

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

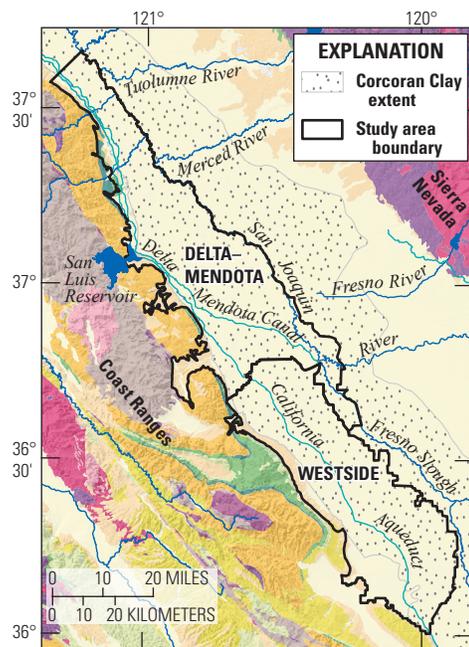
Groundwater Quality in the Western San Joaquin Valley, California



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 Western San Joaquin Valley is one of the study units being evaluated.

The Western San Joaquin Valley Study Unit

The Western San Joaquin Valley (WSJV) study unit covers approximately 5,600 square miles and includes the Delta–Mendota and Westside subbasins of the San Joaquin Valley groundwater basin (California Department of Water Resources, 2003; Fram, 2017). The freshwater aquifer system in the WSJV study unit primarily is composed of late Tertiary to Quaternary age alluvial and fluvial sediments derived from the Coast Ranges to the west and the Sierra Nevada to the east, and is divided into upper and lower zones by a clay-rich lacustrine unit, the Corcoran Clay (Faunt, 2009).

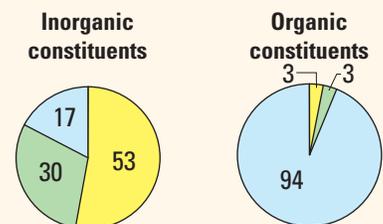


Base modified from U.S. Geological Survey and other Federal and State digital data, various scales; Albers Equal Area Projection; North American Datum of 1983

The groundwater resources used for public drinking water are defined as those parts of the aquifer system tapped by wells listed in the State of California's database of public supply wells. In the Delta–Mendota subbasin, public supply wells are typically drilled to depths of 150 to 600 feet, consist of solid casing from land surface to depths of 130 to 290 feet, and are screened below the solid casing. In the Westside subbasin, public supply wells are typically drilled to depths of 575 to 1,550 feet, and have solid casing from land surface to depths of 375 to 650 feet. Zones above and below the Corcoran Clay are used for public drinking water in both subbasins. Water quality in groundwater resources used for public drinking water can differ from that in shallower and deeper parts of the aquifer system.

The hydrology of the WSJV study unit has been extensively altered by human activity (Faunt, 2009). Under natural conditions, the primary sources of groundwater recharge were infiltration of sparse streamflow from the Coast Ranges through alluvial fans and from the San Joaquin and Kings Rivers in the basin, primarily during the winter rainy season. Agricultural development began more than a century ago, and about 70 percent of the land now is used for agriculture. Irrigation with groundwater and imported surface water is now the primary source of groundwater recharge, and pumping for agricultural use is now the primary source of discharge from the aquifer system. Drainage from WSJV agricultural lands can have high concentrations of trace elements and salts and, thus, must be managed.

Overview of Water Quality



CONSTITUENT CONCENTRATIONS

● High ● Moderate ● Low or not detected

Pie charts illustrate the percentage of the primary aquifer system, on an areal basis, with concentrations in the three specified categories.

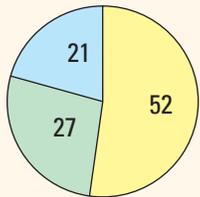
GAMA's Priority Basin Project evaluates the quality of untreated groundwater. For context, however, concentrations measured in groundwater are compared to benchmarks established for drinking-water quality, such as maximum contaminant levels (MCL). A concentration above a benchmark is defined as high. Benchmarks and definitions of moderate and low concentrations are discussed in the inset box on page 3.

Many inorganic constituents exist naturally in groundwater, and their concentrations can be affected by natural processes as well as by human activities. In the WSJV study unit, one or more inorganic constituents were present at high concentrations in about 53 percent of the groundwater resources used for public drinking water.

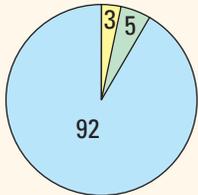
Organic constituents are found in products used in the home, business, industry, and agriculture, and can enter the environment through normal usage, spills, or improper disposal. Some organic constituents also can have natural sources, such as petroleum deposits. In this study unit, organic constituents were present at high concentrations in about 3 percent of the groundwater resources used for public drinking water.

RESULTS: Groundwater Quality in the Western San Joaquin Valley

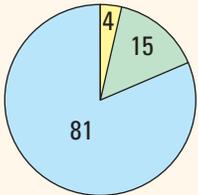
INORGANIC CONSTITUENTS



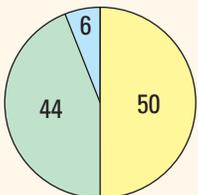
Trace elements



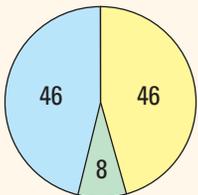
Uranium and radioactive constituents



Nitrates



Total dissolved solids



Manganese or iron

Inorganic Constituents with Human-Health Benchmarks

Trace elements are naturally present in the minerals of rocks and sediments and in the water that comes into contact with those materials. In the WSJV study unit, one or more trace elements were present at high concentrations in about 52 percent of the groundwater resources used for public drinking water. Six trace elements were present at concentrations above benchmarks: boron (51 percent), hexavalent chromium (25 percent), arsenic (10 percent), strontium (5 percent), molybdenum (4 percent), and selenium (3 percent). Different combinations of trace elements are present at high concentrations in different areas of the WSJV study unit because the compositions of the rocks and sediments through which groundwater recharge passes and the geochemical conditions in the groundwater that control the solubility of minerals vary across the study unit.

Radioactivity is the release of energy or energetic particles during spontaneous decay of unstable atoms. Most of the radioactivity in groundwater comes from the decay of natural isotopes of uranium and thorium in minerals in aquifer materials. Radioactive constituents were at high levels in about 3 percent of the groundwater resources used for public drinking water. Uranium, radium, and gross alpha-particle activity were the radioactive constituents present at high levels.

Nutrients, including nitrate, are naturally present at low concentrations in groundwater, and high concentrations generally are caused by human activities. Common sources of nutrients include fertilizer applied to crops and landscaping, seepage from septic systems, and human and animal waste. Nitrate was present at high concentrations in about 4 percent of the groundwater resources used for public drinking water.

Inorganic Constituents with Non-Health Benchmarks

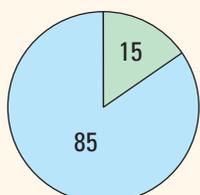
(Not included in water-quality overview charts shown on the front page)

Some constituents affect the aesthetic properties of water, such as taste, color, and odor, or can create nuisance problems, such as staining and scaling. The benchmarks used for these constituents were non-regulatory secondary maximum contaminant levels.

Total dissolved solids (TDS) concentration is a measure of the salinity of the groundwater, and all natural waters contain TDS as a result of the weathering and dissolution of minerals in rocks and sediments. The State of California has a recommended and an upper limit for TDS in drinking water. Concentrations of TDS were high (greater than the upper limit) in about 50 percent of the groundwater resources used for public drinking water.

Anoxic conditions in groundwater (low amounts of dissolved oxygen) can result in release of manganese, iron, and other associated trace elements from minerals into groundwater. Manganese or iron was present at high concentrations in about 46 percent of the groundwater resources used for public drinking water.

SPECIAL-INTEREST CONSTITUENT



Perchlorate

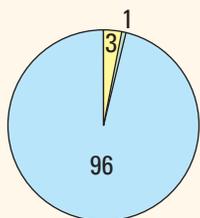
Perchlorate

(Not included in water-quality overview charts shown on the front page)

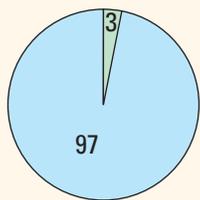
Perchlorate is an inorganic constituent that has been regulated in California drinking water since 2007. It is an ingredient in rocket fuel, fireworks, safety flares, and some fertilizers, and also exists naturally at low concentrations in groundwater. In the WSJV study unit, perchlorate was not detected at high concentrations in the groundwater resources used for public drinking water and was detected at moderate concentrations in about 15 percent.

RESULTS: Groundwater Quality in the Western San Joaquin Valley

ORGANIC CONSTITUENTS



VOCs



Pesticides

Organic Constituents with Human-Health Benchmarks

The Priority Basin Project uses laboratory methods that can detect low concentrations of volatile organic compounds (VOCs) and pesticides, far below human-health benchmarks. Pesticides and VOCs detected at these very low concentrations can be used to help trace water movement from the landscape into the aquifer system.

Many household, commercial, industrial, and agricultural products contain VOCs, which are characterized by their tendency to volatilize (evaporate) into the air. In the WSJV study unit, VOCs were present at high concentrations in about 3 percent of the groundwater resources used for public drinking water. Benzene and tetrachloroethene (PCE) were the VOCs found at high concentrations. The likely source of the benzene was nearby natural petroleum deposits (Fram, 2017). PCE is a commonly used solvent.

Pesticides, including herbicides, insecticides, and fumigants, are applied to crops, gardens, lawns, around buildings, and along roads to help control unwanted vegetation (weeds), insects, fungi, and other pests. In the WSJV study unit, pesticides were not found at high concentrations in the groundwater resources used for public drinking water. The pesticide found at moderate concentrations was the fumigant 1,2-dibromo-3-chloropropane (DBCP). The use of DBCP as a soil fumigant was discontinued in California in 1977.

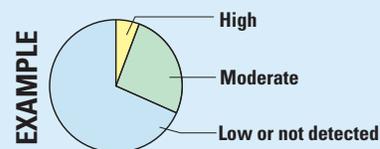
BENCHMARKS FOR EVALUATING GROUNDWATER QUALITY

GAMA's Priority Basin Project uses benchmarks established for drinking water to provide context for evaluating the quality of untreated groundwater. After withdrawal, groundwater may be disinfected, filtered, mixed, and exposed to the atmosphere before being delivered to consumers. Federal and California regulatory benchmarks for protecting human health (maximum contaminant level, MCL) are used when available. Otherwise, nonregulatory benchmarks for protecting aesthetic properties, such as taste and odor (secondary maximum contaminant level, SMCL), and nonregulatory benchmarks for protecting human health (notification level, NL, and lifetime health advisory, HAL) are used.

High, moderate, and low concentrations are defined relative to benchmarks

Concentrations are considered high if they are greater than a benchmark. For inorganic constituents, concentrations are moderate if they are greater than one-half of a benchmark. For organic constituents, concentrations are moderate if they are greater than one-tenth of a benchmark; this lower threshold was used because organic constituents are generally less prevalent in groundwater and have lower concentrations relative to benchmarks than inorganic constituents. Low concentrations include non-detections and values less than moderate concentrations. Methods for evaluating water quality are discussed by Fram (2017).

CONSTITUENT CONCENTRATIONS



Sizes of pie-graph slices correspond with percentages of the area of the groundwater resources used for public drinking water with concentrations in the three specified categories.

Benchmark type and value for selected constituents.

[Benchmark types: California, State Water Resources Control Board Division of Drinking Water; Federal, U.S. Environmental Protection Agency; HAL, lifetime health advisory level; MCL, maximum contaminant level; NL, notification level; SMCL, secondary maximum contaminant level. Abbreviations: ppb, parts per billion or micrograms per liter (µg/L); ppm, parts per million or milligrams per liter (mg/L)]

Constituent	Benchmark		Constituent	Benchmark	
	Type	Value		Type	Value
Arsenic	Federal MCL	10 ppb	Nitrate, as nitrate	Federal MCL	45 ppm
Boron	California NL	1 ppm	Total dissolved solids (TDS)	California SMCL	1,000 ppm
Hexavalent chromium	California MCL	10 ppb	Iron	California SMCL	300 ppb
Molybdenum	Federal HAL	40 ppb	Manganese	California SMCL	50 ppb
Selenium	Federal MCL	50 ppb	Benzene	California MCL	1 ppb
Strontium	Federal HAL	4 ppm	Tetrachloroethene (PCE)	Federal MCL	5 ppb
Perchlorate	California MCL	6 ppb	DBCP	Federal MCL	0.2 ppb

Factors that Affect Groundwater Quality

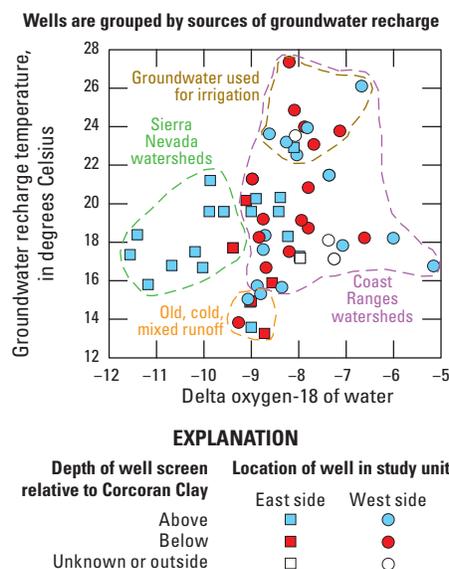
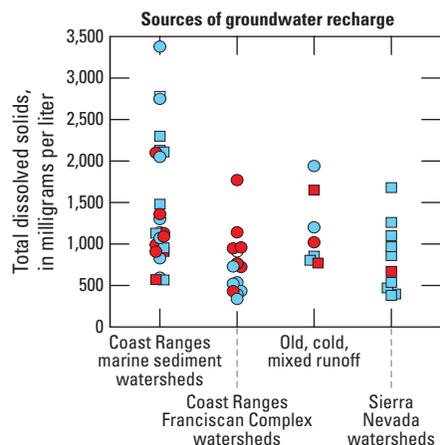
The source of groundwater recharge is one of many factors that can affect groundwater quality. In the WSJV study unit, stable oxygen and hydrogen isotope ratios of water were used to distinguish between groundwater derived from recharge of runoff from the Sierra Nevada (delta oxygen-18 less than -9.5 per mil) and from the Coast Ranges (delta oxygen-18 greater than -8.5 per mil) (Dubrovsky and others, 1991; Fram, 2017). Groundwater from Sierra Nevada runoff generally has lower concentrations of total dissolved solids (TDS), and is found in some wells on the eastern side of the study unit (near the San Joaquin River and Fresno Slough). Groundwater from Coast Ranges runoff can have varying water quality depending on the geology of the watershed. Runoff from watersheds dominated by the Franciscan Complex (mostly metamorphic rock) generally has low TDS concentrations, whereas runoff from watersheds dominated by marine sedimentary deposits generally has high TDS and sulfate concentrations. The sulfate is derived from oxidation of biogenic pyrite in organic-rich, reduced marine shales (Presser and others, 1990; Fram 2017).

Noble gas concentrations in groundwater are used to calculate the temperature of the water when it recharged the aquifer. Most WSJV study unit groundwater was recharged at temperatures less than 20°C , consistent with natural recharge dominated by winter runoff from the Coast Ranges or Sierra Nevada. Water used for irrigation has warmer recharge temperatures because most irrigation occurs during the warm growing season. Because the WSJV study unit groundwater with warm recharge temperatures (greater than 22°C) also has delta oxygen-18 greater than -8.5 per mil, it likely represents recharge from groundwater originally derived from Coast Ranges runoff that was pumped and used for irrigation. The warm recharge water is found both above and below the Corcoran Clay, which supports conclusions from other studies that the Corcoran Clay is no longer an intact confining layer (Dubrovsky and others, 1991; Faunt, 2009).

By Miranda S. Fram

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EXPLANATION

Depth of well screen relative to Corcoran Clay	Location of well in study unit
Above	East side
Below	West side
Unknown or outside	

Priority Basin Assessments

GAMA's Priority Basin Project (PBP) assesses water quality in groundwater resources used for drinking-water supply. This study in the Western San Joaquin Valley focused on groundwater resources used for public drinking water. Domestic wells typically tap shallower parts of aquifers systems than public-supply wells, and water quality can vary with depth in aquifer systems. Ongoing assessments are being carried out in more than 120 basins and areas outside of basins throughout California.

The PBP assessments compare constituent concentrations in untreated groundwater with benchmarks established for the protection of human health and for aesthetic concerns. The PBP does not evaluate the quality of drinking water delivered to consumers.

The PBP uses two scientific approaches for assessing groundwater quality. The first approach uses a network of wells to statistically assess the status of groundwater quality. The second approach combines water-quality, hydrologic, geographic, and other data to help assess the factors that affect water quality. In the Western San Joaquin Valley study unit, data were collected by the PBP in 2010 and from the State's database of regulatory compliance monitoring data for 2007–10. The PBP includes chemical analyses not generally available as part of regulatory compliance monitoring, including measurements at concentrations lower than human-health benchmarks and measurement of constituents that can be used to trace the sources and movement of groundwater.

For more information

Technical reports and hydrologic data collected for the GAMA Program may be obtained from:

GAMA Project Chief

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