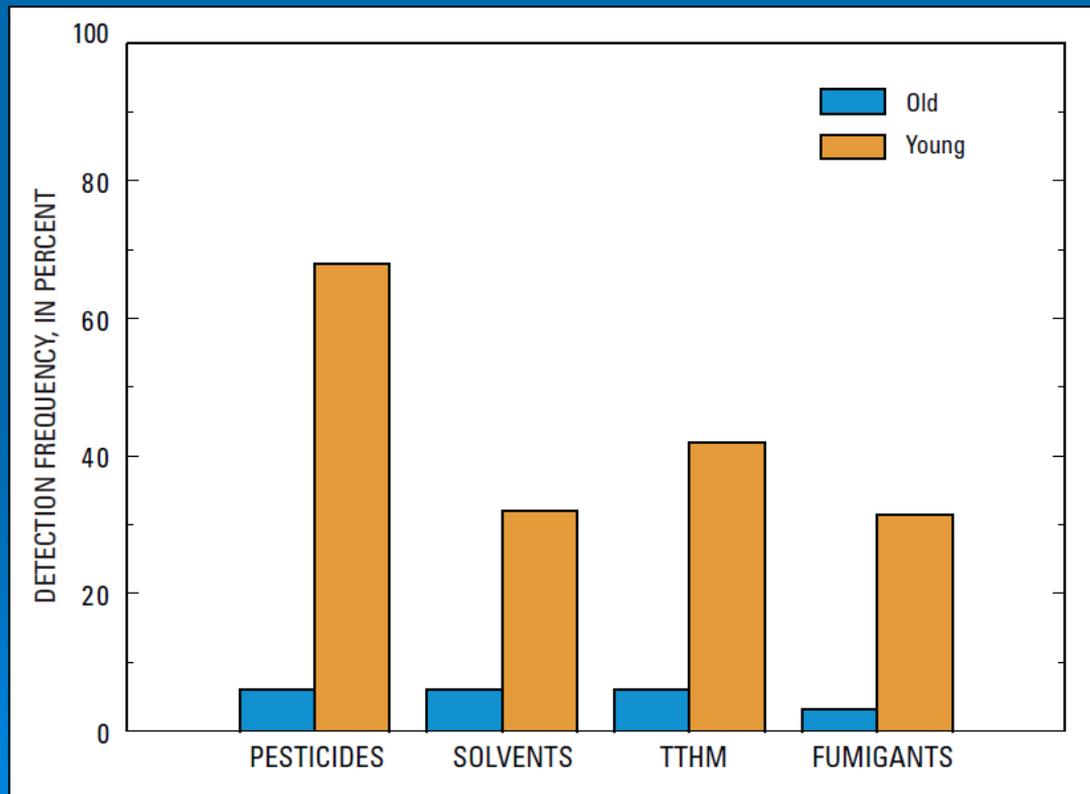
Land use

- Urban
- Agricultural
- Natural
- Orchards and vineyards

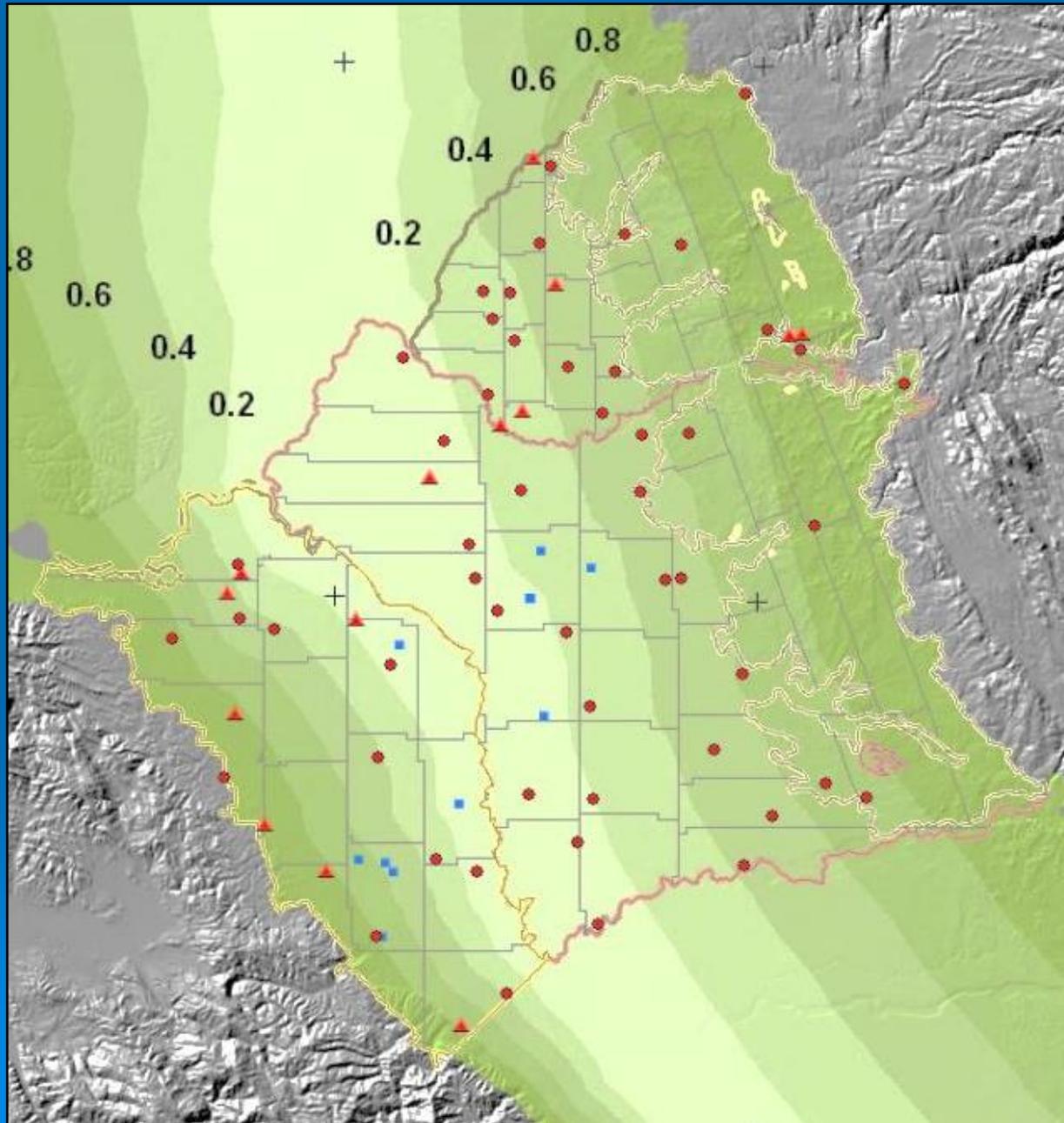
• DBCP concentrations were also significantly negatively correlated with depth.

Organic constituent detection frequency and groundwater age

- All organic constituent class concentrations higher in water classified as young as compared to old.

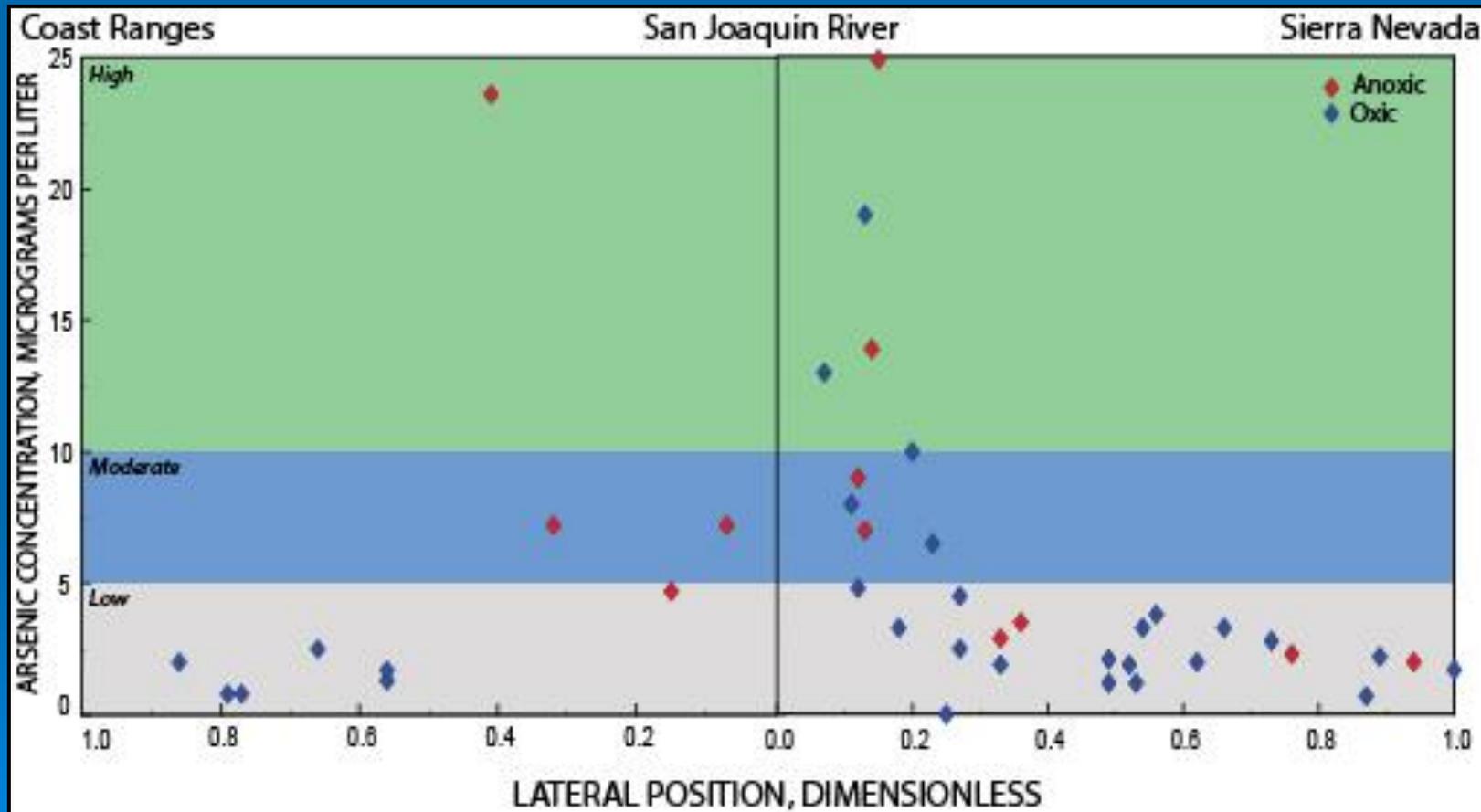


Lateral position as an explanatory factor

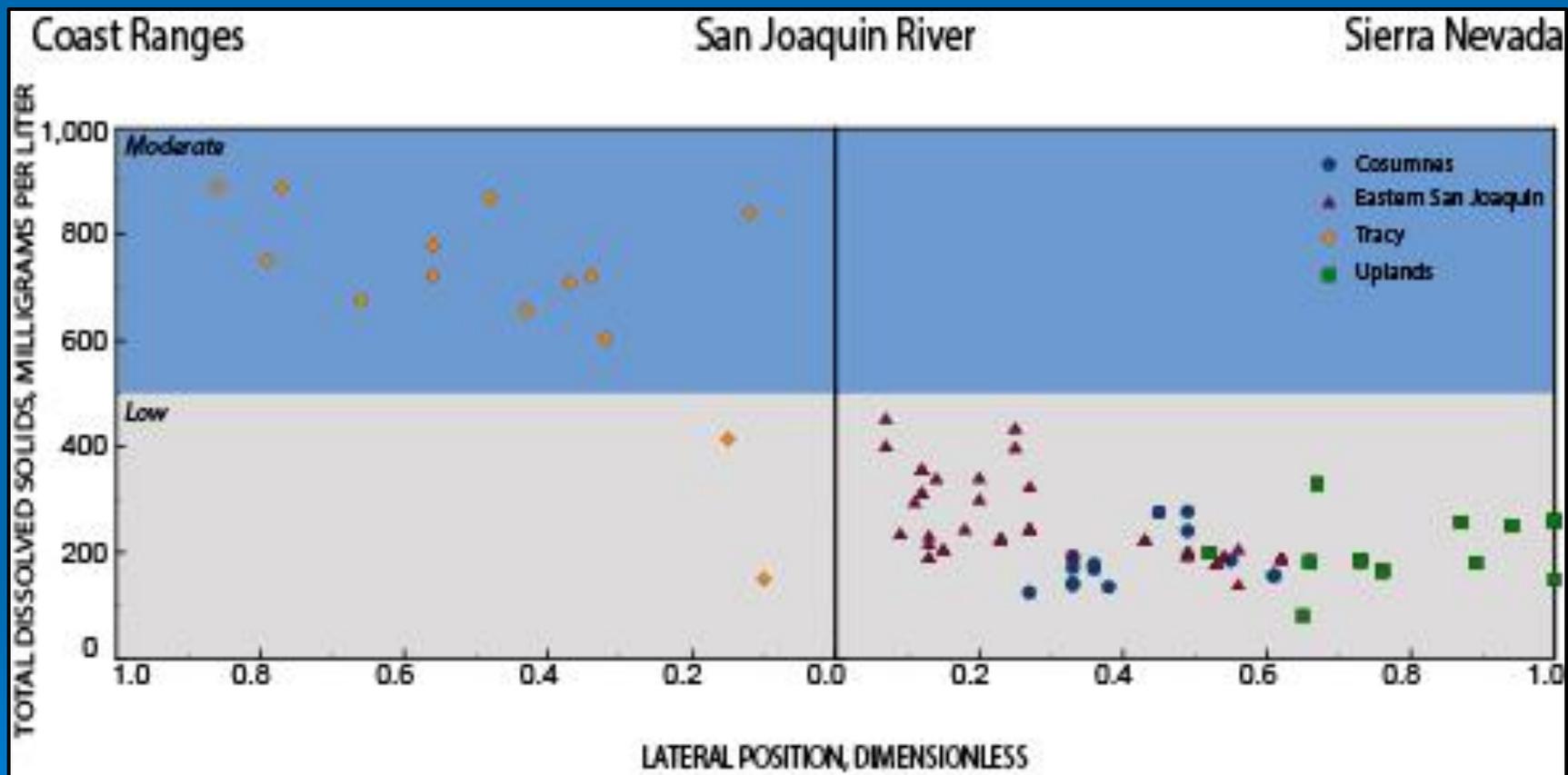


Arsenic versus lateral position

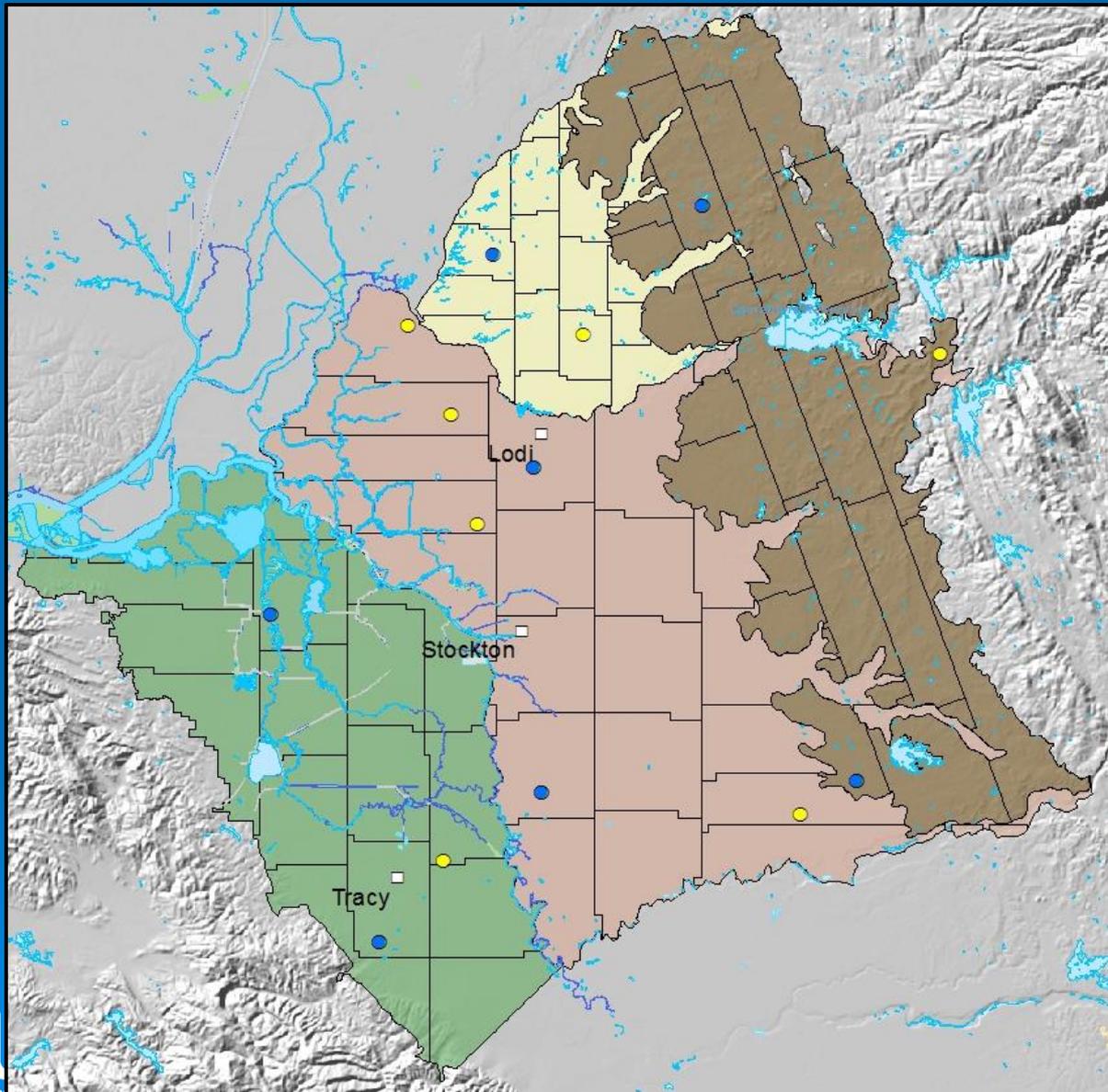
- Arsenic concentrations significantly negatively correlated with lateral position.



TDS versus lateral position



Other GAMA projects in the area



GAMA Trends

- **Triennial trend wells**
 - Sampled twice since 2005
 - Upcoming GAMA-PBP report covers trends statewide.

- **Decadal trend wells**
 - First decadal samples collected early March, 2014
 - Decadal wells include previously selected wells in the triennial network.

GAMA-PBP Synthesis Papers

Selected journal articles prepared by the GAMA-PBP that are relevant to the Northern San Joaquin Valley

- **High concentrations of uranium in the Central Valley are due to the mobilization of naturally-occurring uranium by downward-moving, bicarbonate-rich irrigation return flows. Elevated bicarbonate is a result of plant productivity. In the future, an increasing number of public supply wells are expected to be affected by high concentrations of uranium.** [Jurgens and others, Groundwater, 2010]
- **High concentrations of vanadium are associated with sediment derived from mafic, igneous source rock and alkaline conditions.** [Wright and Belitz, Groundwater, 2010]
- **Perchlorate can occur naturally in deep groundwater at low concentrations (0.1 to 0.5 $\mu\text{g/L}$) under a range of climatic conditions (arid to humid). Concentrations above 4.0 $\mu\text{g/L}$ are unlikely to be natural.** [Fram and Belitz, ES&T, 2011]
- **Lateral position and depth to the water table are predictive of redox condition in the Central Eastside. San Joaquin Valley. Depth of well screen is not as predictive.** [Landon and others, Hydrogeology Journal, 2011]

GAMA-PBP Shallow Aquifer Assessment - ongoing

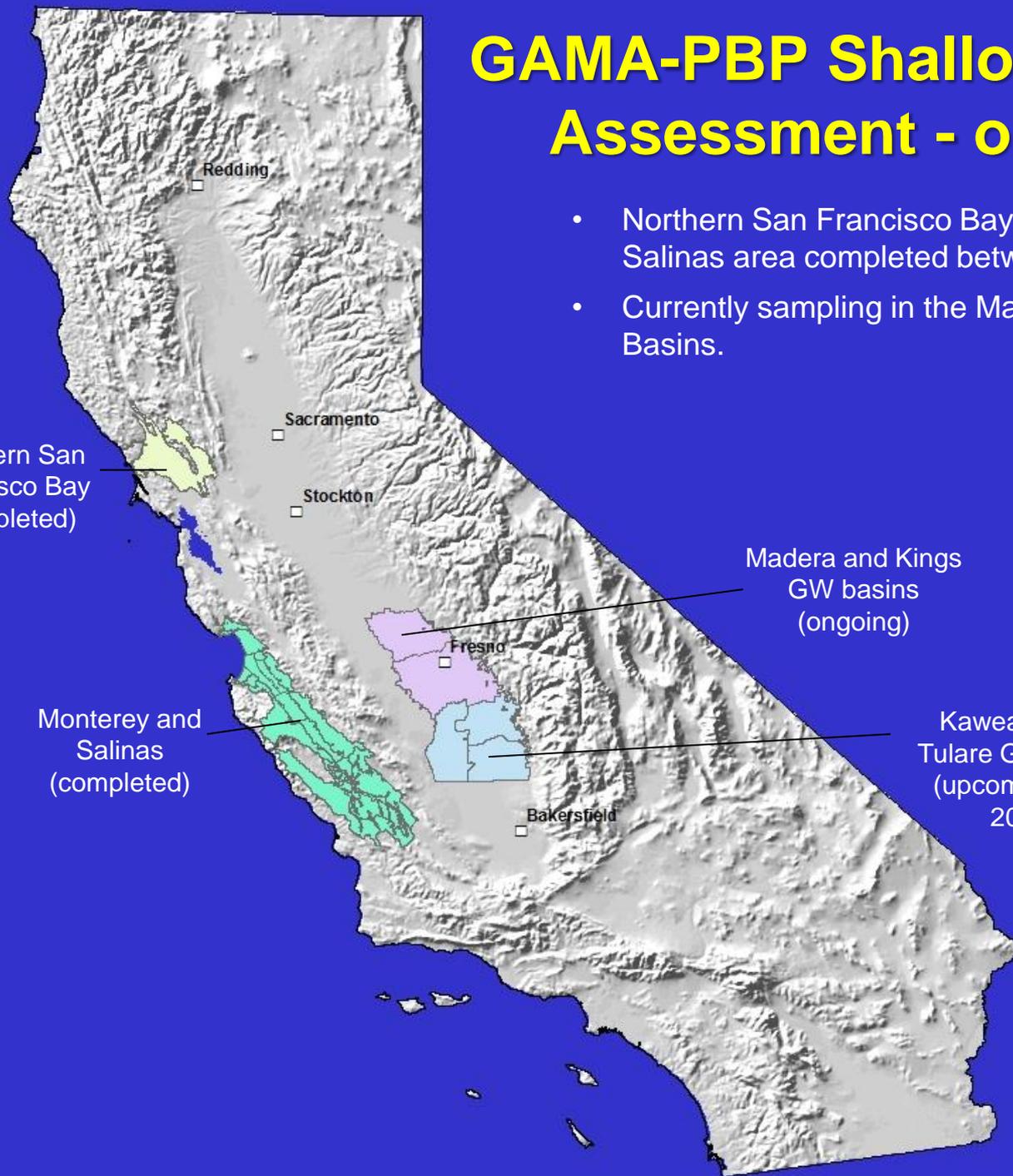
- Northern San Francisco Bay and Monterey and Salinas area completed between 2012-2013
- Currently sampling in the Madera and Kings Basins.

Northern San Francisco Bay (completed)

Monterey and Salinas (completed)

Madera and Kings GW basins (ongoing)

Kaweah, Tule, Tulare GW basins (upcoming ,Fall 2014)



Data Series Report

Scientific Investigations Report

Fact Sheet

USGS
science for a changing world

Water Boards

In cooperation with the California State Water Resources Control Board

California GAMA Program: Ground-Water Quality Data in the Northern San Joaquin Basin Study Unit, 2005

Data Series 196

Ground-Water Ambient Monitoring and Assessment (GAMA) Program

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

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Water Boards

In cooperation with the California State Water Resources Control Board

A product of the California Groundwater Ambient Monitoring and Assessment (GAMA) Program

Status and Understanding of Groundwater Quality in the Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project

CALIFORNIA
GAMA
PROGRAM

Scientific Investigations Report 2010–5175

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

USGS
science for a changing world

Water Boards

U.S. Geological Survey and the California State Water Resources Control Board

Groundwater Quality in the Northern San Joaquin Valley, California

Groundwater provides more than 40 percent of California's drinking water. To protect this vital resource, the State of California created the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The Priority Basin Project of the GAMA Program provides a comprehensive assessment of the State's groundwater quality and increases public access to groundwater-quality information. The Northern San Joaquin constitutes one of the study units being evaluated.

The Northern San Joaquin Study Unit

The Northern San Joaquin (NSJ) study unit is located in California's San Joaquin Valley and includes the Cosumnes, Eastern San Joaquin, and Tracy groundwater sub-basins (California Department of Water Resources, 2003). The 2,079-square-mile study unit was divided into four study areas: Cosumnes, Eastern San Joaquin, Tracy, and Uplands (Quaternary-Pleistocene semiconsolidated deposits). The NSJ study unit has hot and dry summers and cool, moist, winters. Average annual rainfall ranges from 11 to 15 inches. Most rivers and streams flowing across the study unit drain into the San Joaquin River, which flows northwestward into the Sacramento-San Joaquin Delta and San Francisco Bay estuary.

Aquifers in the study unit consist of interlayered lenses of gravel, sand, silt, and clay deposited by rivers draining the Sierra Nevada to the east but also from the Coast Ranges to the west. The primary aquifers in the NSJ study unit are defined as those parts of the aquifers corresponding to the perforated intervals of the wells listed in the California Department of Public Health (CDPH) database. The public-supply wells monitored by CDPH typically are completed in the primary aquifers to depths of 250–500 feet below land surface (bls). The wells contain solid casing reaching from the land surface to about 100 to 250 feet bls and are perforated below the solid casing to allow water into the well. Water quality in the primary aquifers may differ from the water in shallow and deep parts of the aquifer system.

Land use in the study unit is about 57 percent (%) agricultural, 36% natural (primarily grassland), and 7% urban. The largest urban area in the study unit is the City of Stockton, with a population of 287,578 (U.S. Census Bureau, 2009 estimate).

Recharge to the groundwater flow system primarily is from percolation of irrigation return water, precipitation, seepage from reservoirs and rivers, and urban runoff (Northeastern San Joaquin County Groundwater Banking Authority, 2004). The primary sources of groundwater discharge are pumping for irrigation and municipal water supply, evaporation from areas with a shallow depth to water, and discharge to streams.

Overview of Water Quality

Inorganic constituents

Organic constituents

CONSTITUENT CONCENTRATIONS

High Moderate Low or not detected

Values are a percentage of the total of the primary aquifer, with concentrations in the three specified samples.

GAMA's Priority Basin Project evaluates the quality of untreated groundwater, however, for context, benchmarks established for drinking-water quality are used for comparison. Benchmarks, and definitions of high, moderate, and low concentrations, are discussed in the inset box on page 3.

Many inorganic constituents occur naturally in groundwater. The concentrations of the inorganic constituents can be affected by natural processes as well as by human activity. In the NSJ study unit, one or more inorganic constituents were detected at high concentrations in about 13% of the primary aquifers and at moderate concentrations in about 29%.

Organic constituents are present in products used in the home, business, industry, and agriculture. Organic constituents can enter the environment through normal usage, spills, or improper disposal. In the NSJ study unit, one or more organic constituents were present at high concentrations in about 3% of the primary aquifers and at moderate concentration in about 7%.

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

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Fact Sheet 2010–2076
September 2010

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