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

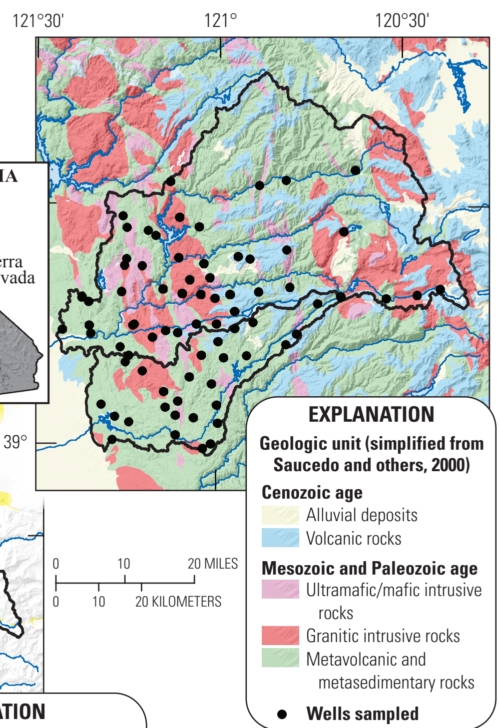
Groundwater Quality in the Yuba River and Bear River Watersheds, Sierra Nevada, California

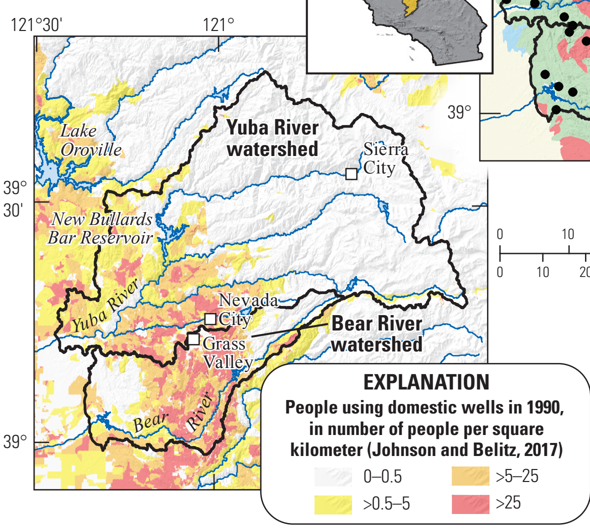
Groundwater provides more than 40 percent of California's drinking water. To protect this vital resource, the State of California created the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA Program's Priority Basin Project assesses the quality of groundwater resources used for drinking water supply and increases public access to groundwater-quality information. In the Yuba River and Bear River Watersheds of the Sierra Nevada, many rural households rely on private wells for their drinking water supplies.

The Yuba-Bear Watersheds

The Yuba River and Bear River Watersheds study unit (Yuba-Bear Watersheds) covers approximately 4,400 square kilometers on the western slope of the Sierra Nevada. Groundwater composes about 10 percent of overall water use in the region, but is the sole supply for many individual homes beyond the limits of public water supply infrastructure (Cosumnes, American, Bear, Yuba Integrated Regional Water Management Group, 2014). Recent drought conditions highlighted the vulnerability of private wells to diminished groundwater supplies in the study area and many wells required deepening (California Department of Water Resources, 2014).

Well water in the Yuba-Bear Watersheds mostly comes from fractured-rock aquifers. The quality of groundwater in these aquifers primarily depends on the type of rock, the age of the groundwater, and the type of human activities at the land surface. Previous groundwater studies in this area found elevated concentrations of nitrate, microbial indicators, and some trace elements in some wells (California State Water Resources Control Board, 2010; Fram and Belitz, 2014).

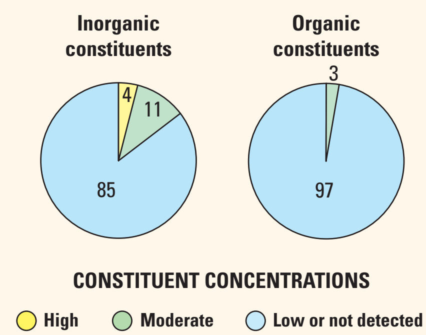




Base modified from U.S. Geological Survey and other Federal and State digital data, various scales; Albers Equal-Area Conic projection, standard parallels are 29° 30' and 45° 30'; North American Datum of 1983

This study was designed to provide a statistically representative assessment of the quality of groundwater resources used for domestic drinking water in the Yuba-Bear Watersheds. A total of 71 wells and 4 springs were sampled between October 2015 and May 2016 (Jasper and others, 2017). The wells in the study unit typically were 30–150 meters deep, and water levels typically were 7–25 meters below land surface.

Overview of Water Quality



Values indicate percentages of the area of the groundwater resources used for domestic drinking water with concentrations in the three specified categories.

GAMA's Priority Basin Project evaluates the quality of untreated groundwater. For context, 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 on page 3.

Many inorganic constituents are natural in groundwater, and their concentrations can be affected by natural processes as well as by human activities. In the Yuba-Bear Watersheds, one or more inorganic constituents were present at high concentrations in about 4 percent of the groundwater resources used for domestic 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. Organic constituents were not present at high concentrations in the groundwater resources used for domestic drinking water in the Yuba-Bear Watersheds.

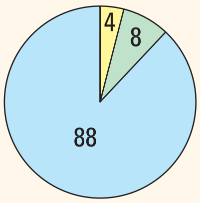
U.S. Department of the Interior
U.S. Geological Survey

ISSN 0196-1497 (print)
ISSN 2331-1258 (online)
https://doi.org/10.3133/ofr20171115

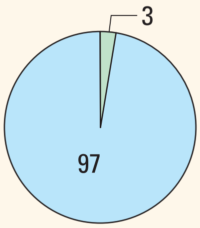
Open-File Report 2017–1115
September 2017

INORGANIC CONSTITUENTS

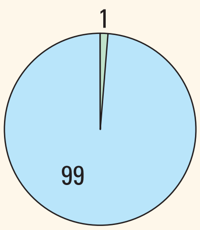
Trace elements



Uranium and radioactive constituents



Nitrate



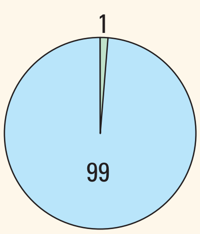
Inorganic Constituents with Human-Health Benchmarks

Historical gold-mining activity in the Yuba-Bear Watersheds has resulted in elevated concentrations of mercury and other trace elements in water and sediments in rivers and reservoirs. Trace elements also are naturally present in the minerals of rocks and sediments and in the groundwater that comes into contact with those materials. About 4 percent of the groundwater resources used for domestic drinking water had high concentrations of one or more trace elements and 8 percent had moderate concentrations. Four trace elements were present at high concentrations (arsenic, barium, molybdenum, and strontium), and three were present at moderate concentrations (arsenic, molybdenum, and vanadium). Mercury was detected at low concentrations in 4 percent of the groundwater resources.

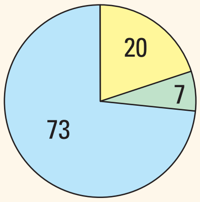
Most of the radioactivity in groundwater comes from the decay of naturally radioactive isotopes of uranium, thorium, and potassium in minerals in aquifer materials. Radioactive constituents were not present at high levels in the groundwater resources used for domestic drinking water. Gross alpha-particle activity and gross beta-particle activity were present at moderate levels in about 3 percent.

Nutrients, including nitrate, are naturally present at low concentrations in groundwater, but moderate and high concentrations generally indicate contamination from human activities. Common sources of nutrients include fertilizer applied to crops and landscaping, seepage from septic systems, and human and animal waste. Nitrate was not present at high concentrations in the groundwater resources used for domestic drinking water.

Total dissolved solids



Manganese or iron



Inorganic Constituents with Non-Health Benchmarks

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

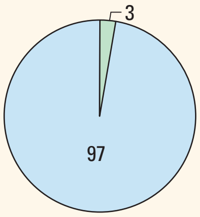
Some constituents affect the aesthetic properties of water, such as taste, color, and odor, or can create nuisance problems, such as staining and scaling. The benchmarks used for these constituents were non-regulatory secondary maximum contaminant level benchmarks.

Total dissolved solids (TDS) concentration is a measure of the salinity of the groundwater, and all water naturally contains dissolved solids 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. Total dissolved solids were not present at high concentrations (greater than the upper limit), but was present at moderate concentrations (between the recommended and upper limits) in about 1 percent of the groundwater resources used for domestic drinking water.

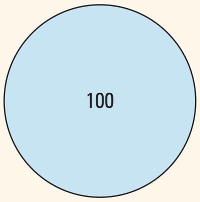
Anoxic conditions (low amounts of dissolved oxygen) can result in the release of natural manganese, iron, and other associated trace elements from minerals into groundwater. Manganese or iron was present at high concentrations in about 20 percent of the groundwater resources used for domestic drinking water. In the entire Sierra Nevada, groundwater from wells in metamorphic rocks more commonly had high concentrations of manganese or iron than groundwater from wells in granitic, volcanic, or sedimentary rocks (Fram and Belitz, 2014). Over half of the wells sampled for the Yuba-Bear Watersheds were in metamorphic rocks.

ORGANIC CONSTITUENTS

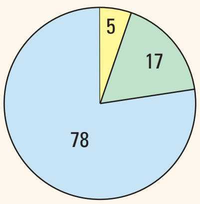
VOCs



Pesticides



E. Coli and total coliforms



Organic Constituents with Human-Health Benchmarks

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

Volatile organic compounds, including solvents, gasoline components, and refrigerants, are contained in many household, commercial, and industrial products. No VOCs were detected at high concentrations in the groundwater resources used for domestic drinking water in the Yuba-Bear Watersheds, and VOCs were detected at moderate concentrations in about 3 percent. The VOCs detected at moderate concentrations were tetrachloroethene (PCE), trichloroethene (TCE), and toluene.

Pesticides, including herbicides, insecticides, and fumigants, are applied to crops, gardens, lawns, around buildings, and along roads to help control unwanted vegetation, insects, fungi, and other pests. Pesticides were not detected at high or moderate concentrations in the groundwater resources used for domestic drinking water. Low concentrations of herbicides or degradates of herbicides were detected in about 4 percent of the groundwater resources.

Microbial Indicators

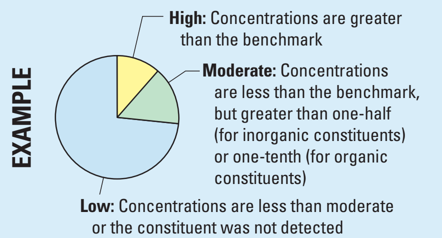
(Not included in water-quality overview charts shown on the front page)

Microbial indicators are used to evaluate the potential for fecal contamination of water sources. In the Yuba-Bear Watersheds, total coliforms and *Escherichia coli* (*E. coli*) were detected in 5 percent of the wells sampled, and total coliforms alone were detected in another 17 percent of the wells samples. Total coliforms are present naturally in soils and in digestive tracts of animals, whereas *E. coli* specifically indicate contamination with animal (or human) fecal waste (California State Water Resources Control Board, 2016).

METHODS FOR EVALUATING GROUNDWATER QUALITY

This study used comparison to benchmarks established for drinking water to provide context for evaluating the quality of groundwater. The quality of drinking water can differ from the quality of groundwater because of contact with household plumbing, exposure to the atmosphere, or water treatment. U.S. Environmental Protection Agency and California State Water Resources Control Board Division of Drinking Water regulatory benchmarks set for the protection of human health (maximum contaminant level, MCL) were used for comparison when available. Otherwise, non-regulatory benchmarks set for protection of aesthetic and technical properties, such as taste and odor (secondary maximum contaminant level, SMCL), and non-regulatory benchmarks set for the protection of human health (notification levels, NL, and lifetime health advisory levels, HAL) were used. Water quality in domestic wells is not regulated in California.

CONSTITUENT CONCENTRATIONS



Pie diagrams are used to summarize groundwater quality results. The pie slices represent the percentages of the groundwater resources with high, moderate, and low concentrations of a constituent. Methods for calculating these percentages are discussed by Fram and Belitz (2014).

Benchmark type and value for selected constituents.

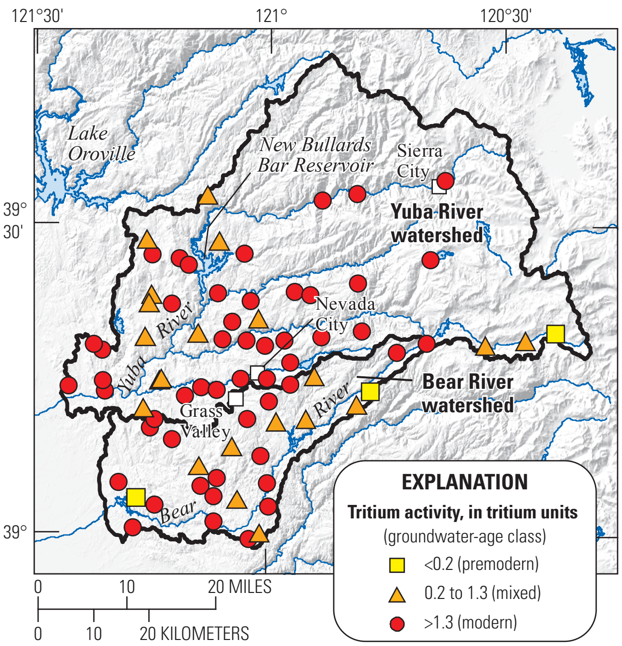
[**Benchmark type**: CA, State Water Resources Control Board Division of Drinking Water; EPA, U.S. Environmental Protection Agency; HAL, lifetime health advisory level; MCL, maximum contaminant level; NL, notification level; SMCL, secondary maximum contaminant level. **Abbreviations**: pCi/L, picocuries per liter; 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	EPA MCL	10 ppb	Nitrate, as nitrogen	EPA MCL	10 ppm
Barium	CA MCL	1,000 ppb	Total dissolved solids (TDS), upper and recommended	CA SMCL	1,000 ppm 500 ppm
Molybdenum	EPA MCL	40 ppb			
Strontium	EPA HAL	4,000 ppb	Manganese	CA SMCL	50 ppb
Vanadium	CA NL	50 ppb	Iron	CA SMCL	300 ppb
Mercury	EPA MCL	2 ppb	Tetrachloroethene (PCE)	EPA MCL	5 ppb
Gross alpha-particle activity	EPA MCL	15 pCi/L	Trichloroethene (TCE)	EPA MCL	5 ppb
Gross beta-particle activity	CA MCL	50 pCi/L	Toluene	CA MCL	150 ppb

Factors that Affect Groundwater Quality

Groundwater is generally a mixture of waters that recharged the aquifer system at different times. Groundwater 'age' — the time since the water was at the land surface — can range from less than 1 year to more than 50,000 years. The distribution of ages in a groundwater sample affects the water quality. Some constituents can be present at higher concentrations in older groundwater because of slow dissolution of minerals. Some constituents can be present at higher concentrations in groundwater with ages corresponding to particular times when human activities introduced contaminants to the recharged water. Preliminary groundwater ages based on tritium data for samples from the Yuba-Bear Watershed are summarized here.

Tritium is a radioactive isotope of hydrogen that forms in the atmosphere naturally and in nuclear explosions and reactors. Atmospheric nuclear-weapons testing in the 1950s and 1960s increased tritium concentrations to far above natural levels. The tritium concentration in groundwater can be used to estimate whether the groundwater recharged before or after about 1950 (Jurgens and others, 2012). Two-thirds of the samples from the Yuba-Bear Watershed study unit had tritium concentration greater than 1.3 tritium units (TU), indicating they were "modern" (recharged after 1950). A few samples had tritium concentrations less than 0.2 TU, indicating they were "pre-modern" groundwater recharged before 1950, and the rest were mixtures of water recharged before and after 1950. Because most samples indicated relatively recent groundwater recharge, groundwater resources used for domestic supply in the Yuba-Bear Watersheds study unit could be vulnerable to water-quality changes resulting from human activities at the land surface and to relatively rapid depletion during periods of drought.



Base modified from U.S. Geological Survey and other Federal and State digital data, various scales; Albers Equal-Area Conic projection, standard parallels are 29° 30' and 45° 30'; North American Datum of 1983

By Miranda S. Fram, Monica Jasper, and Kim A. Taylor

Priority Basin Assessments

GAMA's Priority Basin Project (PBP) assesses water quality in groundwater resources used for public and domestic drinking-water supplies. This study in the Yuba and Bear River Watersheds in the Sierra Nevada focused on groundwater resources used for domestic drinking water. 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.

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 Yuba-Bear Watersheds study unit, data were collected by the PBP in 2015–16. 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 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
U.S. Geological Survey
California Water Science Center
6000 J Street, Placer Hall
Sacramento, CA 95819
Telephone number: (916) 278-3000
WEB: *http://ca.water.usgs.gov/gama*

GAMA Program Unit Chief
State Water Resources Control Board
Division of Water Quality
PO Box 2231, Sacramento, CA 95812
Telephone number: (916) 341-5855
WEB:
http://www.waterboards.ca.gov/gama

REFERENCES CITED

California Department of Water Resources, 2014, Public update for drought response: Groundwater basins with potential water shortages and gaps in groundwater monitoring, http://groundwater.ca.gov/docs/Drought_Response-Groundwater_Basins_April30_Final_BC.pdf.

California State Water Resources Control Board, 2010, GAMA Domestic Well Project—Groundwater quality data report, Yuba County focus area, http://www.waterboards.ca.gov/water_issues/programs/gama/docs/yubareportsummary.pdf.

California State Water Resources Control Board, 2016, Groundwater Information Sheet: Bacterial Indicators, http://www.waterboards.ca.gov/gama/docs/coc_bacteria_indicators.pdf.

Cosumnes, American, Bear, Yuba Integrated Regional Water Management Group (CABY), 2014, CABY Integrated Regional Water Management Plan 2014 Update, http://cabyregion.org/caby-plan/.

Fram, M.S., and Belitz, Kenneth, 2014, Status and understanding of groundwater quality in the Sierra Nevada Regional study unit, 2008—California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2014–5174, https://doi.org/10.3133/sir20145174.

Jasper, M., Bennett, G.L., and Fram, M.S., 2017, Groundwater-quality data in the Yuba and Bear Watersheds Shallow Aquifer Study Unit, 2015-2016: Results from the California GAMA Priority Basin Project: U.S. Geological Survey Data Release, https://doi.org/10.5066/F73F4MS9.

Johnson, T.D., and Belitz, Kenneth, 2017, Domestic well locations and populations served in the contiguous U.S.: 1990: Science of the Total Environment, v. 607–608, p. 658–668, https://doi.org/10.1016/j.scitotenv.2017.07.018.

Jurgens, B.C., Böhlke, J.K., and Eberts, S.M., 2012, TracerLPM (Version 1): An Excel® workbook for interpreting groundwater age distributions from environmental tracer data: U.S. Geological Survey Techniques and Methods Report 4-F3, 60 p. http://pubs.usgs.gov/tm/4-f3/.

Saucedo, G.J., Bedford, D.R., Raines, G.L., Miller, R.J., and Wentworth, C.M., 2000, GIS data for the geologic map of California: California Department of Conservation, Division of Mines and Geology, CD-ROM 2000-007.