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

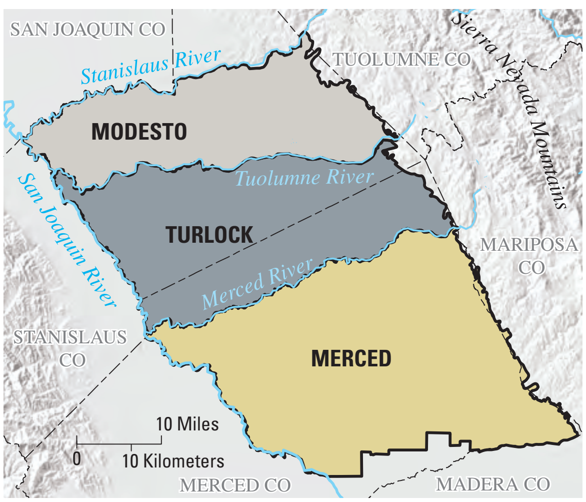
Groundwater Quality in the Central Eastside San Joaquin Valley, California

Groundwater provides more than 40 percent of Californian's drinking water. To protect this vital resource, the State of California has created the Groundwater Ambient Monitoring and Assessment (GAMA) Program. This program will provide a comprehensive assessment of the State's groundwater quality. The Central Eastside is one of the study units being evaluated.

The Central Eastside Study Unit

The Central Eastside study unit is located in California's San Joaquin Valley. The 1,695 square mile study unit includes three groundwater subbasins: Modesto, Turlock, and Merced (California Department of Water Resources, 2003). The primary water-bearing units consist of discontinuous lenses of gravel, sand, silt, and clay, which are derived largely from the Sierra Nevada Mountains to the east. Public-supply wells provide most of the drinking water supply in the Central Eastside. Consequently, the primary aquifer in the Central Eastside study unit is defined as that part of the aquifer corresponding to the perforated interval of wells listed in the California Department of Public Health database. Public-supply wells are typically drilled to depths of 200 to 350 feet, consist of solid casing from the land surface to a depth of about 100 to 200 feet, and they are perforated below the solid casing. Water quality in the shallower and deeper parts of the aquifer system may differ from that in the primary aquifer.

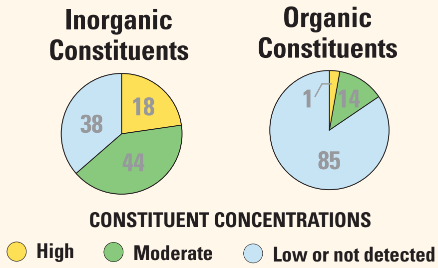
The Central Eastside study unit has hot and dry summers and cool, moist, winters. Average annual rainfall ranges from 11 to 15 inches. The Stanislaus, Tuolumne, and Merced Rivers, with headwaters in the Sierra Nevada Mountains, are the primary streams traversing the study unit.



Land use in the study unit is approximately 59 percent (%) agricultural, 34% natural (primarily grassland), and 7% urban. The primary crops are almonds, walnuts, peaches, grapes, grain, corn, and alfalfa. The largest urban areas (2003 population in parentheses) are the cities of Modesto (206,872), Turlock (63,467), and Merced (69,512).

Municipal water use accounts for about 5% of the total water use in the Central Eastside study unit, with the remainder used for irrigated agriculture. Groundwater accounts for about 75% of the municipal supply, and surface water accounts for about 25%. Recharge to the groundwater flow system is primarily from percolation of irrigation return, precipitation, seepage from reservoirs and rivers, and urban return (Burow and others, 2004; Phillips and others, 2007). The primary sources of discharge are pumping for irrigation and municipal supply, evaporation from areas with a shallow depth to water, and discharge to streams. Recharge at shallow depths and pumping from wells at greater depths causes downward movement of groundwater in the aquifer in the Central Eastside. This vertical movement of water has the potential to carry chemical constituents from shallow depths to the greater depths where supply wells commonly are perforated.

Overview of Water Quality



Pie charts illustrate the proportion of the primary aquifer with concentrations in specified categories.

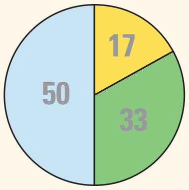
GAMA's Priority Basin Project (PBP) evaluates the quality of untreated groundwater, but for context, uses benchmarks established for drinking water. Benchmarks and definitions of high, moderate, and low concentrations are discussed in the inset box on page 3.

Most inorganic constituents are naturally present in groundwater. The concentrations of inorganic constituents can be affected by natural processes and by human activity. One or more inorganic constituents are present at high concentrations in 18% of the primary aquifer and at moderate concentrations in 44%.

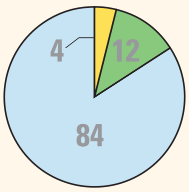
Organic constituents are present in products used in the home, business, industry, and agriculture. Organic constituents can enter the environment through normal usage, spills, or improper disposal. One or more organic constituents are present at high concentrations in 1% of the primary aquifer and at moderate concentrations in 14%.

RESULTS: Groundwater quality in the Central Eastside Study Unit

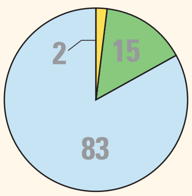
INORGANIC CONSTITUENTS



Trace elements



Radiologic constituents



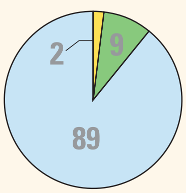
Nutrients

Inorganic constituents with human-health benchmarks

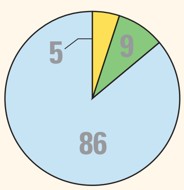
Trace elements are naturally present in rocks, soils and minerals, and in the water that comes into contact with those materials. In the Central Eastside study unit, trace elements are present at high concentrations in about 17% of the primary aquifer. Arsenic and vanadium are the two trace elements that most frequently occur at concentrations above benchmarks. Trace elements are present at either low or moderate concentrations in about 83% of the primary aquifer.

Radioactivity is the release of energy or energetic particles during structural changes in the nucleus of an atom. Most of the radioactivity in groundwater comes from decay of naturally occurring isotopes of uranium and thorium that are present in minerals in the sediments of the aquifer. Radiologic constituents occur at values above benchmarks in about 4% of the primary aquifer and at moderate values in about 12%. Radiologic constituents are present at low values in about 84% of the primary aquifer.

Nutrients, such as nitrate, are naturally present at low concentrations in groundwater. High and moderate concentrations generally occur owing to human factors such as fertilizer application or septic-system seepage. Nitrate is present at high concentrations in about 2% of the primary aquifer. Nutrients are present at moderate concentrations in about 15% of the primary aquifer. Concentrations of nutrients are low in 83% of the primary aquifer in the Central Eastside study unit.



Total Dissolved Solids



Iron or Manganese

Inorganic constituents with non-health benchmarks

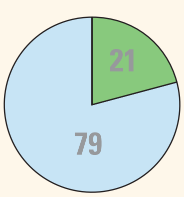
(Not included in water-quality overview charts shown on the front page)

Some constituents, such as total dissolved solids (TDS), affect the aesthetic properties of water, such as taste, color, or odor. Other constituents, such as iron and manganese, can create nuisance problems, such as scaling and staining.

The State of California has a recommended and an upper limit for TDS in drinking water. In the Central Eastside, TDS is present at high concentrations (greater than the upper limit) in about 2% of the primary aquifer. About 9% of the primary aquifer has moderate TDS concentrations (between the recommended and upper limit), and about 89% has low concentrations (less than the recommended limit).

Iron and manganese are naturally occurring elements and are present at high concentrations in about 5% of the primary aquifer. Iron or manganese are present at moderate concentrations in about 9% of the primary aquifer, and are low in about 86%.

SPECIAL INTEREST CONSTITUENTS



Perchlorate

Perchlorate

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

Perchlorate is an inorganic constituent of special interest in California because it has recently been found in, or is considered to have the potential to reach, drinking-water supplies, and its presence in groundwater is monitored by the California Department of Public Health (http://www.cdph.ca.gov). Perchlorate is an ingredient in rocket fuel, fireworks, safety flares, and other products, but can also be present in some fertilizers. Perchlorate can also be naturally present in areas with an arid climate.

In the Central Eastside, perchlorate was not detected at high concentrations in the primary aquifer. Perchlorate was detected at moderate concentrations in about 21% of the primary aquifer and was low or not detected in about 79%.

This study was designed to characterize the quality of untreated groundwater. It did not evaluate the quality of drinking water. After withdrawal, groundwater may be subject to disinfection, filtration, mixing, and exposure to the atmosphere prior to delivery to consumers.

Organic Constituents

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

Volatile organic compounds with human-health benchmarks

Volatile organic compounds (VOCs) are present in many household, commercial, industrial, and agricultural products, and are characterized by their tendency to volatilize into the air.

Solvents are used for a number of purposes, including manufacturing and cleaning. In the Central Eastside, solvents are present at high concentrations in less than (<) 1% of the primary aquifer. Solvents are present at moderate concentrations in about 3% of the primary aquifer, and are low or not detected in about 96%.

Water delivered to municipal users is commonly disinfected to help control the presence of microbiological organisms; the disinfection process can lead to the formation of trihalomethanes (THMs). When municipal water enters the ground, for example by landscape irrigation, THMs can be introduced, usually at low concentrations, into the aquifer system. In the Central Eastside, THMs are not present at high concentrations in the primary aquifer. THMs are present at moderate concentrations in about 3% of the primary aquifer, and are low (or not detected) in about 97%.

Apart from solvents and THMs, other VOCs were not detected at high or moderate concentrations in the primary aquifer.

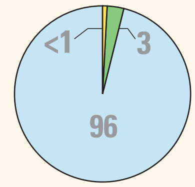
Pesticides with human-health benchmarks

Pesticides are used on lawns, in gardens, around buildings, along roads, and in agriculture to help control unwanted vegetation (weeds), insects, fungi, and other pests. In the Central Eastside, herbicides and insecticides were not detected at high or moderate concentrations in the primary aquifer.

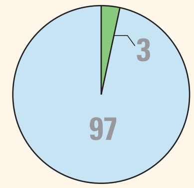
In the Central Eastside, the fumigant dibromochloropropane (DBCP) was detected at high concentrations in about 1% of the primary aquifer. DBCP was detected at moderate concentrations in about 8% of the primary aquifer, and was low or not detected in about 91%. Use of DBCP as a soil fumigant was discontinued in California in 1977 (California State Water Resources Control Board, 2002).

ORGANIC CONSTITUENTS

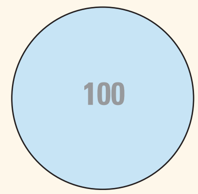
Solvents



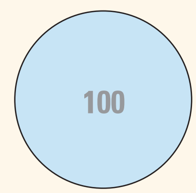
Trihalomethanes



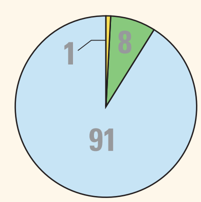
Other volatile organic compounds



Herbicides and insecticides



Fumigants



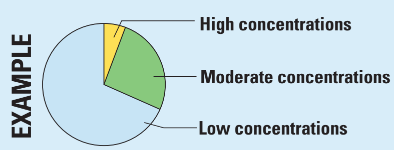
BENCHMARKS FOR EVALUATING GROUNDWATER QUALITY

GAMA's Priority Basin Project (PBP) uses benchmarks established for drinking water to provide context for evaluating the quality of groundwater. Some benchmarks are for protecting human health and others are for protecting aesthetic properties, such as taste and odor. When available, regulatory benchmarks such as Maximum Contaminant Levels are used. Otherwise, non-regulatory guidelines such as Health Advisory Levels are used as benchmarks. Although the PBP uses benchmarks for providing context, groundwater samples were collected prior to treatment or blending, and therefore might not represent the quality of drinking water.

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

Concentrations are considered high if they are above a benchmark. For inorganic constituents, concentrations are moderate if they are above one-half of a benchmark. For organic and special-interest constituents, concentrations are moderate if they are above one-tenth of a benchmark; a threshold of one-tenth was used because organic constituents are generally less prevalent and have smaller concentrations relative to benchmarks than inorganic constituents. Low values are those that are neither high nor moderate and include non-detections as well as detections. Methods for evaluating proportions are discussed in Landon and others (2010).

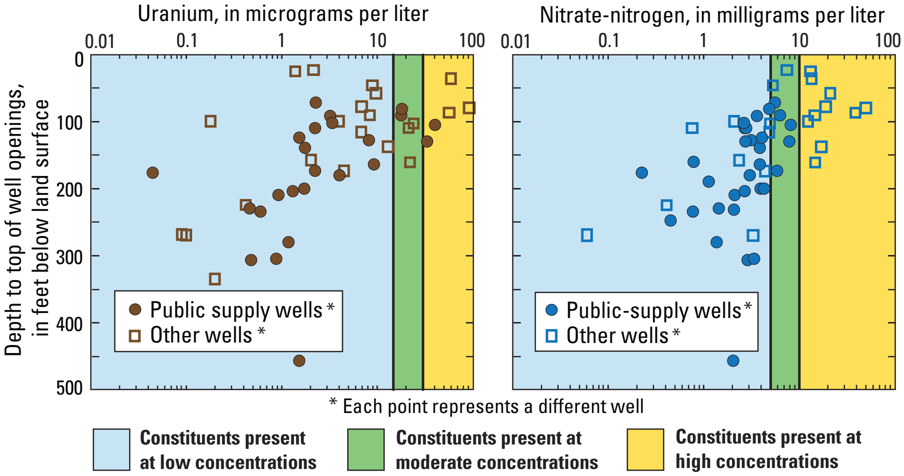
CONSTITUENT CONCENTRATIONS



Pie charts illustrate the proportion of the primary aquifer with concentrations in specified categories.

Factors That Affect Groundwater Quality

The quality of groundwater can be affected by many factors, both natural and human. For example, trace elements, such as uranium, can be naturally present in the rocks and minerals of an aquifer system. Uranium has a human-health regulatory benchmark of 30 micrograms per liter. In the Central Eastside, uranium is present at high concentrations (above the benchmark) and moderate concentrations (more than one-half the benchmark), but only in the upper part of the aquifer system (see figure below). Water from wells with perforations within the upper 200 feet of the aquifer system have either low, moderate, or high concentrations. At depths below 200 feet, uranium has been detected only at low concentrations. Overall, there is a statistically significant correlation between uranium concentrations and depth (Landon and others, 2010)



The quality of groundwater can be affected by human activities. For example, nitrate can be introduced into an aquifer system from a variety of agricultural and urban sources. These sources can include fertilizer used for agriculture and landscape maintenance, animal manure, and septic systems. Nitrate (as nitrogen) has human-health regulatory benchmark of 10 milligrams per liter. Nitrate, like uranium, is present at moderate and high concentrations in groundwater in the Central Eastside, but only in the upper 200 feet of the aquifer system (see figure above). Within the shallower part of the aquifer, nitrate concentrations are low, moderate, or high. At depths below 200 feet, nitrate has been detected only at low concentrations. Groundwater in the shallower parts of the aquifer system tends to be younger than groundwater in the deeper parts of the aquifer system and is likely to be more affected by human activities.

By Kenneth Belitz and Matthew K. Landon

SELECTED REFERENCES

Burow, K.R., Shelton, J.L., Hevesi, J.A., and Weissmann, G.S., 2004, Hydrogeologic characterization of the Modesto area, San Joaquin Valley, California: U.S. Geological Survey Scientific Investigations Report 2004-5232, 54 p. http://pubs.usgs.gov/sir/2004/5232/.

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Phillips, S.P., Green, C.T., Burow, K.R., Shelton, J.L., and Rewis, D.L., 2007, Simulation of multiscale groundwater flow in part of the northeastern San Joaquin Valley, California: U.S. Geological Survey Scientific-Investigations Report 2007–5009, 43 p.

Priority Basin Assessments

GAMA's Priority Basin Project (PBP) is designed primarily to assess water quality in that part of the aquifer system used for drinking water, primarily public supply; water quality in shallower and deeper parts of the aquifer may differ from the primary aquifer. GAMA's Domestic Well Project is designed to assess water quality in the shallower parts of the aquifer system. Ongoing assessments are being conducted in more than 120 basins throughout California.

The PBP assessments are based on a comparison of constituent concentrations in untreated groundwater to benchmarks established for the protection of human health and for aesthetic concerns. The PBP does not evaluate the quality of water delivered to consumers.

The PBP uses two approaches for assessing groundwater quality. The first approach uses a network of wells to provide a statistically based assessment of the status of groundwater quality. The second approach uses additional wells to help assess the factors that affect water quality. Both approaches use data routinely collected for regulatory compliance, as well as data collected by the PBP. The PBP includes chemical analyses not generally available as part of regulatory compliance monitoring, including measurements at concentrations much lower than human-health benchmarks, and measurement of constituents that can be used to trace the source and movement of groundwater.

For more information

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

GAMA Project Chief
U.S. Geological Survey
California Water Science Center
4165 Spruance Road, Suite 200
San Diego, CA 92101
Telephone number: (619) 225-6104
WEB: http://ca.water.usgs.gov/gama

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