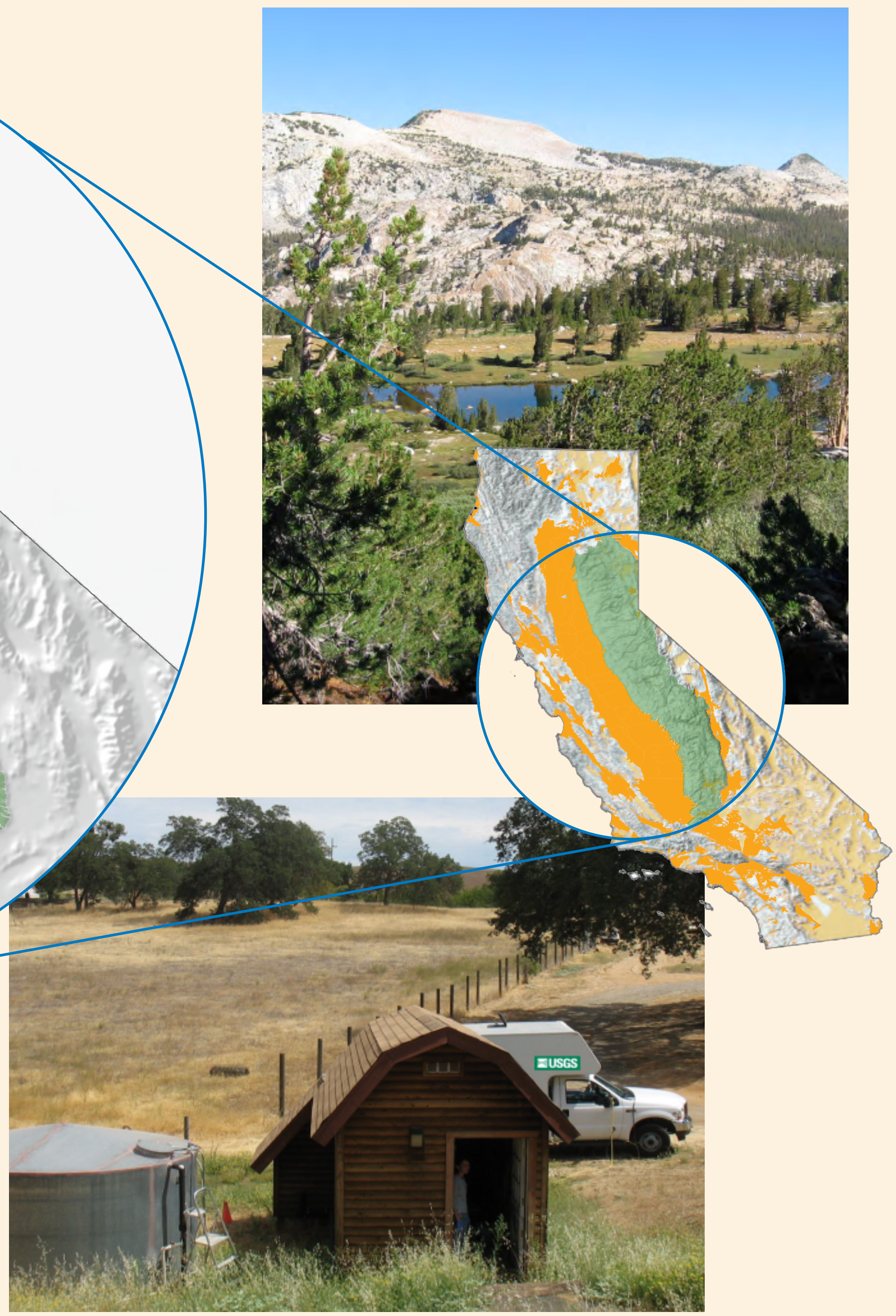
In cooperation with the California State Water Resources Control Board

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

Groundwater-Quality Data for the Sierra Nevada Study Unit, 2008: Results from the California GAMA Program



Data Series 534

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

Cover photographs:

Top: View near Tuolumne Meadows in Yosemite National Park, California. (Photograph taken by George L. Bennett, U.S. Geological Survey.)
Bottom: Wellhouse and holding tank near Angels Camp, California. (Photograph taken by Barbara J. Dawson, U.S. Geolgical Survey.)

Groundwater-Quality Data for the Sierra Nevada Study Unit, 2008: Results from the California GAMA Program

By Jennifer L. Shelton, Miranda S. Fram, Cathy M. Munday, and Kenneth Belitz

Prepared in cooperation with the California State Water Resources Control Board

Data Series 534

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2010

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit http://www.usgs.gov or call 1-888-ASK-USGS

For an overview of USGS information products, including maps, imagery, and publications, visit http://www.usgs.gov/pubprod

To order this and other USGS information products, visit http://store.usgs.gov

Suggested citation:
Shelton, J.L., Fram, M.S., Munday, C.M., and Belitz, Kenneth, 2010, Groundwater-quality data for the Sierra Nevada study unit, 2008: Results from the California GAMA program: U.S. Geological Survey Data Series 534, 106 p.

Contents

Figures

Tables

Abbreviations and Acronyms

AL-US	action level (USEPA)
CAS	Chemical Abstract Service (American Chemical Society)
CASRN	Chemical Abstract Service (American Chemical Society) Registry Number®
CSU	combined standard uncertainty
D	detected in groundwater samples
DBP	disinfection by-product
E	estimated or having a higher degree of uncertainty
GAMA	Groundwater Ambient Monitoring and Assessment program
GPS	Global Positioning System
HAL-US	lifetime health advisory level (USEPA)
HPLC	high-performance liquid chromatography
LRL	laboratory reporting level
LSD	land surface datum
LT-MDL	long-term method detection level
Ma	megaannum, one million years
MCL-US	maximum contaminant level (USEPA)
MCL-CA	maximum contaminant level (CDPH)
MDL	method detection limit
MRL	minimum reporting level
MU	method uncertainty
na	not available
nc	sample not collected
NL-CA	notification level (CDPH)
nv	no values in category
np	no preference
NWIS	National Water Information System (USGS)
PCFF	portable computer field forms program designed for USGS sampling
QA	quality assurance
QC	quality control
RPD	relative percent difference
RSD	relative standard deviation
RSD5-US	risk-specific dose at 10^{-5} (USEPA)
SD	standard deviation
SIERRA-G	Sierra Nevada study unit primary grid well in granitic rocks
SIERRA-M	Sierra Nevada study unit primary grid well in metamorphic rocks
SIERRA-S	Sierra Nevada study unit primary grid well in sedimentary deposit
SIERRA-V	Sierra Nevada study unit primary grid well in volcanic rocks
SIERRA-GL	Sierra Nevada study unit lithologic grid well in granitic rocks
SIERRA-ML	Sierra Nevada study unit lithologic grid well in metamorphic rocks
SIERRA-SL	Sierra Nevada study unit lithologic grid well in sedimentary deposit

SIERRA-VL	Sierra Nevada study unit lithologic grid well in volcanic rocks
SIERRA-XL	natural spring not used for drinking water sampled to compare with SIERRA-V-03
SMCL-CA	secondary maximum contaminant level (CDPH)
SMCL-US	secondary maximum contaminant level (USEPA)
SRL	study reporting level (concentration cutoff for applying the ≤ symbol)
ssL_C	sample-specific critical level
U.S.	United States
UV	ultraviolet
VPDB	Vienna Pee Dee Belemnite (the international reference standard for carbon isotopes)
VSMOW	Vienna Standard Mean Ocean Water (an isotopic water standard defined in 1968 by the International Atomic Energy Agency)

Organizations

CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CDWR	California Department of Water Resources
LLNL	Lawrence Livermore National Laboratory
NAWQA	National Water Quality Assessment (USGS)
NELAP	National Environmental Laboratory Accreditation Program
NWQL	National Water Quality Laboratory (USGS)
NRP	National Research Program (USGS)
SWRCB	California State Water Resources Control Board
TML	Trace Metal Laboratory (USGS)
USEPA	U.S. Environmental Protection Agency
USGS	U. S. Geological Survey

Selected Chemical Names

$CaCO_3$	calcium carbonate
CO_3^{-2}	carbonate
CO_2	carbon dioxide
CFC	chlorofluorocarbon
H_2O	water
HCl	hydrochloric acid
HCO_3^-	bicarbonate
MEK	methyl ethyl ketone (2-butanone)
MTBE	methyl *tert*-butyl ether
$Na_2S_2O_3$	sodium thiosulfate
NDMA	*N*-nitrosodimethylamine
$NO_2^- + NO_3^-$	nitrite plus nitrate, as nitrogen
PCE	perchloroethene (tetrachloroethylene, tetrachloroethene)
TCE	trichloroethene
TDS	total dissolved solids
THM	trihalomethane

Selected Terms and Symbols

cm^3 STP/g	cubic centimeters of gas at standard temperature and pressure (0 degrees Celsius and 1 atmosphere of pressure) per gram of water
δ^iE	delta notation, the ratio of a heavier isotope of an element (^iE) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil
=	equal to
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
N	Normal (1-mole-equivalent per liter of solution)
—	not detected
pH	measure of the acidity or basicity of water
$pK_{1,2}$	acid dissociation constants of carbonic acid
pK_w	acid dissociation constant of water
±	plus or minus
*	value is greater than the benchmark level
**	value is greater than the upper benchmark level
VOC	volatile organic compound

Notes

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32.$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88). Well depths are given in feet below land-surface datum (LSD), which is a datum plane that is approximately at land surface. The LSD for each well is referenced to the NAVD 88.

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance in feet (ft) above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is equivalent to parts per million (ppm) and micrograms per liter is equivalent to parts per billion (ppb). Activities of radioactive constituents in water are given in picocuries per liter (pCi/L).

This page intentionally left blank.

Groundwater-Quality Data for the Sierra Nevada Study Unit, 2008: Results from the California GAMA Program

By Jennifer L. Shelton, Miranda S. Fram, Cathy M. Munday, and Kenneth Belitz

Abstract

Groundwater quality in the approximately 25,500-square-mile Sierra Nevada study unit was investigated in June through October 2008, as part of the Priority Basin Project of the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA Priority Basin Project is being conducted by the U.S. Geological Survey (USGS) in cooperation with the California State Water Resources Control Board (SWRCB). The Sierra Nevada study was designed to provide statistically robust assessments of untreated groundwater quality within the primary aquifer systems in the study unit, and to facilitate statistically consistent comparisons of groundwater quality throughout California. The primary aquifer systems (hereinafter, primary aquifers) are defined by the depth of the screened or open intervals of the wells listed in the California Department of Public Health (CDPH) database of wells used for public and community drinking-water supplies. The quality of groundwater in shallower or deeper water-bearing zones may differ from that in the primary aquifers; shallow groundwater may be more vulnerable to contamination from the surface.

In the Sierra Nevada study unit, groundwater samples were collected from 84 wells (and springs) in Lassen, Plumas, Butte, Sierra, Yuba, Nevada, Placer, El Dorado, Amador, Alpine, Calaveras, Tuolumne, Madera, Mariposa, Fresno, Inyo, Tulare, and Kern Counties. The wells were selected on two overlapping networks by using a spatially-distributed, randomized, grid-based approach. The primary grid-well network consisted of 30 wells, one well per grid cell in the study unit, and was designed to provide statistical representation of groundwater quality throughout the entire study unit. The lithologic grid-well network is a secondary grid that consisted of the wells in the primary grid-well network plus 53 additional wells and was designed to provide statistical representation of groundwater quality in each of the four major lithologic units in the Sierra Nevada study unit: granitic, metamorphic, sedimentary, and volcanic rocks. One natural spring that is not used for drinking water was sampled for comparison with a nearby primary grid well in the same cell.

Groundwater samples were analyzed for organic constituents (volatile organic compounds [VOC], pesticides and pesticide degradates, and pharmaceutical compounds), constituents of special interest (*N*-nitrosodimethylamine [NDMA] and perchlorate), naturally occurring inorganic constituents (nutrients, major ions, total dissolved solids, and trace elements), and radioactive constituents (radium isotopes, radon-222, gross alpha and gross beta particle activities, and uranium isotopes). Naturally occurring isotopes and geochemical tracers (stable isotopes of hydrogen and oxygen in water, stable isotopes of carbon, carbon-14, strontium isotopes, and tritium), and dissolved noble gases also were measured to help identify the sources and ages of the sampled groundwater.

Three types of quality-control samples (blanks, replicates, and samples for matrix spikes) each were collected at approximately 10 percent of the wells sampled for each analysis, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that contamination from sample collection, handling, and analytical procedures was not a significant source of bias in the data for the groundwater samples. Differences between replicate samples were within acceptable ranges, with few exceptions. Matrix-spike recoveries were within acceptable ranges for most compounds.

This study did not attempt to evaluate the quality of water delivered to consumers; after withdrawal from the ground, groundwater typically is treated, disinfected, or blended with other waters to maintain water quality. Regulatory benchmarks apply to finished drinking water that is served to the consumer, not to untreated groundwater. However, to provide some context for the results, concentrations of constituents measured in the groundwater were compared with regulatory and nonregulatory health-based benchmarks established by the U.S. Environmental Protection Agency (USEPA) and CDPH and with nonregulatory aesthetic and technical benchmarks established by CDPH. Comparisons between data collected for this study and drinking-water benchmarks are for illustrative purposes only and do not indicate compliance or noncompliance with regulatory benchmarks.

All organic constituents and most inorganic constituents that were detected in groundwater samples from the 30 primary grid wells in the Sierra Nevada study unit were detected at concentrations less than drinking-water benchmarks.

Of the 150 organic and special-interest constituents analyzed, 21 were detected in groundwater samples; all concentrations were less than regulatory and nonregulatory health-based benchmarks, and most were less than 1/10 of benchmark levels. One or more organic constituents were detected in 37 percent of the primary grid wells, and perchlorate was detected in 27 percent of the primary grid wells.

Most samples analyzed for inorganic and radioactive constituents had concentrations or activities less than regulatory and nonregulatory health-based benchmarks. Nutrients were not detected at concentrations greater than health-based benchmarks. Six of the 30 primary grid wells (20 percent) and 7 of the 53 lithologic grid wells had concentrations of or activities for one or two constituents that were greater than the benchmarks. Constituents present in one or more samples at concentrations or activities greater than health-based benchmarks were arsenic (5 wells, MCL-US), gross alpha particle activity (4 wells, MCL-US), boron (2 wells, NL-CA), fluoride (1 well, MCL-CA), and selenium (1 well, MCL-US). Two of the wells that had high gross alpha particle activities had uranium concentrations (MCL-CA) and uranium activities (MCL-CA) greater than the benchmark levels. Four of the 29 samples analyzed had activities of radon-222 greater than the proposed alternative MCL-US.

Most samples analyzed for inorganic constituents that had nonregulatory, aesthetic-based benchmarks (SMCLs) had concentrations less than these benchmarks. Total dissolved solids concentrations were less than the upper SMCL-CA in all 83 primary and lithologic grid well samples, and TDS concentrations were less than the recommended SMCL-CA in 79 of these samples. Manganese concentrations were greater than the SMCL-CA in 2 of the 30 primary grid wells (7 percent) and in 6 of the 53 lithologic grid wells, and iron concentrations were greater than the SMCL-CA in the same 2 primary grid wells and in 5 of the same lithologic grid wells.

Introduction

Groundwater comprises nearly half of the water used for public and domestic drinking-water supply in California (Hutson and others, 2004). To assess the quality of ambient groundwater in aquifers used for drinking-water supply and to establish a baseline groundwater quality monitoring program, the California State Water Resources Control Board (SWRCB), in collaboration with the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL), implemented the Groundwater Ambient Monitoring and Assessment (GAMA) Program (http://www.swrcb.ca.gov/gama). The GAMA Program currently consists of three projects: GAMA Priority Basin Project, conducted by the USGS (http://ca.water.usgs.gov/gama/); GAMA Domestic Well Project, conducted by the SWRCB; and GAMA Special Studies, conducted by LLNL. On a statewide basis, the GAMA Priority Basin Project primarily focuses on the deep part of the groundwater resource, which is typically used for public drinking water supply. The GAMA Domestic Well Project generally focuses on the shallow aquifer systems, which may be particularly at risk due to surficial contamination.

All published and quality-assurance/quality-control (QA/QC) approved analytical data collected for the GAMA program are stored in the web-based Geotracker Database (https://geotracker.waterboards.ca.gov/gama/). In addition, the Geotracker Database stores groundwater-quality data and related reports collected by other State agencies, such as the California Department of Public Health (CDPH), California Department of Water Resources (CDWR), California Department of Pesticide Regulation (CDPR), and data collected by the SWRCB and other Regional Boards from environmental monitoring wells at contaminated and (or) remediated sites.

The SWRCB initiated the GAMA Program in 2000 in response to a legislative mandate (Supplemental Report of the 1999 Budget Act 1999-00 Fiscal Year). The GAMA Priority Basin Project was initiated in response to the Groundwater Quality Monitoring Act of 2001 (Sections 10780-10782.3 of the California Water Code, Assembly Bill 599) to assess and monitor the quality of groundwater in California. The GAMA Priority Basin Project is a comprehensive assessment of statewide groundwater quality designed to help better understand and identify risks to groundwater resources and to increase the availability of information about groundwater quality to the public. For the GAMA Priority Basin Project, the USGS, in collaboration with the SWRCB, developed the monitoring plan to assess groundwater basins through direct and other statistically reliable sample approaches (Belitz and others, 2003; State Water Resources Control Board, 2003). Additional partners in the GAMA Priority Basin Project include the California Department of Public Health (CDPH), California Department of Pesticide Regulation (CDPR), California Department of Water Resources (CDWR), and local water agencies and well owners (Kulongoski and Belitz, 2004). Local participation in the project is entirely voluntary.

The GAMA Priority Basin Project is unique in California because it includes many chemical analyses that are not otherwise available in statewide water-quality monitoring datasets. Groundwater samples collected for the project are analyzed for approximately 300 chemical constituents by using analytical methods with lower detection limits than those required by the CDPH for regulatory monitoring of drinking-water wells. These analyses will be especially useful for providing an early indication of changes in groundwater quality. In addition, the GAMA Priority Basin Project analyzes samples for a suite of constituents more extensive than that required by CDPH and for a suite of chemical and isotopic tracers of hydrologic and geochemical processes. A broader understanding of groundwater composition is useful for identifying the natural and human factors affecting water quality. Understanding the occurrence and distribution of chemical constituents of significance to water quality is important for the long-term management and protection of groundwater resources.

The range of hydrologic, geologic, and climatic conditions that exist in California must be considered when assessing state-wide groundwater quality. Belitz and others (2003) partitioned the state into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics (fig. 1). All these hydrogeologic provinces include groundwater basins and subbasins designated by the CDWR (California Department of Water Resources, 2003). Groundwater basins and subbasins generally consist of fairly permeable, unconsolidated deposits of alluvial or volcanic origin (California Department of Water Resources, 2003). Eighty percent of California's approximately 16,000 active and standby drinking-water wells listed in the statewide database maintained by the CDPH (hereinafter, CDPH wells) are located in groundwater basins and subbasins within these 10 hydrogeologic provinces. Groundwater basins and subbasins were prioritized for sampling on the basis of the number of CDPH wells in the basin, with secondary consideration given to municipal groundwater use, agricultural pumping, the number of formerly leaking underground fuel tanks, and registered pesticide applications (Belitz and others, 2003). One hundred sixteen of the 472 basins and subbasins designated by the CDWR contain approximately 95 percent of the CDPH wells in groundwater basins. These 116 priority basins, plus some areas outside of the defined groundwater basins, were aggregated into 35 GAMA study units. Of the 10 hydrogeologic provinces, the Sierra Nevada hydrogeologic province contains the largest number of CDPH wells outside of defined groundwater basins. About 97 percent of the total area and approximately 85 percent of the CDPH wells in the Sierra Nevada hydrogeologic province are outside of the mapped groundwater basins. The Sierra Nevada GAMA study unit consists of the entire Sierra Nevada hydrogeologic province (fig. 1) and was the 26th study unit sampled by the GAMA Priority Basin Project. Previously, the GAMA Priority Basin Project collected groundwater-quality data in three smaller study units within the Sierra Nevada hydrogeologic province: the Southern Sierra study unit (Fram and Belitz, 2007), the Central Sierra study unit (Ferrari and others, 2008), and the Tahoe–Martis study unit (Fram and others, 2009).

Three types of water-quality assessments are being conducted with the data collected in each study unit: (1) Status: assessing the current quality of the groundwater resource, (2) Understanding: identifying the natural and human factors affecting groundwater quality, and (3) Trends: detecting changes in groundwater quality (Kulongoski and Belitz, 2004). The assessments are intended to characterize the quality of groundwater within the primary aquifer systems of the study unit, not the treated drinking water delivered to consumers by water purveyors. The primary aquifer systems (hereinafter, primary aquifers) are defined by the depths of the screened or open intervals of the wells listed in the CDPH database for the study unit. The CDPH database lists wells used for municipal and community drinking-water supplies and includes wells from systems classified as nontransient (such as those in cities, towns, and mobile-home parks) and transient (such as those in schools, campgrounds, and restaurants). The CDPH refers to these wells as "public-supply" wells. Groundwater quality in shallower or deeper parts of the aquifer systems may differ from that in the primary aquifers. In particular, shallow groundwater may be more vulnerable to surface contamination. As a result, samples from shallow wells (such as many private domestic wells and environmental monitoring wells) can have higher concentrations of constituents from anthropogenic sources (such as VOCs and nitrate) than samples from wells screened in the deep primary aquifer (Landon and others, 2010).

This USGS Data Series Report is the first in a series of reports presenting the water-quality data collected in the Sierra Nevada study unit and is similar to other USGS Data Series Reports written for the GAMA study units sampled to date (**San Diego Drainages Hydrogeologic Province**: Wright and others, 2005; **Northern San Joaquin Basin**: Bennett and others, 2006; **North San Francisco Bay**: Kulongoski and others, 2006; **Southern Sierra**: Fram and Belitz, 2007; **Monterey Bay and Salinas Valley Basins**: Kulongoski and Belitz, 2007; **Southeast San Joaquin Valley**: Burton and Belitz, 2008; **Southern Sacramento Valley**: Dawson and others, 2008; **Central Sierra**: Ferrari and others, 2008; **San Fernando–San Gabriel**: Land and Belitz, 2008; **Central Eastside San Joaquin**: Landon and Belitz, 2008; **Coastal Los Angeles Basin**: Mathany and others, 2008; **Middle Sacramento Valley**: Schmitt and others, 2008; **Kern County Subbasin**: Shelton and others, 2008; **Northern Sacramento Valley**: Bennett and others, 2009; **Owens and Indian Wells Valleys**: Densmore and others, 2009; **Tahoe–Martis**: Fram and others, 2009; **Coachella Valley**: Goldrath and others, 2009; **Upper Santa Ana Watershed**: Kent and Belitz, 2009; **Mojave**: Mathany and Belitz, 2009; **South Coast Interior Basins**: Mathany and others, 2009; **Santa Clara River Valley**: Montrella and Belitz, 2009; **San Francisco Bay**: Ray and others, 2009; **Madera–Chowchilla**: Shelton and others, 2009; **Antelope**: Schmitt and others, 2009; **Colorado River**: Goldrath and others, 2010; and **South Coast Range Coastal**: Mathany and others, 2010). Subsequent reports will address the status, understanding, and trends aspects of the water-quality assessments of each study unit.

Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006.
Albers Equal Area Conic Projection

Provinces from Belitz and others, 2003

Figure 1. The hydrogeologic provinces of California and the location of the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study unit.

Purpose and Scope

The purposes of this report are (1) to describe the study design and the study methods, (2) to present the results of quality-control tests, and (3) to present the analytical results for groundwater samples collected in the Sierra Nevada study unit. Groundwater samples were analyzed for field water-quality indicators, organic, inorganic, and radioactive constituents, and isotopic tracers. The chemical data presented in this report were evaluated by comparison to State and Federal drinking-water regulatory and nonregulatory health-based standards that are applied to finished drinking water. Regulatory and nonregulatory benchmarks considered for this report are those established by the U.S. Environmental Protection Agency (USEPA) and/or the CDPH. The data presented in this report are intended to characterize the quality of untreated groundwater in the primary aquifers in the Sierra Nevada study unit, not the finished drinking water delivered to consumers by water purveyors. Discussion of the factors that influence the distribution and occurrence of the constituents detected in groundwater samples will be the subject of subsequent publications.

Hydrogeologic Setting

The Sierra Nevada study unit is defined by the boundaries of the Sierra Nevada hydrogeologic province (fig. 1). The study unit includes 22 groundwater basins and 61 watersheds, and consists primarily of areas not mapped as groundwater basins as defined by CDWR (Belitz and others, 2003; California Department of Water Resources, 2003). The Sierra Nevada study unit covers an area of approximately 25,500 mi^2 (66,000 square kilometers [km^2]) in parts of 23 of California's 58 counties (fig. 2).

The Sierra Nevada hydrogeologic province encompasses a broad range of geologic, hydrologic, and land use settings. The Sierra Nevada is an asymmetric mountain range that extends for 400 miles mostly along the eastern border of California. The western side slopes gradually from the crest towards the Central Valley, and the eastern side is a steep escarpment that marks the western edge of active extensional faulting in the Basin and Range province (fig. 1). The elevation of the Sierra Nevada crest is highest in the south, with several peaks over 14,000 ft, and decreases northward, with the highest peaks north of Lake Tahoe only 8,000 ft high. The western boundary of the Sierra Nevada province is defined by the eastern limits of Quaternary sediments of the Central Valley. The eastern boundary is defined by the western limits of basins in the Basin and Range province and the Nevada state line. The province is terminated by a major physiographic boundary with the Desert province at the southern end and by the Modoc Plateau in the north (fig. 1).

The dominant geologic feature of the province is the Sierra Nevada Batholith, a complex of Mesozoic granodiorite, quartz-diorite, and granite plutons that intruded the North American Plate above the subducting Farallon Plate, mostly between 80 and 150 Ma (megaannum) (Evernden and Kistler, 1970; Bateman, 1992). Roof pendants of older Mesozoic and Paleozoic metamorphic rocks, remnants of the terrain into which the plutons intruded, are scattered throughout the batholith, particularly in the southern part of the province. The Western Metamorphic Belt occupies the foothills in the northern half of the province, and consists of a deformed package of imbricate thrust slices of Mesozoic and Paleozoic ophiolites and oceanic sedimentary rocks that were accreted onto the western margin of the North American Plate as subduction proceeded (Day and others, 1985). The Mother Lode gold deposits are hosted by quartz veins injected along the Melones Fault zone, a major fault zone that likely marks the Mesozoic subduction plate boundary. Late Cenozoic (approximately 35 Ma to 1 Ma) volcanism blanketed areas of the Sierra Nevada, particularly in the northern part of the province, and most of the uplift of the modern Sierra Nevada range has occurred within the last 5 Ma (Wakabayashi and Sawyer, 2001). Portions of the Sierra Nevada were glaciated in the multiple major glacial advances during the Pleistocene (Birkeland, 1964; Raub and others, 2006).Like much of California, the Sierra Nevada has a Mediterranean climate pattern: warm, dry summers and cool, wet winters. Annual precipitation ranges from 10 to 80 in/yr of water and varies with both elevation and latitude (Western Regional Climate Center, 2009; PRISM Group, Oregon State University, 2007). Most of the precipitation falls in the winter season, between October and April. Precipitation is generally greater at higher elevations and more northerly locations. Above about 6,500 ft, most of the precipitation falls as snow. Runoff from Sierra Nevada watersheds, primarily in the form of snow melt, provides approximately 50 percent of California's developed water (Carle, 2004).

Groundwater is used extensively for municipal, community, and domestic drinking-water supplies in the Sierra Nevada. Because 97 percent of the province area is not part of CDWR-defined groundwater basins, fractured rock systems are the primary aquifer types in the province. Granitic and metamorphic rocks of the Sierra Nevada have low permeability except where fractured. Fractures and joints generally are more extensive in size and number in the upper few hundred feet of bedrock and typically decrease with depth (Borchers, 1996; Page and others, 1984). Fracture permeability tends to decrease with depth because of increased lithostatic pressure (Ingebritsen and Sanford, 1998); however, because crystalline rocks remain brittle to depths of several kilometers, some fracture permeability may persist to great depths (Freeze and Cherry, 1979). The three-dimensional complexity and variability of fracture systems can cause well yields and water quality to vary widely on a local scale.

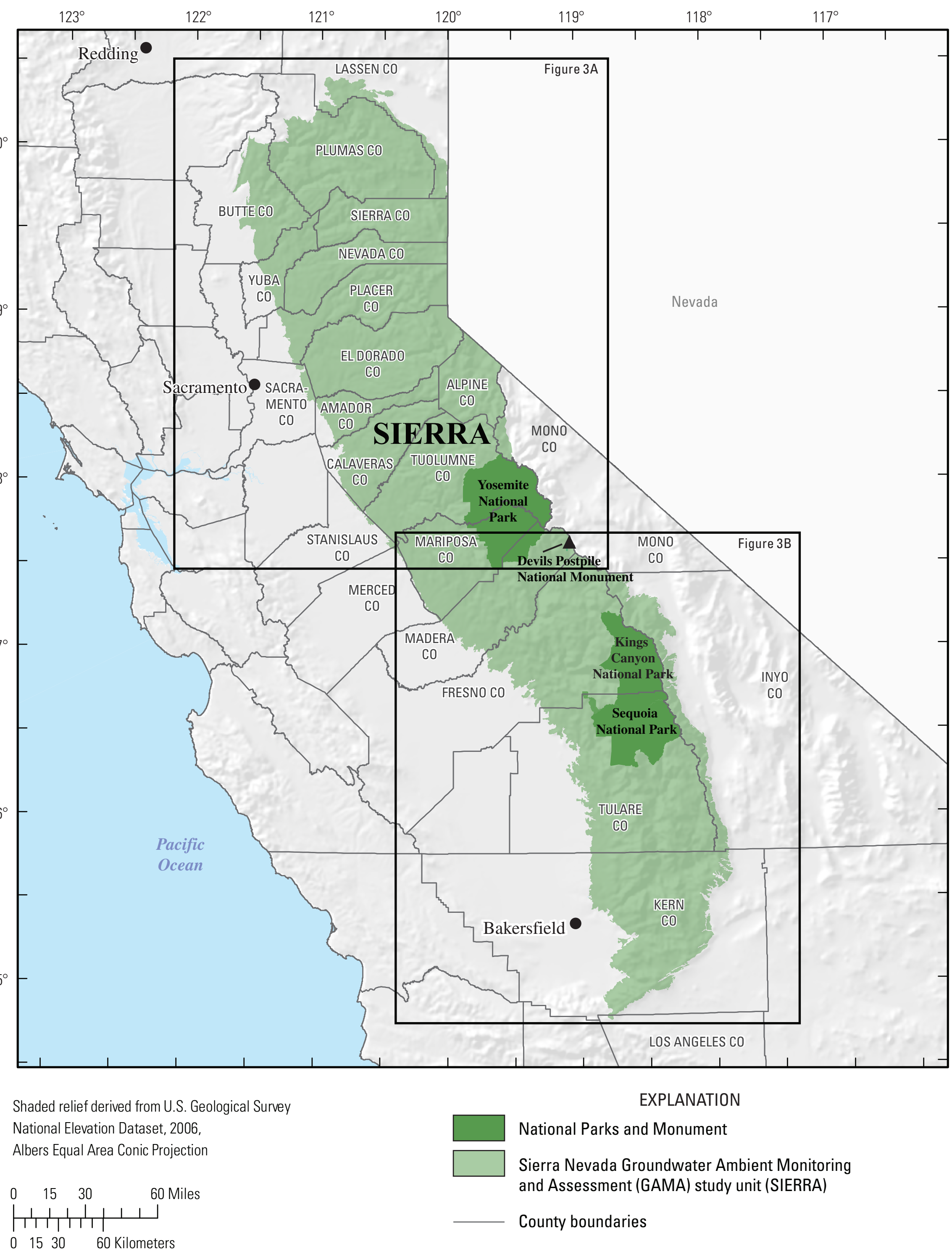


Figure 2. County boundaries and selected cities in the Sierra Nevada Groundwater Ambient Monitoring and Assessent (GAMA) study unit, California.

Although groundwater basins comprise a small part of the province area, they generally have a high density of groundwater use because they commonly contain population centers and have wells with much greater yields than those in the surrounding fractured rock aquifers. The basins are small and composed of fluvial, alluvial, or glacial sediments.

Methods

Methods used for the GAMA Program were selected to achieve the following objectives: (1) design a sampling plan suitable for statistical analysis, (2) collect samples in a consistent manner statewide, (3) analyze samples using proven and reliable laboratory methods, (4) assure the quality of the groundwater data, and (5) maintain data securely and with relevant documentation. The appendix to this report contains detailed descriptions of the sample collection protocols and analytical methods, the quality-assurance methods, and the results of analyses of quality-control samples.

Study Design

The wells sampled in this study were selected by using a spatially-distributed, randomized, grid-based approach (Scott, 1990). Approximately 30 percent of the wells listed in the CDPH database for Sierra Nevada study unit were springs. Springs are sites where groundwater naturally flows from a aquifer to the land surface, sometimes through a horizontal well bore. All sites are referred to as wells in this report unless the difference between a well and a spring is important to the discussion. The study unit was divided into 30 equal-area grid cells, and wells were sampled for two types of grid-well networks—a primary grid-well network and four lithologic grid-well networks (figs. 3A,B). The primary grid-well network consisted of 30 wells, one well per cell, and was designed to enable statistically unbiased assessment of the quality of groundwater resources in the entire Sierra Nevada study unit.

The lithologic grid-well networks were created on the basis of a four-fold classification of geologic units in the Sierra Nevada study unit. All 83 wells sampled—the 30 primary grid wells and the 53 additional wells (referred to as lithologic grid wells) selected on the basis of their aquifer lithologies—were included in the lithologic grid-well networks. The 33 geologic units exposed in the Sierra Nevada study unit, as shown on the California state geologic map (Jennings, 1977; Saucedo and others, 2000), were grouped into the following four classes:

- Granitic rocks: Mesozoic granitic rocks of the Sierra Nevada Batholith
- Metamorphic rocks: Paleozoic and Mesozoic metasedimentary, metavolcanic, mafic, and ultramafic rocks
- Volcanic rocks: Tertiary and Quaternary volcanic rocks and volcaniclastic deposits
- Sedimentary deposits: Tertiary and Quaternary fluvial, alluvial, and glacial sediments.

Each well was assigned a lithologic class on the basis of its location by using ArcGIS 9.3. Because the State geologic map shows surficial geology and not necessarily the geology at the depth at which a particular well is perforated, the lithologic classifications of all wells sampled were verified by using information from driller's logs. Driller's logs were available for nearly all wells sampled. Wells located in sedimentary deposits at land surface in the Sierra Nevada study unit are more likely to be perforated in aquifer lithologies other than sediment, because the sedimentary deposits may be thin; driller's logs were obtained for all sampled wells classified as sedimentary.

Each grid cell was approximately 850 mi^2 (2,200 km^2), considerably larger than the design objective for grid cells in large groundwater basins, such as in the Central Valley (38.6 mi^2 or 100 km^2), or in the rest of the State (9.7 mi^2 or 25 km^2) (Belitz and others, 2003). The approximately 2,200 active and standby wells listed in the CDPH database for the Sierra Nevada study unit were unevenly distributed, and selecting a large cell size was necessary to ensure that all grid cells contained CDPH wells; the resulting network had 30 grid cells. For the three smaller GAMA study units within the borders of the Sierra Nevada study unit (the Tahoe–Martis, the Central Sierra, and the Southern Sierra study units), the study unit was defined as the collective areas within 3 km of each CDPH well (Fram and others, 2009; Ferrari and others, 2008; Fram and Belitz, 2007). This approach was not used for the Sierra Nevada study unit, because most of the 2,200 CDPH wells were too far apart for the 3-km buffers around them to intersect.

For the primary grid-well network, the objective was to select one well per cell, and for the lithologic grid-well networks, the objective was to select one well from each geologic unit containing wells in each cell. Wells were selected from among the 2,200 active and standby wells listed in the CDPH database for the region corresponding to the Sierra Nevada study unit. Within each cell, each well was randomly assigned a rank. The highest ranked well that met basic sampling criteria (for example, capability to pump for several hours and available well-construction information) and for which permission to sample could be obtained was then sampled as part of the primary grid-well network. The lithologic unit containing the primary grid well was defined as the primary lithologic unit of the cell. If there were wells in other lithologic units in that cell, the highest ranking well in each lithologic unit that met basic sampling criteria and for which permission to sample could be obtained was sampled as part of the lithologic grid-well networks.

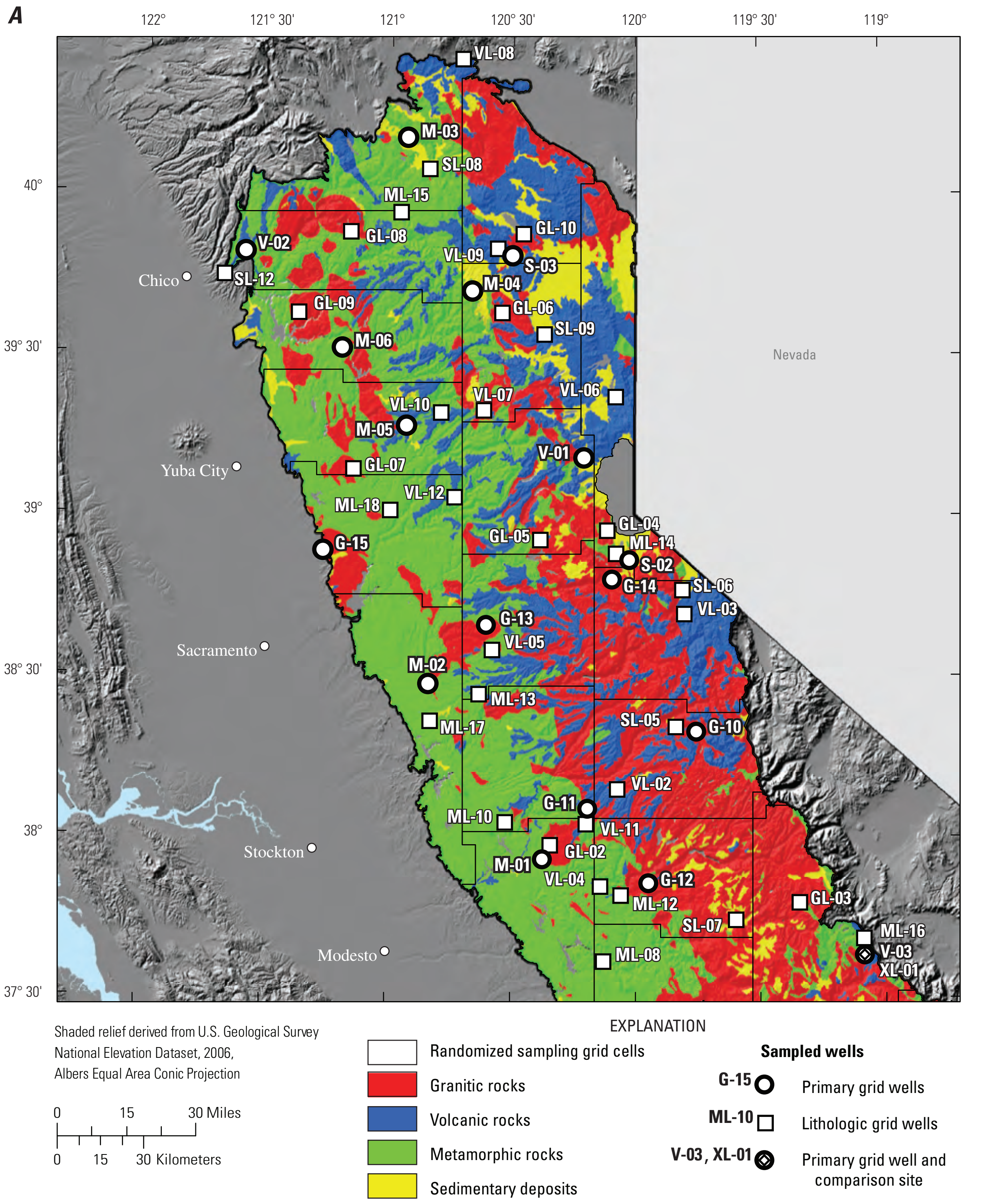


Figure 3. A. The northern part and B. the southern part of the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, showing the distribution of study area grid cells, the locations of sampled wells, and the surficial geology grouped into four major lithologic units.

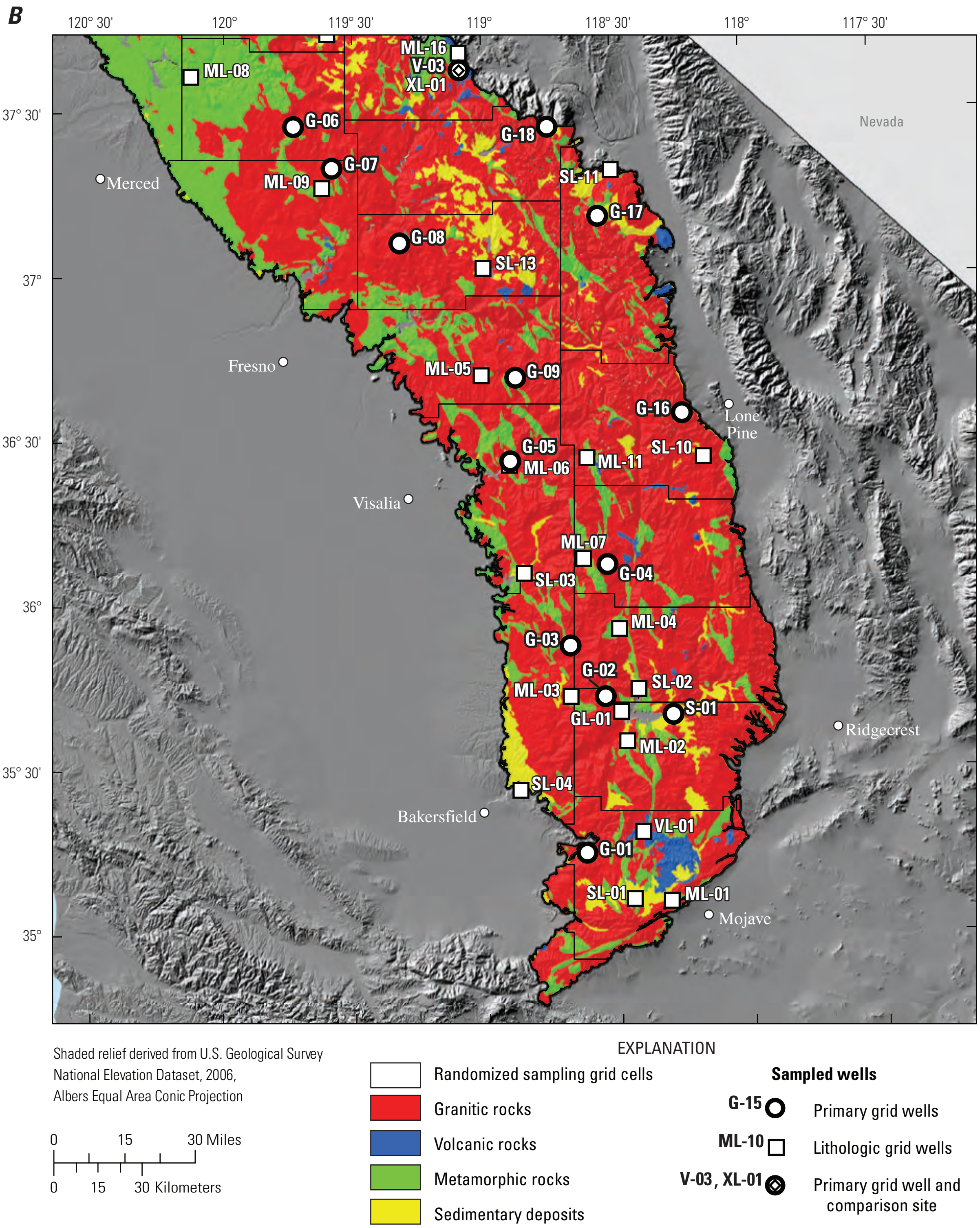


Figure 3. Continued

The 30 primary grid wells sampled in the Sierra Nevada study unit were numbered in the order that they were sampled; the prefix "SIERRA" plus an extension indicates the aquifer lithology in which the well was located: "SIERRA-G," primary grid well in granitic rocks; "SIERRA-M," primary grid well in metamorphic rocks; "SIERRA-S," primary grid well in sedimentary deposits; "SIERRA-V," primary grid well in volcanic rocks (figs. 3A,B).

The 53 lithologic grid wells sampled in the Sierra Nevada study unit were numbered in the order that they were sampled with the prefix "SIERRA"; to the prefix was added an extension to indicate the class of lithologic unit and an "L" to indicate that the wells were selected according to location within a lithologic unit and were not part of the primary grid well network: SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks (noted in abbreviated form without the prefix SIERRA in figs. 3A,B). In addition, one natural spring that was not used for drinking water, SIERRA-XL, was sampled to be compared with a nearby primary grid well in the same cell, SIERRA-V-03. SIERRA-XL is referred to as a comparison site.

Table 1 (all tables at back of report) provides the GAMA alphanumeric identification number for each well, along with the date sampled, sampling schedule, well elevation, well type, and well-construction information. Wells classified as production wells are vertically drilled into the ground and have pumps that pump the groundwater from the aquifer to a distribution system. Wells were classified as springs if groundwater could discharge from the aquifer into the distribution system without a pump and the well was drilled horizontally or had no drilled hole. The wells were sampled during the period from June through October 2008.

Well locations and identifications were verified using GPS, 1:24,000 scale USGS topographic maps, existing well information in USGS and CDPH databases, and information provided by well owners. Driller's logs for wells were obtained when available. Well information was recorded by hand on field sheets and electronically using specialized software on field laptop computers. All information was verified and then uploaded into the USGS National Water Information System (NWIS). Well owner information is confidential. Well location information and all chemical data are currently inaccessible from NWIS's public website.

The wells in the Sierra Nevada study unit were sampled using a tiered analytical approach. All wells were sampled for a standard set of constituents, including field water-quality parameters, organic constituents (VOCs and pesticides), perchlorate, inorganic constituents (nutrients, major and minor ions, trace elements, and species of arsenic and iron), isotopic tracers (stable isotopes of hydrogen and oxygen of water, stable isotopes of carbon, carbon-14 activity, strontium isotopes, tritium activity, and dissolved noble gases), and radioactive constituents (uranium isotopes, and gross alpha and gross beta particle activities). The standard set of constituents was termed the intermediate schedule (table 2). Wells on the slow schedule were sampled for all the constituents on the intermediate schedule plus pharmaceutical compounds, NDMA, radon-222, and radium isotope activities. Intermediate and slow refer to the time required to sample the well for all the constituents on the respective schedules. Generally, two intermediate wells or one slow and one intermediate well could be sampled in one day. Many of the other GAMA study units had a shorter list of standard constituents termed the fast schedule; three or four fast wells could be sampled in one day. In the Sierra Nevada study unit, 56 of the wells were sampled on the intermediate schedule and 28 were sampled on the slow schedule.

Sample Collection and Analysis

Samples were collected in accordance with the protocols established by the USGS National Water Quality Assessment (NAWQA) program (Koterba and others, 1995) and the USGS National Field Manual (U.S. Geological Survey, variously dated). These sampling protocols ensure that a representative sample of groundwater is collected at each site and that the samples are collected and handled in a way that minimizes potential contamination of samples. The methods used for sample collection and analysis are described in the appendix section "Sample Collection and Analysis." The methods used for data reporting are described in more detail in the appendix section "Data Reporting."

Tables 3A–I list the compounds analyzed in each constituent class. Groundwater samples were analyzed for 85 VOCs (table 3A); 63 pesticides and pesticide degradates (table 3B); 12 pharmaceutical compounds (table 3C); 2 constituents of special interest (table 3D); 5 nutrients (table 3E); 10 major and minor ions and total dissolved solids (table 3F); 25 trace elements (table 3F); arsenic and iron species (table 3G); stable isotopes of hydrogen and oxygen of water, stable isotopes of carbon of carbonate, strontium isotopes, carbon-14 activity, tritium activity, gross alpha and gross beta particle activities (72-hour and 30-day counts), radon-222, radium isotopes, and uranium isotope activities (table 3H); and stable isotopes of helium ratios, 5 dissolved noble gases, and tritium activity (table 3I). The methods and laboratories used for sample analysis are described in the appendix section "Sample Collection and Analysis."

Quality Assurance

The quality-assurance and quality-control procedures used for this study followed the protocols used by the USGS NAWQA program (Koterba and others, 1995) and described in the USGS National Field Manual (U.S. Geological Survey, variously dated). The quality-assurance plan followed by the NWQL, the primary laboratory used to analyze samples for this study, is described by Maloney (2005) and Pirkey and Glodt (1998). Quality-control (QC) samples collected in the Sierra Nevada study unit study include field blanks, replicates, and matrix and surrogate spikes. QC samples were collected to evaluate potential contamination bias or variability of the data that may have resulted from collecting, processing, storing, transporting, and analyzing the samples. Quality-assurance and quality-control procedures are described in the appendix section “Quality-Assurance Methods,” and quality-control-sample results are described in the appendix section “Quality-Control Results.”

Water-Quality Results

Quality-Control Results

Results of quality-control analyses (blanks, replicates, matrix spikes, and surrogates) were used to evaluate the quality of the data for the groundwater samples. Of the approximately 240 constituents analyzed, 10 constituents were detected in at least one field blank. On the basis of detections in field blanks, detections reported by the laboratory for three organic compounds were considered suspect and, therefore, were removed from the set of groundwater-quality data presented in this report (described in the appendix section “Detections in Field Blanks”). Concentrations of inorganic constituents detected in field blanks were less than 1/10 of benchmarks, indicating contamination of groundwater samples during collecting, handling, and analysis was negligible. Results from the replicates confirm that the procedures used to collect and analyze the samples were consistent. Variability for over 95 percent of the replicate pairs analyzed for constituents detected in samples was within the acceptable limits of 10 percent relative standard deviation and (or) standard deviation (tables A4A–C); additional discussion is in the appendix. Median matrix-spike recoveries for 20 of the 149 organic constituents analyzed were lower than the acceptable limits (tables 3A–B), which may indicate that these constituents might not have been detected in some samples if they had been present at very low concentrations; these compounds are indicated with a footnote in the “Detection” column. The quality-control results are described in the appendix section “Quality-Control Results.”

Comparison Benchmarks

Concentrations of constituents detected in groundwater samples were compared with CDPH and USEPA regulatory and nonregulatory drinking-water health-based benchmarks and benchmarks established for aesthetic purposes (California Department of Public Health, 2008a,b,c; U.S. Environmental Protection Agency, 2008a,b). The chemical data in this report characterize the quality of the untreated groundwater resources within the Sierra Nevada study unit and do not represent the finished drinking water delivered to consumers by water purveyors. The chemical composition of finished drinking water may differ from that of untreated groundwater because finished drinking water may be disinfected, filtered, mixed with other waters, and exposed to the atmosphere before being delivered to consumers. Comparisons between concentrations of constituents in raw, untreated groundwater and drinking-water benchmarks are for illustrative purposes only and do not indicate compliance or noncompliance with drinking-water regulations.

The following benchmarks were used for comparisons:

- MCL—Maximum Contaminant Level. Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of contaminants in drinking water. MCLs established by the USEPA are the minimum standards with which states are required to comply, and individual states may choose to set more stringent standards. CDPH has established MCLs for constituents not regulated by the USEPA, and has lowered the benchmark concentration for a number of constituents with MCLs established by the USEPA. In this report, a benchmark set by the USEPA and adopted by CDPH is labeled “MCL-US” and one set by CDPH that is more stringent than the MCL-US is labeled “MCL-CA.” CDPH is notified when constituents are detected at concentrations greater than an MCL-US or MCL-CA benchmark in samples collected for the GAMA Priority Basin Project, but these concentrations do not constitute violations of CDPH regulations.

- AL—Action Level. Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of copper and lead in drinking water. Detections of copper or lead greater than the action-level benchmarks trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and CDPH currently are the same, thus the benchmarks are labeled “AL-US” in this report.

- SMCL—Secondary Maximum Contaminant Level. Nonenforceable standards applied to constituents that affect the aesthetic qualities of drinking water, such as taste, odor, and color, or technical qualities of drinking water, such as scaling and staining. Both the USEPA and CDPH define SMCLs, but unlike MCLs, SMCLs established by CDPH are not required to be at least as stringent as those established by USEPA. SMCLs established by CDPH are used in this report (SMCL-CA) for all constituents that have SMCL-CA values. The SMCL-US is used for pH because no SMCL-CA has been defined.

- NL—Notification Level. Health-based notification levels established by CDPH for some of the constituents in drinking water that lack MCLs (NL-CA). If a constituent is detected at concentrations greater than its NL-CA, California state law requires timely notification of local governing bodies and recommends consumer notification.

- HAL—Lifetime Health Advisory Level. The maximum concentration of a constituent at which its presence in drinking water is not expected to cause any adverse carcinogenic effects for a lifetime of exposure. HALs are established by the USEPA (HAL-US) and are calculated assuming consumption of 2 liters (2.1 quarts) of water per day over a 70-year lifetime by a 70-kilogram (154-pound) adult and that 20 percent of a person's exposure comes from drinking water.

- RSD5—Risk-Specific Dose. The concentration of a constituent in drinking water corresponding to an estimated excess lifetime cancer risk of 1 in 100,000. RSD5 is an acronym for risk-specific dose at 10^{-5}. RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by ten (RSD5-US).

For constituents that have MCLs, concentrations in groundwater samples were compared with the MCL-US or MCL-CA. Constituents with SMCLs were compared with the SMCL-CA. For chloride, sulfate, specific conductance, and total dissolved solids, CDPH defines a "recommended" and an "upper" SMCL-CA; concentrations of these constituents in groundwater samples were compared with both levels. The SMCL-US values for these constituents correspond to the recommended SMCL-CAs. Detected concentrations of constituents that lack an MCL or an SMCL were compared with the NL-CA. Detected concentrations of constituents that lack an MCL, SMCL, or NL-CA were compared with the HAL-US. Detected concentrations of constituents that lack an MCL, SMCL, NL-CA, or HAL-US were compared with the RSD5-US. Note that if a constituent has more than one type of established benchmark, using this hierarchy to select the comparison benchmark will not necessarily result in selecting the benchmark with the lowest concentration. For example, zinc has an SMCL-CA of 5,000 µg/L and a HAL-US of 2,000 µg/L, and the comparison benchmark selected by this hierarchy is the SMCL-CA. The comparison benchmarks used in this report are given in tables 3A–I for all constituents analyzed and in tables 4 through 13 for constituents detected in groundwater samples from the Sierra Nevada study unit. Note that not all constituents analyzed for this study have established benchmarks. Detections of constituents at concentrations greater than the selected comparison benchmarks are marked with asterisks in tables 4 through 13.

Groundwater-Quality Data

Results from analyses of untreated groundwater samples from the Sierra Nevada study unit are given in tables 4 through 13. Groundwater samples collected in the Sierra Nevada study unit were analyzed for 150 organic and special-interest constituents, of which 129 were not detected in any of the samples (tables 3A,B,D). The samples were analyzed for up to 69 naturally occurring inorganic constituents, isotopic tracers, radioactivity, and field water-quality indicators (tables 3E–H, 4). The results tables give only the constituents that were detected and list only samples in which at least one constituent was detected. The tables containing organic constituent classes and constituents of special interest that were analyzed at all of the primary grid wells give the number of wells at which each constituent was detected, the percentage of primary grid wells in which each constituent was detected, and the total number of constituents detected in each sample (tables 5–7). Results from the lithologic grid wells and the comparison site are given in the tables, but these results were excluded from the primary-grid detection frequency calculations to avoid statistically over-representing the areas near the lithologic grid wells. Detection frequencies are not presented for the lithologic grid-well networks because the unequal distribution of lithologies in the grid cells requires designing a method for appropriately weighting the samples in the calculation, which is beyond the scope of a data series report.

Field water-quality indicators measured in the field and at the NWQL are included in table 4. The results of chemical analyses of groundwater samples organized by constituent classes are presented in tables 5 through 13:

- Organic constituents
  - VOCs (table 5)
  - Pesticides and pesticide degradates (table 6)
- Constituents of special interest (table 7)
- Inorganic constituents
  - Nutrients (table 8)
  - Major and minor ions and total dissolved solids (table 9)
  - Trace elements (table 10)

- Species of arsenic and iron (table 11)
- Isotopic tracers and dissolved gases (table 12)
- Radioactive constituents (tables 13A,B,C)

Results for pharmaceutical compounds and dissolved noble gases are not presented in this report; they will be included in subsequent publications.

Field Water-Quality Indicators

Field and laboratory measurements of dissolved oxygen, water temperature, pH, specific conductance, and alkalinity are given in table 4. Alkalinity and dissolved oxygen are used as indicators of natural processes that control water chemistry. The pH value indicates the acidity of the water. Low pH in water may contribute to corrosion of pipes, and high pH in water may contribute to scaling. Samples from 14 of the 30 primary grid wells and 14 of the 53 lithologic grid wells had field pH values outside the SMCL-US range for pH (lower pH in 24 samples and higher pH in 4 samples). Most of the samples that had a low pH were from wells in granitic rocks. Laboratory pH values may differ from field pH values because the pH of groundwater may change when exposed to the atmosphere. Specific conductance values for all 83 grid wells were less than the upper SMCL-CA benchmark; three lithologic grid wells had specific conductance values between the recommended and the upper benchmarks (table 4).

Organic Constituents

Volatile organic compounds (VOC) can be in paints, solvents, fuels, fuel additives, refrigerants, fumigants, and disinfected water and are characterized by their tendency to evaporate. VOCs generally persist longer in groundwater than in surface water because groundwater is isolated from the atmosphere. Of the 85 VOCs analyzed, 12 were detected in groundwater samples; all concentrations were less than health-based benchmarks, and most were less than 1/100th of the benchmark levels (table 5). Chloroform, a byproduct of drinking-water disinfection, and methyl tert-butyl ether (MTBE), a gasoline oxygenate, were detected in 10 percent or more of the primary grid well samples. Chloroform is among the most commonly detected VOCs in groundwater nationally (Zogorski and others, 2006). One or more VOCs were detected in samples from 7 of the 30 primary grid wells and 18 of the 53 lithologic grid wells.

Pesticides include herbicides, insecticides, and fungicides and are used to control weeds, insects, fungi, and other pests in agricultural, urban, and suburban settings. Of the 63 pesticides and pesticide degradates analyzed, 8 were detected in groundwater samples; all concentrations were less than health-based benchmarks, and nearly all were less than 1/100th of the benchmark levels (table 6). The herbicide, simazine, was detected in 10 percent of the 30 primary grid well samples. Simazine is among the most commonly detected pesticide compounds in groundwater nationally (Gilliom and others, 2006). Pesticide compounds were detected in samples from 5 of the 30 primary grid wells and 6 of the 53 lithologic grid wells.

Constituents of Special Interest

NDMA and perchlorate are constituents of special interest in California because recent advances in analytical methods have resulted in detections of low concentrations of these constituents in water supplies in many parts of the State (California Department of Public Health, 2008c). NDMA was analyzed for in samples from 31 wells and was not detected in any of these samples. All detected concentrations of perchlorate were less than the MCL-CA, and most were less than 1/10 of the benchmark (table 7). Perchlorate was detected in samples from 8 of the 30 primary grid wells and in samples from 18 of the 53 lithologic grid wells. Most of the concentrations were detected in samples from wells in granitic or metamorphic rocks.

Inorganic Constituents

Unlike the organic constituents, inorganic constituents generally are naturally present in groundwater, although their concentrations may be influenced by human activities.

Nutrients (nitrogen and phosphorus) in groundwater can affect biological activity in aquifers and in surface-water bodies that receive groundwater discharge. Nitrogen may exist in the form of ammonia, nitrite, or nitrate, depending on the oxidation-reduction state of the groundwater. High concentrations of nitrate can adversely affect human health, particularly the health of infants. All concentrations of nutrients measured in samples from the Sierra Nevada study unit were less than the health-based benchmarks (table 8).

The major-ion composition, total dissolved solids (TDS) content, and levels of certain trace elements in groundwater can affect the aesthetic properties of water, such as taste, color, and odor, and the technical properties, such as scaling and staining. Although no adverse health effects are directly associated with these properties, they may reduce consumer satisfaction with the water or may have economic effects. CDPH has established nonenforceable benchmarks (SMCL-CA) that are based on aesthetic or technical properties, rather than health-based concerns, for chloride and sulfate, TDS, iron, manganese, silver, and zinc.

TDS concentrations in all 83 primary and lithologic grid wells were less than the upper SMCL-CA, and concentrations in 1 primary grid well and 3 lithologic grid wells were between the recommended and the upper benchmarks (table 9). Manganese was detected at concentrations greater than the SMCL-CA in 2 of the 30 primary grid well samples and 6 of the 53 lithologic grid well samples (table 10). Half the samples that had high manganese concentrations were from wells in metamorphic rocks. Seven of the 8 samples that had manganese concentrations greater than the SMCL-CA had concentrations of iron also greater than the respective SMCL-CA. Concentrations of chloride, sulfate, silver, and zinc in all Sierra Nevada study unit grid well samples were less than the corresponding SMCL-CAs (tables 9, 10).

One of the major and minor ions (fluoride) and 19 of the 25 trace elements analyzed and detected in this study have regulatory or nonregulatory health-based benchmarks (table 3F). Of these 20 constituents with health-based benchmarks, concentrations of 16 constituents in primary grid wells were less than their respective benchmarks. Fluoride (MCL-CA), arsenic (MCL-US), boron (NL-CA), and uranium (MCL-US) each were detected at concentrations greater than their respective benchmarks in 1 of the 30 primary grid wells (tables 9 and 10). In the 53 lithologic grid wells, arsenic (4 wells), boron (1 well), selenium (1 well), and uranium (1 well) were detected at concentrations greater than their health-based benchmarks (table 10). Among the 83 grid wells, all of the uranium concentrations greater than the MCL-US for uranium were in samples from wells in sedimentary deposits, and most of the arsenic concentrations greater than the MCL-US for arsenic were in samples from wells in volcanic rocks.

Arsenic and iron exist as different species depending on the oxidation-reduction state of the groundwater. The oxidized and reduced species have different solubilities in groundwater and may have different effects on human health. The relative proportions of the oxidized and reduced species of each element can be used to help interpret the oxidation–reduction state of the aquifer. Concentrations of total arsenic, total iron, and the concentrations of the more reduced species of each element are reported in table 11. The concentrations of the other species can be calculated by difference. The concentrations of arsenic and iron reported in table 11 may be different from those reported in table 10 because different analytical methods were used (see appendix). The concentrations reported in table 10 are preferred.

Isotopic Tracers and Dissolved Gases

Isotopic tracers and dissolved gases may be used to help interpret natural and human processes affecting groundwater composition and to estimate groundwater age distribution. Groundwater age is the time since the water infiltrated into the aquifer. Groundwater samples generally are mixtures of water of a range of ages.

The isotopic stable ratios of hydrogen and oxygen in water (table 12) aid in the interpretation of the sources of groundwater recharge. These isotopic ratios reflect the altitude, latitude, and temperature of precipitation and also the extent of evaporation of water from surface water bodies or soils before infiltrating into the aquifer. The isotopic ratio of strontium in groundwater reflects the strontium isotopic ratios in the aquifer materials contributing strontium (and other inorganic constituents) to the groundwater. In regions that have diverse geology, strontium isotope ratios may aid in estimating groundwater flow paths. Strontium isotope ratio analyses were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

Tritium activities (table 12), helium stable-isotopic ratios, and carbon-14 abundances (table 12) provide information about the age of groundwater. Tritium is a short-lived radioactive isotope of hydrogen that is incorporated into the water molecule. Low levels of tritium are continuously produced by interaction of cosmic radiation with the Earth's atmosphere, and a large amount of tritium was produced as a result atmospheric testing of nuclear weapons between 1952 and 1963. Thus, concentrations of tritium greater than background concentrations generally indicate the presence of water recharged since the early 1950s. Helium isotope ratios are used in conjunction with tritium concentrations to estimate ages for young groundwater. Helium isotope ratio analyses were not completed in time for inclusion in this report; results will be presented in a subsequent publication. Carbon-14 is a radioactive isotope of carbon. Low levels of carbon-14 are continuously produced by interaction of cosmic radiation with the Earth's atmosphere and are incorporated into atmospheric carbon dioxide. The carbon dioxide dissolves in precipitation, surface water, and groundwater exposed to the atmosphere, thereby entering the hydrologic cycle. Because carbon-14 decays with a half-life of approximately 5,700 years, low activities of carbon-14 relative to modern values generally indicate the presence of groundwater that is several thousand years old.

Concentrations of dissolved noble gases are used to estimate the conditions of groundwater recharge, particularly the temperature of the recharge water. Noble gases dissolve in water that is in contact with the atmosphere, and the solubilities of the different noble-gas species vary with temperature. Dissolved noble gas analyses were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

Of the isotopic tracer constituents analyzed for this study, tritium is the only one that has a health-based benchmark. All measured tritium activities in samples from Sierra Nevada study unit wells were less than 1/1,000 of the MCL-CA (table 12).

Radioactive Constituents

Radioactivity is the release of energy or energetic particles during changes in the structure of the nucleus of an atom. Most of the radioactivity in groundwater comes from decay of naturally occurring isotopes of uranium and thorium that are in minerals in the sediments or fractured rocks of the aquifer. Uranium and thorium decay in a series of steps, eventually forming stable isotopes of lead (Soddy, 1913; Faure and Mensing, 2005). Radium-226, radium-228, and radon-222 are radioactive isotopes formed during the uranium or thorium decay series. In each step in the decay series, one radioactive element turns into a different radioactive element by emitting an alpha or a beta particle from its nucleus. For example, radium-226 emits an alpha particle and therefore turns into radon-222. Radium-228 decays to form actinium-228 by emitting a beta particle. The alpha and beta particles emitted during radioactive decay are hazardous to human health because these energetic particles may damage cells. Radiation damage to cell DNA may increase the risk of getting cancer.

Activity is often used instead of concentration for reporting the presence of radioactive constituents. Activity of radioactive constituents in groundwater is measured in units of picocuries per liter (pCi/L), and one picocurie equals 2.22 atoms decaying per minute. The number of atoms decaying can be determined by counting the number of alpha or beta particles emitted.

Radon-222 activities were greater than the proposed alternative MCL-US in 4 of the 28 primary grid wells in which it was analyzed (table 13A). Gross alpha particle activities were greater than the MCL-US in samples from 3 of the 30 primary grid wells and 1 of the 53 lithologic grid wells (table 13B). The two samples that had uranium concentrations greater than the MCL-US (SIERRA-S-01, SL-3, table 10) had total uranium activities greater than the MCL-CA also (table 13A). All of the samples that had radon-222 activities greater than the proposed alternative MCL-US were from wells in granitic rocks, and most of the samples that had gross alpha particle activities greater than the MCL-US were from wells in sedimentary deposits. All samples analyzed for radium and gross beta particles had activities less than their respective MCL-US benchmarks (tables 13B,C).

Future Work

Subsequent reports will focus on assessing the data presented in this report by using a variety of statistical, qualitative, and quantitative approaches to evaluate the natural and human factors affecting groundwater quality. Water-quality data contained in the CDPH and the USGS NWIS databases and water-quality data available from other State and local water agencies will be compiled, evaluated, and used in combination with the data in this report; the results of these future efforts will appear in one or more subsequent publications.

Summary

Groundwater quality in the approximately 25,500-square-mile Sierra Nevada study unit was investigated in June through October 2008 as part of the Priority Basin Project of the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA Priority Basin Project is being conducted by the U.S. Geological Survey (USGS) in cooperation with the California State Water Resources Control Board (SWRCB). The project is a comprehensive assessment of statewide groundwater quality intended to identify and characterize risks to groundwater quality and to increase the availability of information about groundwater quality to the public.

The Sierra Nevada study unit was designed to provide a spatially unbiased assessment of untreated groundwater quality within the primary aquifer systems in the study unit and to facilitate statistically consistent comparisons of groundwater quality throughout California. The primary aquifer systems are defined by the depth intervals of the wells listed in the California Department of Public Health (CDPH) database of wells that are used for public and community drinking water supplies. The quality of groundwater in shallower or deeper water-bearing zones may differ from that in the primary aquifers; shallow groundwater may be more vulnerable to contamination from the surface.

This report describes the well selection, sampling, and analytical and quality-control methods used in the study. It presents tabulations of the water-quality data collected and analyses of the quality-control results. Groundwater samples were collected from 84 wells and springs (all are referred to as wells for convenience) in Lassen, Plumas, Butte, Sierra, Yuba, Nevada, Placer, El Dorado, Amador, Alpine, Calaveras, Tuolumne, Madera, Mariposa, Fresno, Inyo, Tulare, and Kern Counties. The wells were selected on nested networks using a spatially-distributed, randomized, grid-based approach. The primary grid-well network consisted of 30 wells, one well per grid cell in the study unit, and was designed to provide statistical representation of groundwater quality for the entire study unit. The lithologic grid-well network consisted of the wells in the primary grid-well network plus 53 additional wells and was designed to provide statistical representation of groundwater quality in each of the four major lithologic units in the Sierra Nevada study unit: granitic, metamorphic, sedimentary, and volcanic rocks. One natural spring that is not used for drinking water was sampled to be compared with a nearby primary grid well in the same cell.

Groundwater samples were analyzed for organic constituents [volatile organic compounds (VOC), pesticides and pesticide degradates, and pharmaceutical compounds], constituents of special interest [*N*-nitrosodimethylamine (NDMA) and perchlorate], naturally occurring inorganic constituents [nutrients, major ions, total dissolved solids, and trace elements], and radioactive constituents [radium isotopes, radon-222, gross alpha and gross beta particle activities, and uranium isotopes]. Naturally occurring isotopes and geochemical tracers (stable isotopes of hydrogen and oxygen of water, stable isotopes of carbon, carbon-14, strontium isotopes, and tritium), and dissolved noble gases also were measured to help identify the sources and ages of the sampled groundwater.

Three types of quality-control samples (blanks, replicates, and samples for matrix spikes) each were collected at approximately 10 percent of the sites sampled for each analysis, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that data for the groundwater samples were not compromised by contamination during sample collection, handling or analysis. Differences between replicate samples were within acceptable ranges with few exceptions. Matrix spike recoveries were within acceptable ranges for most compounds.

This study did not attempt to evaluate the quality of water delivered to consumers; after withdrawal from the ground, groundwater typically is treated, disinfected, or blended with other waters to maintain water quality. Regulatory benchmarks apply to finished drinking water that is served to the consumer, not to untreated groundwater. However, to provide some context for the results, concentrations of constituents measured in the groundwater were compared with regulatory and nonregulatory health-based benchmarks established by the U.S. Environmental Protection Agency (USEPA) and CDPH and with nonregulatory aesthetic and technical benchmarks established by CDPH. Comparisons between data collected for this study and drinking-water benchmarks are for illustrative purposes only and do not indicate compliance or noncompliance with regulatory benchmarks.

All organic constituents and most inorganic constituents that were detected in groundwater samples from the 30 primary grid wells in the Sierra Nevada study unit were detected at concentrations less than drinking-water benchmarks.

Of the 150 organic and special interest constituents analyzed, 21 were detected in groundwater samples; concentrations of all detected constituents were less than regulatory and nonregulatory health-based benchmarks, and most were less than 1/10 of benchmark levels. One or more organic constituents were detected in 37 percent of the primary grid wells, and perchlorate was detected in 27 percent of the primary grid wells.

Most samples analyzed for inorganic and radioactive constituents had concentrations or activities less than the regulatory and the nonregulatory health-based benchmarks. Nutrients were not detected at concentrations greater than the health-based benchmarks. Six of the 30 primary grid wells and 7 of the 53 lithologic grid wells had concentrations or activities of one or two constituents greater than the benchmarks. Constituents in one or more samples at concentrations or activities greater than health-based benchmarks were arsenic (5 wells, MCL-US), gross alpha particle activity (4 wells, MCL-US), boron (2 wells, NL-CA), fluoride (1 well, MCL-CA), and selenium (1 well, MCL-US). Two of the wells that had high gross alpha particle activities also had uranium concentrations (MCL-CA) and uranium activities (MCL-CA) greater than benchmark levels. Four of the 29 samples analyzed had activities of radon-222 greater than the proposed alternative MCL-US.

Most samples analyzed for inorganic constituents that had nonregulatory, aesthetic-based benchmarks (SMCLs) had concentrations less than the benchmarks. All 83 primary and lithologic grid well samples had concentrations of total dissolved solids less than the upper SMCL-CA, and 79 also had TDS concentrations less than the recommended SMCL-CA. Two of the primary grid wells and 6 of the lithologic grid wells had concentrations of manganese greater than the SMCL-CA, and 7 of these 8 wells also had concentrations of iron greater than the SMCL-CA.

Subsequent reports will present evaluations of the data given in this report using a variety of statistical, qualitative, and quantitative approaches to assess the natural and human factors affecting groundwater quality in the Sierra Nevada study unit.

Acknowledgments

The authors thank the well owners and water purveyors for their generosity in allowing the USGS to collect samples from their wells. We also thank the following cooperators for their support: the SWRCB, CDPH, CDWR, and LLNL. Four reviewers, Jan Stepek (SWRCB), Bryan Downing (USGS), Dara Goldrath (USGS), and Tracy Davis (USGS) provided comments to improve this work. Funding for this work was provided by State of California bonds authorized by Proposition 50 and administered by the SWRCB.

References Cited

American Public Health Association, 1998, Standard methods for the examination of water and wastewater (20th ed.): Washington, D.C., American Public Health Association, American Water Works Association, and Water Environment Federation, p. 3-37–3-43.

American Society for Testing and Materials, 2002, Standard test method for isotopic uranium in water by radiochemistry: American Society for Testing and Materials International, D 3972–02.

Anderson, C.W., 2005, Turbidity (ver. 2.1): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.7, accessed February 2008 at http://pubs.water.usgs.gov/twri9A6.7/

Anderson, R.L., 1987, Practical statistics for analytical chemists: New York, Van Nostrand Reinhold Company, Inc., 315 p.

Ball, J.W., and McCleskey, R.B., 2003a, A new cation-exchange method for accurate field speciation of hexavalent chromium: U.S. Geological Survey Water-Resources Investigations Report 03–4018, 17 p.

Ball, J.W., and McCleskey, R.B., 2003b, A new cation-exchange method for accurate field speciation of hexavalent chromium: Talanta, v. 61, p. 305–313.

Bateman, P.C., 1992, Plutonism in the central part of the Sierra Nevada batholiths, California: U.S. Geological Survey Professional paper 1493, 186 p.

Belitz, Kenneth, Dubrovsky, N.M., Burow, K.R., Jurgens, B.C., and Johnson, Tyler, 2003, Framework for a ground-water quality monitoring and assessment program for California: U.S. Geological Survey Water-Resources Investigations Report 03–4166, 78 p.

Bennett, G.L., V, Belitz, Kenneth, and Milby Dawson, B.J., 2006, California GAMA Program: Ground-water quality data in the northern San Joaquin basin study unit, 2005: U.S. Geological Survey Data Series 196, 122 p.

Bennett, P.A., Bennett, G.L., V, and Belitz, Kenneth, 2009, Groundwater quality data for the northern Sacramento Valley, 2007: Results from the California GAMA program: U.S. Geological Survey Data-Series 452, 90 p.

Birkeland, P.W., 1964, Pleistocene glaciation of the northern Sierra Nevada, north of Lake Tahoe, California: Journal of Geology, v. 72, no. 6, p. 810–825.

Borchers, J.W., 1996, Ground-water resources and water-supply alternatives in the Wawona area of Yosemite National Park, California: U.S. Geological Survey Water-Resources Investigations Report 95-4229, 77 p.

Bullen, T.D., Krabbenhoft, D.P., and Kendall, Carol, 1996, Kinetic and mineralogic controls on the evolution of groundwater chemistry and $^{87}Sr/^{86}Sr$ in a sandy silicate aquifer, northern Wisconsin, USA: Geochimica et Cosmochimica Acta, v. 60, no. 10, p. 1807–1821.

Burton, C.A., and Belitz, Kenneth, 2008, Ground-water quality data in the southeast San Joaquin Valley, 2005–2006—Results from the California GAMA Program: U.S. Geological Survey Data Series 351, 103 p.

California Department of Public Health, 2008a, California drinking water-related laws: Drinking water-related regulations (Title 22), accessed February 5, 2008, at http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Lawbook.aspx

California Department of Public Health, 2008b, Drinking water notification levels: Notification levels, accessed February 5, 2008, at http://www.cdph.ca.gov/certlic/drinkingwater/Pages/NotificationLevels.aspx

California Department of Public Health, 2008c, Chemicals and contaminants in drinking water, accessed February 5, 2008, at http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chemicalcontaminants.aspx

California Department of Water Resources, 2003, California's groundwater: California Department of Water Resources Bulletin 118, 246 p., accessed February 5, 2008 at http://www.groundwater.water.ca.gov/bulletin118

Carle, D., 2004, Introduction to water in California: Berkeley, California, University of California Press.

Childress, C.J.O., Foreman, W.T., Connor, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations for interpretations of water-quality data provided by the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 99-193, 19 p.

Connor, B.F., Rose, D.L., Noriega, M.C., Murtagh, L.K., and Abney, S.R., 1998, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of 86 volatile organic compounds in water by gas chromatography/mass spectrometry, including detections less than reporting limits: U.S. Geological Survey Open-File Report 97-829, 78 p.

Coplen, T.B., Wildman, J.D., and Chen, J., 1991, Improvements in the gaseous hydrogen-water equilibrium technique for hydrogen isotope analysis: Analytical Chemistry, v. 63, p. 910–912.

Coplen, T.B., 1994, Reporting of stable hydrogen, carbon, and oxygen isotopic abundances: Pure and Applied Chemistry, v. 66, p. 273–276.

Coplen, T.B., Hopple, J.A., Böhlke, J.K., Peiser, H.S., Rieder, S.E., Krouse, H.R., Rosman, K.J.R., Ding, T., Vocke, R.D., Jr., Revesz, K.M., Lamberty, A., Taylor, P., and DeBierve, P., 2002, Compilation of minimum and maximum isotope ratios of selected elements in naturally occurring terrestrial materials and reagents: U.S. Geological Survey Water-Resources Investigations Report 01-4222, 98 p.

Dawson, B.J., Bennett, G.L., V, and Belitz, Kenneth, 2008, Ground-water quality data in the southern Sacramento Valley, California, 2005—Results from the California GAMA Program: U.S. Geological Survey Data Series 285, 93 p.

Day, H.W., Moores, E.M., and Tuminas, A.C., 1985, Structure and tectonics of the northern Sierra Nevada. Geological Society of America Bulletin, v. 96, p. 436-450.

Densmore, J.N., Fram, M.S., and Belitz, Kenneth, 2009, Ground-water quality data in the Owens and Indian Wells Valleys study unit, 2006: Results from the California GAMA program: U.S. Geological Survey Data Series 427, 86 p.

Donahue, D.J., Linick, T.W., and Jull, A.J.T., 1990, Ratio and background corrections for accelerator mass spectrometry radiocarbon measurements: Radiocarbon, v. 32, p. 135–142.

Eaton, G.F., Hudson, G.B., and Moran, J.E., 2004, Tritium-helium-3 age-dating of groundwater in the Livermore Valley of California: American Chemical Society ACS Symposium Series, v. 868, p. 235–245.

Epstein, S., and Mayeda, T.K., 1953, Variation of O-18 content of water from natural sources: Geochimica et Cosmochimica Acta, v. 4, p. 213–224.

Evernden, J.F., and Kistler, R.W., 1970, Chronology and emplacement of Mesozoic batholithic complexes in California and Western Nevada: U.S. Geological Survey Professional Paper 623, 42 p.

Faires, L.M., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of metals in water by inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 92-634, 28 p.

Faure, G., and Mensing, T.M., 2005, Isotopes: Principles and applications (3rd ed.): Hoboken, New Jersey, John Wiley & Sons, Inc., 897 p.

Ferrari, M.J., Fram, M.S., and Belitz, Kenneth, 2008, Ground-water quality data in the central Sierra study unit, 2006—Results from the California GAMA Program: U.S. Geological Survey Data Series 335, 60 p.

Firestone, R.B., Shirley, V.S., Baglin, C.M., Chu, S.Y.F., and Zipkin, J., 1996, Table of isotopes (8th ed.): New York, John Wiley & Sons, 3168 p., accessed on April 1, 2007, at http://ie.lbl.gov/toipdf/toi20.pdf

Fishman, M.J., and Friedman, L.C., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Fishman, M.J., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93-125, 217 p.

Fram, M.S., Belitz, Kenneth, 2007, Ground-water quality in the southern Sierra study unit, 2006— Results from the California GAMA Program: U.S. Geological Survey Data Series 301, 78 p.

Fram, M.S., Munday, Cathy, and Belitz, Kenneth, 2009, Groundwater quality data for the Tahoe–Martis study unit, 2007: Results from the California GAMA Program: U.S. Geological Survey Data Series 432, 88 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 604 p.

Furlong, E.T., Werner, S.L., Anderson, B.D., and Cahill, J.D., 2008, Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of human-health pharmaceuticals in filtered water by chemically modified styrene-divinylbenzene resin-based solid-phase extraction and high-performance liquid chromatography/mass spectrometry: U.S. Geological Survey Techniques and Methods, book 5, chap. A9, 56 p.

Garbarino, J.R., 1999, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of dissolved arsenic, boron, lithium, selenium, strontium, thallium, and vanadium using inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 99-093, 31 p.

Garbarino, J.R., and Damrau, D.L., 2001, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of organic plus inorganic mercury in filtered and unfiltered natural water with cold vapor-atomic fluorescence spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01-4132, 16 p.

Garbarino, J.R., Kanagy, J.R., and Cree, M.E., 2006, Determination of elements in natural-water, biota, sediment, and soil samples using collision/reaction cell inductively coupled plasma-mass spectrometry: U.S. Geological Survey Techniques and Methods, book 5, chap. B1, 88 p.

Gilliom, R.J., Barbash, J.E., Crawford, C.G., Hamilton, P.A., Martin, J.D., Nakagaki, Naomi, Nowell, L.H., Scott, J.C., Stackelberg, P.E., Thelin, G.P., and Wolock, D.M., 2006, The quality of our Nation's waters: Pesticides in the Nation's streams and ground water, 1992–2001: U.S. Geological Survey Circular 1291, 172 p.

Goldrath, D.A., Wright, M.T., and Belitz, Kenneth, 2009, Ground-water quality data in the Coachella Valley study unit, 2007: Results from the California GAMA Program: U.S. Geological Survey Data-Series 373, 70 p.

Goldrath, D.A., Wright, M.T., and Belitz, Kenneth, 2010, Groundwater-quality data in the Colorado River study unit, 2007: Results from the California GAMA Program: U.S. Geological Survey Data-Series 474, 66 p.

Gran, G., 1952, Determination of the equivalence point in potentiometric titration. Part II: Analyst, v. 77, p. 661–671.

Grob, R.L, ed., 1995, Modern practice of gas chromatography (3rd ed.): New York, John Wiley & Sons, 888 p.

Hahn, G.J., and Meeker, W.Q., 1991, Statistical intervals: a guide for practitioners: New York, John Wiley & Sons, 392 p.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 263 p., 3 pls.

Hutson, S.S., Barber, N.L., Kenny, J.F., Linsey, K.S., Lumia, D.S., and Maupin, M.A., 2004, Estimated use of water in the United States in 2000: U.S. Geological Survey Circular 1268, 46 p.

Ingebritsen, S.E., and Sanford, W.E., 1998, Groundwater in geologic processes: Cambridge, England, Cambridge University Press, 341 p.

Jennings, C.W., 1977, Geologic map of California: California Department of Conservation, Division of Mines and Geology, Geologic Data Map No. 2, scale 1:750,000.

Jull, A.J.T., Burr, G.S., McHargue, L.R., Lange, T.E., Lifton, N.A., Beck, J.W., Donahue, D.J., and Lal, D., 2004, New frontiers in dating of geological, paleoclimatic, and anthropological applications using accelerator mass spectrometric measurements of ^{14}C and ^{10}Be in diverse samples: Global and Planetary Change, v. 41, p. 309–323.

Kent, R.H., and Belitz, Kenneth, 2009, Ground-water quality data in the Upper Santa Ana Watershed Study Unit, November 2006 to March 2007–Results from the California GAMA Program: U.S. Geological Survey Data-Series 404, 116 p.

Kolpin, D.W., Furlong, E.T., Meyer, M.T., Thurman, E.M., Zaugg, S.D., Barber, L.B., and Buxton, H.T., 2002, Pharmaceuticals, hormones and other organic wastewater contaminants in U.S. streams, 1999–2000: Environmental Science & Technology, v. 36, no. 6, p. 1202–1211.

Koterba, M.T., Wilde, F.D., and Lapham, W.W., 1995, Ground-water data-collection protocols and procedures for the National Water-Quality Assessment Program—Collection and documentation of water-quality samples and related data: U.S. Geological Survey Open-File Report 95-399, 113 p.

Krieger, H.L., and Whittaker, E.L., 1980, Prescribed procedures for measurement of radioactivity in drinking water: U.S. Environmental Protection Agency EPA-600-4-80-032, 142 p. Available as PB80-224744 from the National Technical Information Service at http://www.ntis.gov

Kulongoski, J.T., and Belitz, Kenneth, 2004, Groundwater ambient monitoring and assessment program: U.S. Geological Survey Fact Sheet 2004–3088, 2 p.

Kulongoski, J.T., Belitz, Kenneth, and Dawson, B.J., 2006, Ground-water quality data in the North San Francisco Bay hydrogeologic provinces, California, 2004: Results from the California Groundwater Ambient Monitoring and Assessment (GAMA) Program: U.S. Geological Survey Data Series 167, 100 p.

Kulongoski, J.T., and Belitz, Kenneth, 2007, Ground-water quality data in the Monterey Bay and Salinas Valley Basins, California, 2005—Results from the California GAMA Program: U.S. Geological Survey Data Series 258, 84 p.

Land, Michael, and Belitz, Kenneth, 2008, Ground-water quality data in the San Fernando–San Gabriel study unit, 2005—Results from the California GAMA Program: U.S. Geological Survey Data Series 356, 84 p.

Landon, M.K., and Belitz, Kenneth, 2008, Ground-water quality data in the Central Eastside San Joaquin Basin 2006: Results from the California GAMA Program: U.S. Geological Survey Data Series 325, 88 p.

Landon, M.K., Belitz, Kenneth, Jurgens, B.C., Kulongoski, J.T., and Johnson, T.D., 2010, Status and understanding of groundwater quality in the Central–Eastside San Joaquin Basin, 2006—California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2009–5266, 97 p.

Lane, S.L., Flanagan, Sarah, and Wilde, F.D., 2003, Selection of equipment for water sampling (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A2, accessed February 2008 at http://pubs.water.usgs.gov/twri9A2/

Lewis, M.E., 2006, Dissolved oxygen (ver. 2.1): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.2, accessed February 5, 2008, at http://pubs.water.usgs.gov/twri9A6.2/

Lindley, C.E., Stewart, J.T., and Sandstrom, M.W., 1996, Determination of low concentrations of acetochlor in water by automated solid-phase extraction and gas chromatography with mass selective detection: Journal of AOAC International, v. 79, no. 4, p. 962–966.

Madsen, J.E., Sandstrom, M.W., and Zaugg, S.D., 2003, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—A method supplement for the determination of fipronil and degradates in water by gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 02–462, 11 p.

Maloney, T.J., ed., 2005, Quality management system, U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 2005–1263, accessed February 5, 2008, at http://pubs.usgs.gov/of/2005/1263/pdf/OFR2005-1263.pdf

Mathany, T.M., Land, Michael, and Belitz, Kenneth, 2008, Ground-water quality data in the Coastal Los Angeles Basin study unit, 2006: Results from the California GAMA Program: U.S. Geological Survey Data Series 387, 98 p.

Mathany, T.M., Burton, C.A., Land, Michael, and Belitz, Kenneth, 2010, Groundwater-quality data in the South Coast Range–Coastal study unit, 2008: Results from the California GAMA program: U.S. Geological Survey Data Series 504, 105 p.

Mathany, T.M., Kulongoski, J.T., Ray, M.C., and Belitz, Kenneth, 2009, Groundwater-quality data in the South Coast Interior Basins study unit, 2008: Results from the California GAMA program: U.S. Geological Survey Data Series 463, 82 p.

Mathany, T.M., and Belitz, Kenneth, 2009, Groundwater quality data in the Mojave study unit, 2008: Results from the California GAMA Program: U.S. Geological Survey Data-Series 440, 80 p.

McCleskey, R.B., Nordstrom, D.K., and Ball, J.W., 2003, Metal interferences and their removal prior to the determination of As(T) and As(III) in acid mine waters by hydride generation atomic absorption spectrometry: U.S. Geological Survey Water-Resources Investigations Report 03–4117.

McCurdy, D.E., Garbarino, J.R., and Mullin, A.H., 2008, Interpreting and reporting radiological water-quality data: U.S. Geological Survey Techniques and Methods, book 5, chap. B6, 33 p.

McLain, B.J., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of chromium in water by graphite furnace atomic absorption spectrophotometry: U.S. Geological Survey Open-File Report 93-449, 16 p.

Montrella, Joseph, and Belitz, Kenneth, 2009, Groundwater quality data in the Santa Clara River Valley study unit, 2007: Results from the California GAMA Program: U.S. Geological Survey Data-Series 408, 84 p.

Moran, J.E., Hudson, G.B., Eaton, G.F., and Leif, R., 2002, A contamination vulnerability assessment for the Livermore–Amador and Niles Cone Groundwater Basins: UCRL-AR-148831, 25 p.

Mueller, D.K., and Titus, C.J., 2005, Quality of nutrient data from streams and ground water sampled during water years 1992–2001: U.S. Geological Survey Scientific Investigations Report 2005–5106, 27 p.

Olsen, L.D., Fram, M.S., and Belitz, Kenneth, 2010, Review of trace-element field-blank data collected for the California Groundwater Ambient Monitoring and Assessment (GAMA) Program, May 2004–January 2008: U.S. Geological Survey Scientific Investigations Report 2009–5220, 47 p.

Page, R.W., Anttila, P.W., Johnson, K.L., and Piercem, M.J., 1984, Ground-water conditions and well yields in fractured rocks, southwestern Nevada County, California: U.S. Geological Survey Water-Resources Investigations Report 83-4262, 38 p.

Patton, C.J., and Kryskalla, J.R., 2003, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Evaluation of alkaline persulfate digestion as an alternative to Kjeldahl digestion for determination of total and dissolved nitrogen and phosphorous in water: U.S. Geological Survey Water-Resources Investigations Report 03–4174, 33 p.

Pirkey, K.D., and Glodt, S.R., 1998, Quality control at the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Fact-Sheet 026-98, 4 p. Available at http://pubs.er.usgs.gov/usgspubs/fs/fs02698

Plomley, J.B., Koester, C.J., and March, R.E., 1994, Determination of NDMA in complex environmental matrices by quadrupole ion storage tandem mass spectrometry enhanced by unidirectional ion ejection: Analytical Chemistry, v. 66, no. 24, p. 4437–4443.

PRISM Group, Oregon State University, 2007, United States average annual precipitation, maximum and minimum temperature, 1971–2000: accessed August 9, 2007, at http://prism.oregonstate.edu/

Radtke, D.B., Davis, J.V., and Wilde, F.D., 2005, Specific electrical conductance (ver. 1.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.3, accessed February 5, 2008, at http://pubs.water.usgs.gov/twri9A6.3/

Raub, W., Brown, C.S., and Post, A., 2006, Inventory of glaciers in the Sierra Nevada, California: U.S. Geological Survey Open-File Report 2006–1239, 232 p.

Ray, M.C., Kulongoski, J.T., Belitz, Kenneth, 2009, Ground-water quality data in the San Francisco Bay study unit, 2007: Results from the California GAMA program: U.S. Geological Survey Data Series 396, 93 p.

Rounds, S.A., 2006, Alkalinity and acid neutralizing capacity (ver. 3): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.6, accessed February 5, 2008, at http://pubs.water.usgs.gov/twri9A6.6/

Sandstrom, M.W., Stroppel, M.E., Foreman, W.T., and Schroeder, M.P., 2001, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of moderate-use pesticides and selected degradates in water by C-18 solid-phase extraction and gas chromatography/mass spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01–4098, 70 p.

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 (ver. 2.0): California Department of Conservation, Division of Mines and Geology, CD 2000–07.

Schmitt, S.J., Fram, M.S., Milby Dawson, B.J., Belitz, Kenneth, 2008, Ground-water quality data in the middle Sacramento Valley study unit, 2006—Results from the California GAMA program: U.S. Geological Survey Data Series 385, 100 p.

Schmitt, S.J., Fram, M.S., Milby Dawson, B.J., Belitz, Kenneth, 2009, Ground-water quality data in the Antelope Valley study unit, 2008—Results from the California GAMA program: U.S. Geological Survey Data Series 479, 80 p.

Scott, J.C., 1990, Computerized stratified random site selection approaches for design of a ground-water quality sampling network: U.S. Geological Survey Water-Resources Investigations Report 90-4101, 109 p.

Shelton, J.L., Burow, K.R., Belitz, Kenneth, Dubrovsky, N.M., Land, M.T., and Gronberg, J.M., 2001, Low-level volatile organic compounds in active public supply wells as ground-water tracers in the Los Angeles physiographic basin, California, 2000: U.S. Geological Survey Water-Resources Investigations Report 01-4188. 29 p.

Shelton, J.L., Pimentel, Isabel, Fram, M.S., and Belitz, Kenneth, 2008, Ground-water quality data for the Kern County Subbasin study unit, 2006 – Results from the California GAMA Program: U.S. Geological Survey Data Series 337, 75 p.

Shelton, J.L., Fram, M.S., and Belitz, Kenneth, 2009, Ground-water quality data for the Madera-Chowchilla study unit, 2008 – Results from the California GAMA Program: U.S. Geological Survey Data Series 455, 80 p.

Soddy, F., 1913, Radioactivity: Annual reports on the progress of chemistry, v. 10, p. 262–288.

State Water Resources Control Board, 2003, Report to the Governor and Legislature, A comprehensive groundwater quality monitoring program for California: Assembly Bill 599 March 2003, 100 p. http://www.waterboards.ca.gov/gama/docs/final_ab_599_rpt_to_legis_7_31_03.pdf

Stookey, L.L., 1970, FerroZine—A new spectrophotometric reagent for iron: Analytical Chemistry, v. 42, p. 779–781.

Stumm, W. and Morgan, J.J., 1996, Aquatic chemistry: Chemical equilibria and rates in natural waters (3rd ed.): New York, John Wiley & Sons, 1022 p.

Thatcher, L.L., Janzer, V.J., and Edwards, K.W., 1977, Methods for the determination of radioactive substances in water: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A5, 95 p.

Timme, P.J., 1995, National Water Quality Laboratory 1995 services catalog: U.S. Geological Survey Open-File Report 95-352, 120 p.

To, T.B., Nordstrom, D.K., Cunningham, K.M., Ball, J.W., and McCleskey, R.B., 1998, New method for the direct determination of dissolved Fe(III) concentration in acid mine waters: Environmental Science and Technology, v. 33, p. 807–813.

U.S. Environmental Protection Agency, 1989, Semivolatile organic compounds by isotope dilution GSMS: U.S. Environmental Protection Agency, 68 p.

U.S. Environmental Protection Agency, 2002, Guidelines for establishing procedures for the analysis of pollutants: U.S. Code of Federal Regulations, Title 40, 136 p.

U.S. Environmental Protection Agency, 2005, Method 331.0—Determination of perchlorate in drinking water by liquid chromatography electrospray ionization mass spectrometry (rev. 1.0,): Office of Ground Water and Drinking Water, EPA Document # 815-R-05-007, 34 p., accessed February 5, 2008, at http://www.epa.gov/safewater/methods/pdfs/methods/met331_0.pdf

U.S. Environmental Protection Agency, 2008a, Drinking water contaminants, accessed February 5, 2008, at http://www.epa.gov/safewater/contaminants/index.html

U.S. Environmental Protection Agency, 2008b, Water quality criteria, Drinking water health advisories, 2006 drinking water standards and health advisory tables, accessed February 5, 2008, at http://www.epa.gov/waterscience/criteria/drinking/

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: Techniques of Water-Resources Investigations, book 9, chap. A1–A9, accessed February 5, 2008, at http://water.usgs.gov/owq/FieldManual/

Wakabayashi, J., and Sawyer, T.L., 2001, Stream incision, tectonics, uplift, and evolution of topography of the Sierra Nevada, California: The Journal of Geology, v. 109, p. 539–562.

Weiss, R.F., 1968, Piggyback sampler for dissolved gas studies on sealed water samples: Deep Sea Research, v. 15, p. 721–735.

Western Regional Climate Center, 2009, Western Regional Climate Center, Summary climate data for California, average monthly precipitation data, accessed July 23, 2009, at http://www.wrcc.dri.edu/summary/Climsmcca.html

Wilde, F.D., 2006, Temperature (ver. 2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.1, accessed February 2008 at http://pubs.water.usgs.gov/twri9A6.1/

Wilde, F.D., ed., 2004, Cleaning of equipment for water sampling (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, accessed February 5, 2008, at http://pubs.water.usgs.gov/twri9A3/

Wilde, F.D., Busenberg, E., and Radtke, D.B., 2006, pH (ver. 1.3): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.4, accessed February 5, 2008, at http://pubs.water.usgs.gov/twri9A6.4/

Wilde, F.D., and Radtke, D.B., 2005, Guidelines for field-measured water-quality properties (ver. 1.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.0, accessed February 5, 2008, at http://pubs.water.usgs.gov/twri9A6.0/

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1999, Collection of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, accessed February 5, 2008, at http://pubs.water.usgs.gov/twri9A4/

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 2004, Processing of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5, accessed February 5, 2008, at http://pubs.water.usgs.gov/twri9A5/

Wright, M.T., Belitz, Kenneth, and Burton, C.A., 2005, California GAMA program: Ground-water quality data in the San Diego drainages hydrogeologic province, California, 2004: U.S. Geological Survey Data Series 129, 91 p.

Zaugg, S.D., Sandstrom, M.W., Smith, S.G., and Fehlberg, K.M., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of pesticides in water by C-18 solid-phase extraction and capillary-column gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 95-181, 60 p.

Zogorski, J.S., Carter, J.M., Ivahnenko, T., Lapham, W.W., Moran, M.J., Rowe, B.L., Squillace, P.J., and Toccalino, P.L., 2006, Volatile organic compounds in the Nation's ground water and drinking-water supply wells: U.S. Geological Survey Circular 1292, 101 p.

Tables

Table 1. Identification, sampling, and construction information for wells sampled for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[**GAMA identification number:** SIERRA, Sierra Nevada study unit; SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. **Other abbreviations:** ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

Sampling information					Construction information		
GAMA identification number	Date (mm/dd/yy)	Sampling schedule [1]	Elevation of LSD (ft above NAVD 88) [2]	Well type	Well depth (ft below LSD)	Top of opening (ft below LSD)	Bottom of opening (ft below LSD)
Primary grid wells							
SIERRA-G-01	06/23/08	Slow	3,248	Production	600	300	600
SIERRA-G-02	07/08/08	Slow	5,964	Spring	na	na	na
SIERRA-G-03	07/09/08	Slow	2,985	Production	300	30	[3] 300
SIERRA-G-04	07/10/08	Intermediate	7,600	Spring	na	na	na
SIERRA-G-05	07/15/08	Slow	823	Production	120	120	120
SIERRA-G-06	07/21/08	Slow	3,105	Production	900	100	900
SIERRA-G-07	07/22/08	Slow	3,401	Production	700	52	700
SIERRA-G-08	07/23/08	Slow	5,606	Production	120	57	120
SIERRA-G-09	07/24/08	Slow	7,460	Spring	na	na	na
SIERRA-G-10	07/28/08	Slow	6,248	Production	105	105	105
SIERRA-G-11	07/29/08	Intermediate	3,777	Production	650	na	na
SIERRA-G-12	08/14/08	Slow	3,870	Production	675	[3] 57	[3] 675
SIERRA-G-13	08/21/08	Slow	2,763	Production	400	60	400
SIERRA-G-14	08/26/08	Slow	6,755	Production	400	50	400
SIERRA-G-15	09/08/08	Slow	200	Production	480	60	480
SIERRA-G-16	09/22/08	Slow	8,596	Spring	na	na	na
SIERRA-G-17	09/23/08	Slow	9,800	Spring	na	na	na
SIERRA-G-18	09/24/08	Slow	10,110	Spring	na	na	na
SIERRA-M-01	07/30/08	Slow	1,521	Production	[3] 400	na	na
SIERRA-M-02	08/06/08	Slow	1,103	Production	[3] >440	na	na
SIERRA-M-03	09/10/08	Slow [4]	3,903	Spring	na	na	na
SIERRA-M-04	09/17/08	Slow	6,424	Spring	na	na	na
SIERRA-M-05	10/08/08	Slow	3,075	Production	na	na	na
SIERRA-M-06	10/08/08	Slow	3,361	Production	190	150	190
SIERRA-S-01	06/25/08	Slow	2,653	Production	120	78	120
SIERRA-S-02	08/19/08	Slow	6,304	Production	600	130	310
SIERRA-S-03	10/20/08	Slow	4,845	Production	520	110	520
SIERRA-V-01	08/27/08	Slow	6,758	Spring	na	na	na
SIERRA-V-02	10/07/08	Slow	2,364	Production	702	280	702
SIERRA-V-03	10/21/08	Slow	7,654	Production	220	60	220

Table 1. Identification, sampling, and construction information for wells sampled for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[**GAMA identification number:** SIERRA, Sierra Nevada study unit; SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. **Other abbreviations:** ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

Sampling information					Construction information		
GAMA identification number	Date (mm/dd/yy)	Sampling schedule [1]	Elevation of LSD (ft above NAVD 88) [2]	Well type	Well depth (ft below LSD)	Top of opening (ft below LSD)	Bottom of opening (ft below LSD)
Lithologic grid wells							
SIERRA-GL-01	06/26/08	Intermediate	3,646	Production	285	160	280
SIERRA-GL-02	07/30/08	Intermediate	2,079	Production	400	52	400
SIERRA-GL-03	08/12/08	Intermediate	10,280	Spring	na	na	na
SIERRA-GL-04	08/20/08	Intermediate	6,584	Spring	na	na	na
SIERRA-GL-05	08/25/08	Intermediate	5,637	Production	150	50	150
SIERRA-GL-06	09/16/08	Intermediate	6,019	Spring	na	na	na
SIERRA-GL-07	09/18/08	Intermediate	1,687	Production	100	65	100
SIERRA-GL-08	10/06/08	Intermediate	5,267	Production	100	na	na
SIERRA-GL-09	10/07/08	Intermediate	2,320	Production	205	50	205
SIERRA-GL-10	10/21/08	Intermediate	5,647	Production	610	470	610
SIERRA-ML-01	06/24/08	Intermediate	3,848	Production	135	70	130
SIERRA-ML-02	06/25/08	Intermediate	2,967	Production	165	140	165
SIERRA-ML-03	07/08/08	Intermediate	3,522	Production	190	50	190
SIERRA-ML-04	07/09/08	Intermediate	3,554	Production	na	na	na
SIERRA-ML-05	07/14/08	Intermediate	4,203	Production	300	[3] 60	300
SIERRA-ML-06	07/15/08	Intermediate	962	Production	75	30	75
SIERRA-ML-07	07/16/08	Intermediate	4,813	Production	300	na	na
SIERRA-ML-08	07/21/08	Intermediate	872	Production	[3] 122	na	na
SIERRA-ML-09	07/22/08	Intermediate	3,699	Production	250	124	250
SIERRA-ML-10	08/05/08	Intermediate	1,546	Production	275	na	na
SIERRA-ML-11	08/07/08	Intermediate	8,120	Spring	na	na	na
SIERRA-ML-12	08/13/08	Intermediate	3,094	Production	360	100	360
SIERRA-ML-13	08/18/08	Intermediate	2,080	Production	1,000	60	890
SIERRA-ML-14	08/25/08	Intermediate	6,780	Spring	na	na	na
SIERRA-ML-15	09/09/08	Intermediate	3,443	Production	[3] 171	na	na
SIERRA-ML-16	09/25/08	Intermediate	8,309	Production	70	na	na
SIERRA-ML-17	10/15/08	Intermediate	1,343	Production	245	100	245
SIERRA-ML-18	10/22/08	Intermediate	1,920	Production	225	55	225
SIERRA-SL-01	06/24/08	Intermediate	4,183	Production	400	200	400
SIERRA-SL-02	07/07/08	Intermediate	2,643	Production	55	10	55
SIERRA-SL-03	07/16/08	Intermediate	783	Production	155	20	155
SIERRA-SL-04	07/17/08	Intermediate	563	Production	360	na	na
SIERRA-SL-05	07/28/08	Intermediate	5,920	Spring	na	na	na

Table 1. Identification, sampling, and construction information for wells sampled for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[**GAMA identification number:** SIERRA, Sierra Nevada study unit; SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. **Other abbreviations:** ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

Sampling information					Construction information		
GAMA identification number	Date (mm/dd/yy)	Sampling schedule [1]	Elevation of LSD (ft above NAVD 88) [2]	Well type	Well depth (ft below LSD)	Top of opening (ft below LSD)	Bottom of opening (ft below LSD)
SIERRA-SL-06	08/04/08	Intermediate	5,633	Production	490	260	490
SIERRA-SL-07	08/13/08	Intermediate	3,944	Production	800	360	780
SIERRA-SL-08	09/10/08	Intermediate	3,550	Production	200	110	196
SIERRA-SL-09	09/16/08	Intermediate	5,174	Spring	na	na	na
SIERRA-SL-10	09/22/08	Intermediate	9,918	Production	163	na	na
SIERRA-SL-11	09/23/08	Intermediate	5,212	Production	300	50	280
SIERRA-SL-12	10/06/08	Intermediate	505	Production	77	77	77
SIERRA-SL-13	10/16/08	Intermediate	7,980	Spring	na	na	na
SIERRA-VL-01	07/07/08	Intermediate	2,801	Production	93	na	na
SIERRA-VL-02	07/31/08	Intermediate	5,570	Production	580	na	na
SIERRA-VL-03	08/04/08	Intermediate	5,677	Production	280	131	280
SIERRA-VL-04	08/14/08	Intermediate	3,072	Production	307	57	307
SIERRA-VL-05	08/18/08	Intermediate	3,591	Production	500	445	500
SIERRA-VL-06	08/27/08	Intermediate	5,596	Production	383	363	383
SIERRA-VL-07	08/28/08	Intermediate	5,391	Production	380	51	380
SIERRA-VL-08	09/11/08	Intermediate	4,551	Spring	na	na	na
SIERRA-VL-09	09/15/08	Intermediate	5,340	Spring	na	na	na
SIERRA-VL-10	10/09/08	Intermediate	4,564	Spring	na	na	na
SIERRA-VL-11	10/15/08	Intermediate	4,015	Production	400	50	400
SIERRA-VL-12	10/22/08	Intermediate	3,991	Production	930	235	930
Comparison site							
SIERRA-XL-01	09/25/08	Intermediate [5]	7,218	Spring	na	na	na

[1] Sampling schedules are described in table 2.

[2] Land-surface datum (LSD) is a datum plane that is approximately at land surface at each well. The elevation of the LSD is described in feet above the North American Vertical Datum 1988.

[3] Construction information estimated from a variety of well records.

[4] Changes in pump speed during sampling may have caused samples to be more aerated than what is typical.

[5] Sampling schedule modified, see table 2.

Table 2. Classes of chemical constituents and field water-quality indicators collected for the slow and intermediate well sampling schedules in the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[X, constituent class collected; —, constituent class not collected or no table provided]

Constituent classes	Slow schedule [1]	Intermediate schedule [2]	Analyte list table	Results table
Field water-quality indicators				
Dissolved oxygen, temperature, specific conductance	X	X	—	4
pH, alkalinity	X	X	—	4
Organic constituents				
Volatile organic compounds (VOC)	X	X	3A	5
Pesticides and pesticide degradates	X	X	3B	6
Pharmaceutical compounds	X	—	3C	— [3]
Constituents of special interest				
Perchlorate	X	X	3D	7
N-Nitrosodimethylamine (NDMA)	X	—	3D	7
Inorganic constituents				
Nutrients	X	X	3E	8
Major and minor ions and trace elements	X	X	3F	9, 10
Arsenic and iron species	X	X	3G	11
Isotope tracers				
Stable isotopes of hydrogen and oxygen of water	X	X	3H	12
Stable isotopes of carbon and carbon-14 activity	X	X	3H	12
Strontium isotopes	X	X	3H	— [3]
Tritium activity	X	X	3H	12
Radioactivity and noble gases				
Uranium isotope activities	X	X	3H	13A
Radon-222	X	—	3H	13A
Gross alpha and gross beta particle activities	X	X	3H	13B
Radium isotope activities	X	—	3H	13C
Tritium activity and noble gases	X	X	3I	— [3]

[1] The slow schedule was collected from 28 primary grid wells.

[2] The intermediate schedule was collected from 2 primary grid wells, 53 lithologic grid wells, and 1 comparison site. The schedule for the comparison site was modified and consisted of field water-quality indicators, inorganic constituents, isotope tracers, and tritium.

[3] Results will be published in a subsequent publication.

Table 3A. Volatile organic compounds (VOC), primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2020.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number [1]	LRL (µg/L)	Benchmark type [2]	Benchmark level (µg/L)	Detection
Acetone	Solvent	81552	67-64-1	4.0	na	na	—
Acrylonitrile	Organic synthesis	34215	107-13-1	0.40	RSD5-US	0.6	—
tert-Amyl methyl ether (TAME)	Gasoline oxygenate	50005	994-05-8	0.06	na	na	—
Benzene	Gasoline hydrocarbon	34030	71-43-2	0.016	MCL-CA	1	—
Bromobenzene	Solvent	81555	108-86-1	0.02	na	na	—
Bromochloromethane	Fire retardant	77297	74-97-5	0.06	HAL-US	90	—
Bromodichloromethane	Disinfection byproduct (THM)	32101	75-27-4	0.04	MCL-US	[3] 80	—
Bromoform (Tribromomethane)	Disinfection byproduct (THM)	32104	75-25-2	[4] 0.08, 0.10	MCL-US	[3] 80	—
Bromomethane (Methyl bromide)	Fumigant	34413	74-83-9	0.40	HAL-US	10	—
n-Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	[4] 0.14, 0.08	NL-CA	260	—
sec-Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	[4] 0.04, 0.02	NL-CA	260	—
tert-Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	0.06	NL-CA	260	—
Carbon disulfide	Natural	77041	75-15-0	[4] 0.06, 0.04	NL-CA	160	D
Carbon tetrachloride (Tetrachloromethane)	Solvent	32102	56-23-5	[4] 0.08, 0.06	MCL-CA	0.5	—
Chlorobenzene	Solvent	34301	108-90-7	0.02	MCL-CA	70	—
Chloroethane	Solvent	34311	75-00-3	0.10	na	na	—
Chloroform (Trichloromethane)	Disinfection byproduct (THM)	32106	67-66-3	[4] 0.02, 0.04	MCL-US	[3] 80	D
Chloromethane	Refrigerant	34418	74-87-3	[4] 0.10, 0.14	HAL-US	30	—
3-Chloropropene	Organic synthesis	78109	107-05-1	0.08	na	na	—
2-Chlorotoluene	Solvent	77275	95-49-8	[4] 0.04, 0.02	NL-CA	140	—
4-Chlorotoluene	Solvent	77277	106-43-4	[4] 0.04, 0.02	NL-CA	140	—
Dibromochloromethane	Disinfection byproduct (THM)	32105	124-48-1	0.12	MCL-US	[3] 80	—
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	[4] 0.5, 1.0	MCL-US	0.2	—
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.04	MCL-US	0.05	—
Dibromomethane	Solvent	30217	74-95-3	0.04	na	na	—
1,2-Dichlorobenzene	Solvent	34536	95-50-1	0.02	MCL-US	600	—
1,3-Dichlorobenzene	Solvent	34566	541-73-1	[4] 0.04, 0.02	HAL-US	600	—
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	0.02	MCL-CA	5	D

Table 3A. Volatile organic compounds, primary uses or sources, comparative benchmarks, and reporting information for the USGS National Water Quality Laboratory Schedule 2020—Continued.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number [1]	LRL (µg/L)	Benchmark type [2]	Benchmark level (µg/L)	Detection
trans-1,4-Dichloro-2-butene	Organic synthesis	73547	110-57-6	[4] 0.60, 0.40	na	na	—
Dichlorodifluoromethane (CFC-12)	Refrigerant	34668	75-71-8	[4] 0.14, 0.10	NL-CA	1,000	—
1,1-Dichloroethane (1,1-DCA)	Solvent	34496	75-34-3	0.04	MCL-CA	5	D
1,2-Dichloroethane (1,2-DCA)	Solvent	32103	107-06-2	0.06	MCL-CA	0.5	D
1,1-Dichloroethene (1,1-DCE)	Organic synthesis	34501	75-35-4	0.02	MCL-CA	6	D
cis-1,2-Dichloroethene	Solvent	77093	156-59-2	0.02	MCL-CA	6	D
trans-1,2-Dichloroethene	Solvent	34546	156-60-5	0.018	MCL-CA	10	—
1,2-Dichloropropane	Fumigant	34541	78-87-5	0.02	MCL-US	5	—
1,3-Dichloropropane	Fumigant	77173	142-28-9	0.06	na	na	—
2,2-Dichloropropane	Fumigant	77170	594-20-7	0.06	na	na	—
1,1-Dichloropropene	Organic synthesis	77168	563-58-6	0.04	na	na	—
cis-1,3-Dichloropropene	Fumigant	34704	10061-01-5	0.10	RSD5-US	[5] 4	—
trans-1,3-Dichloropropene	Fumigant	34699	10061-02-6	0.10	RSD5-US	[5] 4	—
Diethyl ether	Solvent	81576	60-29-7	0.12	na	na	—
Diisopropyl ether (DIPE)	Gasoline oxygenate	81577	108-20-3	0.06	na	na	—
Ethylbenzene	Gasoline hydrocarbon	34371	100-41-4	0.04	MCL-CA	300	—
Ethyl tert-butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.04	na	na	—
Ethyl methacrylate	Organic synthesis	73570	97-63-2	0.14	na	na	—
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	Gasoline hydrocarbon	77220	611-14-3	[4] 0.04, 0.02	na	na	—
Hexachlorobutadiene	Organic synthesis	39702	87-68-3	0.06	RSD5-US	9	—
Hexachloroethane	Solvent	34396	67-72-1	0.14	HAL-US	1	—
2-Hexanone (*n*-Butyl methyl ketone)	Solvent	77103	591-78-6	0.60	na	na	—
Iodomethane (Methyl iodide)	Organic synthesis	77424	74-88-4	[4] 0.4, 0.8	na	na	—
Isopropylbenzene	Gasoline hydrocarbon	77223	98-82-8	0.04	NL-CA	770	—
4-Isopropyl-1-methyl benzene	Gasoline hydrocarbon	77356	99-87-6	[4] 0.08, 0.06	na	na	—

Table 3A. Volatile organic compounds, primary uses or sources, comparative benchmarks, and reporting information for the USGS National Water Quality Laboratory Schedule 2020—Continued.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number [1]	LRL (µg/L)	Benchmark type [2]	Benchmark level (µg/L)	Detection
Methyl acrylate	Organic synthesis	49991	96-33-3	0.60	na	na	—
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	0.20	na	na	—
Methyl *tert*-butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.10	MCL-CA	13	D
Methyl *iso*-butyl ketone (MIBK)	Solvent	78133	108-10-1	0.40	NL-CA	120	—
Methylene chloride (Dichloromethane)	Solvent	34423	75-09-2	0.04	MCL-US	5	—
Methyl ethyl ketone (2-butanone, MEK)	Solvent	81595	78-93-3	1.6	HAL-US	4,000	—
Methyl methacrylate	Organic synthesis	81597	80-62-6	0.20	na	na	—
Naphthalene	Gasoline hydrocarbon	34696	91-20-3	0.20	NL-CA	17	—
Perchloroethene (Tetrachloroethene, PCE)	Solvent	34475	127-18-4	0.04	MCL-US	5	D
n-Propylbenzene	Solvent	77224	103-65-1	0.04	NL-CA	260	—
Styrene	Gasoline hydrocarbon	77128	100-42-5	0.04	MCL-US	100	—
1,1,1,2-Tetrachloroethane	Solvent	77562	630-20-6	0.04	HAL-US	70	—
1,1,2,2-Tetrachloroethane	Solvent	34516	79-34-5	0.10	MCL-CA	1	—
Tetrahydrofuran	Solvent	81607	109-99-9	1.4	na	na	—
1,2,3,4-Tetramethylbenzene	Gasoline hydrocarbon	49999	488-23-3	[4] 0.14, 0.08	na	na	—
1,2,3,5-Tetramethylbenzene	Gasoline hydrocarbon	50000	527-53-7	[4] 0.12, 0.08	na	na	—
Toluene	Gasoline hydrocarbon	34010	108-88-3	[6] 0.44	MCL-CA	150	— [6]
1,2,3-Trichlorobenzene	Organic synthesis	77613	87-61-6	[4] 0.08, 0.06	na	na	—
1,2,4-Trichlorobenzene	Solvent	34551	120-82-1	[4] 0.08, 0.04	MCL-CA	5	—
1,1,1-Trichloroethane (1,1,1-TCA)	Solvent	34506	71-55-6	0.02	MCL-US	200	D
1,1,2-Trichloroethane (1,1,2-TCA)	Solvent	34511	79-00-5	0.06	MCL-US	5	—
Trichloroethene (TCE)	Solvent	39180	79-01-6	0.02	MCL-US	5	D
Trichlorofluoromethane (CFC-11)	Refrigerant	34488	75-69-4	0.08	MCL-CA	150	D
1,2,3-Trichloropropane (1,2,3-TCP)	Solvent/organic synthesis	77443	96-18-4	0.12	HAL-US	40	—
Trichlorotrifluoroethane (CFC-113)	Refrigerant	77652	76-13-1	0.04	MCL-CA	1,200	—

Table 3A. Volatile organic compounds, primary uses or sources, comparative benchmarks, and reporting information for the USGS National Water Quality Laboratory Schedule 2020—Continued.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number [1]	LRL (µg/L)	Benchmark type [2]	Benchmark level (µg/L)	Detection
1,2,3-Trimethylbenzene	Gasoline hydrocarbon	77221	526-73-8	0.08	na	na	—
1,2,4-Trimethylbenzene	Gasoline hydrocarbon	77222	95-63-6	[6] 0.34	NL-CA	330	— [6]
1,3,5-Trimethylbenzene	Organic synthesis	77226	108-67-8	0.04	NL-CA	330	—
Vinyl bromide (Bromoethene)	Fire retardant	50002	593-60-2	0.12	na	na	—
Vinyl chloride (Chloroethene)	Organic synthesis	39175	75-01-4	0.08	MCL-CA	0.5	—
m- and *p*-Xylene	Gasoline hydrocarbon	85795	108-38-3/ 106-42-3	0.08	MCL-CA	[7] 1,750	—
o-Xylene	Gasoline hydrocarbon	77135	95-47-6	0.04	MCL-CA	[7] 1,750	—

[1] This report contains CAS Registry Numbers®, which is a Registered Trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client Services[SM].

[2] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[3] The MCL-US benchmark for trihalomethanes is the sum of the concentrations of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

[4] LRL for samples collected before 10/01/08, LRL for samples collected 10/01/08 and thereafter.

[5] The RSD5 benchmark for 1,3-dichloropropene is the sum of the concentrations of its isomers (*cis* and *trans*).

[6] Study reporting limits (SRL) were defined for toluene and 1,2,4-trimethylbenzene on the basis of detections in field blanks collected for previous GAMA study units. All concentrations of these two constituents were less than or equal to the SRLs; therefore, these constituents are not considered detected in this study unit.

[7] The MCL-CA benchmark for *m*- and *p*-Xylene, and *o*-Xylene is the sum all three xylene compounds.

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2003.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Benchmark type [1]	Benchmark level (µg/L)	Detection
Acetochlor	Herbicide	49260	34256-82-1	[2] 0.006, 0.01	na	na	—
Alachlor	Herbicide	46342	15972-60-8	[2] 0.006, 0.008	MCL-US	2	—
Atrazine	Herbicide	39632	1912-24-9	0.007	MCL-CA	1	D
Azinphos-methyl	Insecticide	82686	86-50-0	0.12	na	na	—
Azinphos-methyl-oxon	Insecticide degradate	61635	961-22-8	0.042	na	na	—
Benfluralin	Herbicide	82673	1861-40-1	[2] 0.01, 0.014	na	na	— [3]
Carbaryl	Insecticide	82680	63-25-2	[2] 0.06, 0.2	RSD5-US	400	—
2-Chloro-2,6-diethylacetanilide	Herbicide degradate	61618	6967-29-9	0.01	na	na	—
4-Chloro-2-methylphenol	Herbicide degradate	61633	1570-64-5	0.005	na	na	— [3]
Chlorpyrifos	Insecticide	38933	2921-88-2	[2] 0.005, 0.01	HAL-US	2	—
Chlorpyrifos oxon	Insecticide degradate	61636	5598-15-2	[2] 0.0562, 0.05	na	na	— [3]
Cyfluthrin	Insecticide	61585	68359-37-5	0.016	na	na	— [3]
Cypermethrin	Insecticide	61586	52315-07-8	[2] 0.014, 0.02	na	na	— [3]
Dacthal (DCPA)	Herbicide	82682	1861-32-1	[2] 0.003, 0.006	HAL-US	70	—
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine)	Herbicide degradate	04040	6190-65-4	0.014	na	na	D [3]
Desulfinylfipronil	Insecticide degradate	62170	na	0.012	na	na	D
Desulfinylfipronil amide	Insecticide degradate	62169	na	0.029	na	na	—
Diazinon	Insecticide	39572	333-41-5	0.005	HAL-US	1	—
3,4-Dichloroaniline	Herbicide degradate	61625	95-76-1	[2] 0.006, 0.004	na	na	D
Dichlorvos	Insecticide	38775	62-73-7	[2] 0.013, 0.02	na	na	— [3]
Dicrotophos	Insecticide	38454	141-66-2	[2] 0.0843, 0.08	na	na	— [3]
Dieldrin	Insecticide	39381	60-57-1	0.009	RSD5-US	0.02	—
2,6-Diethylaniline	Herbicide degradate	82660	579-66-8	0.006	na	na	—
Dimethoate	Insecticide	82662	60-51-5	0.006	na	na	— [3]
Ethion	Insecticide	82346	563-12-2	[2] 0.006, 0.012	na	na	—
Ethion monoxon	Insecticide degradate	61644	17356-42-2	0.021	na	na	— [3]
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	0.01	na	na	—
Fenamiphos	Insecticide	61591	22224-92-6	0.029	HAL-US	0.7	—
Fenamiphos sulfone	Insecticide degradate	61645	31972-44-8	0.053	na	na	—
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	[2] 0.20, 0.08	na	na	— [3]
Fipronil	Insecticide	62166	120068-37-3	[2] 0.02, 0.04	na	na	D
Fipronil sulfide	Insecticide degradate	62167	120067-83-6	0.013	na	na	—
Fipronil sulfone	Insecticide degradate	62168	120068-36-2	0.024	na	na	D
Fonofos	Insecticide	04095	944-22-9	0.01	HAL-US	10	—
Hexazinone	Herbicide	04025	51235-04-2	0.008	HAL-US	400	D [3]

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2003.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Benchmark type [1]	Benchmark level (µg/L)	Detection
Iprodione	Fungicide	61593	36734-19-7	[2] 0.01, 0.014	na	na	—
Isofenphos	Insecticide	61594	25311-71-1	0.006	na	na	—
Malaoxon	Insecticide degradate	61652	1634-78-2	[2] 0.02, 0.08	na	na	—
Malathion	Insecticide	39532	121-75-5	[2] 0.016, 0.02	HAL-US	100	—
Metalaxyl	Fungicide	61596	57837-19-1	0.0069	na	na	—
Methidathion	Insecticide	61598	950-37-8	[2] 0.004, 0.006	na	na	—
Metolachlor	Herbicide	39415	51218-45-2	[2] 0.01, 0.014	HAL-US	700	—
Metribuzin	Herbicide	82630	21087-64-9	[2.] 0.012, 0.016	HAL-US	70	—
Myclobutanil	Fungicide	61599	88671-89-0	0.01	na	na	—
1-Naphthol	Insecticide degradate	49295	90-15-3	0.04	na	na	— [3]
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	0.01	na	na	— [3]
Parathion-methyl	Insecticide	82667	298-00-0	0.008	HAL-US	1	—
Pendimethalin	Herbicide	82683	40487-42-1	0.012	na	na	—
cis-Permethrin	Insecticide	82687	54774-45-7	[2] 0.01, 0.014	na	na	— [3]
Phorate	Insecticide	82664	298-02-2	[2] 0.04, 0.02	na	na	— [3]
Phorate oxon	Insecticide degradate	61666	2600-69-3	0.027	na	na	—
Phosmet	Insecticide	61601	732-11-6	[2] 0.0079, 0.20	na	na	— [3]
Phosmet oxon	Insecticide degradate	61668	3735-33-9	0.0511	na	na	— [3]
Prometon	Herbicide	04037	1610-18-0	0.01	HAL-US	100	—
Prometryn	Herbicide	04036	7287-19-6	0.0059	na	na	—
Pronamide (Propyzamide)	Herbicide	82676	23950-58-5	0.004	RSD5-US	20	—
Simazine	Herbicide	04035	122-34-9	[2] 0.006, 0.01	MCL-US	4	D
Tebuthiuron	Herbicide	82670	34014-18-1	[2] 0.016, 0.02	HAL-US	500	—
Terbufos	Insecticide	82675	13071-79-9	0.018	HAL-US	0.4	—
Terbufos oxon sulfone	Insecticide degradate	61674	56070-15-6	0.045	na	na	—
Terbuthylazine	Herbicide	04022	5915-41-3	[2] 0.0083, 0.006	na	na	—
Tribufos	Defoliant	61610	78-48-8	0.035	na	na	— [3]
Trifluralin	Herbicide	82661	1582-09-8	[2] 0.009, 0.012	HAL-US	10	— [3]

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] LRL for samples collected before 10/01/08, LRL for samples collected 10/01/08 and thereafter.

[3] The median matrix-spike recovery was less than 70 percent. Low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations.

Table 3C. Pharmaceutical compounds, primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2080.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Abbreviations:** CAS, Chemical Abstract Service; SRL, study reporting level; na, not available; µg/L, micrograms per liter]

Constituent	Primary use or source	USGS parameter code	CAS number	SRL [1] (µg/L)	Benchmark type	Benchmark level (µg/L)
Acetaminophen	Analgesic	62000	103-90-2	0.06	na	na
Albuterol	Bronchodilator	62020	18559-94-9	0.04	na	na
Caffeine	Stimulant	50305	58-08-2	0.11	na	na
Carbamazepine	Anticonvulsant; mood stabilizer	62793	298-46-4	0.03	na	na
Codeine	Opioid narcotic	62003	76-57-3	0.02	na	na
Cotinine	Nicotine metabolite	62005	486-56-6	0.02	na	na
Dehydronifedipine	Antianginal metabolite	62004	67035-22-7	0.04	na	na
Diltiazem	Antianginal; antihypertensive	62008	42399-41-7	0.04	na	na
1,7-Dimethylxanthine	Caffeine metabolite	62030	611-59-6	0.06	na	na
Sulfamethoxazole	Antibiotic	62021	723-46-6	0.08	na	na
Thiabendazole	Antihelminthic	62801	148-79-8	0.03	na	na
Trimethoprim	Antibiotic	62023	738-70-5	0.02	na	na
Warfarin	Anticoagulant	62024	81-81-2	0.05	na	na

[1]The California Groundwater Ambient Monitoring and Assessment (GAMA) program uses more-conservative reporting limits for the pharmaceutical compounds than are used by the USGS National Water Information System database (NWIS). For acetaminophen, albuterol, carbamazepine, codeine, cotinine, dehydronifedipine, diltiazem, 1,7-dimethylxanthine, sulfamethoxazole, thiabendazole, trimethoprim, and warfarin, the SRL corresponds to the highest long-term method detection limit (LT-MDL) or interim method detection limit (I-MDL) used by the laboratory during the period GAMA samples were analyzed (May 2004 through June 2010). For caffeine, the SRL is higher than the highest LT-MDL or I-MDL and corresponds to the concentration of the 99th percentile of the laboratory preparation set blanks. Results reported in NWIS with concentrations below the SRL for a compound are not reported as detections by the GAMA program. Because diphenhydramine was detected very frequently in laboratory preparation set blanks and in field blanks collected during the period GAMA samples were analyzed, no results for diphenhydramine are reported by the GAMA program. Results for pharmaceutical compounds in groundwater samples from the GAMA Sierra Nevada study unit will be included in a subsequent report.

Table 3D. Constituents of special interest, primary uses or sources, comparative benchmarks, and reporting information for Weck Laboratories, Inc.

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** CAS, Chemical Abstract Service; MRL, minimum reporting level; D, detected in groundwater samples (table 7); µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	MRL (µg/L)	Benchmark type [1]	Benchmark levels (µg/L)	Detection
N-Nitrosodimethylamine (NDMA)	Rocket fuel, plasticizer, disinfection by-product	34438	62-75-9	0.002	NL-CA	0.010	—
Perchlorate	Rocket fuel, fireworks, flares, natural, fertilizer	63790	14797-73-0	0.10	MCL-CA	6	D

[1]Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

Table 3E. Nutrients, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2755.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 8); na, not available; mg/L, milligrams per liter]

Constituent	USGS parameter code	CAS number	LRL (mg/L)	Benchmark type [1]	Benchmark level (mg/L)	Detection
Ammonia (as nitrogen)	00608	7664-41-7	0.020	HAL-US	[2] 24.7	D
Nitrite (as nitrogen)	00613	14797-65-0	0.002	MCL-US	1	D
Nitrate plus nitrite (as nitrogen)	00631	na	0.04	MCL-US	10	D
Total nitrogen (ammonia, nitrite, nitrate, and organic nitrogen)	62854	17778-88-0	[3] 0.06, 0.10	na	na	D
Orthophosphate (as phosphorus)	00671	14265-44-2	[3] 0.006, 0.008	na	na	D

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] The HAL-US is 30 mg/L "as ammonia." To facilitate comparison to the analytical results, we converted and reported this HAL-US as 24.7 mg/L "as nitrogen."

[3] LRL for samples collected before 10/01/08, LRL for samples collected 10/01/08 and thereafter.

Table 3F. Major and minor ions, total dissolved solids, and trace elements, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH Health notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; IRL, interim reporting level; MRL, minimum reporting level; D, detected in groundwater samples (tables 9 and 10); na, not available; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not detected]

Constituent	USGS parameter code	CAS number	LRL	Benchmark type [1]	Benchmark level	Detection
Major and minor ions (mg/L)						
Bromide	71870	24959-67-9	[2] 0.02	na	na	D
Calcium	00915	7440-70-2	[3] 0.04, 0.02	na	na	D
Chloride	00940	16887-00-6	0.12	SMCL-CA	[4] 250 (500)	D
Fluoride	00950	16984-48-8	[3] 0.12, 0.08	MCL-CA	2	D
Iodide	71865	7553-56-2	0.002	na	na	D
Magnesium	00925	7439-95-4	[3] 0.02, 0.012	na	na	D
Potassium	00935	7440-09-7	[3] 0.02, 0.06	na	na	D
Silica	00955	7631-86-9	[3] 0.018, 0.02	na	na	D
Sodium	00930	7440-23-5	0.12	na	na	D
Sulfate	00945	14808-79-8	0.18	SMCL-CA	[4] 250 (500)	D
Total dissolved solids (TDS)	70300	na	[5] 10	SMCL-CA	[4] 500 (1,000)	D
Trace elements (µg/L)						
Aluminum	01106	7429-90-5	[3] 1.6, 4	MCL-CA	1,000	D
Antimony	01095	7440-36-0	[3] 0.14, 0.04	MCL-US	6	D
Arsenic	01000	7440-38-2	0.12	MCL-US	10	D
Barium	01005	7440-39-3	0.2	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	0.06	MCL-US	4	D
Boron	01020	7440-42-8	8	NL-CA	1,000	D
Cadmium	01025	7440-43-9	0.04	MCL-US	5	D
Chromium	01030	7440-47-3	[2] 0.04	MCL-CA	50	D
Cobalt	01035	7440-48-4	0.04	na	na	D
Copper	01040	7440-50-8	0.4	AL-US	1,300	D
Iron	01046	7439-89-6	6	SMCL-CA	300	D
Lead	01049	7439-92-1	0.08	AL-US	15	D
Lithium	01130	7439-93-2	0.6	na	na	D
Manganese	01056	7439-96-5	0.2	SMCL-CA	50	D
Mercury	71890	7439-97-6	0.010	MCL-US	2	D
Molybdenum	01060	7439-98-7	0.4	HAL-US	40	D
Nickel	01065	7440-02-0	0.06	MCL-CA	100	D
Selenium	01145	7782-49-2	0.08	MCL-US	50	D
Silver	01075	7440-22-4	0.20	SMCL-CA	100	D

Table 3F. Major and minor ions, total dissolved solids, and trace elements, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 1948.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH Health notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; IRL, interim reporting level; MRL, minimum reporting level; D, detected in groundwater samples (tables 9 and 10); na, not available; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not detected]

Constituent	USGS parameter code	CAS number	LRL	Benchmark type [1]	Benchmark level	Detection
Strontium	01080	7440-24-6	0.4	HAL-US	4,000	D
Thallium	01057	7440-28-0	0.04	MCL-US	2	D
Tungsten	01155	7440-33-7	0.06	na	na	D
Uranium	22703	7440-61-1	0.04	MCL-US	30	D
Vanadium	01085	7440-62-2	0.10	NL-CA	50	D
Zinc	01090	7440-66-6	0.6	HAL-US	2,000	D

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] Value is an IRL rather than an LRL.

[3] LRL for samples collected before 10/01/08, LRL for samples collected 10/01/08 and thereafter.

[4] The recommended SMCL-CA benchmarks for chloride, sulfate, and TDS are listed with the upper SMCL-CA benchmarks in parentheses.

[5] Value is an MRL rather than an LRL.

Table 3G. Arsenic and iron species, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) Trace Metal Laboratory, Boulder, Colorado.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** SMCL-CA, California Department of Public Health secondary maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** na, not available; µg/L, micrograms per liter; CAS, Chemical Abstract Service; MDL, method detection limit; D, detected in groundwater samples (table 11)]

Constituent (valence state)	USGS parameter code	CAS number	MDL (µg/L)	Benchmark type [1]	Benchmark level (µg/L)	Detection
Arsenic (III)	99034	22569-72-8	1	na	na	D
Arsenic (total)	99033	7440-38-2	0.5	MCL-US	10	D
Iron (II)	01047	7439-89-6	2	na	na	D
Iron (total)	01046	7439-89-6	2	SMCL-CA	300	D

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

Table 3H. Isotopic and radioactive constituents, comparative benchmarks, and reporting information for laboratories.

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Analyzing laboratory entity codes are listed in the footnotes. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to a more common lighter isotope of that element, relative to a standard reference material. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; CSU, combined standard uncertainty; 2SCU, 2-sigma combined uncertainty; ssLC, sample-specific critical level; MRL, minimum reporting level; MU, method uncertainty; na, not available; pCi/L, picocuries per liter; D, detected in groundwater samples (tables 12 and 13)]

Constituent	USGS parameter code	CAS number	Reporting level type	Reporting level or uncertainty	Benchmark type [1]	Benchmark level	Detection
Stable isotope ratios (per mil)							
δ^{2}H of water [2]	82082	na	MU	2	na	na	D
δ^{18}O of water [2]	82085	na	MU	0.20	na	na	D
δ^{13}C of dissolved carbonates [3]	82081	na	1-sigma	0.05	na	na	D
Isotope ratios (atom ratio)							
Strontium isotope ratio (^{87}Sr/^{86}Sr)[4]	75978	na	MU	0.00005	na	na	na [5]
Radioactive constituents (percent modern)							
Carbon-14 [6]	49933	14762-75-5	1-sigma	0.0015	na	na	D
Radioactive constituents (pCi/L)							
Radon-222 [7]	82303	14859-67-7	na	2SCU	Proposed MCL-US	[8] 300 (4,000)	D
Tritium [9]	07000	10028-17-8	MRL	0.3	MCL-CA	20,000	D
Gross-alpha radioactivity, 72-hour and 30-day counts [10]	62636, 62639	12587-46-1	ssLC	CSU	MCL-US	15	D
Gross-beta radioactivity, 72-hour and 30-day counts [10]	62642, 62645	12587-47-2	ssLC	CSU	MCL-CA	50	D
Radium-226 [10]	09511	13982-63-3	ssLC	CSU	MCL-US	[11] 5	D
Radium-228 [10]	81366	15262-20-1	ssLC	CSU	MCL-US	[11] 5	D
Uranium-234 [10]	22610	13966-29-5	ssLC	CSU	MCL-CA	[12] 20	D
Uranium-235 [10]	22620	15117-96-1	ssLC	CSU	MCL-CA	[12] 20	D
Uranium-238 [10]	22603	7440-61-1	ssLC	CSU	MCL-CA	[12] 20	D

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA).

[3] University of Waterloo (contract laboratory, CAN-UWIL).

[4] USGS Metals Isotope Research Laboratory, Menlo Park, California.

[5] Data will be presented in subsequent reports.

[6] University of Arizona, Accelerator Mass Spectrometry Laboratory (contract laboratory, A2-UAMSL).

[7] USGS National Water Quality Laboratory (USGSNWQL).

[8] Two MCLs have been proposed for Radon-222. The proposed alternative MCL is in parentheses.

[9] USGS Tritium Laboratory, Menlo Park, California (USGSH3CA).

[10] Eberline Analytical Service (contract laboratory, CA-EBERL).

[11] The MCL-US benchmark for radium is the sum of radium-226 and radium-228.

[12] The MCL-CA benchmark for uranium is the sum of uranium-234, uranium-235, and uranium-238.

Table 3I. Noble gases and tritium activity, comparison benchmarks, and reporting information for the Lawrence Livermore National Laboratory.

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MU, method uncertainty; na, not available; cm^3 STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water; pCi/L, picocuries per liter]

Constituent	USGS parameter code	CAS number	MU (percent)	Reporting units	Benchmark type [1]	Benchmark level (pCi/L)
Helium-3/Helium-4	61040	na/7440-59-7	0.75	atom ratio	na	na
Argon	85563	7440-37-1	2	cm^3 STP/g	na	na
Helium-4	85561	7440-59-7	2	cm^3 STP/g	na	na
Krypton	85565	7439-90-9	2	cm^3 STP/g	na	na
Neon	61046	7440-01-09	2	cm^3 STP/g	na	na
Xenon	85567	7440-63-3	2	cm^3 STP/g	na	na
Tritium activity	07000	10028-17-8	1	pCi/L	MCL-CA	20,000

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

Table 4. Field water-quality indicators in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[The five-digit number below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degree Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, sample not collected; na, not available; RL, reporting limit or range; µS/cm, microsiemens per centimeter; $CaCO_3$, calcium carbonate; <, less than; >, greater than; *, value above benchmark level or outside benchmark range; **, value above upper benchmark level]

GAMA identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25 °C) (00095)	Specific conductance, lab (µS/cm at 25 °C) (90095)	Alkalinity, field (mg/L as $CaCO_3$) (29802)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)
Benchmark type	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**na**	**na**
Benchmark level	**na**	**na**	**<6.5 or >8.5**	**<6.5 or >8.5**	**[1] 900 (1,600)**	**[1] 900 (1,600)**	**na**	**na**
[RL]	**[0.2]**	**[0.0–38.5]**	**[0–14]**	**[0–14]**	**[5]**	**[5]**	**[1]**	**[2] [5, 8]**
				Primary grid wells				
SIERRA-G-01	0.3	19.5	7.7	8.0	306	303	134	139
SIERRA-G-02	7.3	8.5	*5.9	6.8	237	241	114	120
SIERRA-G-03	<0.2	19.0	6.6	7.4	257	255	98	101
SIERRA-G-04	nc	nc	nc	7.5	nc	E 39	nc	19
SIERRA-G-05	5.8	20.0	6.5	6.8	344	346	126	130
SIERRA-G-06	<0.2	17.5	7.5	7.8	327	345	91	97
SIERRA-G-07	2.1	15.5	*6.2	6.6	238	239	112	115
SIERRA-G-08	5.2	9.5	*5.8	6.7	324	329	43	47
SIERRA-G-09	7.6	6.0	*5.4	7.0	41	E 44	18	22
SIERRA-G-10	4.7	8.0	*6.4	7.2	116	119	54	60
SIERRA-G-11	9.4	11.5	*6.3	7.3	110	114	nc	59
SIERRA-G-12	7.5	15.5	6.6	7.0	258	268	126	131
SIERRA-G-13	9.8	15.0	*6.2	6.6	147	150	54	61
SIERRA-G-14	4.8	9.0	*6.3	6.6	80	E 83	36	43
SIERRA-G-15	0.2	21.0	*9.1	*9.2	792	802	210	218
SIERRA-G-16	8.4	6.5	*6.4	6.9	51	E 54	19	22
SIERRA-G-17	9.9	5.0	*8.6	*8.9	65	E 69	21	25
SIERRA-G-18	8.1	7.5	*6.3	7.8	27	E 31	12	16
SIERRA-M-01	<0.2	19.0	7.7	7.6	389	421	100	104
SIERRA-M-02	<0.2	18.5	7.2	7.0	517	520	172	178
SIERRA-M-03	3.9	14.0	7.4	7.7	256	264	nc	138
SIERRA-M-04	6.5	12.0	7.4	7.7	142	147	72	75
SIERRA-M-05	0.3	10.5	7.0	7.0	197	200	98	100
SIERRA-M-06	9.6	10.0	*6.0	*6.3	80	E 86	40	44

Table 4. Field water-quality indicators in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degree Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, sample not collected; na, not available; RL, reporting limit or range; µS/cm, microsiemens per centimeter; $CaCO_3$, calcium carbonate; <, less than; >, greater than; *, value above benchmark level or outside benchmark range; **, value above upper benchmark level]

GAMA identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25 °C) (00095)	Specific conductance, lab (µS/cm at 25 °C) (90095)	Alkalinity, field (mg/L as $CaCO_3$) (29802)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)
Benchmark type	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**na**	**na**
Benchmark level	**na**	**na**	**<6.5 or >8.5**	**<6.5 or >8.5**	**[1] 900 (1,600)**	**[1] 900 (1,600)**	**na**	**na**
[RL]	**[0.2]**	**[0.0–38.5]**	**[0–14]**	**[0–14]**	**[5]**	**[5]**	**[1]**	**[2] [5, 8]**
SIERRA-S-01	6.6	17.0	7.3	7.5	840	842	248	260
SIERRA-S-02	3.6	10.5	*8.7	*8.7	164	166	57	63
SIERRA-S-03	2.7	12.5	6.9	7.4	243	252	96	101
SIERRA-V-01	9.3	6.5	7.4	7.6	135	139	70	74
SIERRA-V-02	6.2	13.0	7.0	7.0	195	199	97	103
SIERRA-V-03	[3] >1	6.5	6.5	7.3	101	112	43	52
Lithologic grid wells								
SIERRA-GL-01	6.6	19.0	6.9	7.5	298	298	118	124
SIERRA-GL-02	2.6	17.0	*6.3	6.9	286	303	nc	123
SIERRA-GL-03	9.2	3.5	7.3	6.6	36	E 38	nc	19
SIERRA-GL-04	3.4	8.0	*6.0	6.8	44	E 47	nc	25
SIERRA-GL-05	7.9	9.0	6.9	6.9	103	106	nc	53
SIERRA-GL-06	8.8	6.0	*5.8	6.9	53	E 57	nc	29
SIERRA-GL-07	7.6	17.0	6.8	7.1	356	365	nc	152
SIERRA-GL-08	9.5	7.0	*6.0	6.7	58	E 61	nc	30
SIERRA-GL-09	7.3	13.5	*5.5	*6.0	54	E 57	nc	25
SIERRA-GL-10	2.4	10.5	7.5	7.5	224	243	nc	125
SIERRA-ML-01	3.1	17.5	7.3	7.5	*1,060	*1,072	nc	278
SIERRA-ML-02	6.3	18.5	7.1	7.3	377	378	nc	148
SIERRA-ML-03	0.3	18.5	7.0	7.4	529	535	nc	208
SIERRA-ML-04	3.3	18.0	*6.3	7.0	382	387	nc	180
SIERRA-ML-05	10.0	13.0	*5.9	*6.4	210	212	nc	96
SIERRA-ML-06	5.6	20.0	7.0	7.1	561	566	nc	232
SIERRA-ML-07	1.9	14.5	7.6	7.8	338	342	nc	170
SIERRA-ML-08	0.3	17.5	6.9	7.2	686	726	nc	310
SIERRA-ML-09	4.5	13.5	6.7	7.2	195	218	nc	111
SIERRA-ML-10	7.3	18.0	7.1	7.4	497	501	nc	227

Table 4. Field water-quality indicators in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degree Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, sample not collected; na, not available; RL, reporting limit or range; µS/cm, microsiemens per centimeter; $CaCO_3$, calcium carbonate; <, less than; >, greater than; *, value above benchmark level or outside benchmark range; **, value above upper benchmark level]

GAMA identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25 °C) (00095)	Specific conductance, lab (µS/cm at 25 °C) (90095)	Alkalinity, field (mg/L as $CaCO_3$) (29802)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)
Benchmark type	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**na**	**na**
Benchmark level	**na**	**na**	**<6.5 or >8.5**	**<6.5 or >8.5**	**[1] 900 (1,600)**	**[1] 900 (1,600)**	**na**	**na**
[RL]	**[0.2]**	**[0.0–38.5]**	**[0–14]**	**[0–14]**	**[5]**	**[5]**	**[1]**	**[2] [5, 8]**
SIERRA-ML-11	11.6	7.0	7.5	7.8	175	178	nc	90
SIERRA-ML-12	0.2	15.0	6.8	6.6	287	282	nc	122
SIERRA-ML-13	2.7	17.0	7.0	7.3	544	548	nc	289
SIERRA-ML-14	10.8	8.5	6.9	7.4	54	E 56	nc	25
SIERRA-ML-15	6.5	8.5	6.5	7.1	126	133	nc	61
SIERRA-ML-16	<0.2	7.0	7.3	7.6	205	206	83	85
SIERRA-ML-17	7.1	19.0	6.6	6.9	225	239	nc	73
SIERRA-ML-18	2.1	15.5	6.6	7.1	185	187	nc	88
SIERRA-SL-01	6.1	18.0	7.5	7.7	462	459	nc	206
SIERRA-SL-02	0.5	18.0	*6.3	6.8	518	509	nc	251
SIERRA-SL-03	1.7	24.0	7.3	7.5	656	660	nc	209
SIERRA-SL-04	<0.2	30.0	*8.9	*8.9	*1,220	*1,214	nc	351
SIERRA-SL-05	9.2	8.0	*6.4	7.5	118	120	nc	56
SIERRA-SL-06	4.8	11.0	6.8	7.7	146	149	nc	78
SIERRA-SL-07	7.7	9.0	7.1	7.3	40	E 43	nc	20
SIERRA-SL-08	2.5	12.0	6.7	7.6	124	130	nc	64
SIERRA-SL-09	9.7	10.5	7.5	7.8	208	215	nc	115
SIERRA-SL-10	7.5	6.0	7.0	7.5	42	E 45	nc	24
SIERRA-SL-11	4.5	15.0	7.2	7.6	160	163	nc	73
SIERRA-SL-12	0.3	19.5	7.3	7.4	337	337	nc	172
SIERRA-SL-13	5.8	9.0	*5.7	7.0	24	E 27	nc	13
SIERRA-VL-01	4.4	17.5	7.1	7.4	*1,040	*1,036	nc	365
SIERRA-VL-02	6.2	11.0	6.6	7.3	226	229	nc	122
SIERRA-VL-03	<0.2	15.0	7.9	8.1	516	515	nc	269
SIERRA-VL-04	4.2	15.5	*6.4	7.1	178	180	nc	82
SIERRA-VL-05	6.4	14.0	7.2	7.6	239	255	nc	129
SIERRA-VL-06	<0.2	15.5	7.9	7.9	329	334	nc	157

Table 4. Field water-quality indicators in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degree Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, sample not collected; na, not available; RL, reporting limit or range; µS/cm, microsiemens per centimeter; $CaCO_3$, calcium carbonate; <, less than; >, greater than; *, value above benchmark level or outside benchmark range; **, value above upper benchmark level]

GAMA identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25 °C) (00095)	Specific conductance, lab (µS/cm at 25 °C) (90095)	Alkalinity, field (mg/L as $CaCO_3$) (29802)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)
Benchmark type	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**na**	**na**
Benchmark level	**na**	**na**	**<6.5 or >8.5**	**<6.5 or >8.5**	**[1] 900 (1,600)**	**[1] 900 (1,600)**	**na**	**na**
[RL]	**[0.2]**	**[0.0–38.5]**	**[0–14]**	**[0–14]**	**[5]**	**[5]**	**[1]**	**[2] [5, 8]**
SIERRA-VL-07	0.3	8.5	7.5	7.4	231	234	nc	95
SIERRA-VL-08	8.6	12.0	7.1	7.5	174	178	nc	94
SIERRA-VL-09	8.8	9.0	7.2	7.5	162	166	nc	88
SIERRA-VL-10	8.8	10.0	*5.2	*6.3	18	E 21	nc	10
SIERRA-VL-11	5.6	11.5	*6.2	6.5	153	160	nc	74
SIERRA-VL-12	4.0	13.0	7.5	7.7	218	238	nc	118
Comparison site								
SIERRA-XL-01	0.5	13.0	*6.0	*6.2	**2,200	**2,305	831	846

[1]The SMCL-CA for specific conductance has recommended and upper benchmark levels. The upper value is shown in parentheses.

[2] RL for samples collected before 10/01/08, RL for samples collected 10/01/08 and thereafter.

[3] The CHEMets kit rather than the multi-probe meter was used to measure dissolved oxygen..

Table 5. Volatile organic compounds (VOC) detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October, 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Constituents are grouped by primary use or source and listed in order of decreasing detection frequency in the 30 primary grid wells within each group. All constituents are listed in table 3A. Samples from 30 primary grid and 53 lithologic grid wells were analyzed, but only wells with detections are listed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level. **Other abbreviations:** DBP, disinfection by-product; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; —, not detected]

	Gasoline oxygenate	DBP	Solvent						Organic synthesis	Natural	Fumigant	Refrigerant	
GAMA identification number	**Methyl *tert*-butyl ether (MTBE) (µg/L) (78032)**	**Chloroform (µg/L) (32106)**	**Perchloroethene (PCE) (µg/L) (34475)**	**1,1-Dichloroethane (µg/L) (34496)**	**1,2-Dichloroethane (µg/L) (32103)**	***cis*-1,2-Dichloroethene (µg/L) (77093)**	**1,1,1-Trichloroethane (µg/L) (34506)**	**Trichloroethene (TCE) (µg/L) (39180)**	**1,1-Dichloroethene (µg/L) (34501)**	**Carbon disulfide (µg/L) (77041)**	**1,4-Dichlorobenzene (µg/L) (34571)**	**Trichlorofluoromethane (CFC-11) (µg/L) (34488)**	**VOC detections per well [1]**
Benchmark type [2]	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-CA	MCL-CA	MCL-US	MCL-US	MCL-CA	NL-CA	MCL-CA	MCL-CA	
Benchmark level	13	[3] 80	5	5	0.5	6	200	5	6	160	5	150	
[LRL]	[0.1]	[4] [0.02, 0.04]	[0.04]	[0.04]	[0.06]	[0.02]	[0.02]	[0.02]	[0.02]	[4] [0.06, 0.04]	[0.02]	[0.08]	
						Primary grid wells							
SIERRA-G-07	E0.1	E0.10	—	—	—	—	—	—	—	—	—	—	2
SIERRA-G-08	0.8	—	—	—	E0.1	—	—	—	—	—	—	—	2
SIERRA-G-15	—	—	—	E0.03	—	—	—	—	E0.03	—	—	—	2
SIERRA-M-06	E0.05	E0.02	—	—	—	—	—	—	—	—	—	—	2
SIERRA-S-02	0.2	E0.10	—	—	—	—	—	—	—	—	—	—	2
SIERRA-S-03	E0.05	—	E0.01	—	—	—	—	—	—	—		—	2
SIERRA-V-03	—	0.13	—	—	—	—	—	—	—	—		—	1
Number of detections	5	4	1	1	1	—	—	—	1	—	—	—	
Detection frequency (percent)	17	13	3	3	3	—	—	—	3	—	—	—	[5] 23

Table 5. Volatile organic compounds (VOC) detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October, 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Constituents are grouped by primary use or source and listed in order of decreasing detection frequency in the 30 primary grid wells within each group. All constituents are listed in table 3A. Samples from 30 primary grid and 53 lithologic grid wells were analyzed, but only wells with detections are listed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level. **Other abbreviations:** DBP, disinfection by-product; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; —, not detected]

GAMA identification number	Gasoline oxygenate	DBP	Solvent						Organic synthesis	Natural	Fumigant	Refrigerant	VOC detections per well [1]
	Methyl *tert*-butyl ether (MTBE) (µg/L) (78032)	Chloroform (µg/L) (32106)	Perchloroethene (PCE) (µg/L) (34475)	1,1-Dichloroethane (µg/L) (34496)	1,2-Dichloroethane (µg/L) (32103)	*cis*-1,2-Dichloroethene (µg/L) (77093)	1,1,1-Trichloroethane (µg/L) (34506)	Trichloroethene (TCE) (µg/L) (39180)	1,1-Dichloroethene (µg/L) (34501)	Carbon disulfide (µg/L) (77041)	1,4-Dichlorobenzene (µg/L) (34571)	Trichlorofluoromethane (CFC-11) (µg/L) (34488)	
Benchmark type [2]	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-CA	MCL-CA	MCL-US	MCL-US	MCL-CA	NL-CA	MCL-CA	MCL-CA	
Benchmark level	13	[3] 80	5	5	0.5	6	200	5	6	160	5	150	
[LRL]	[0.1]	[4] [0.02, 0.04]	[0.04]	[0.04]	[0.06]	[0.02]	[0.02]	[0.02]	[0.02]	[4] [0.06, 0.04]	[0.02]	[0.08]	
						Lithologic grid wells							
SIERRA-GL-01	—	E0.05	—	—	—	—	—	—	—	—	—	—	1
SIERRA-GL-02	—	0.15	1.05	—	—	0.18	—	0.21	—	—	—	—	4
SIERRA-GL-05	0.3	—	—	—	—	—	—	—	—	—	—	—	1
SIERRA-GL-08	—	—	—	—	—	—	—	—	—	—	E0.06	—	1
SIERRA-GL-09	—	E0.03	—	—	—	—	E0.01	—	—	—	—	0.15	3
SIERRA-GL-10	0.1	1.38	0.15	—	—	—	E0.02	—	—	—	—	—	4
SIERRA-ML-03	0.4	—	—	—	—	—	—	—	—	—	—	—	1
SIERRA-ML-11	—	—	—	—	—	—	—	—	—	E0.03	—	—	1
SIERRA-ML-13	—	E0.04	—	—	—	—	—	—	—	—	—	—	1
SIERRA-ML-17	—	0.71	—	—	—	—	—	—	—	—	—	—	1
SIERRA-ML-18	—	E0.02	—	—	—	—	—	—	—	—	—	—	1
SIERRA-SL-03	—	E0.05	—	—	—	—	—	—	—	—	—	—	1

Table 5. Volatile organic compounds (VOC) detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October, 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Constituents are grouped by primary use or source and listed in order of decreasing detection frequency in the 30 primary grid wells within each group. All constituents are listed in table 3A. Samples from 30 primary grid and 53 lithologic grid wells were analyzed, but only wells with detections are listed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level. **Other abbreviations:** DBP, disinfection by-product; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; —, not detected]

	Gasoline oxygenate	DBP	Solvent						Organic synthesis	Natural	Fumigant	Refrigerant	
GAMA identification number	Methyl *tert*-butyl ether (MTBE) (µg/L) (78032)	Chloroform (µg/L) (32106)	Perchloroethene (PCE) (µg/L) (34475)	1,1-Dichloroethane (µg/L) (34496)	1,2-Dichloroethane (µg/L) (32103)	*cis*-1,2-Dichloroethene (µg/L) (77093)	1,1,1-Trichloroethane (µg/L) (34506)	Trichloroethene (TCE) (µg/L) (39180)	1,1-Dichloroethene (µg/L) (34501)	Carbon disulfide (µg/L) (77041)	1,4-Dichlorobenzene (µg/L) (34571)	Trichlorofluoromethane (CFC-11) (µg/L) (34488)	VOC detections per well [1]
Benchmark type [2]	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-CA	MCL-CA	MCL-US	MCL-US	MCL-CA	NL-CA	MCL-CA	MCL-CA	
Benchmark level	13	[3] 80	5	5	0.5	6	200	5	6	160	5	150	
[LRL]	[0.1]	[4] [0.02, 0.04]	[0.04]	[0.04]	[0.06]	[0.02]	[0.02]	[0.02]	[0.02]	[4] [0.06, 0.04]	[0.02]	[0.08]	
SIERRA-VL-01	—	E0.07	—	—	—	—	—	—	—	—	—	—	1
SIERRA-VL-02	—	E0.05	—	—	—	—	—	—	—	—	—	—	1
SIERRA-VL-05	—	E0.04	—	—	—	—	—	—	—	—	—	—	1
SIERRA-VL-06	—	0.16	—	—	—	—	—	—	—	—	—	—	1
SIERRA-VL-10	—	E0.02	—	—	—	—	—	—	—	—	—	—	1
SIERRA-VL-11	E0.03	0.16	—	—	—	—	—	—	—	—	—	—	2

[1] Study reporting levels (SRL) were defined for toluene, 1,2,4-trimethylbenzene, and tetrahydrofuran on the basis of detections of these constituents in field blanks in the previous 25 GAMA study units. All concentrations of these consitituents were below the SRLs and are therefore not reported as detections: toluene (SIERRA-V-03: 0.03 µg/L; SIERRA-GL-03: 0.03 µg/L; SIERRA-ML-06: 0.04 µg/L), and 1,2,4-trimethylbenzene (SIERRA-G-04: 0.13 µg/L; SIERRA-V-03: 0.02 µg/L; SIERRA-SL-13: 0.03 µg/L; SIERRA-VL-04: 0.14 µg/L), and tetrahydrofuran (SIERRA-V-03: 0.5 µg/L).).

[2] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists

[3] The MCL-US benchmark for trihalomethanes is for the sum of the concentrations of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

[4] LRL for samples collected before 10/01/08, LRL for samples collected 10/01/08 and thereafter.

[5] Frequency of detecting at least one VOC in the 30 primary grid wells.

Table 6. Pesticides and pesticide degradates detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October, 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Constituents are grouped by primary use or sources and listed in order of decreasing detection frequency in the 30 primary grid wells within each group. All constituents are listed in table 3B. Samples from 30 primary grid and 53 lithologic grid wells were analyzed, but only wells with detections are listed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; Benchmarks and thres.old values as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; na, not available; µg/L, micrograms per liter; —, not detected]

	Herbicide			Herbicide degradate		Insecticide	Insecticide degradate		
GAMA identification number	Simazine (µg/L) (04035)	Atrazine (µg/L) (39632)	Hexazinone (µg/L) (04025)	Deethyl-atrazine (µg/L) (04040)	3,4-Dichloro-aniline (µg/L) (61625)	Fipronil (µg/L) (62166)	Desulfinyl-fipronil (µg/L) (62170)	Fipronil sulfone (µg/L) (62168)	Pesticide detections per well
Benchmark type [1]	**MCL-US**	**MCL-CA**	**HAL-US**	**na**	**na**	**na**	**na**	**na**	
Benchmark level	**4**	**1**	**400**	**na**	**na**	**na**	**na**	**na**	
[LRL]	**[2] [0.006, 0.01]**	**[0.007]**	**[0.008]**	**[0.014]**	**[2] [0.006, 0.004]**	**[2] [0.02, 0.04]**	**[0.012]**	**[0.024]**	
				Primary grid wells					
SIERRA-G-08	E0.005	0.01	—	E0.005	—	—	—	—	3
SIERRA-G-11	—	—	—	—	—	E0.011	E0.005	E0.008	3
SIERRA-G-13	—	—	—	—	E0.004	—	—	—	1
SIERRA-M-01	E0.005	—	—	—	—	—	—	—	1
SIERRA-S-01	E0.005	—	—	—	—	—	—	—	1
Number of detections	3	1	—	1	1	1	1	1	
Detection frequency (percent)	10	3	—	3	3	3	3	3	[3] 17
				Lithologic grid wells					
SIERRA-GL-02	—	0.015	0.008	E0.08	E0.004	—	—	—	4
SIERRA-ML-03	—	—	—	E0.006	—	—	—	—	1
SIERRA-ML-05	—	—	—	E0.006	—	—	—	—	1
SIERRA-ML-06	0.015	—	—	—	E0.006	—	—	—	2
SIERRA-ML-13	E0.005	—	—	—	—	—	—	—	1
SIERRA-SL-03	0.031	0.008	—	E0.08	E0.003	—	—	—	4

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] LRL for samples collected before 10/01/08, LRL for samples collected 10/01/08 and thereafter.

[3] Frequency of detecting at least one pesticide in the 30 primary grid wells.

Table 7. Constituents of special interest detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3D contains additional information about the constituents. Samples from all 30 primary and all 53 lithologic grid wells were analyzed for perchlorate. Samples from lithologic grid wells SIERRA-GL-01 and -ML-16 and samples from all primary grid wells except SIERRA-G-11 were analyzed for NDMA. NDMA was not detected in any samples. Only wells with detections of perchlorate are listed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** MRL, minimum reporting level; µg/L, micrograms per liter; —, not detected]

GAMA identification number	Perchlorate (µg/L) (63790)
Benchmark type [1]	**MCL-CA**
Benchmark level	**6**
[MRL]	**[0.10]**
Primary grid wells	
SIERRA-G-03	0.21
SIERRA-G-05	0.37
SIERRA-G-07	0.14
SIERRA-G-08	0.33
SIERRA-G-09	0.11
SIERRA-G-12	0.15
SIERRA-G-13	0.18
SIERRA-S-01	0.75
Number of wells with detections	8
Detection frequency (percent)	[2] 27
Lithologic grid wells	
SIERRA-GL-01	0.25
SIERRA-GL-02	0.17
SIERRA-GL-07	0.20
SIERRA-GL-10	0.10
SIERRA-ML-01	0.19
SIERRA-ML-02	0.12
SIERRA-ML-03	0.62
SIERRA-ML-05	0.28
SIERRA-ML-06	0.42
SIERRA-ML-09	0.26
SIERRA-ML-13	0.11
SIERRA-ML-17	0.31
SIERRA-ML-18	0.12
SIERRA-SL-01	0.17
SIERRA-SL-03	1.20
SIERRA-VL-01	0.18
SIERRA-VL-02	0.12
SIERRA-VL-08	0.11

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] Frequency of detecting perchlorate in the 30 primary grid wells.

Table 8. Nutrients detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3E contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US; U.S. Environmental Protection Agency maximum contaminant level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; mg/L, milligrams per liter; —, not detected; ≤, less than or equal to]

GAMA identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-nitrogen), as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorus (mg/L) (00671)
Benchmark type [1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Benchmark level	**[2] 24.7**	**10**	**1**	**na**	**na**
[LRL] or [SRL]	**[3] [0.014]**	**[0.04]**	**[0.002]**	**[4,5] [0.06, 0.1]**	**[4] [0.006, 0.008]**
		Primary grid wells			
SIERRA-G-01	—	—	—	—	0.014
SIERRA-G-02	—	0.14	—	0.14	0.030
SIERRA-G-03	—	1.46	—	1.54	0.064
SIERRA-G-04	—	0.08	—	0.08	0.028
SIERRA-G-05	—	5.19	—	5.54	0.146
SIERRA-G-06	—	0.09	—	E0.06	0.015
SIERRA-G-07	—	0.42	—	0.46	0.039
SIERRA-G-08	—	0.73	—	0.79	0.031
SIERRA-G-09	—	0.07	—	E0.04	0.036
SIERRA-G-10	—	0.05	—	E0.06	0.013
SIERRA-G-11	—	0.06	—	E0.04	0.095
SIERRA-G-12	—	0.70	—	0.69	0.036
SIERRA-G-13	—	2.85	—	2.94	0.078
SIERRA-G-14	—	0.10	—	0.12	0.024
SIERRA-G-15	0.268	—	—	0.37	E0.005
SIERRA-G-16	—	0.17	—	0.15	—
SIERRA-G-17	—	0.08	—	0.06	0.019
SIERRA-G-18	—	0.12	—	0.13	0.008
SIERRA-M-01	≤0.012	0.24	—	0.26	0.012
SIERRA-M-02	≤0.011	—	—	—	0.035
SIERRA-M-03	—	E0.02	—	—	0.010
SIERRA-M-04	—	E0.03	—	—	E0.005
SIERRA-M-05	≤0.013	—	—	—	0.027
SIERRA-M-06	—	E0.03	—	E0.05	E0.006
SIERRA-S-01	—	8.32	—	8.70	0.046

Table 8. Nutrients detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3E contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US; U.S. Environmental Protection Agency maximum contaminant level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; mg/L, milligrams per liter; —, not detected; ≤, less than or equal to]

GAMA identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-nitrogen), as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorus (mg/L) (00671)
Benchmark type [1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Benchmark level	[2] **24.7**	**10**	**1**	**na**	**na**
[LRL] or [SRL]	[3] **[0.014]**	**[0.04]**	**[0.002]**	[4,5] **[0.06, 0.1]**	[4] **[0.006, 0.008]**
SIERRA-S-02	—	0.44	—	0.44	0.031
SIERRA-S-03	—	0.36	—	0.37	0.049
SIERRA-V-01	—	E0.03	—	—	0.039
SIERRA-V-02	—	0.05	—	E0.07	0.079
SIERRA-V-03	—	E0.03	—	—	0.090
Lithologic grid wells					
SIERRA-GL-01	—	3.71	—	3.62	0.103
SIERRA-GL-02	—	2.44	—	2.56	0.052
SIERRA-GL-03	—	0.25	—	0.28	0.018
SIERRA-GL-04	—	E0.03	—	—	0.009
SIERRA-GL-05	—	0.11	—	0.10	0.019
SIERRA-GL-06	—	0.09	—	0.09	0.035
SIERRA-GL-07	—	2.27	—	2.25	0.032
SIERRA-GL-08	—	—	—	—	0.061
SIERRA-GL-09	—	0.63	—	0.64	0.046
SIERRA-GL-10	—	0.26	—	0.26	0.012
SIERRA-ML-01	—	2.69	—	2.64	0.088
SIERRA-ML-02	—	1.00	—	0.95	0.016
SIERRA-ML-03	—	2.65	—	2.76	0.033
SIERRA-ML-04	—	0.20	—	0.19	0.024
SIERRA-ML-05	—	0.30	—	0.32	0.048
SIERRA-ML-06	—	6.07	—	6.36	0.061
SIERRA-ML-07	≤0.012	0.08	—	0.08	0.041
SIERRA-ML-08	—	0.62	E0.001	0.65	0.028
SIERRA-ML-09	—	E0.04	—	—	0.156
SIERRA-ML-10	—	0.28	—	0.33	0.016

Table 8. Nutrients detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3E contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US; U.S. Environmental Protection Agency maximum contaminant level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; mg/L, milligrams per liter; —, not detected; ≤, less than or equal to]

GAMA identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-nitrogen), as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorus (mg/L) (00671)
Benchmark type [1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Benchmark level	[2] **24.7**	**10**	**1**	**na**	**na**
[LRL] or [SRL]	[3] **[0.014]**	**[0.04]**	**[0.002]**	[4,5] **[0.06, 0.1]**	[4] **[0.006, 0.008]**
SIERRA-ML-11	—	0.08	—	E0.05	0.014
SIERRA-ML-12	≤0.013	—	—	—	0.017
SIERRA-ML-13	—	0.10	—	0.09	0.026
SIERRA-ML-14	—	0.08	—	E0.06	0.018
SIERRA-ML-15	—	0.29	—	0.29	0.014
SIERRA-ML-16	0.029	—	—	E0.03	0.050
SIERRA-ML-17	—	2.58	0.037	2.60	0.067
SIERRA-ML-18	—	0.40	—	0.42	0.058
SIERRA-SL-01	—	3.86	—	3.86	0.024
SIERRA-SL-02	0.087	E0.03	—	0.08	0.018
SIERRA-SL-03	≤0.010	9.78	—	10.20	0.115
SIERRA-SL-04	1.66	—	—	1.88	0.139
SIERRA-SL-05	—	0.10	—	0.12	0.021
SIERRA-SL-06	—	0.36	—	0.38	0.064
SIERRA-SL-07	—	0.07	—	E0.06	0.043
SIERRA-SL-08	—	0.59	—	0.58	0.019
SIERRA-SL-09	—	0.05	—	E0.04	0.034
SIERRA-SL-10	—	0.06	—	E0.04	0.024
SIERRA-SL-11	—	0.41	—	0.40	0.012
SIERRA-SL-12	0.032	—	—	—	0.075
SIERRA-SL-13	—	0.05	—	—	0.010
SIERRA-VL-01	—	9.78	—	9.56	0.056
SIERRA-VL-02	—	0.17	—	0.17	0.152
SIERRA-VL-03	—	—	—	—	0.017
SIERRA-VL-04	—	0.38	—	0.35	0.265
SIERRA-VL-05	—	0.21	—	0.21	0.060

Table 8. Nutrients detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3E contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US; U.S. Environmental Protection Agency maximum contaminant level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; mg/L, milligrams per liter; —, not detected; ≤, less than or equal to]

GAMA identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-nitrogen), as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorus (mg/L) (00671)
Benchmark type [1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Benchmark level	**[2] 24.7**	**10**	**1**	**na**	**na**
[LRL] or [SRL]	**[3] [0.014]**	**[0.04]**	**[0.002]**	**[4,5] [0.06, 0.1]**	**[4] [0.006, 0.008]**
SIERRA-VL-06	0.139	—	—	0.15	0.164
SIERRA-VL-07	0.798	—	—	0.81	0.154
SIERRA-VL-08	—	0.27	—	0.26	0.042
SIERRA-VL-09	—	0.10	—	0.07	0.024
SIERRA-VL-10	≤0.012	0.09	—	0.10	—
SIERRA-VL-11	—	0.07	—	—	0.016
SIERRA-VL-12	—	—	—	—	0.117
Comparison site					
SIERRA-XL-01	≤0.013	—	—	—	0.152

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] The HAL-US is 30 mg/L "as ammonia." To facilitate comparison to the analytical results, we have converted and reported this HAL-US as 24.7 mg/L "as nitrogen."

[3] The study reporting level (SRL) of 0.014 mg/L for ammonia was defined on the basis of the highest and only concentration detected in the eight field blanks collected for this study. Values below the SRL are reported as less than or equal to (≤) the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is ≤ reported value, based on quallity-control data collected for this study.

[4] LRL for samples collected before 10/01/08, LRL for samples collected 10/01/08 and thereafter.

[5] The agreement between the sum of nitrogen species concentrations (ammonia and nitrate plus nitrite) and the total nitrogen concentrations is acceptable for all samples.

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA; California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; na, not available; mg/L, milligrams per liter; —, not detected; *, value above recommended benchmark level; **, value above upper benchmark level]

GAMA identification number	Calcium, (mg/L) (00915)	Magnesium, (mg/L) (00925)	Potassium, (mg/L) (00935)	Sodium, (mg/L) (00930)	Bicarbonate [1] (mg/L)	Carbonate [1] (mg/L)	Bromide, (mg/L) (71870)	Chloride, (mg/L) (00940)	Fluoride, (mg/L) (00950)	Iodide, (mg/L) (71865)	Silica, (mg/L) (00955)	Sulfate, (mg/L) (00945)	Total dissolved solids (TDS), (mg/L) (70300)
Benchmark type [2]	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**SMCL-CA**	**MCL-CA**	**na**	**na**	**SMCL-CA**	**SMCL-CA**
Benchmark level	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**[3] 250 (500)**	**2**	**na**	**na**	**[3] 250 (500)**	**[3] 500 (1,000)**
[LRL]	**[4] [0.04, 0.02]**	**[4] [0.02, 0.012]**	**[4] [0.02, 0.06]**	**[0.12]**	**[1]**	**[1]**	**[0.02]**	**[0.12]**	**[4] [0.12, 0.08]**	**[0.002]**	**[4] [0.018, 0.02]**	**[0.18]**	**[10]**
						Primary grid wells							
SIERRA-G-01	26.1	11.0	5.84	16.9	168	1	0.04	6.95	0.57	0.006	23.5	11.2	175
SIERRA-G-02	36.5	4.12	1.43	6.89	146	—	—	1.95	E0.10	—	31.5	5.46	164
SIERRA-G-03	16.1	3.45	2.65	30.5	123	—	0.04	12.3	0.61	E0.001	42.5	5.21	183
SIERRA-G-04	3.75	0.493	0.83	3.15	23	—	—	0.81	—	—	18.4	0.44	42
SIERRA-G-05	31.0	8.12	4.11	23.4	159	—	0.06	11.7	0.17	0.002	56.4	10.7	254
SIERRA-G-06	18.0	0.474	0.89	51.1	118	—	0.08	45.4	0.62	0.009	25.0	5.43	204
SIERRA-G-07	24.9	5.81	3.19	14.0	140	—	E0.02	5.08	E0.09	0.003	46.7	2.59	174
SIERRA-G-08	25.1	3.84	2.84	28.0	57	—	0.03	63.6	—	0.006	30.9	3.57	266
SIERRA-G-09	4.00	0.592	1.05	3.25	27	—	—	0.38	—	—	23.2	0.43	45
SIERRA-G-10	12.8	3.73	2.24	4.17	73	—	—	0.92	—	—	17.9	1.32	86
SIERRA-G-11	11.1	3.88	1.66	5.58	72	—	—	0.82	—	—	50.0	0.20	88
SIERRA-G-12	32.8	7.46	2.63	9.64	160	—	—	1.79	E0.07	—	40.3	6.83	184
SIERRA-G-13	12.4	3.70	3.01	9.92	74	—	E0.02	2.52	E0.08	—	49.7	1.65	139
SIERRA-G-14	9.09	1.02	1.50	6.12	52	—	—	0.47	—	—	22.6	0.40	71
SIERRA-G-15	1.91	0.044	0.82	173	231	17	0.24	89.9	*2.01	0.231	15.2	42.9	486
SIERRA-G-16	6.76	0.523	0.72	2.33	27	—	—	1.41	0.14	—	8.6	2.60	35
SIERRA-G-17	8.25	0.503	1.02	3.25	28	1	0.04	0.16	E0.07	—	14.3	8.24	48
SIERRA-G-18	4.09	0.183	0.40	1.04	19	—	—	E0.12	—	—	7.88	0.33	25

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA; California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; na, not available; mg/L, milligrams per liter; —, not detected; *, value above recommended benchmark level; **, value above upper benchmark level]

GAMA identification number	Calcium, (mg/L) (00915)	Magnesium, (mg/L) (00925)	Potassium, (mg/L) (00935)	Sodium, (mg/L) (00930)	Bicarbonate [1] (mg/L)	Carbonate [1] (mg/L)	Bromide, (mg/L) (71870)	Chloride, (mg/L) (00940)	Fluoride, (mg/L) (00950)	Iodide, (mg/L) (71865)	Silica, (mg/L) (00955)	Sulfate, (mg/L) (00945)	Total dissolved solids (TDS), (mg/L) (70300)
Benchmark type [2]	na	na	na	na	na	na	na	SMCL-CA	MCL-CA	na	na	SMCL-CA	SMCL-CA
Benchmark level	na	na	na	na	na	na	na	[3] 250 (500)	2	na	na	[3] 250 (500)	[3] 500 (1,000)
[LRL]	[4] [0.04, 0.02]	[4] [0.02, 0.012]	[4] [0.02, 0.06]	[0.12]	[1]	[1]	[0.02]	[0.12]	[4] [0.12, 0.08]	[0.002]	[4] [0.018, 0.02]	[0.18]	[10]
SIERRA-M-01	29.5	6.91	1.49	44.6	126	—	0.12	41.3	0.64	0.105	21.4	37.8	254
SIERRA-M-02	62.6	17.1	3.22	20.5	217	—	0.07	23.6	0.3	0.03	44.5	57.2	356
SIERRA-M-03	26.2	10.7	0.36	14.5	168	—	—	0.57	E0.08	—	23.6	5.53	159
SIERRA-M-04	24.8	1.64	0.38	1.57	91	—	—	0.17	—	—	8.27	1.68	104
SIERRA-M-05	22.5	6.70	1.70	8.98	122	—	—	0.64	0.14	—	32.8	4.56	135
SIERRA-M-06	10.2	2.71	0.09	2.50	54	—	—	0.82	—	—	17.8	0.46	54
SIERRA-S-01	99.2	16.9	2.79	56.1	316	—	0.16	32.1	0.64	0.002	28.8	111	*559
SIERRA-S-02	15.1	0.902	2.03	17.0	73	2	E0.01	11.6	E0.11	E0.001	24.2	3.07	102
SIERRA-S-03	22.6	6.05	2.55	20.5	123	—	E0.01	9.04	—	E0.001	47.6	14.7	180
SIERRA-V-01	14.7	4.95	3.02	4.31	90	—	—	0.21	—	—	36.0	0.20	115
SIERRA-V-02	19.3	9.48	1.67	7.06	126	—	E0.01	1.85	—	—	62.7	1.16	164
SIERRA-V-03	4.95	5.30	2.49	8.44	63	—	E0.01	3.15	0.18	0.003	33.6	0.83	80
Lithologic grid wells													
SIERRA-GL-01	28.7	6.29	3.71	23.1	151	—	0.04	7.71	0.25	—	42.7	6.92	212
SIERRA-GL-02	26.9	14.4	1.62	12.0	150	—	0.03	11.4	0.17	0.002	47.9	9.34	217
SIERRA-GL-03	5.84	0.093	0.20	1.34	23	—	—	0.21	—	—	6.94	0.56	33
SIERRA-GL-04	4.67	0.982	1.64	2.27	30	—	—	0.26	—	—	16.3	0.52	36
SIERRA-GL-05	11.2	2.35	2.33	6.08	65	—	—	0.44	—	—	31.4	1.95	86
SIERRA-GL-06	5.52	0.883	0.33	4.19	35	—	—	0.24	—	—	22.3	—	57
SIERRA-GL-07	37.2	17.0	1.01	11.3	185	—	0.02	13.1	E0.10	E0.002	57.1	11.0	258

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA; California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; na, not available; mg/L, milligrams per liter; —, not detected; *, value above recommended benchmark level; **, value above upper benchmark level]

GAMA identification number	Calcium, (mg/L) (00915)	Magnesium, (mg/L) (00925)	Potassium, (mg/L) (00935)	Sodium, (mg/L) (00930)	Bicarbonate [1] (mg/L)	Carbonate [1] (mg/L)	Bromide, (mg/L) (71870)	Chloride, (mg/L) (00940)	Fluoride, (mg/L) (00950)	Iodide, (mg/L) (71865)	Silica, (mg/L) (00955)	Sulfate, (mg/L) (00945)	Total dissolved solids (TDS), (mg/L) (70300)
Benchmark type [2]	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**SMCL-CA**	**MCL-CA**	**na**	**na**	**SMCL-CA**	**SMCL-CA**
Benchmark level	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**[3] 250 (500)**	**2**	**na**	**na**	**[3] 250 (500)**	**[3] 500 (1,000)**
[LRL]	**[4] [0.04, 0.02]**	**[4] [0.02, 0.012]**	**[4] [0.02, 0.06]**	**[0.12]**	**[1]**	**[1]**	**[0.02]**	**[0.12]**	**[4] [0.12, 0.08]**	**[0.002]**	**[4] [0.018, 0.02]**	**[0.18]**	**[10]**
SIERRA-GL-08	5.84	1.12	1.20	4.34	37	—	—	1.54	—	—	24.5	E0.14	63
SIERRA-GL-09	3.21	0.288	0.53	7.80	31	—	—	1.55	—	—	40.0	E0.16	75
SIERRA-GL-10	26.4	9.60	4.75	7.45	152	—	—	2.62	E0.04	—	23.6	2.74	150
SIERRA-ML-01	87.6	27.6	3.33	108	338	—	0.18	25.7	0.64	0.003	27.6	*256	*722
SIERRA-ML-02	43.0	7.79	1.52	22.7	180	—	0.05	10.8	0.48	—	37.4	29.0	252
SIERRA-ML-03	62.9	16.2	5.80	23.7	253	—	0.04	15.7	0.21	0.003	31.2	42.5	350
SIERRA-ML-04	52.3	7.36	3.98	16.0	219	—	E0.01	4.82	0.30	E0.001	31.0	18.8	251
SIERRA-ML-05	23.4	4.57	3.12	11.2	117	—	E0.01	6.99	E0.07	—	46.6	3.00	162
SIERRA-ML-06	88.2	7.06	3.56	16.0	283	—	0.05	18.3	0.17	E0.001	40.3	20.1	398
SIERRA-ML-07	54.9	4.86	2.32	9.88	206	1	—	1.73	0.12	—	37.8	11.9	232
SIERRA-ML-08	121	11.2	0.47	23.1	378	—	0.05	15.5	0.27	0.012	24.9	67.1	469
SIERRA-ML-09	25.7	7.16	1.48	7.91	135	—	—	1.71	0.16	—	60.0	3.20	176
SIERRA-ML-10	70.8	16.1	0.47	11.9	276	—	0.04	12.2	E0.11	0.004	19.9	27.8	319
SIERRA-ML-11	31.3	1.84	0.94	1.95	109	—	—	0.26	—	—	21.8	3.90	132
SIERRA-ML-12	40.0	5.18	2.31	8.33	149	—	0.02	2.40	0.19	0.002	42.3	22.6	216
SIERRA-ML-13	99.5	5.06	1.11	5.78	352	—	0.03	8.87	E0.08	0.010	20.6	4.42	323
SIERRA-ML-14	8.10	0.406	0.81	1.75	30	—	—	0.21	—	—	10.9	3.70	37
SIERRA-ML-15	11.3	2.97	0.96	10.0	74	—	—	3.15	—	E0.001	10.8	3.21	92
SIERRA-ML-16	27.9	2.28	2.43	9.40	103	—	—	0.34	0.63	E0.001	47.6	18.3	153
SIERRA-ML-17	21.8	10.2	0.99	9.88	89	—	0.05	6.67	0.15	0.003	55.6	27.3	193
SIERRA-ML-18	21.8	5.56	0.63	9.24	107	—	E0.01	3.14	0.16	—	27.8	4.82	133

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA; California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; na, not available; mg/L, milligrams per liter; —, not detected; *, value above recommended benchmark level; **, value above upper benchmark level]

GAMA identification number	Calcium, (mg/L) (00915)	Magnesium, (mg/L) (00925)	Potassium, (mg/L) (00935)	Sodium, (mg/L) (00930)	Bicarbonate [1] (mg/L)	Carbonate [1] (mg/L)	Bromide, (mg/L) (71870)	Chloride, (mg/L) (00940)	Fluoride, (mg/L) (00950)	Iodide, (mg/L) (71865)	Silica, (mg/L) (00955)	Sulfate, (mg/L) (00945)	Total dissolved solids (TDS), (mg/L) (70300)
Benchmark type [2]	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**SMCL-CA**	**MCL-CA**	**na**	**na**	**SMCL-CA**	**SMCL-CA**
Benchmark level	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**[3] 250 (500)**	**2**	**na**	**na**	**[3] 250 (500)**	**[3] 500 (1,000)**
[LRL]	**[4] [0.04, 0.02]**	**[4] [0.02, 0.012]**	**[4] [0.02, 0.06]**	**[0.12]**	**[1]**	**[1]**	**[0.02]**	**[0.12]**	**[4] [0.12, 0.08]**	**[0.002]**	**[4] [0.018, 0.02]**	**[0.18]**	**[10]**
SIERRA-SL-01	63.4	8.17	1.14	21.3	250	1	0.05	7.60	0.14	—	22.6	20.8	293
SIERRA-SL-02	54.8	10.8	6.05	32.4	306	—	0.03	11.4	0.38	0.037	33.3	9.27	323
SIERRA-SL-03	67.8	12.5	6.35	46.6	254	—	0.10	32.6	0.19	0.007	34.2	39.5	424
SIERRA-SL-04	4.43	1.26	6.59	252	398	15	0.26	47.4	1.18	0.025	52.8	187	*784
SIERRA-SL-05	14.6	1.89	1.08	6.31	68	—	—	1.74	—	—	18.8	2.88	78
SIERRA-SL-06	13.4	4.93	1.49	9.45	95	—	—	0.56	E0.09	—	42.6	0.81	124
SIERRA-SL-07	3.56	0.562	1.90	3.17	24	—	—	1.17	—	E0.001	15.0	0.74	38
SIERRA-SL-08	7.56	7.80	0.24	7.07	78	—	E0.01	0.79	E0.06	—	25.5	2.97	93
SIERRA-SL-09	22.0	9.64	3.92	7.22	139	—	—	0.44	—	—	39.1	E0.12	161
SIERRA-SL-10	3.90	0.63	0.58	3.98	29	—	—	0.22	—	—	22.5	0.31	41
SIERRA-SL-11	19.6	2.91	1.82	8.69	89	—	E0.01	0.96	0.19	—	19.8	7.84	109
SIERRA-SL-12	31.6	17.5	1.94	14.3	209	—	0.02	3.75	E0.06	0.004	58.9	6.53	221
SIERRA-SL-13	2.34	0.222	0.49	1.87	16	—	—	0.15	—	—	15.8	0.19	—
SIERRA-VL-01	88.4	23.4	5.39	103	444	1	0.21	50.8	0.81	0.005	31.2	88.5	*676
SIERRA-VL-02	19.1	13.2	4.42	6.75	149	—	—	0.99	—	—	60.0	0.44	175
SIERRA-VL-03	21.3	12.1	5.41	77.6	324	2	0.02	8.16	0.20	0.002	22.1	9.75	336
SIERRA-VL-04	16.0	6.19	3.12	9.29	100	—	E0.02	2.33	0.13	—	81.2	7.52	187
SIERRA-VL-05	22.4	13.1	4.21	7.47	157	—	—	1.43	E0.10	—	52.9	7.45	192
SIERRA-VL-06	9.33	7.30	4.66	54.9	190	1	0.02	6.2	0.19	0.012	43.5	12.1	217

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA; California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; na, not available; mg/L, milligrams per liter; —, not detected; *, value above recommended benchmark level; **, value above upper benchmark level]

GAMA identification number	Calcium, (mg/L) (00915)	Magnesium, (mg/L) (00925)	Potassium, (mg/L) (00935)	Sodium, (mg/L) (00930)	Bicarbonate [1] (mg/L)	Carbonate [1] (mg/L)	Bromide, (mg/L) (71870)	Chloride, (mg/L) (00940)	Fluoride, (mg/L) (00950)	Iodide, (mg/L) (71865)	Silica, (mg/L) (00955)	Sulfate, (mg/L) (00945)	Total dissolved solids (TDS), (mg/L) (70300)
Benchmark type [2]	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**SMCL-CA**	**MCL-CA**	**na**	**na**	**SMCL-CA**	**SMCL-CA**
Benchmark level	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**[3] 250 (500)**	**2**	**na**	**na**	**[3] 250 (500)**	**[3] 500 (1,000)**
[LRL]	**[4] [0.04, 0.02]**	**[4] [0.02, 0.012]**	**[4] [0.02, 0.06]**	**[0.12]**	**[1]**	**[1]**	**[0.02]**	**[0.12]**	**[4] [0.12, 0.08]**	**[0.002]**	**[4] [0.018, 0.02]**	**[0.18]**	**[10]**
SIERRA-VL-07	28.4	6.34	1.92	5.94	116	—	—	14.2	—	E0.002	22.6	4.18	149
SIERRA-VL-08	14.8	9.35	2.51	5.86	114	—	—	0.56	—	—	37.0	0.18	129
SIERRA-VL-09	17.0	6.46	2.78	5.54	107	—	—	0.36	—	—	37.7	0.26	135
SIERRA-VL-10	1.53	0.49	0.30	1.20	12	—	—	0.5	—	—	13.1	—	23
SIERRA-VL-11	16.3	4.32	1.41	9.31	90	—	—	1.45	E0.05	—	43.4	6.17	120
SIERRA-VL-12	26.3	10.4	2.34	7.18	143	—	—	1.05	0.12	E0.001	43.4	8.36	174
Comparison site													
SIERRA-XL-01	44.6	25.3	20.1	453	1,032	—	—	*251	*2.50	0.358	69.4	30.2	**1,430

[1] Bicarbonate and carbonate concentrations were calculated from the laboratory alkalinity and pH values (table 4) using the advanced speciation method (http://or.water.usgs.gov/alk/methods.html) with constants determined from the equilibrium chemistry of the carbonate species as described by Stumm and Morgan (1996).

[2] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[3] The SMCL-CA for chloride, sulfate, and total dissolved solids have recommended and upper benchmark levels. The upper value is shown in parentheses.

[4] LRL for samples collected before 10/01/08, LRL for samples collected 10/01/08 and thereafter.

Table 10. Trace elements detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the study reporting limit or less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level; ≤, less than or equal to]

GAMA identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type [1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**MCL-US**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**AL-US**	**SMCL-CA**	**AL-US**
Benchmark level	**1,000**	**6**	**10**	**1,000**	**4**	**1,000**	**5**	**50**	**na**	**1,300**	**300**	**15**
[LRL] or [SRL]	**[2] [1.6]**	**[3] [0.14, 0.04]**	**[0.06]**	**[2] [0.36]**	**[3] [0.008, 0.02]**	**[6, 4]**	**[3] [0.04, 0.02]**	**[2] [0.42]**	**[0.02]**	**[2] [1.7]**	**[2] [6]**	**[2] [0.65]**
						Primary grid wells						
SIERRA-G-01	≤1.4	—	0.26	22	—	24	0.05	—	E0.02	2.4	—	2.26
SIERRA-G-02	—	—	0.11	38	—	10	E0.02	≤0.08	E0.02	≤1.2	10	≤0.06
SIERRA-G-03	—	—	4.3	10	—	128	0.05	—	E0.02	≤1.2	9	—
SIERRA-G-04	1.7	—	—	7	0.02	E4	—	—	—	13.4	—	2.80
SIERRA-G-05	—	—	0.95	99	—	20	—	—	0.08	3.0	—	≤0.30
SIERRA-G-06	—	—	2.5	0.6	E0.01	183	E0.03	≤0.07	—	≤0.98	≤6	1.33
SIERRA-G-07	—	—	0.63	9	—	E4	E0.03	—	0.02	≤1.1	48	3.11
SIERRA-G-08	—	—	E0.03	122	E0.01	11	—	—	0.03	2.4	9	2.25
SIERRA-G-09	—	—	E0.04	7	0.02	—	—	—	—	≤0.60	—	0.77
SIERRA-G-10	2.2	—	0.09	9	—	6	—	≤0.12	E0.01	≤0.75	E7	≤0.42
SIERRA-G-11	—	—	0.26	19	—	—	—	≤0.17	—	5.0	—	0.98
SIERRA-G-12	—	—	0.24	5	E0.01	—	—	≤0.11	0.02	≤1.5	—	≤0.44
SIERRA-G-13	—	—	0.17	53	—	—	—	≤0.21	—	2.5	—	≤0.44
SIERRA-G-14	—	—	0.59	23	—	26	—	≤0.18	0.04	≤0.71	≤5	≤0.23
SIERRA-G-15	4.6	—	1.5	4	0.03	*8,450	—	—	0.03	—	—	≤0.07
SIERRA-G-16	≤1.5	—	0.32	1	E0.01	15	—	—	E0.01	≤0.80	11	≤0.38
SIERRA-G-17	2.2	—	7.2	≤0.3	—	E5	—	≤0.39	—	—	—	≤0.17
SIERRA-G-18	2.1	—	0.09	—	—	—	—	—	—	≤0.72	—	≤0.26
SIERRA-M-01	—	—	0.61	11	E0.01	449	—	—	E0.02	—	≤5	0.97
SIERRA-M-02	—	—	0.71	36	0.01	67	—	—	0.33	—	*539	5.84

Table 10. Trace elements detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the study reporting limit or less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level; ≤, less than or equal to]

GAMA identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type [1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**MCL-US**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**AL-US**	**SMCL-CA**	**AL-US**
Benchmark level	**1,000**	**6**	**10**	**1,000**	**4**	**1,000**	**5**	**50**	**na**	**1,300**	**300**	**15**
[LRL] or [SRL]	**[2] [1.6]**	**[3] [0.14, 0.04]**	**[0.06]**	**[2] [0.36]**	**[3] [0.008, 0.02]**	**[6, 4]**	**[3] [0.04, 0.02]**	**[2] [0.42]**	**[0.02]**	**[2] [1.7]**	**[2] [6]**	**[2] [0.65]**
SIERRA-M-03	—	—	0.52	41	—	—	—	≤0.19	E0.02	—	28	—
SIERRA-M-04	2.8	—	0.20	10	—	—	—	≤0.39	0.02	≤0.62	≤5	≤0.16
SIERRA-M-05	—	—	1.1	64	0.03	10	0.02	—	0.04	—	*1,030	—
SIERRA-M-06	—	—	1.1	0.6	—	—	—	≤0.20	—	5.6	≤3	1.09
SIERRA-S-01	—	—	0.85	163	—	263	E0.02	1.1	0.06	≤0.62	—	≤0.09
SIERRA-S-02	9.3	E0.11	7.0	3	—	41	—	≤0.28	—	—	—	≤0.18
SIERRA-S-03	—	0.12	3.1	84	—	40	E0.01	—	E0.01	2.1	≤4	≤0.32
SIERRA-V-01	—	—	0.09	38	—	E4	—	≤0.28	—	≤0.71	—	≤0.31
SIERRA-V-02	—	E0.02	0.63	9	—	43	—	0.76	—	—	≤3	≤0.05
SIERRA-V-03	—	—	*15.8	2	—	49	—	—	0.30	≤1.1	—	0.66
Lithologic grid wells												
SIERRA-GL-01	≤1.4	—	*13.8	15	—	11	—	—	0.02	≤1.3	E7	≤0.38
SIERRA-GL-02	—	E0.07	1.5	6	—	35	—	≤0.23	E0.01	2.4	—	≤0.28
SIERRA-GL-03	14.8	E0.08	0.37	—	—	—	0.04	—	—	—	—	—
SIERRA-GL-04	≤1.6	—	0.08	2	—	—	—	≤0.19	E0.01	—	—	—
SIERRA-GL-05	—	—	—	7	—	—	—	≤0.39	E0.01	≤1.1	—	≤0.58
SIERRA-GL-06	—	—	—	—	—	—	—	—	—	—	—	—
SIERRA-GL-07	≤1.2	—	0.25	9	—	—	—	0.71	0.03	4.1	—	≤0.12
SIERRA-GL-08	—	—	E0.03	13	—	—	—	0.63	E0.01	2.0	—	0.80
SIERRA-GL-09	—	—	E0.04	16	0.06	E2	—	—	—	2.6	≤5	2.32
SIERRA-GL-10	—	0.21	0.43	9	—	E2	0.07	—	0.03	≤0.52	17	≤0.14

Table 10. Trace elements detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the study reporting limit or less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level; ≤, less than or equal to]

GAMA identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type [1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**MCL-US**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**AL-US**	**SMCL-CA**	**AL-US**
Benchmark level	**1,000**	**6**	**10**	**1,000**	**4**	**1,000**	**5**	**50**	**na**	**1,300**	**300**	**15**
[LRL] or [SRL]	**[2] [1.6]**	**[3] [0.14, 0.04]**	**[0.06]**	**[2] [0.36]**	**[3] [0.008, 0.02]**	**[6, 4]**	**[3] [0.04, 0.02]**	**[2] [0.42]**	**[0.02]**	**[2] [1.7]**	**[2] [6]**	**[2] [0.65]**
SIERRA-ML-01	—	0.73	8.2	36	—	721	—	0.82	0.05	≤0.60	≤5	≤0.18
SIERRA-ML-02	≤1.0	E0.07	8.3	22	—	16	—	≤0.15	0.02	3.2	—	1.68
SIERRA-ML-03	1.7	—	5.6	1	—	46	E0.03	—	0.05	≤1.6	—	≤0.12
SIERRA-ML-04	—	0.31	2.7	63	0.01	76	—	—	0.03	≤1.3	—	≤0.06
SIERRA-ML-05	≤0.8	—	0.28	278	—	E4	E0.03	—	—	≤0.88	10	≤0.26
SIERRA-ML-06	—	—	2.9	254	—	17	—	≤0.16	0.09	3.1	—	0.78
SIERRA-ML-07	—	0.17	3.2	38	—	32	—	≤0.41	E0.02	—	—	≤0.43
SIERRA-ML-08	—	0.32	0.42	23	—	26	0.12	—	0.18	3.5	—	1.47
SIERRA-ML-09	—	—	0.64	24	—	—	E0.02	9.3	—	≤0.84	—	≤0.09
SIERRA-ML-10	—	3.49	9.0	26	—	22	—	≤0.07	0.04	1.9	—	2.08
SIERRA-ML-11	—	E0.11	4.4	0.6	—	8	E0.02	≤0.28	E0.01	—	—	1.50
SIERRA-ML-12	—	—	0.22	30	0.03	—	—	—	0.05	—	*2,240	—
SIERRA-ML-13	—	—	0.20	38	—	12	0.05	≤0.12	0.10	2.7	79	0.80
SIERRA-ML-14	2.1	0.22	3.7	≤0.3	—	—	—	≤0.17	—	≤0.99	—	≤0.29
SIERRA-ML-15	3.9	—	0.15	14	—	51	—	—	—	≤1.3	—	≤0.36
SIERRA-ML-16	—	—	6.1	52	E0.01	32	—	—	0.03	—	*971	—
SIERRA-ML-17	—	0.10	1.7	1	—	11	0.04	—	0.04	4.9	14	1.30
SIERRA-ML-18	—	—	—	98	—	50	—	≤0.24	—	1.7	9	≤0.18
SIERRA-SL-01	—	—	0.49	55	—	12	—	1.8	0.04	≤1.0	—	≤0.19
SIERRA-SL-02	—	—	*14.5	56	0.01	217	0.05	≤0.09	0.28	—	*3,470	≤0.54
SIERRA-SL-03	—	—	6.2	2	—	86	E0.03	≤0.34	0.04	1.8	—	≤0.51
SIERRA-SL-04	≤1.2	—	E0.03	5	—	939	—	—	E0.01	—	—	—

Table 10. Trace elements detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the study reporting limit or less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level; ≤, less than or equal to]

GAMA identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type [1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**MCL-US**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**AL-US**	**SMCL-CA**	**AL-US**
Benchmark level	**1,000**	**6**	**10**	**1,000**	**4**	**1,000**	**5**	**50**	**na**	**1,300**	**300**	**15**
[LRL] or [SRL]	**[2] [1.6]**	**[3] [0.14, 0.04]**	**[0.06]**	**[2] [0.36]**	**[3] [0.008, 0.02]**	**[6, 4]**	**[3] [0.04, 0.02]**	**[2] [0.42]**	**[0.02]**	**[2] [1.7]**	**[2] [6]**	**[2] [0.65]**
SIERRA-SL-05	—	—	0.39	16	—	22	—	—	—	—	—	—
SIERRA-SL-06	2.0	—	0.11	31	—	—	—	1.2	—	—	—	≤0.39
SIERRA-SL-07	≤1.6	—	2.2	E0.6	—	E5	—	≤0.09	—	—	—	—
SIERRA-SL-08	—	—	0.09	7	—	—	—	≤0.19	—	≤0.77	33	1.35
SIERRA-SL-09	2.8	—	0.29	56	—	E5	—	≤0.21	—	4.6	—	2.81
SIERRA-SL-10	—	—	E0.03	2	—	—	—	≤0.10	—	—	—	≤0.08
SIERRA-SL-11	—	—	0.33	46	—	10	—	≤0.14	E0.01	≤1.4	—	≤0.32
SIERRA-SL-12	—	—	9.2	231	—	28	—	—	E0.01	—	*592	≤0.07
SIERRA-SL-13	E3.8	—	—	3	0.02	—	E0.01	—	—	≤0.98	—	5.62
SIERRA-VL-01	—	0.18	4.5	161	E0.01	*1,090	E0.03	≤0.19	0.13	5.9	9	≤0.61
SIERRA-VL-02	—	—	0.38	26	—	7	—	≤0.19	—	1.7	E7	0.88
SIERRA-VL-03	—	0.17	*11.8	390	—	88	—	—	0.03	—	66	≤0.09
SIERRA-VL-04	—	—	1.9	35	E0.01	6	—	1.8	—	≤0.65	—	≤0.19
SIERRA-VL-05	—	—	3.3	12	—	11	E0.03	≤0.20	E0.02	5.0	≤5	≤0.53
SIERRA-VL-06	≤0.9	—	*34.7	51	—	368	—	—	E0.02	—	106	—
SIERRA-VL-07	3.4	—	0.69	35	—	7	—	—	0.08	—	*378	≤0.06
SIERRA-VL-08	—	—	0.09	8	—	E3	—	0.77	—	≤1.2	—	≤0.54
SIERRA-VL-09	16.9	—	0.37	38	—	E5	—	≤0.20	E0.01	2.6	—	3.81
SIERRA-VL-10	9.1	—	—	29	0.02	—	—	—	0.05	1.9	—	4.32
SIERRA-VL-11	—	—	E0.05	73	—	—	E0.01	≤0.15	0.39	8.0	205	≤0.18
SIERRA-VL-12	—	E0.03	4.5	59	—	140	—	—	E0.01	1.8	17	≤0.47
Comparison site												
SIERRA-XL-01	37.3	—	*169	19	1.3	*5,650	0.10	1.1	3.5	—	E15	—

Table 10. Trace elements detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the study reporting limit or less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level; ≤, less than or equal to]

GAMA identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type [1]	**na**	**SMCL-CA**	**MCL-US**	**HAL-US**	**MCL-CA**	**MCL-US**	**SMCL-CA**	**HAL-US**	**MCL-US**	**na**	**MCL-US**	**NL-CA**	**SMCL-CA**
Benchmark level	**na**	**50**	**2**	**40**	**100**	**50**	**100**	**4,000**	**2**	**na**	**30**	**50**	**5,000**
[LRL] or [SRL]	**[1]**	**[2] [0.2]**	**[2] [0.012]**	**[3] [0.2, 0.02]**	**[2] [0.36]**	**[3] [0.04, 0.06]**	**[4] [1.08]**	**[0.8]**	**[0.04]**	**[2] [0.11]**	**[3] [0.02, 0.006]**	**[2] [0.1]**	**[2] [4.8]**
Primary grid wells													
SIERRA-G-01	31.1	3.5	—	17.3	≤0.25	0.05	—	51.3	—	0.29	0.09	0.46	9.3
SIERRA-G-02	5.1	—	—	0.40	≤0.22	0.10	—	310	—	≤0.11	0.99	0.70	25.9
SIERRA-G-03	36.3	2.4	—	24.4	≤0.22	0.16	—	110	—	13.4	8.12	8.4	17.4
SIERRA-G-04	E0.5	0.6	—	—	1.6	—	—	52.9	—	—	—	0.28	7.0
SIERRA-G-05	11.6	≤0.2	—	2.2	≤0.23	0.15	—	199	—	—	12.2	15	20.4
SIERRA-G-06	84.0	0.6	—	19.6	2.1	0.09	—	19.7	—	17.2	3.81	1.6	40.4
SIERRA-G-07	42.0	4.2	≤0.005	0.40	≤0.13	0.07	—	183	—	—	9.83	5.2	68.0
SIERRA-G-08	8.2	1.3	≤0.007	—	≤0.15	—	—	306	—	—	0.50	0.60	≤1.3
SIERRA-G-09	E0.7	0.7	≤0.008	—	≤0.29	—	—	50.5	—	—	0.05	0.32	51.4
SIERRA-G-10	10.8	0.3	—	—	0.59	—	—	155	—	—	2.12	0.32	50.2
SIERRA-G-11	3.8	—	—	2.6	—	—	—	119	—	0.27	1.45	2.2	5.9
SIERRA-G-12	5.0	≤0.1	—	0.40	0.42	0.42	—	106	—	—	1.07	3.8	16.9
SIERRA-G-13	8.9	≤0.2	—	0.60	0.82	0.32	—	142	—	—	0.38	6.1	32.9
SIERRA-G-14	4.4	0.4	—	3.3	≤0.16	E0.02	—	72.9	—	2.9	3.87	0.85	8.4
SIERRA-G-15	51.1	0.4	—	6.2	0.72	E0.03	—	36.1	—	74	0.16	0.12	—
SIERRA-G-16	2.2	0.5	—	3.6	≤0.12	E0.02	—	45.9	—	0.47	5.26	0.51	90.3
SIERRA-G-17	E0.9	—	—	4.3	—	0.64	—	19.8	—	3.1	3.33	5.8	—
SIERRA-G-18	—	—	—	E0.10	—	—	—	9.47	E0.02	≤0.10	15.6	0.48	≤2.8
SIERRA-M-01	2.6	4.7	≤0.005	2.7	≤0.16	0.25	—	346	—	17.3	0.05	0.20	30.7
SIERRA-M-02	9.1	*593	—	1.8	0.53	—	—	599	—	0.33	0.13	≤0.05	≤2.2

Table 10. Trace elements detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the study reporting limit or less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level; ≤, less than or equal to]

GAMA identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type [1]	**na**	**SMCL-CA**	**MCL-US**	**HAL-US**	**MCL-CA**	**MCL-US**	**SMCL-CA**	**HAL-US**	**MCL-US**	**na**	**MCL-US**	**NL-CA**	**SMCL-CA**
Benchmark level	**na**	**50**	**2**	**40**	**100**	**50**	**100**	**4,000**	**2**	**na**	**30**	**50**	**5,000**
[LRL] or [SRL]	**[1]**	**[2] [0.2]**	**[2] [0.012]**	**[3] [0.2, 0.02]**	**[2] [0.36]**	**[3] [0.04, 0.06]**	**[4] [1.08]**	**[0.8]**	**[0.04]**	**[2] [0.11]**	**[3] [0.02, 0.006]**	**[2] [0.1]**	**[2] [4.8]**
SIERRA-M-03	—	1.1	—	0.20	≤0.11	0.12	—	82.8	—	—	0.13	4.3	≤4.6
SIERRA-M-04	—	0.5	—	—	≤0.14	0.05	—	45.3	—	—	0.09	0.31	56.5
SIERRA-M-05	7.7	*306	—	3.0	≤0.30	—	—	233	—	≤0.03	0.01	—	319
SIERRA-M-06	E0.5	—	—	E0.02	0.47	—	—	26.9	—	≤0.05	—	0.40	≤2.7
SIERRA-S-01	11.8	≤0.1	—	6.2	0.65	0.86	—	707	—	0.17	*45.1	4.0	≤1.1
SIERRA-S-02	6.5	—	≤0.006	2.9	—	E0.03	—	54.3	—	3.4	14.9	1.8	—
SIERRA-S-03	7.2	0.6	—	5.5	≤0.11	0.10	—	230	—	3.4	17.3	4.3	5.0
SIERRA-V-01	1.3	—	—	—	≤0.11	—	—	145	—	—	0.24	1.0	≤1.5
SIERRA-V-02	1.9	—	—	0.10	0.38	E0.04	—	133	—	≤0.02	0.11	14.5	≤1.6
SIERRA-V-03	30.7	0.7	—	0.80	0.47	—	—	83.8	—	0.23	0.16	2.1	14.2
Lithologic grid wells													
SIERRA-GL-01	26.4	≤0.1	—	0.90	≤0.19	0.09	—	258	—	—	3.71	7.0	14.6
SIERRA-GL-02	4.7	0.4	—	5.2	≤0.21	E0.04	—	129	—	0.65	3.17	5.3	≤2.8
SIERRA-GL-03	1.2	—	—	26.1	—	0.04	—	17.1	—	5.2	12.8	0.73	≤2.5
SIERRA-GL-04	—	≤0.2	—	E0.20	—	—	—	26.1	—	—	1.11	1.3	≤0.97
SIERRA-GL-05	E0.8	≤0.2	—	1.9	≤0.18	E0.03	—	93.7	—	—	0.42	1.5	≤3.2
SIERRA-GL-06	—	—	—	—	—	—	—	—	—	—	—	—	—
SIERRA-GL-07	1.0	—	—	0.30	0.46	0.08	—	128	—	—	0.44	19.7	≤1.7
SIERRA-GL-08	E0.9	0.9	0.021	E0.02	≤0.28	—	—	102	—	—	0.01	0.68	≤4.0
SIERRA-GL-09	2.4	≤0.2	—	—	—	—	—	85.8	—	—	0.01	0.29	8.1
SIERRA-GL-10	3.3	6.4	0.019	2.1	0.38	0.07	—	106	—	≤0.02	4.35	1.3	625

Table 10. Trace elements detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the study reporting limit or less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level; ≤, less than or equal to]

GAMA identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type [1]	**na**	**SMCL-CA**	**MCL-US**	**HAL-US**	**MCL-CA**	**MCL-US**	**SMCL-CA**	**HAL-US**	**MCL-US**	**na**	**MCL-US**	**NL-CA**	**SMCL-CA**
Benchmark level	**na**	**50**	**2**	**40**	**100**	**50**	**100**	**4,000**	**2**	**na**	**30**	**50**	**5,000**
[LRL] or [SRL]	**[1]**	**[2] [0.2]**	**[2] [0.012]**	**[3] [0.2, 0.02]**	**[2] [0.36]**	**[3] [0.04, 0.06]**	**[4] [1.08]**	**[0.8]**	**[0.04]**	**[2] [0.11]**	**[3] [0.02, 0.006]**	**[2] [0.1]**	**[2] [4.8]**
SIERRA-ML-01	60.3	5.6	—	5.5	0.67	2.3	—	675	—	0.37	13.7	6.2	≤1.6
SIERRA-ML-02	17.6	—	—	1.5	≤0.29	0.10	—	199	—	0.40	2.00	7.2	≤1.4
SIERRA-ML-03	17.7	≤0.2	—	13.2	0.40	3.2	—	109	—	≤0.08	7.24	7.5	40.1
SIERRA-ML-04	14.4	1.9	—	5.0	0.43	0.14	—	186	—	≤0.07	1.85	1.0	≤3.8
SIERRA-ML-05	12.8	0.3	—	1.1	≤0.19	0.08	—	184	—	—	0.30	4.0	≤2.9
SIERRA-ML-06	6.7	—	—	5.2	0.48	0.66	—	544	—	≤0.05	4.97	23.3	8.9
SIERRA-ML-07	11.2	—	—	2.0	≤0.25	0.06	—	212	—	0.66	4.84	4.6	≤1.4
SIERRA-ML-08	8.0	24.6	—	6.3	1.1	*64.3	—	1,030	—	—	0.85	0.73	6.7
SIERRA-ML-09	2.7	—	—	E0.20	1.3	0.61	—	91.3	—	—	0.15	23.8	—
SIERRA-ML-10	1.3	0.8	—	5.3	8.0	3.1	—	495	—	—	8.14	0.83	10.1
SIERRA-ML-11	2.5	—	—	2.0	≤0.12	0.29	—	148	—	0.39	3.75	0.85	—
SIERRA-ML-12	4.1	*172	—	0.40	≤0.19	—	—	187	—	0.56	—	—	—
SIERRA-ML-13	3.0	6.5	—	1.1	1.9	0.22	—	224	0.05	—	0.48	0.41	249
SIERRA-ML-14	—	—	—	0.90	—	0.09	—	16.0	—	≤0.10	0.03	1.0	≤0.97
SIERRA-ML-15	E0.9	—	—	—	≤0.27	0.06	—	97.6	—	—	0.11	≤0.07	≤1.3
SIERRA-ML-16	21.9	*288	—	2.2	0.42	—	—	93.3	—	3.2	0.04	≤0.02	26.1
SIERRA-ML-17	5.3	41.5	≤0.005	1.5	2.9	2.4	—	244	—	—	0.14	1.9	38.6
SIERRA-ML-18	4.7	6.2	—	0.30	0.82	0.47	—	136	—	≤0.10	—	1.2	≤1.6
SIERRA-SL-01	E0.8	≤0.1	—	3.8	0.46	0.50	—	189	—	0.27	1.72	6.6	≤4.0
SIERRA-SL-02	123	*2,130	—	4.1	0.52	—	—	350	—	≤0.11	7.13	0.12	≤4.2
SIERRA-SL-03	16.2	—	—	20.7	≤0.25	0.22	—	122	—	2.2	*59.0	22.4	5.0

Table 10. Trace elements detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the study reporting limit or less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level; ≤, less than or equal to]

GAMA identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type [1]	**na**	**SMCL-CA**	**MCL-US**	**HAL-US**	**MCL-CA**	**MCL-US**	**SMCL-CA**	**HAL-US**	**MCL-US**	**na**	**MCL-US**	**NL-CA**	**SMCL-CA**
Benchmark level	**na**	**50**	**2**	**40**	**100**	**50**	**100**	**4,000**	**2**	**na**	**30**	**50**	**5,000**
[LRL] or [SRL]	**[1]**	**[2] [0.2]**	**[2] [0.012]**	**[3] [0.2, 0.02]**	**[2] [0.36]**	**[3] [0.04, 0.06]**	**[4] [1.08]**	**[0.8]**	**[0.04]**	**[2] [0.11]**	**[3] [0.02, 0.006]**	**[2] [0.1]**	**[2] [4.8]**
SIERRA-SL-04	55.6	1.3	—	6.2	—	E0.04	—	69.9	—	39	E0.02	≤0.07	—
SIERRA-SL-05	10.2	—	≤0.007	0.70	—	—	—	124	—	—	9.88	0.37	—
SIERRA-SL-06	2.4	—	—	0.90	—	E0.03	—	160	—	≤0.08	0.62	2.7	8.8
SIERRA-SL-07	1.4	1.8	—	1.7	—	E0.03	—	26.0	—	4.5	7.45	6.3	≤1.3
SIERRA-SL-08	—	1.0	—	E0.20	0.54	0.36	—	40.4	—	—	—	2.1	6.2
SIERRA-SL-09	1.8	—	—	E0.20	—	—	—	290	—	—	1.65	3.4	6.1
SIERRA-SL-10	E0.8	—	—	0.20	—	E0.03	—	71.5	—	0.26	0.11	0.54	72.5
SIERRA-SL-11	2.8	0.6	—	4.0	≤0.13	0.25	—	94.6	—	0.55	5.77	1.2	≤3.7
SIERRA-SL-12	48.8	*439	—	0.30	0.55	—	—	305	—	≤0.03	—	—	≤3.7
SIERRA-SL-13	—	0.8	—	0.10	≤0.08	—	—	29.6	—	—	0.20	E0.14	≤1.7
SIERRA-VL-01	107	2.1	—	5.0	0.90	0.37	—	833	—	0.88	19.8	3.2	19.9
SIERRA-VL-02	4.2	≤0.1	—	—	—	—	—	228	—	—	0.36	4.7	21.6
SIERRA-VL-03	23.9	15	0.014	2.9	≤0.15	—	—	508	—	0.29	0.26	≤0.05	5.6
SIERRA-VL-04	4.8	0.3	—	0.50	0.62	0.45	—	229	—	—	0.13	9.5	11.8
SIERRA-VL-05	9.5	3.4	≤0.012	21.1	≤0.29	0.05	—	180	—	0.83	1.62	1.7	6.1
SIERRA-VL-06	19.9	*105	≤0.005	5.0	—	—	—	133	—	0.61	E0.02	≤0.04	—
SIERRA-VL-07	2	*281	—	2.8	≤0.2	—	—	148	—	1.1	0.96	≤0.05	5.1
SIERRA-VL-08	—	—	—	E0.10	0.39	E0.03	—	129	—	—	0.41	5.2	—

Table 10. Trace elements detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008. —Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Table 3F contains additional information about the constituents. Samples from all 84 wells were analyzed. Values less than the study reporting limit or less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level; ≤, less than or equal to]

GAMA identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type [1]	**na**	**SMCL-CA**	**MCL-US**	**HAL-US**	**MCL-CA**	**MCL-US**	**SMCL-CA**	**HAL-US**	**MCL-US**	**na**	**MCL-US**	**NL-CA**	**SMCL-CA**
Benchmark level	**na**	**50**	**2**	**40**	**100**	**50**	**100**	**4,000**	**2**	**na**	**30**	**50**	**5,000**
[LRL] or [SRL]	**[1]**	**[2] [0.2]**	**[2] [0.012]**	**[3] [0.2, 0.02]**	**[2] [0.36]**	**[3] [0.04, 0.06]**	**[4] [1.08]**	**[0.8]**	**[0.04]**	**[2] [0.11]**	**[3] [0.02, 0.006]**	**[2] [0.1]**	**[2] [4.8]**
SIERRA-VL-09	1.5	≤0.2	—	—	≤0.14	E0.03	—	257	—	—	0.90	1.6	≤3.5
SIERRA-VL-10	—	2.9	—	—	—	—	≤0.005	24.4	—	—	—	—	≤1.2
SIERRA-VL-11	2.2	16.4	≤0.008	0.40	1.8	0.09	—	104	—	—	0.23	1.6	96.1
SIERRA-VL-12	6.1	39.5	—	0.60	≤0.14	—	—	337	—	≤0.07	0.08	0.18	109
						Comparison site							
SIERRA-XL-01	1,750	*338	—	35.9	9.6	0.06	—	1,530	0.11	≤0.05	19.5	1.5	≤4.4

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] The study reporting level (SRL) is defined based on examinations of GAMA quality-control samples collected May 2004 through January 2008 (Olsen and others, 2010). Values below an SRL are reported as less than or equal to (≤) the value reported by the laboratory. In the USGS National Water Information System (NWIS) database, the result is accompanied with the following comment: Result is ≤ reported value, based on quality-control data (may include field blanks, source-solution blanks, trip blanks, National Water Quality Laboratory (NWQL) set blanks, NWQL blank water certificates, and USGS Office of Water Quality Branch of Quality Systems Blind Blank Program data).

[3] LRL for samples collected before 10/01/08, LRL for samples collected 10/01/08 and thereafter.

[4] Study reporting level (SRL) of 1.08 µg/L for silver is defined on the basis of the highest and only concentration detected in the eight field blanks collected for this study. Values below the SRL are reported as less than or equal to the value reported by the laboratory (≤). In the USGS NWIS database, the result is accompanied with the following comment: Result is ≤ reported value, based on quality-control data collected for this study.

Table 11. Species of dissolved inorganic arsenic and iron detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[Data in this table were analyzed at U.S. Geological Survey (USGS) Trace Metal Laboratory in Boulder, Colorado. Table 3G contains additional information about the constituents. Values less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). Samples from all 84 wells were analyzed, but only wells with detections are listed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** MDL, method detection limit; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level]

GAMA identification number	Arsenic (total) (µg/L)	Arsenic (III) (µg/L)	Iron (total) (µg/L)	Iron (II) (µg/L)
Benchmark type [1]	**MCL-US**	**na**	**SMCL-CA**	**na**
Benchmark level	**10**	**na**	**300**	**na**
[MDL] or [SRL]	**[0.5]**	**[1]**	**[2] [2]**	**[2]**
		Primary grid wells		
SIERRA-G-03	3.3	—	7	4
SIERRA-G-05	0.79	—	—	—
SIERRA-G-06	2.0	—	5	—
SIERRA-G-07	0.53	—	52	44
SIERRA-G-08	—	—	10	7
SIERRA-G-10	—	—	7	—
SIERRA-G-14	—	—	6	4
SIERRA-G-15	1.1	1.0	—	—
SIERRA-G-17	5.9	—	—	—
SIERRA-M-01	—	—	4	3
SIERRA-M-02	0.50	—	*521	423
SIERRA-M-03	—	—	≤2	—
SIERRA-M-05	0.96	—	*984	971
SIERRA-M-06	0.96	—	—	—
SIERRA-S-01	0.59	—	—	—
SIERRA-S-02	6.2	—	—	—
SIERRA-S-03	2.9	—	5	4
SIERRA-V-03	*16	—	≤2	2
		Lithologic grid wells		
SIERRA-GL-01	*11	—	≤2	—
SIERRA-GL-02	1.4	—	3	—
SIERRA-GL-08	—	—	3	—
SIERRA-GL-09	—	—	4	—
SIERRA-GL-10	—	—	15	5

Table 11. Species of dissolved inorganic arsenic and iron detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[Data in this table were analyzed at U.S. Geological Survey (USGS) Trace Metal Laboratory in Boulder, Colorado. Table 3G contains additional information about the constituents. Values less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). Samples from all 84 wells were analyzed, but only wells with detections are listed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** MDL, method detection limit; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level]

GAMA identification number	Arsenic (total) (µg/L)	Arsenic (III) (µg/L)	Iron (total) (µg/L)	Iron (II) (µg/L)
Benchmark type [1]	**MCL-US**	**na**	**SMCL-CA**	**na**
Benchmark level	**10**	**na**	**300**	**na**
[MDL] or [SRL]	**[0.5]**	**[1]**	**[2] [2]**	**[2]**
SIERRA-ML-02	6.2	—	—	—
SIERRA-ML-03	4.1	—	—	—
SIERRA-ML-04	2.1	—	4	—
SIERRA-ML-05	—	—	12	12
SIERRA-ML-06	2.5	—	—	—
SIERRA-ML-07	2.7	—	—	—
SIERRA-ML-08	—	—	4	—
SIERRA-ML-09	0.53	—	—	—
SIERRA-ML-10	5.6	—	3	—
SIERRA-ML-11	3.5	—	3	—
SIERRA-ML-12	—	—	*1,990	1,990
SIERRA-ML-13	—	—	66	51
SIERRA-ML-14	2.5	—	—	—
SIERRA-ML-16	4.9	3.9	86	83
SIERRA-ML-17	1.4	—	13	3
SIERRA-ML-18	—	—	9	8
SIERRA-SL-02	*11	9.8	*2,940	2,940
SIERRA-SL-03	5.1	—	—	—
SIERRA-SL-05	—	—	3	—
SIERRA-SL-07	1.8	—	—	—
SIERRA-SL-08	—	—	≤2	2
SIERRA-SL-12	9.1	8.7	*615	537
SIERRA-VL-01	3.4	—	4	—
SIERRA-VL-02	—	—	6	4
SIERRA-VL-03	9.7	8.2	69	52
SIERRA-VL-04	1.2	—	≤2	—

Table 11. Species of dissolved inorganic arsenic and iron detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[Data in this table were analyzed at U.S. Geological Survey (USGS) Trace Metal Laboratory in Boulder, Colorado. Table 3G contains additional information about the constituents. Values less than the concentrations measured in field blanks (table A3) are reported with a less than or equal to sign (≤). Samples from all 84 wells were analyzed, but only wells with detections are listed. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** MDL, method detection limit; SRL, study reporting level; na, not available; µg/L, micrograms per liter; —, not detected; *, value above benchmark level]

GAMA identification number	Arsenic (total) (µg/L)	Arsenic (III) (µg/L)	Iron (total) (µg/L)	Iron (II) (µg/L)
Benchmark type [1]	**MCL-US**	**na**	**SMCL-CA**	**na**
Benchmark level	**10**	**na**	**300**	**na**
[MDL] or [SRL]	**[0.5]**	**[1]**	**[2] [2]**	**[2]**
SIERRA-VL-05	1.5	—	4	—
SIERRA-VL-06	*27	6.9	92	19
SIERRA-VL-07	—	—	*319	297
SIERRA-VL-11	—	—	189	163
SIERRA-VL-12	4.2	—	20	12
		Comparison site		
SIERRA-XL-01	*100	7.2	—	—

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] Study reporting level (SRL) of 2 µg/L for iron (total) is defined of the basis of the highest and only concentration detected in the eight field blanks collected for this study. Values below the SRL are reported as less than or equal to (≤) the value reported by the laboratory. In the USGS National Water Information System database, the result is accompanied with the following comment: Result is ≤ reported value, based on quality-control data collected for this study.

Table 12. Results for analyses of stable isotope ratios, and tritium and carbon–14 activities in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to the more common lighter isotope of that element, relative to a standard reference material. Samples from all 84 wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008.**Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** H, hydrogen; O, oxygen; C, carbon; pCi/L, picocuries per liter; MRL, minimum reporting level; <, less than; nc, sample not collected]

GAMA identification number	$\delta^{2}H$ of water (per mil) (82082)	$\delta^{18}O$ of water (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{13}C$ of dissolved carbonates (per mil) (82081)	Carbon-14 (percent modern) [1] (49933)
Benchmark type [2]	**na**	**na**	**MCL-CA**	**na**	**na**
Benchmark level	**na**	**na**	**20,000**	**na**	**na**
			Primary grid wells		
SIERRA-G-01	–61.2	–8.89	0.8	–14.53	58
SIERRA-G-02	–73.5	–11.12	13.3	–16.65	88
SIERRA-G-03	–69.1	–10.06	1.1	–14.42	71
SIERRA-G-04	–80.9	–11.90	9.1	–20.73	110
SIERRA-G-05	–62.1	–8.86	6.8	–17.87	109
SIERRA-G-06	–82.6	–11.65	2.2	–19.13	81
SIERRA-G-07	–73.5	–10.84	11.6	–20.93	106
SIERRA-G-08	–80.5	–11.77	7.8	–20.91	105
SIERRA-G-09	–85.2	–12.42	9.2	–20.73	110
SIERRA-G–10	–103	–14.08	9.4	–16.26	102
SIERRA-G–11	–77.0	–10.85	9.7	–19.52	104
SIERRA-G–12	–77.5	–10.90	8.0	–17.43	105
SIERRA-G–13	–69.2	–9.80	8.3	–19.57	109
SIERRA-G–14	–97.9	–13.61	8.6	–20.80	107
SIERRA-G–15	61.2	–8.13	4.8	–17.70	65
SIERRA-G–16	–119	–15.82	14.4	–18.31	79
SIERRA-G–17	–132	–17.59	11.3	–16.43	99
SIERRA-G–18	–120	–16.15	15.2	–15.25	86
SIERRA-M-01	–65.0	–8.92	4.4	–15.25	72
SIERRA-M-02	–59.6	–8.34	4.7	–16.16	61
SIERRA-M-03	–99.7	–13.60	1.8	nc	nc
SIERRA-M-04	–86.1	–12.39	10.3	–14.09	64
SIERRA-M-05	–70.6	–10.60	4.3	–20.49	70
SIERRA-M-06	–68.8	–10.38	9.9	–20.42	95
SIERRA-S-01	–82.1	–11.07	8.0	–13.05	120
SIERRA-S-02	–102	–14.00	8.0	–19.90	100
SIERRA-S-03	–102	–13.84	4.4	–17.09	92
SIERRA-V-01	–101	–14.24	5.3	–18.19	97

Table 12. Results for analyses of stable isotope ratios, and tritium and carbon–14 activities in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to the more common lighter isotope of that element, relative to a standard reference material. Samples from all 84 wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008.**Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** H, hydrogen; O, oxygen; C, carbon; pCi/L, picocuries per liter; MRL, minimum reporting level; <, less than; nc, sample not collected]

GAMA identification number	$\delta^{2}H$ of water (per mil) (82082)	$\delta^{18}O$ of water (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{13}C$ of dissolved carbonates (per mil) (82081)	Carbon-14 (percent modern) [1] (49933)
Benchmark type [2]	**na**	**na**	**MCL-CA**	**na**	**na**
Benchmark level	**na**	**na**	**20,000**	**na**	**na**
SIERRA-V-02	–64.9	–9.80	2.9	–20.47	91
SIERRA-V-03	–102	–14.27	11.9	–11.80	59
			Lithologic grid wells		
SIERRA-GL-01	–76.3	–9.99	4.9	–15.47	104
SIERRA-GL-02	–64.0	–9.20	8.6	–19.66	106
SIERRA-GL-03	–107	–14.36	15.6	–13.21	74
SIERRA-GL-04	–99.2	–13.54	12.3	–16.97	105
SIERRA-GL-05	–83.1	–12.09	17.3	–21.13	105
SIERRA-GL-06	–89.3	–12.78	7.9	–21.05	114
SIERRA-GL-07	–59.9	–8.62	10.3	–18.95	115
SIERRA-GL-08	–82.2	–11.95	8.1	–19.84	109
SIERRA-GL-09	–66.6	–9.70	8.6	–22.24	116
SIERRA-GL–10	–100	–13.92	12.9	–15.35	80
SIERRA-ML-01	–76.4	–10.20	5.0	–11.47	71
SIERRA-ML-02	–76.8	–10.73	7.9	–15.25	108
SIERRA-ML-03	–65.2	–9.49	6.7	–16.11	97
SIERRA-ML-04	–93.5	–12.92	8.1	–6.56	43
SIERRA-ML-05	–74.2	–11.10	11.1	–18.92	117
SIERRA-ML-06	–62.1	–8.70	9.1	–16.12	109
SIERRA-ML-07	–81.6	–11.95	0.7	–10.37	50
SIERRA-ML-08	–64.3	–8.98	9.6	–14.12	63
SIERRA-ML-09	–72.2	–10.83	5.1	–19.66	90
SIERRA-ML–10	–59.2	–8.49	8.8	–16.46	77
SIERRA-ML–11	–96.8	–13.59	11.9	–15.58	87
SIERRA-ML–12	–74.4	–10.62	9.2	nc	nc
SIERRA-ML–13	–65.2	–9.37	7.4	–14.89	91
SIERRA-ML–14	–97.4	–13.50	13.0	–18.51	93
SIERRA-ML–15	–90.4	–12.59	9.4	–15.34	81
SIERRA-ML–16	–114	–15.74	5.9	–15.73	95
SIERRA-ML–17	–56.4	–8.20	6.7	–17.50	91
SIERRA-ML–18	–63.6	–9.50	9.4	–18.20	80

Table 12. Results for analyses of stable isotope ratios, and tritium and carbon–14 activities in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to the more common lighter isotope of that element, relative to a standard reference material. Samples from all 84 wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008.**Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** H, hydrogen; O, oxygen; C, carbon; pCi/L, picocuries per liter; MRL, minimum reporting level; <, less than; nc, sample not collected]

GAMA identification number	$\delta^{2}H$ of water (per mil) (82082)	$\delta^{18}O$ of water (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{13}C$ of dissolved carbonates (per mil) (82081)	Carbon-14 (percent modern) [1] (49933)
Benchmark type [2]	**na**	**na**	**MCL-CA**	**na**	**na**
Benchmark level	**na**	**na**	**20,000**	**na**	**na**
SIERRA-SL-01	–74.8	–10.56	0.6	–12.40	85
SIERRA-SL-02	–99.4	–13.59	12.2	5.11	23
SIERRA-SL-03	–66.2	–9.22	8.5	–12.45	103
SIERRA-SL-04	–76.8	–10.47	<0.3	–14.34	1
SIERRA-SL-05	–101	–13.94	9.0	–17.50	97
SIERRA-SL-06	–114	–15.43	1.1	–16.27	90
SIERRA-SL-07	–95.6	–12.72	8.8	–17.62	104
SIERRA-SL-08	–90.9	–12.64	6.3	–19.52	95
SIERRA-SL-09	–106	–14.60	0.9	–17.80	88
SIERRA-SL–10	–121	–16.35	16.8	–17.29	84
SIERRA-SL–11	–128	–17.18	7.0	–15.16	96
SIERRA-SL–12	–61.9	–9.01	2.0	–17.98	97
SIERRA-SL–13	–96.9	–13.33	8.8	–19.82	107
SIERRA-VL-01	–68.9	–9.47	6.7	–11.45	84
SIERRA-VL-02	–88.4	–12.31	5.4	–17.86	90
SIERRA-VL-03	–108	–14.31	7.4	–12.62	60
SIERRA-VL-04	–73.6	–10.28	<0.3	–19.43	85
SIERRA-VL-05	–74.4	–10.65	2.7	–19.87	59
SIERRA-VL-06	–117	–15.55	<0.3	–15.83	27
SIERRA-VL-07	–83.0	–11.89	7.3	–14.08	64
SIERRA-VL-08	–107	–14.73	3.9	–16.05	96
SIERRA-VL-09	–102	–14.17	1.1	–18.33	97
SIERRA-VL–10	–74.1	–10.96	7.5	–23.36	111
SIERRA-VL–11	–75.6	–11.08	11.5	–18.82	101
SIERRA-VL–12	–71.6	–10.62	0.8	–17.14	53
Comparison site					
SIERRA-XL-01	–105	–14.85	5.0	–14.93	103

[1] 100-percent modern carbon is referenced to atmospheric carbon-14 production rates in 1950. Values of percent modern carbon can be greater than 100 percent because the atmospheric production rate was much higher during the period of above-ground nuclear testing in the 1950s and 1960s.

[2] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

Table 13A. Uranium isotopes and radon-222 detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. Values less than the sample-specific critical level (ssLC) are reported as nondetections (—). Samples from all 30 primary and all 53 lithologic grid wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; nc, sample not collected; *, value above benchmark level; **, value above proposed alternative MCL-US for radon-222]

GAMA identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)		Radon-222 (pCi/L) (82303)
Benchmark type [1]	**MCL-CA**		**MCL-CA**		**MCL-CA**		**Proposed MCL-US**
Benchmark level	**[2] 20**		**[2] 20**		**[2] 20**		**[3] 300 (4,000)**
Reporting level method	**Result ± CSU**	**ssLC**	**Result ± CSU**	**ssLC**	**Result ± CSU**	**ssLC**	**Result ± CSU [4]**
			Primary grid wells				
SIERRA-G-01	0.036 ± 0.022	0.024	—	0.02	0.036 ± 0.022	0.017	110 ± 5
SIERRA-G-02	0.465 ± 0.072	0.029	—	0.044	0.340 ± 0.057	0.021	*2,300 ± 10
SIERRA-G-03	5.22 ± 0.51	0.09	—	0.11	2.73 ± 0.33	0.09	[5] **5,450 ± 22
SIERRA-G-04	1.66 ± 0.18	0.066	—	0.046	1.42 ± 0.17	0.094	nc
SIERRA-G-05	4.15 ± 0.22	0.023	0.243 ± 0.035	0.011	3.50 ± 0.19	0.021	*890 ± 16
SIERRA-G-06	3.18 ± 0.17	0.018	0.055 ± 0.018	0.011	1.120 ± 0.079	0.012	*3,180 ± 26
SIERRA-G-07	3.71 ± 0.18	0.015	0.158 ± 0.023	0.0092	3.24 ± 0.16	0.015	**5,450 ± 34
SIERRA-G-08	0.226 ± 0.026	0.010	0.0161 ± 0.0080	0.0063	0.186 ± 0.021	0.0052	*2,610 ± 140
SIERRA-G-09	0.031 ± 0.010	0.0084	—	0.0072	0.0230 ± 0.0076	0.006	*3,800 ± 200
SIERRA-G-10	0.749 ± 0.063	0.014	0.036 ± 0.016	0.012	0.664 ± 0.061	0.0099	*1,910 ± 110
SIERRA-G-11	0.837 ± 0.069	0.013	0.024 ± 0.015	0.011	0.563 ± 0.054	0.016	nc
SIERRA-G-12	0.276 ± 0.034	0.013	—	0.009	0.362 ± 0.038	0.0074	*810 ± 47
SIERRA-G-13	0.153 ± 0.024	0.0078	0.0161 ± 0.0080	0.0094	0.107 ± 0.020	0.013	[6] **4,200 ± 230
SIERRA-G-14	1.700 ± 0.098	0.011	0.078 ± 0.017	0.0076	1.200 ± 0.077	0.011	*3,900 ± 210
SIERRA-G-15	0.223 ± 0.030	0.010	0.015 ± 0.012	0.0089	0.104 ± 0.019	0.0073	*530 ± 32
SIERRA-G-16	1.83 ± 0.11	0.017	0.115 ± 0.023	0.009	1.98 ± 0.12	0.015	*3,520 ± 190
SIERRA-G-17	1.290 ± 0.083	0.017	0.098 ± 0.020	0.0091	1.050 ± 0.073	0.013	*2,550 ± 140
SIERRA-G-18	6.29 ± 0.37	0.04	0.294 ± 0.056	0.024	5.12 ± 0.32	0.04	**27,100 ± 1,400
SIERRA-M-01	—	0.021	—	0.013	0.018 ± 0.009	0.011	104 ± 11
SIERRA-M-02	0.078 ± 0.016	0.012	—	0.0088	0.049 ± 0.011	0.0052	*490 ± 30
SIERRA-M-03	0.169 ± 0.028	0.016	—	0.016	0.059 ± 0.016	0.0091	nc
SIERRA-M-04	0.382 ± 0.067	0.025	0.040 ± 0.027	0.031	0.327 ± 0.066	0.051	*330 ± 22
SIERRA-M-05	≤0.0168 ± 0.0085	0.0065	—	0.0079	—	0.0065	*350 ± 23
SIERRA-M-06	—	0.012	—	0.0071	—	0.0059	140 ± 12

Table 13A. Uranium isotopes and radon-222 detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. Values less than the sample-specific critical level (ssLC) are reported as nondetections (—). Samples from all 30 primary and all 53 lithologic grid wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; nc, sample not collected; *, value above benchmark level; **, value above proposed alternative MCL-US for radon-222]

GAMA identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)		Radon-222 (pCi/L) (82303)
Benchmark type [1]	MCL-CA		MCL-CA		MCL-CA		Proposed MCL-US
Benchmark level	[2] 20		[2] 20		[2] 20		[3] 300 (4,000)
Reporting level method	Result ± CSU	ssLC	Result ± CSU	ssLC	Result ± CSU	ssLC	Result ± CSU [4]
SIERRA-S-01	*17.40 ± 0.85	0.041	*0.502 ± 0.063	0.018	*13.20 ± 0.66	0.041	*1,000 ± 8
SIERRA-S-02	6.21 ± 0.30	0.017	0.207 ± 0.030	0.0083	4.74 ± 0.23	0.017	259 ± 18
SIERRA-S-03	9.67 ± 0.45	0.029	0.414 ± 0.044	0.0095	5.62 ± 0.28	0.025	*1,560 ± 87
SIERRA-V-01	0.162 ± 0.024	0.0079	—	0.0095	0.104 ± 0.021	0.0079	*780 ± 45
SIERRA-V-02	0.138 ± 0.021	0.0069	—	0.0083	0.038 ± 0.012	0.0069	170 ± 14
SIERRA-V-03	0.124 ± 0.023	0.0088	—	0.011	0.064 ± 0.015	0.0088	*470 ± 29
Lithologic grid wells							
SIERRA-GL-01	1.480 ± 0.088	0.014	0.045 ± 0.013	0.0074	1.170 ± 0.072	0.0087	*660 ± 6
SIERRA-GL-02	1.90 ± 0.12	0.02	0.047 ± 0.019	0.019	1.060 ± 0.082	0.013	nc
SIERRA-GL-03	4.66 ± 0.22	0.02	0.235 ± 0.029	0.0069	4.36 ± 0.21	0.018	nc
SIERRA-GL-04	0.501 ± 0.052	0.020	0.026 ± 0.011	0.012	0.428 ± 0.046	0.014	nc
SIERRA-GL-05	0.158 ± 0.023	0.013	—	0.0077	0.138 ± 0.020	0.0063	nc
SIERRA-GL-06	—	0.011	—	0.0096	0.0102 ± 0.0070	0.0079	nc
SIERRA-GL-07	0.175 ± 0.029	0.016	0.015 ± 0.010	0.012	0.167 ± 0.029	0.0095	nc
SIERRA-GL-08	—	0.021	—	0.017	0.017 ± 0.011	0.011	nc
SIERRA-GL-09	0.023 ± 0.012	0.0089	—	0.011	0.0153 ± 0.0075	0.0089	nc
SIERRA-GL-10	1.280 ± 0.087	0.032	0.111 ± 0.024	0.022	1.43 ± 0.090	0.018	nc
SIERRA-ML-01	5.68 ± 0.32	0.036	0.295 ± 0.047	0.018	4.10 ± 0.24	0.029	nc
SIERRA-ML-02	1.12 ± 0.11	0.019	0.03 ± 0.02	0.023	0.603 ± 0.079	0.019	nc
SIERRA-ML-03	3.21 ± 0.21	0.037	0.185 ± 0.049	0.023	2.18 ± 0.16	0.032	nc
SIERRA-ML-04	0.926 ± 0.084	0.015	0.030 ± 0.023	0.018	0.586 ± 0.069	0.015	nc
SIERRA-ML-05	0.129 ± 0.030	0.023	—	0.028	0.124 ± 0.025	0.018	nc
SIERRA-ML-06	1.70 ± 0.11	0.016	0.084 ± 0.024	0.011	1.400 ± 0.094	0.016	nc
SIERRA-ML-07	2.50 ± 0.16	0.026	0.084 ± 0.024	0.014	1.48 ± 0.11	0.031	nc
SIERRA-ML-08	0.980 ± 0.076	0.013	0.0234 ± 0.0095	0.011	0.313 ± 0.037	0.009	nc
SIERRA-ML-09	0.059 ± 0.017	0.013	0.014 ± 0.010	0.0079	0.053 ± 0.014	0.0065	nc

Table 13A. Uranium isotopes and radon-222 detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. Values less than the sample-specific critical level (ssLC) are reported as nondetections (—). Samples from all 30 primary and all 53 lithologic grid wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; nc, sample not collected; *, value above benchmark level; **, value above proposed alternative MCL-US for radon-222]

GAMA identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)		Radon-222 (pCi/L) (82303)
Benchmark type [1]	MCL-CA		MCL-CA		MCL-CA		Proposed MCL-US
Benchmark level	[2] 20		[2] 20		[2] 20		[3] 300 (4,000)
Reporting level method	Result ± CSU	ssLC	Result ± CSU	ssLC	Result ± CSU	ssLC	Result ± CSU [4]
SIERRA-ML-10	5.93 ± 0.28	0.017	0.165 ± 0.023	0.0074	2.56 ± 0.14	0.015	nc
SIERRA-ML-11	1.360 ± 0.081	0.01	0.036 ± 0.012	0.0071	1.260 ± 0.078	0.0058	nc
SIERRA-ML-12	0.067 ± 0.025	0.020	—	0.033	—	0.02	nc
SIERRA-ML-13	0.364 ± 0.034	0.0083	0.0092 ± 0.0060	0.0071	0.263 ± 0.028	0.0059	nc
SIERRA-ML-14	0.018 ± 0.012	0.012	0.0110 ± 0.0075	0.0085	0.0182 ± 0.0090	0.007	nc
SIERRA-ML-15	0.120 ± 0.025	0.012	0.018 ± 0.012	0.014	0.045 ± 0.015	0.012	nc
SIERRA-ML-16	0.033 ± 0.013	0.015	—	0.018	—	0.015	nc
SIERRA-ML-17	0.048 ± 0.020	0.019	—	0.011	0.032 ± 0.012	0.0093	nc
SIERRA-ML-18	0.02 ± 0.01	0.0079	—	0.0096	0.041 ± 0.014	0.0079	nc
SIERRA-SL-01	0.547 ± 0.069	0.024	0.044 ± 0.018	0.02	0.432 ± 0.062	0.017	nc
SIERRA-SL-02	2.27 ± 0.18	0.05	0.104 ± 0.035	0.027	2.22 ± 0.17	0.032	nc
SIERRA-SL-03	*25.4 ± 1.2	0.047	*1.000 ± 0.085	0.012	*17.60 ± 0.81	0.045	nc
SIERRA-SL-04	0.031 ± 0.021	0.021	—	0.021	—	0.012	nc
SIERRA-SL-05	3.65 ± 0.20	0.017	0.135 ± 0.027	0.01	3.11 ± 0.17	0.015	nc
SIERRA-SL-06	0.370 ± 0.035	0.011	0.0238 ± 0.0090	0.0069	0.235 ± 0.026	0.0057	nc
SIERRA-SL-07	2.51 ± 0.13	0.018	0.157 ± 0.023	0.01	2.35 ± 0.13	0.015	nc
SIERRA-SL-08	—	0.011	—	0.0098	—	0.0081	nc
SIERRA-SL-09	1.18 ± 0.12	0.031	0.069 ± 0.023	0.027	0.389 ± 0.067	0.022	nc
SIERRA-SL-10	0.068 ± 0.017	0.013	0.013 ± 0.010	0.0076	0.049 ± 0.014	0.0063	nc
SIERRA-SL-11	2.16 ± 0.12	0.023	0.160 ± 0.029	0.0093	1.79 ± 0.11	0.017	nc
SIERRA-SL-12	—	0.016	0.015 ± 0.010	0.012	—	0.013	nc
SIERRA-SL-13	0.109 ± 0.019	0.0071	—	0.0085	0.106 ± 0.018	0.0071	nc

Table 13A. Uranium isotopes and radon-222 detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. Values less than the sample-specific critical level (ssLC) are reported as nondetections (—). Samples from all 30 primary and all 53 lithologic grid wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; nc, sample not collected; *, value above benchmark level; **, value above proposed alternative MCL-US for radon-222]

GAMA identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)		Radon-222 (pCi/L) (82303)
Benchmark type [1]	MCL-CA		MCL-CA		MCL-CA		Proposed MCL-US
Benchmark level	[2] 20		[2] 20		[2] 20		[3] 300 (4,000)
Reporting level method	Result ± CSU	ssLC	Result ± CSU	ssLC	Result ± CSU	ssLC	Result ± CSU [4]
SIERRA-VL-01	7.64 ± 0.35	0.028	0.278 ± 0.033	0.012	6.04 ± 0.28	0.023	nc
SIERRA-VL-02	0.383 ± 0.040	0.013	0.016 ± 0.012	0.0093	0.122 ± 0.021	0.0077	nc
SIERRA-VL-03	0.388 ± 0.033	0.0084	0.0101 ± 0.0075	0.0059	0.098 ± 0.015	0.0049	nc
SIERRA-VL-04	0.145 ± 0.024	0.0095	—	0.0082	0.078 ± 0.018	0.0067	nc
SIERRA-VL-05	0.613 ± 0.051	0.015	0.038 ± 0.012	0.0088	0.438 ± 0.042	0.013	nc
SIERRA-VL-06	0.351 ± 0.038	0.011	0.0125 ± 0.0085	0.0097	0.306 ± 0.037	0.008	nc
SIERRA-VL-07	0.032 ± 0.012	0.0068	—	0.0082	0.0087 ± 0.0085	0.0068	nc
SIERRA-VL-08	0.276 ± 0.034	0.0082	0.0127 ± 0.0085	0.0099	0.116 ± 0.022	0.0082	nc
SIERRA-VL-09	0.879 ± 0.065	0.013	—	0.016	0.263 ± 0.033	0.013	nc
SIERRA-VL-10	—	0.0087	—	0.0075	—	0.0062	nc
SIERRA-VL-11	0.09 ± 0.02	0.017	—	0.016	0.073 ± 0.020	0.015	nc
SIERRA-VL-12	0.126 ± 0.024	0.0089	—	0.011	0.073 ± 0.016	0.0089	nc

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] The MCL-US benchmark for uranium is the sum of activities for uranium-234, uranium-235, and uranium-238.

[3] Two MCL-US have been proposed for radon-222. The proposed alternative MCL-US is in parentheses.

[4] The 2-sigma combined standard uncertainties reported for radon-222 in the U.S. Geological Survey National Water Information System (NWIS) database have been divided by two and reported here as 1-sigma combined standard uncertainties for consistency with reporting of the other radiochemical constituents.

[5] Sample analyzed two days past holding time.

[6] Sample analyzed one day past holding time.

Table 13B. Gross alpha and gross beta particle activities detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. The reference nuclide for measurement of gross alpha is thorium-230 and the reference nuclide for measurement of gross beta is cesium-137. Values less than the sample-specific critical level (ssLC) are reported as nondetections (—). Samples from all 30 primary and all 53 lithologic grid wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; *, value above benchmark level; ssL_C, sample-specific critical level]

GAMA identification number	Gross alpha particle activity, 72-hour count (pCi/L) (62636)		Gross alpha particle activity, 30-day count (pCi/L) (62639)		Gross beta particle activity, 72-hour count (pCi/L) (62642)		Gross beta particle activity, 30-day count (pCi/L) (62645)	
Benchmark type [1]	MCL-US		MCL-US		MCL-CA		MCL-CA	
Benchmark level	15		15		50		50	
Reporting level method	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU	ssL_C
Primary grid wells								
SIERRA-G-01	—	0.54	—	0.56	6.54 ± 0.83	1.00	5.30 ± 0.76	1.00
SIERRA-G-02	—	1.00	—	0.58	1.20 ± 0.65	0.96	1.75 ± 0.49	0.72
SIERRA-G-03	8.1 ± 1.1	0.43	6.7 ± 1.2	0.77	3.01 ± 0.40	0.51	5.44 ± 0.72	0.88
SIERRA-G-04	0.58 ± 0.15	0.087	—	0.2	1.08 ± 0.29	0.43	1.40 ± 0.50	0.80
SIERRA-G-05	8.3 ± 1.2	0.53	4.4 ± 1.1	0.76	4.64 ± 0.44	0.45	6.74 ± 0.66	0.66
SIERRA-G-06	5.40 ± 0.89	0.37	4.4 ± 1.0	0.91	1.40 ± 0.42	0.62	2.71 ± 0.52	0.72
SIERRA-G-07	8.8 ± 1.2	0.36	5.0 ± 1.0	0.75	3.20 ± 0.37	0.43	5.67 ± 0.63	0.72
SIERRA-G-08	1.78 ± 0.45	0.40	—	0.49	3.33 ± 0.53	0.74	3.05 ± 0.72	1.00
SIERRA-G-09	0.27 ± 0.15	0.19	—	0.27	1.09 ± 0.27	0.40	0.84 ± 0.38	0.59
SIERRA-G-10	1.66 ± 0.36	0.28	1.19 ± 0.50	0.58	1.87 ± 0.30	0.41	2.65 ± 0.44	0.59
SIERRA-G-11	2.20 ± 0.42	0.26	1.30 ± 0.49	0.52	1.89 ± 0.47	0.70	2.42 ± 0.61	0.98
SIERRA-G-12	1.00 ± 0.39	0.44	—	0.6	2.48 ± 0.37	0.51	2.19 ± 0.33	0.45
SIERRA-G-13	— [2]	0.51	0.73 ± 0.43	0.51	2.67 ± 0.67 [2]	1.00	3.23 ± 0.63	0.97
SIERRA-G-14	3.76 ± 0.58	0.33	3.89 ± 0.98	1.10	1.92 ± 0.34	0.48	2.83 ± 0.47	0.61
SIERRA-G-15	— [3]	0.99	—	1.5	— [3]	0.89	—	1.2
SIERRA-G-16	6.03 ± 0.86	0.28	5.30 ± 0.81	0.33	—	0.96	1.29 ± 0.50	0.78
SIERRA-G-17	3.22 ± 0.59	0.29	4.17 ± 0.70	0.27	1.15 ± 0.46	0.69	1.53 ± 0.41	0.59
SIERRA-G-18	*19.0 ± 2.2	0.4	*16.8 ± 2.0	0.29	1.27 ± 0.65	0.99	7.86 ± 0.70	0.6
SIERRA-M-01	—	0.45	—	0.73	1.72 ± 0.41	0.6	1.28 ± 0.49	0.76
SIERRA-M-02	7.1 ± 1.1	0.44	—	0.65	5.10 ± 0.46	0.44	2.81 ± 0.57	0.83
SIERRA-M-03	—	0.48	—	0.86	0.64 ± 0.37	0.59	1.89 ± 0.49	0.7
SIERRA-M-04	—	0.47	—	0.89	—	0.82	—	1.1
SIERRA-M-05	2.2 ± 1.0	1.4	—	0.47	1.20 ± 0.44	0.66	1.69 ± 0.44	0.65
SIERRA-M-06	—	0.28	—	0.32	0.84 ± 0.36	0.54	—	0.41

Table 13B. Gross alpha and gross beta particle activities detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. The reference nuclide for measurement of gross alpha is thorium-230 and the reference nuclide for measurement of gross beta is cesium-137. Values less than the sample-specific critical level (ssLC) are reported as nondetections (—). Samples from all 30 primary and all 53 lithologic grid wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; *, value above benchmark level; ssL_C, sample-specific critical level]

GAMA identification number	Gross alpha particle activity, 72-hour count (pCi/L) (62636)		Gross alpha particle activity, 30-day count (pCi/L) (62639)		Gross beta particle activity, 72-hour count (pCi/L) (62642)		Gross beta particle activity, 30-day count (pCi/L) (62645)	
Benchmark type [1]	MCL-US		MCL-US		MCL-CA		MCL-CA	
Benchmark level	15		15		50		50	
Reporting level method	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU	ssL_C
SIERRA-S-01	*44.6 ± 5.3	0.68	*21.4 ± 3.0	1.3	4.48 ± 0.47	0.5	15.10 ± 0.97	0.54
SIERRA-S-02	10.7 ± 1.5	0.58	12.2 ± 1.7	0.46	2.46 ± 0.38	0.49	3.61 ± 0.58	0.79
SIERRA-S-03	*25.6 ± 3.2	0.98	14.5 ± 1.8	0.73	3.10 ± 0.67	1.00	5.71 ± 0.59	0.76
SIERRA-V-01	—	0.4	0.59 ± 0.38	0.49	2.42 ± 0.45	0.69	2.71 ± 0.46	0.61
SIERRA-V-02	—	0.5	—	0.79	1.18 ± 0.42	0.62	1.32 ± 0.56	0.84
SIERRA-V-03	1.18 ± 0.40	0.34	—	0.43	2.72 ± 0.46	0.59	2.30 ± 0.32	0.40
Lithologic grid wells								
SIERRA-GL-01	6.43 ± 0.96	0.41	5.4 ± 1.1	0.77	3.57 ± 0.39	0.44	5.37 ± 0.62	0.68
SIERRA-GL-02	3.05 ± 0.56	0.26	1.58 ± 0.72	0.89	1.83 ± 0.32	0.43	2.40 ± 0.50	0.69
SIERRA-GL-03	[3] 11.7 ± 1.3	0.27	10.0 ± 1.3	0.31	[3] 1.70 ± 0.34	0.45	5.08 ± 0.62	0.74
SIERRA-GL-04	[4] 0.63 ± 0.37	0.48	1.12 ± 0.41	0.47	[4] 2.24 ± 0.46	0.63	3.37 ± 0.63	0.95
SIERRA-GL-05	0.74 ± 0.28	0.32	0.89 ± 0.40	0.42	2.75 ± 0.49	0.70	3.73 ± 0.68	0.97
SIERRA-GL-06	—	0.41	—	0.59	—	0.75	—	0.96
SIERRA-GL-07	—	0.78	—	0.8	3.03 ± 0.57	0.88	3.86 ± 0.59	0.76
SIERRA-GL-08	—	0.6	—	0.51	1.58 ± 0.61	0.96	1.47 ± 0.56	0.94
SIERRA-GL-09	—	1.1	—	0.45	—	0.64	—	0.6
SIERRA-GL-10	7.5 ± 1.2	0.58	4.88 ± 0.74	0.37	5.60 ± 0.59	0.62	5.94 ± 0.53	0.57
SIERRA-ML-01	8.5 ± 1.9	1.8	9.0 ± 1.7	1.1	3.48 ± 0.45	0.58	7.14 ± 0.58	0.52
SIERRA-ML-02	2.00 ± 0.54	0.49	1.27 ± 0.57	0.52	1.47 ± 0.51	0.81	3.03 ± 0.52	0.68
SIERRA-ML-03	5.7 ± 1.1	0.86	2.6 ± 1.0	1.0	5.93 ± 0.64	0.74	7.4 ± 1.3	1.8
SIERRA-ML-04	2.61 ± 0.57	0.43	—	1.2	4.21 ± 0.41	0.45	3.91 ± 0.54	0.70
SIERRA-ML-05	[3] 0.89 ± 0.36	0.40	—	0.65	[3] 3.46 ± 0.40	0.48	2.73 ± 0.52	0.72
SIERRA-ML-06	1.79 ± 0.82	1.00	2.7 ± 1.1	1.1	1.91 ± 0.91	1.40	4.19 ± 0.88	1.20
SIERRA-ML-07	2.54 ± 0.65	0.60	3.7 ± 1.0	0.81	2.61 ± 0.42	0.56	3.54 ± 0.58	0.78
SIERRA-ML-08	3.0 ± 1.0	1.1	3.2 ± 1.1	1.1	—	0.56	—	1.2

Table 13B. Gross alpha and gross beta particle activities detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. The reference nuclide for measurement of gross alpha is thorium-230 and the reference nuclide for measurement of gross beta is cesium-137. Values less than the sample-specific critical level (ssLC) are reported as nondetections (—). Samples from all 30 primary and all 53 lithologic grid wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; *, value above benchmark level; ssL_C, sample-specific critical level]

GAMA identification number	Gross alpha particle activity, 72-hour count (pCi/L) (62636)		Gross alpha particle activity, 30-day count (pCi/L) (62639)		Gross beta particle activity, 72-hour count (pCi/L) (62642)		Gross beta particle activity, 30-day count (pCi/L) (62645)	
Benchmark type [1]	MCL-US		MCL-US		MCL-CA		MCL-CA	
Benchmark level	15		15		50		50	
Reporting level method	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU	ssL_C
SIERRA-ML-09	—	0.36	—	0.62	1.19 ± 0.30	0.45	1.42 ± 0.41	0.60
SIERRA-ML-10	5.9 ± 1.0	0.61	6.1 ± 1.1	0.67	1.01 ± 0.45	0.70	3.04 ± 0.62	0.91
SIERRA-ML-11	[2] 1.83 ± 0.48	0.50	1.29 ± 0.37	0.34	[2] 0.83 ± 0.31	0.47	—	0.54
SIERRA-ML-12	7.7 ± 1.1	0.42	0.81 ± 0.48	0.55	4.14 ± 0.41	0.43	3.56 ± 0.73	1.00
SIERRA-ML-13	1.42 ± 0.96	1.20	—	0.9	1.42 ± 0.65	1.00	1.84 ± 0.61	0.96
SIERRA-ML-14	—	0.27	—	0.29	—	0.47	—	0.69
SIERRA-ML-15	— [3]	0.42	—	0.51	[3] 0.83 ± 0.49	0.76	0.79 ± 0.39	0.62
SIERRA-ML-16	10.9 ± 1.6	0.57	5.15 ± 0.96	0.61	5.22 ± 0.58	0.63	3.85 ± 0.51	0.60
SIERRA-ML-17	[2] 0.64 ± 0.41	0.49	—	0.61	[2] 1.14 ± 0.65	1.00	—	0.71
SIERRA-ML-18	—	0.45	—	0.55	0.72 ± 0.40	0.62	0.66 ± 0.30	0.47
SIERRA-SL-01	1.89 ± 0.73	0.80	—	1.0	1.60 ± 0.50	0.75	1.69 ± 0.71	1.10
SIERRA-SL-02	11.6 ± 1.7	0.79	5.9 ± 1.3	0.77	7.11 ± 0.76	0.98	8.28 ± 0.84	0.82
SIERRA-SL-03	*43.9 ± 5.1	0.95	*32.1 ± 3.9	0.88	7.1 ± 1.1	1.5	25.8 ± 1.7	0.87
SIERRA-SL-04	—	1.4	—	1.8	5.69 ± 0.55	0.58	5.82 ± 0.72	0.98
SIERRA-SL-05	9.5 ± 1.2	0.21	9.4 ± 1.4	0.47	1.67± 0.31	0.41	3.92 ± 0.51	0.58
SIERRA-SL-06	1.22 ± 0.33	0.30	0.54 ± 0.39	0.49	1.45 ± 0.30	0.42	1.77 ± 0.45	0.64
SIERRA-SL-07	6.62 ± 0.82	0.18	6.9 ± 1.0	0.33	1.24 ± 0.45	0.68	3.38 ± 0.50	0.61
SIERRA-SL-08	— [3]	0.44	1.34 ± 0.51	0.58	— [3]	0.69	—	0.98
SIERRA-SL-09	2.50 ± 0.65	0.57	1.24 ± 0.66	0.86	3.57 ± 0.47	0.56	3.12 ± 0.67	0.98
SIERRA-SL-10	0.39 ± 0.26	0.33	—	0.34	0.85 ± 0.40	0.61	—	0.58
SIERRA-SL-11	4.45 ± 0.84	0.35	5.8 ± 1.3	1.3	1.68 ± 0.43	0.59	3.08 ± 0.51	0.67
SIERRA-SL-12	1.57 ± 0.67	0.79	—	0.72	2.09 ± 0.61	1.00	1.76 ± 0.44	0.65
SIERRA-SL-13	— [2]	0.41	—	0.29	[2] 0.99 ± 0.55	0.87	2.08 ± 0.32	0.43

Table 13B. Gross alpha and gross beta particle activities detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the constituents. The reference nuclide for measurement of gross alpha is thorium-230 and the reference nuclide for measurement of gross beta is cesium-137. Values less than the sample-specific critical level (ssLC) are reported as nondetections (—). Samples from all 30 primary and all 53 lithologic grid wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks; SIERRA-SL, lithologic grid well in sedimentary deposits; SIERRA-VL, lithologic grid well in volcanic rocks; SIERRA-XL, natural spring not used for drinking water sampled to compare with SIERRA-V-03. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; *, value above benchmark level; ssL_C, sample-specific critical level]

GAMA identification number	Gross alpha particle activity, 72-hour count (pCi/L) (62636)		Gross alpha particle activity, 30-day count (pCi/L) (62639)		Gross beta particle activity, 72-hour count (pCi/L) (62642)		Gross beta particle activity, 30-day count (pCi/L) (62645)	
Benchmark type [1]	MCL-US		MCL-US		MCL-CA		MCL-CA	
Benchmark level	15		15		50		50	
Reporting level method	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU	ssL_C
SIERRA-VL-01	13.6 ± 2.4	1.7	*20.5 ± 3.0	1.6	[3] 5.95 ± 0.54	0.52	11.90 ± 0.82	0.52
SIERRA-VL-02	0.78 ± 0.32	0.33	—	0.88	3.47 ± 0.41	0.51	4.38 ± 0.56	0.68
SIERRA-VL-03	3.60 ± 0.88	0.73	2.9 ± 1.1	1.3	5.76 ± 0.68	0.82	4.8 ± 1.1	1.7
SIERRA-VL-04	0.42 ± 0.30	0.39	—	0.49	3.19 ± 0.37	0.44	2.55 ± 0.46	0.70
SIERRA-VL-05	3.27 ± 0.73	0.62	—	1.8	5.47 ± 0.54	0.59	5.56 ± 0.59	0.65
SIERRA-VL-06	0.56 ± 0.37	0.48	—	0.98	4.36 ± 0.53	0.72	3.56 ± 0.78	1.10
SIERRA-VL-07	2.80 ± 0.49	0.27	0.48 ± 0.36	0.45	1.48 ± 0.30	0.44	0.82 ± 0.46	0.73
SIERRA-VL-08	0.84 ± 0.37	0.46	1.02 ± 0.66	0.88	2.28 ± 0.45	0.69	1.75 ± 0.61	1.00
SIERRA-VL-09	1.15 ± 0.71	1.00	—	2.5	2.72 ± 0.35	0.44	2.66 ± 0.86	1.20
SIERRA-VL-10	0.44 ± 0.22	0.24	—	0.39	—	0.63	—	0.46
SIERRA-VL-11	— [2]	0.6	—	0.52	[2] 1.52 ± 0.44	0.64	1.99 ± 0.33	0.46
SIERRA-VL-12	5.2 ± 1.3	1.5	2.54 ± 0.49	0.35	4.95 ± 0.57	0.68	3.29 ± 0.43	0.56

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] Sample analyzed 3 days past the holding time of 72 hours.

[3] Sample analyzed 1 day past the holding time of 72 hours.

[4] Sample analyzed 4 days past the holding time of 72 hours.

Table 13C. Radium isotopes detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Table 3H contains additional information about the analytes. Values less than the sample-specific critical level (ssLC) are reported as nondetections (—). Samples from all 30 primary grid and 2 lithologic grid wells were analyzed unless otherwise noted. **GAMA identification number:** SIERRA-G, primary grid well in granitic rocks; SIERRA-M, primary grid well in metamorphic rocks; SIERRA-S, primary grid well in sedimentary deposits; SIERRA-V, primary grid well in volcanic rocks; SIERRA-GL, lithologic grid well in granitic rocks; SIERRA-ML, lithologic grid well in metamorphic rocks. Benchmarks and benchmark levels as of June 23, 2008. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, combined standard uncertainty; pCi/L, picocuries per liter; ssL_C, sample-specific critical level; nc, sample not collected]

GAMA identification number	Radium-226 (pCi/L) (09511)		Radium-228 (pCi/L) (81366)	
Benchmark type [1]	MCL-US		MCL-US	
Benchmark level	[2] 5		[2] 5	
Reporting level method	Result ± CSU	ssL_C	Result ± CSU	ssL_C
Primary grid wells				
SIERRA-G-01	0.053 ± 0.013	0.015	—	0.23
SIERRA-G-02	0.076 ± 0.014	0.014	—	0.24
SIERRA-G-03	0.068 ± 0.014	0.014	—	0.27
SIERRA-G-04	nc	nc	nc	nc
SIERRA-G-05	0.058 ± 0.014	0.017	0.58 ± 0.12	0.26
SIERRA-G-06	—	0.016	—	0.24
SIERRA-G-07	0.055 ± 0.011	0.011	—	0.28
SIERRA-G-08	0.102 ± 0.015	0.012	—	0.25
SIERRA-G-09	0.0366 ± 0.0085	0.009	—	0.28
SIERRA-G-10	—	0.015	—	0.35
SIERRA-G-11	nc	nc	nc	nc
SIERRA-G-12	0.031 ± 0.010	0.013	—	0.25
SIERRA-G-13	0.0175 ± 0.0091	0.013	—	0.23
SIERRA-G-14	0.062 ± 0.013	0.014	—	0.24
SIERRA-G-15	0.164 ± 0.021	0.013	—	0.27
SIERRA-G-16	0.037 ± 0.012	0.016	0.37 ± 0.20	0.36
SIERRA-G-17	0.0171 ± 0.0086	0.011	—	0.35
SIERRA-G-18	0.047 ± 0.014	0.015	—	0.25
SIERRA-M-01	0.023 ± 0.011	0.015	—	0.36
SIERRA-M-02	0.230 ± 0.028	0.017	1.95 ± 0.17	0.25
SIERRA-M-03	—	0.015	—	0.27
SIERRA-M-04	—	0.014	—	0.24
SIERRA-M-05	0.092 ± 0.015	0.014	—	0.24
SIERRA-M-06	—	0.014	—	0.24
SIERRA-S-01	0.405 ± 0.041	0.015	0.74 ± 0.12	0.25
SIERRA-S-02	0.048 ± 0.012	0.014	—	0.25
SIERRA-S-03	0.178 ± 0.024	0.014	0.39 ± 0.14	0.29
SIERRA-V-01	0.0161 ± 0.0096	0.013	—	0.26
SIERRA-V-02	0.0284 ± 0.0093	0.012	—	0.32
SIERRA-V-03	—	0.017	—	0.28
Lithologic grid wells				
SIERRA-GL-01	0.028 ± 0.011	0.015	0.38 ± 0.10	0.24
SIERRA-ML-16	2.15 ± 0.19	0.015	0.56 ± 0.16	0.34

[1] Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] The MCL-US benchmark for radium is the sum of activities for radium-226 and radium-228.

Appendix

This appendix includes discussions of the methods used to collect and analyze groundwater and surface-water samples and report the resulting water-quality data. These methods were selected to obtain representative samples of the groundwater from each well and to minimize the potential for contamination of the samples or bias in the data. Procedures used to collect and assess quality-control data and the results of the quality-control assessments also are discussed.

Sample Collection and Analysis

Groundwater samples were collected using standard and modified USGS protocols from the USGS NAWQA program (Koterba and others, 1995) and the USGS National Field Manual (U.S. Geological Survey, variously dated), and protocols described by Weiss (1968), Shelton and others (2001), and Wright and others (2005).

Samples were collected from two types of sites: production wells and springs (“springs” in this study unit include horizontal wells). Sites classified as production wells are vertically drilled into the ground and have pumps that bring the groundwater from the aquifer to a distribution system. Sites were classified as springs if groundwater could discharge from the aquifer into the distribution system without a pump, and if the well was either drilled horizontally or had no drilled hole. A few springs had pumps to transport groundwater from the spring to a storage tank at higher elevation.

Drought conditions during the period of sampling for the Sierra Nevada study unit (June through October 2008) resulted in limitations on the amount of groundwater that could be pumped from some of the wells. In many cases, continuous pumping was limited to 2 hours, either because of limited space in storage tanks for the pumped water or because of drawdown of the water table. A minimum of one casing volume of groundwater was pumped from each well before sampling. The limitation on pumping did not allow sufficient time to complete the sampling of a few wells, and some constituent groups were not collected from these wells.

Groundwater samples were collected through Teflon® tubing attached to a sampling point on the well (or spring) discharge pipe with brass or stainless-steel fittings. The sampling point was located as close as possible to the well-head or point where the spring issued from the ground, upstream from water-storage tanks, and from the well-head treatment system (if any). If a chlorinating system was attached to the well, the chlorinator was shut off before the well or spring was purged and sampled in order to clear all chlorine out of the system. The absence of free chlorine was verified using Hach field kits. The mobile laboratory could not be parked within 50 feet of the sampling point at most of the sampling sites; therefore, all samples were collected outdoors by connecting a 2- to 3-ft length of Teflon® tubing to the sampling point (Lane and others, 2003). All fittings and lengths of tubing were cleaned after each sample was collected (Wilde, 2004). Field water-quality indicators were measured at the wellhead, or in a few cases, samples were hand-carried to the mobile laboratory for analysis.

To measure water-quality indicators in the field, groundwater was pumped through a flow-through chamber fitted with a multi-probe meter that simultaneously measures the field water-quality indicators—dissolved oxygen, pH, specific conductance, and temperature. Field measurements were made in accordance with protocols in the USGS National Field Manual (Radtke and others, 2005; Wilde and Radtke, 2005; Lewis, 2006; Wilde, 2006; Wilde and others, 2006). All sensors on the multi-probe meter were calibrated daily. Measured dissolved oxygen, pH, specific conductance, and temperature values were recorded at approximately 5-minute intervals, and after these values remained stable for several readings, samples to be analyzed in laboratories were collected. The multi-probe meter was not working when SIERRA-G-04 and SIERRA-V-03 were sampled. Laboratory measurements of field water-quality indicators were made for SIERRA-G-04 (table 4) and could be used to estimate the field measurements. Field water-quality measurements of pH and specific conductance were made for SIERRA-V-03 by dipping probes from calibrated meters (Orion pH meter and a Cole Parmer specific conductance meter) into the purge water samples collected in a 1-L plastic cup at about 5-minute intervals, and a CHEMets field kit was used to measure dissolved oxygen. Turbidity was measured in the mobile laboratory with a calibrated turbidity meter (Anderson, 2005) at some sites to determine when the well was ready to be sampled. Field measurements and instrument calibrations were recorded by hand on field record sheets and electronically in PCFF, a software package designed by the USGS with support from the GAMA program. Analytical service requests also were managed by PCFF. Information from PCFF was uploaded directly into NWIS after samples were collected each week.

For analyses requiring filtered water, groundwater was diverted through a 0.45-µm pore size vented capsule filter, a disk filter, or a baked glass-fiber filter depending on the protocol for the analysis (Wilde and others, 1999; Wilde and others, 2004). Before samples were collected, polyethylene sample bottles were pre-rinsed three times using deionized water, and then once with sample water before sample collection. Samples requiring acidification were acidified to a pH of 2 or less with the appropriate acids using ampoules of certified, traceable concentrated acids obtained from the USGS National Water Quality Laboratory (NWQL).

Samples collected to be analyzed for VOCs, pesticides, pharmaceuticals, nutrients, major ions, and trace elements were stored on ice and shipped overnight in coolers with ice to the NWQL within 3 days of sample collection (samples were shipped daily whenever possible). Samples to be analyzed for radium, gross alpha and gross beta particle activities, and radon were shipped overnight within two days of sample collection (samples were shipped daily whenever possible). Samples to be analyzed for NDMA and perchlorate were stored on ice and shipped overnight in coolers with ice at the end of each week. Samples to be analyzed for stable isotopes of hydrogen and oxygen of water, and strontium, uranium, and carbon isotopes, tritium, and noble gases were shipped in batches after the last sample was collected in the study unit.

Detailed sampling protocols for individual analyses and groups of constituents are described by Koterba and others (2005) and in the USGS National Field Manual (Wilde and others, 1999; Wilde and others, 2004) and the references for analytical methods listed in table A1. The brief descriptions given here are organized in the order that samples were collected at each well. VOC samples were collected in 40-mL sample vials that were purged with three vial volumes of sample water before bottom filling to eliminate entrainment of ambient air. Six normal (6 N) hydrochloric acid was added as a preservative to the VOC samples. Each sample to be analyzed for perchlorate was collected in a 125-mL polystyrene bottle and then filtered in two or three 20-mL aliquots through a 0.20-µm pore-size Corning® syringe-tip disk filter into a sterilized 125-mL bottle. Tritium samples were collected by bottom filling two 1-L polyethylene bottles with unfiltered groundwater after first overfilling the each bottle with at least one volume of water. Samples for analysis of stable isotopes of hydrogen and oxygen of water were collected in 60-mL clear glass bottles filled with unfiltered water, sealed with conical caps, and secured with electrical tape to prevent leakage and evaporation.

Samples to be analyzed for pesticides and pesticide degradation products, pharmaceutical compounds, and NDMA were collected in 1-L baked amber bottles. Pesticides and pharmaceutical samples were filtered through a baked, 0.3-µm nominal pore-size glass fiber filter during collection, whereas the NDMA samples were filtered at Weck Laboratories, Inc. before analysis. Samples of NDMA were collected in containers treated with 0.05 g of sodium thiosulfate ($Na_2S_2O_3$).

Groundwater samples collected to be analyzed for inorganic and radioactive constituents were filtered through a 0.45-µm pore-size Whatman® capsule filter. Two 250-mL polyethylene bottles were filled for each sample to be analyzed for major and minor ions, trace elements, and total dissolved solids; one with filtered groundwater and the other with unfiltered groundwater (Wilde and others, 2004). Each 250-mL filtered sample was then preserved with 7.5 N nitric acid. Samples to be used for field and laboratory alkalinity titrations were filtered into 500-mL polyethylene bottles. Samples to be analyzed for species of arsenic and iron were filtered into 250-mL polyethylene bottles that were covered with tape to prevent light exposure, and preserved with 6 N hydrochloric acid. Samples to be analyzed for nutrients were filtered into 125-mL brown polyethylene bottles. Samples to be analyzed for strontium isotopes were filtered into 250-mL polyethylene bottles after bottles were rinsed with filtered groundwater and secured with electrical tape to prevent leakage and evaporation. Samples to be analyzed for uranium isotopes, and gross alpha and gross beta particle activities were filtered into 1-L polyethylene bottles and acidified with nitric acid. Carbon isotope samples were filtered and bottom filled into 500-mL glass bottles that were first overfilled with at least one volume of groundwater. These samples had no headspace and were sealed with conical caps to prevent interaction between the sample and ambient air.

Samples to be analyzed for noble gases were collected from the sampling point on each well (or spring) discharge pipe. Noble gases were collected in 3/8-in copper tubes using reinforced nylon tubing connected to the hose bib at the wellhead. Groundwater was flushed through the tubing to dislodge bubbles before flow was restricted with a back pressure valve. Clamps on either side of the copper tube were then tightened, trapping a sample of groundwater for analyses of noble gases (Weiss, 1968).

Alkalinity of filtered samples was measured in the mobile laboratory ("field" alkalinity) using Gran's titration method (Rounds, 2006; Gran, 1952). Titration data were entered directly into PCFF, and the concentrations of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) were automatically calculated from the titration data using the advanced speciation method with equilibrium constants from Stumm and Morgan (1996). Concentrations of HCO_3^- and CO_3^{2-} were also calculated from the laboratory alkalinity and pH measurements. Calculations were made in a spreadsheet using the advanced speciation method (http://or.water.usgs.gov/alk/methods.html), with $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_W = 14$. pK_1, pK_2, and pK_W are the negative of the base-10 logarithms of the equilibrium constants for the first ionization of carbonic acid, the second ionization of carbonic acid, and the first ionization of water, respectively.

Ten laboratories did chemical analyses for this study (see table A1), although most of the analyses were done at the NWQL or by laboratories contracted by the NWQL. The NWQL maintains a rigorous quality-assurance program (Pirkey and Glodt, 1998; Maloney, 2005). Laboratory quality-control samples, including method blanks, continuing calibration verification standards, standard reference samples, reagent spikes, external certified reference materials, and external blind proficiency samples, are analyzed regularly. Method detection limits are continuously tested and laboratory reporting levels updated accordingly. NWQL maintains the National Environmental Laboratory Accreditation Program (NELAP) and other certifications (http://nwql.usgs.gov/lab_cert.shtml). In addition, the Branch of Quality Systems within the USGS Office of Water Quality independently oversees quality assurance at the NWQL and laboratories contracted by the NWQL. The Branch of Quality Systems also runs the National Field Quality Assurance program, which includes testing all USGS field personnel annually for proficiency in making field water-quality measurements (http://water.usgs.gov/owq/quality.html). Results for analyses made at the NWQL or by laboratories contracted by the NWQL are uploaded from the laboratory directly into NWIS. Results of analyses made at other laboratories are compiled in a project database and uploaded from there into NWIS.

Data Reporting

The following section details the laboratory reporting conventions and the constituents that are determined by multiple methods or by multiple laboratories.

Reporting Limits

The USGS NWQL uses the laboratory reporting level (LRL) as a benchmark for reporting analytical results. The LRL is set to reduce the chance of reporting a false negative (not detecting a compound when it is actually present in a sample) to less than 1 percent (Childress and others, 1999). The LRL is usually set at two times the long-term method detection level (LT-MDL). The LT-MDL is derived from the standard deviation for at least 24 method detection limit (MDL) determinations made over an extended period of time. The MDL is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the concentration is greater than zero (at the MDL there is less than 1 percent chance of a false positive) (Childress and others, 1999; U.S. Environmental Protection Agency, 2002). The USGS NWQL updates LRL values regularly, and the values listed in this report were in effect when groundwater samples from the Sierra Nevada study unit (June through October, 2008) were collected and analyzed. LRL values for some constituents changed on October 1, 2008; therefore, two LRLs are reported in the tables: the LRL for samples collected before October 1, 2008, and the LRL for samples collected on October 1, 2008, and thereafter.

Concentrations between the LRL and the LT-MDL are reported as estimated concentrations (coded by the letter E preceding the values in the tables and text). For information-rich methods, concentrations less than the LT-MDL have a high certainty of detection, but the precise concentration is uncertain. Information-rich methods are those that utilize gas chromatography or high-performance liquid chromatography (HPLC) with mass spectrometry detection, such as those methods used to analyze VOCs and pesticides. Compounds are identified by presence of characteristic fragmentation patterns in their mass spectra in addition to being quantified by measurement of peak areas at their associated chromatographic retention times. E-coded values also may result from detections at concentrations outside the range of calibration standards, from detections that did not meet all laboratory quality-control criteria, and from samples that were diluted before being analyzed (Childress and others, 1999).

Some constituents in this study are reported using minimum reporting levels (MRLs) or method uncertainties. The MRL is the smallest measurable concentration of a constituent that may be reliably reported using a given analytical method (Timme, 1995). The method uncertainty generally indicates the precision of a particular analytical measurement; it gives a range of values wherein the true value will be found.

Results for most constituents are given using the LRL or MRL values provided by the analyzing laboratories. A few constituents are reported using the IRL provided by the laboratory. The IRL is an interim reporting level, usually determined in the same manner as an MDL, for a single analyst and (or) a single instrument over a limited period of time. Results for some constituents are presented using study reporting levels (SRL) derived from assessing results from quality-control samples associated with groundwater samples collected as part of the GAMA project.

The methods used to analyze radiochemical constituents (radon-222, radium isotopes, uranium isotopes, and gross alpha and gross beta particle activities) measure activities by using counting techniques (table A1). The reporting limits for radiochemical constituents are based on sample-specific critical levels (ssL_C) (McCurdy and others, 2008). The critical level is analogous to the LT-MDL used for reporting analytical results for organic and nonradioactive inorganic constituents. In this report, the critical level is defined as the minimum measured activity that indicates a positive detection of the radionuclide in the sample with less than a 5-percent probability of a false positive detection. The critical level depends on instrument background, counting times for the sample and background, and the characteristics of the instrument being used and the nuclide being measured. Sample-specific critical levels are used because the critical level also depends on sample size and sample yield during analytical processing. An ssL_C is calculated for each sample, and the measured activity in the sample is compared to the ssL_C associated with that sample. Measured activities less than the ssL_C are reported as non-detections.

The analytical uncertainties associated with measuring activities are sensitive to sample-specific parameters also, including sample size, sample yield during analytical processing, time elapsed between sample collection and various steps in the analytical procedure, and parameters associated with the instrumentation. Therefore, measured activities of radioactive constituents are reported with sample-specific uncertainties. Activities of radon-222, radium isotopes, uranium isotopes, and gross alpha and gross beta particle activities are reported with sample-specific 1-sigma combined standard uncertainties (CSU).

Notation

Stable isotopic compositions of oxygen, hydrogen, and carbon are reported as relative isotope ratios in units of per mil using the standard delta notation (Coplen and others, 2002):

$$\delta^{i}E = \left[\frac{R_{sample}}{R_{reference}} - 1\right] \times 1{,}000 \text{ per mil}$$

where

i is the atomic mass of the heavier isotope of the element,

E is the element (O for oxygen, C for carbon, or H for hydrogen),

R_{sample} is the ratio of the abundance of the heavier isotope of the element (^{18}O, ^{13}C, or ^{2}H) to that of the lighter isotope of the element, (^{16}O, ^{12}C, or ^{1}H) in the sample and,

$R_{reference}$ is the ratio of the abundance of the heavier isotope of the element to the lighter isotope of the element in the reference material .

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned $\delta^{18}O$ and $\delta^{2}H$ values of 0 per mil (note than $\delta^{2}H$ is sometimes referred to as δD because the common name of the heavier isotope of hydrogen, hydrogen-2, is deuterium). The reference material for carbon is Vienna Peedee Belemnite (VPDB), which is assigned a $\delta^{13}C$ value of 0 per mil. Positive values indicate enrichment of the heavier isotope and negative values indicate depletion of the heavier isotope compared to the ratios observed in the standard reference material.

Constituents on Multiple Analytical Schedules

Six constituents were measured by more than one analytical schedule or more than one laboratory (table A2).

Tritium was measured at the Lawrence Livermore National Laboratory (LLNL) (table 3I) and at the U.S. Geological Survey Stable Isotope and Tritium Laboratory (SITL) (table 3H), but only the data from SITL were available at the time of this publication.

For arsenic and iron concentrations, the approved method, Schedule 1948, used by the NWQL (table 3F) is preferred over the research methods used by the USGS Trace Metal Laboratory (table 3G). The concentrations measured by the Trace Metal Laboratory are used only to calculate ratios of individual species for each element, $\frac{As(V)}{As(III)}$ for arsenic and $\frac{Fe(III)}{Fe(II)}$ for iron; for example,

$$\frac{Fe(III)}{Fe(II)} = \frac{Fe(T) - Fe(II)}{Fe(II)}$$

where

Fe(T) is the total iron concentration (measured),

Fe(II) is the concentration of ferrous iron (measured), and

Fe(III) is the concentration of ferric iron (calculated).

The field water-quality indicators—pH, specific conductance, and alkalinity—were measured in the field and at the NWQL. The field measurements are the preferred method for all three constituents; however, both types are reported because alkalinity was measured in more samples in the laboratory than in the field. Field values are generally preferred because field conditions are considered more representative of groundwater conditions (Hem, 1985).

Quality-Assurance Methods

The purpose of quality assurance is to identify which data best represent environmental conditions and which may have been affected by contamination or bias during sample collection, processing, storage, transportation, and (or) laboratory analysis. Four types of quality-control (QC) tests were used in this study: (1) blank samples were collected to assess positive bias as a result of contamination during sample handling or analysis, (2) replicate samples were collected to assess variability, (3) matrix spike tests were done to assess positive or negative bias, and (4) surrogate compounds were added to samples analyzed for organic constituents to assess bias of laboratory analytical methods. Results that were found to have significant contamination bias, on the basis of the QC data collected from this study and previous studies, were flagged with an appropriate remark code (described later) and rejected from subsequent use, including calculations of detection frequency.

The quality-assurance protocols used for this study followed the protocols used by the USGS NAWQA program (Koterba and others, 1995) and described in the USGS National Field Manual (U.S. Geological Survey, variously dated). The quality-assurance plan followed by the NWQL, the primary laboratory used to analyze samples for this study, is described by Maloney (2005) and Pirkey and Glodt (1998).

Blanks

The primary purposes of collecting blanks are to evaluate the magnitude of potential contamination of samples by constituents of interest during sample collection, handling, or analysis and to identify and mitigate sources of any contamination.

Blank Collection and Analysis

Blanks were collected using blank water certified by the NWQL to contain less than the LRL or MRL of the constituents investigated in the study (James A. Lewis, U.S. Geological Survey, written commun., 2009). Nitrogen-purged, organic-free blank water was used for field blanks for organic constituents, and inorganic-free blank water was used for field blanks for other constituents. Field blanks were collected to assess potential contamination of samples during collection, processing, transport, and analysis. Blank water was pumped or poured through the sampling equipment (fittings and tubing) used to collect groundwater, then processed, transported, and analyzed using the same protocols as were used for the groundwater samples. Four to 12 liters of blank water were pumped or poured through the sampling equipment before each field blank was collected.

For the Sierra Nevada study unit, field blanks were collected at approximately 10 percent of the wells sampled for the various analytical schedules. Field blanks were analyzed for VOCs, pesticides and pesticide degradates, pharmaceuticals, NDMA and perchlorate, nutrients, major and minor ions, trace elements, arsenic and iron species, radium isotopes, gross alpha and gross beta particle activities, and uranium isotopes.

Blanks were not collected for tritium and noble gases. Tritium is in the atmosphere and would dissolve into any solution used in collecting a blank, making it impractical to collect a blank. The concept of blank samples does not apply to analyses of stable-isotope ratios because the constituents (oxygen and hydrogen in water, and carbon in dissolved inorganic carbon) are in all samples.

Assessment of Blanks

Blanks may be contaminated by several different processes that require different strategies to assess the potential for contamination of groundwater samples during sample collection, handling, or analysis. Four primary processes of contamination were assessed in the event of detections in field-blanks or unusual results in groundwater samples: (1) impurities in the water used to collect the blanks, (2) contamination during sample collection and handling from a known source or condition at the field site, (3) “carry-over” of material from one sample to the next sample collected with the same sampling equipment, and (4) systematic and random contamination from field and laboratory equipment and processes. The fourth process of contamination (systematic and random) was addressed using a larger set of field blank results from multiple studies in addition to the results from field blanks collected during the Sierra Nevada study unit study. The development of this approach and its methods are described by Olsen and others (2010).

The first potential process of contamination evaluated was impurities in the blank water. Because the blanks are collected using blank water certified by the NWQL to contain less than the LRL or MRL of the constituents investigated in the study, the blank water itself is very rarely the source of constituents detected in field blanks. However, the certification process is sometimes completed after the blank water has been shipped and used; thus, the certificates of analysis must always be checked for any detectable concentrations. The second potential process evaluated was contamination from identifiable, known sources at a specific field site. Contamination from specific sources may produce distinctive patterns of detections (particularly of VOC constituents) in field blanks and groundwater samples. Substances that may be encountered at the field site, such as lubricants (for example, WD-40), cements used on PVC-piping, exhaust fumes from pump engines, and the methanol used to clean sample lines, contain recognizable associations of VOC constituents. For example, cements used on PVC-piping are composed primarily of tetrahydrofuran, acetone, 2-butanone (methyl ethyl ketone, MEK), and cyclohexanone (not analyzed in this study). However, detecting these recognizable associations of VOC constituents in groundwater samples does not necessarily indicate contamination during sample collection because these VOC constituents may occur together in groundwater also.

If a recognizable association of VOC constituents was detected in a field blank or in a groundwater sample, the field notes and photographs from the site at which the field blank or groundwater sample was collected were examined for conditions that may have caused the field blank or the groundwater sample to be contaminated. If such conditions were present, the detections of VOC constituents in the field blank or groundwater sample were considered suspect.

The third potential process of contamination evaluated was carry-over from the previous groundwater sample or field blank collected with the same equipment. Carry-over between samples is very rare because the procedures used to clean the equipment after each use have been developed and extensively tested to assure that carry-over does not occur. Potential carry-over was evaluated using time-series analysis to look for patterns suggestive of carry-over of constituents from a sample containing high concentrations to the next groundwater sample or field blank collected with the same equipment. If non-detections were reported for a constituent in field blanks or groundwater samples collected after groundwater samples containing high concentrations of the constituent, then carry-over was ruled out as a mode of contamination for that constituent.

The fourth potential process of contamination evaluated was random or systematic contamination from field or laboratory equipment or processes. All detections in field blanks which could not be accounted for by impurities in the source-solution water, specific known conditions at field sites, or carry-over between samples were evaluated for random or systematic contamination. Random or systematic contamination from field and laboratory processes have an equal chance of affecting each groundwater sample; thus, strategies for flagging detections of constituents in samples subject to random or systematic contamination in field and laboratory processes must be applied to all groundwater samples. Random or systematic contamination in field and laboratory processes generally is the most common of the four modes of contamination and is addressed by applying SRLs.

The SRLs for all trace elements except silver were determined by statistical assessment of results from the field blanks collected in the first 20 GAMA study units (May 2004 through January 2008) (Olsen and others, 2010). The assessment used order statistics and binomial probabilities to construct an upper confidence limit (Hahn and Meeker, 1991) for the maximum concentration of constituents possibly introduced while groundwater samples were collected, handled, transported, and analyzed. The resulting SRLs for trace elements were set at concentrations representing a confidence limit of 90 percent for the 90th percentile of the 86 field blanks used in the assessment. Concentrations of those constituents reported by the laboratory that were less than the SRL are marked in tables 10 with a less than or equal to (≤) sign preceding the reported value.

The SRLs for major and minor ions, nutrients, and species of arsenic and iron were determined by assessing the results from field blanks collected in the Sierra Nevada study unit. The maximum concentration of a constituent potentially introduced while groundwater samples were collected, handled, transported, and analyzed was defined as the maximum concentration of the constituent measured in blanks collected in the Sierra Nevada study unit. For most constituents, this maximum concentration was less than the LRL or MRL for the constituent. Data for such constituents are reported as "<" (less than) the LRL or MRL. For some constituents, this maximum concentration was greater than the LRL or MRL and therefore defined as the SRL. Detections of those constituents reported by the laboratory that concentrations greater than the LRL or MDL but less than the SRL are given in tables 8–11 with a less than-or equal to (≤) sign preceding the reported value SRLs for organic constituents were defined on the basis of concentrations and detection frequencies in field blanks and source-solution blanks collected for the previous 25 GAMA study units and in laboratory instrument and preparation blanks analyzed during the same time period as the GAMA samples (Miranda Fram, USGS, unpublished data, 2010). Acetone, 2-butanone, ethylbenzene, styrene, tetrahydrofuran, toluene, 1,2,4-trimethylbenzene, *m*-xylene plus *p*-xylene, and *o*-xylene were detected more frequently in blanks than in groundwater samples and, therefore, all detections of these constituents were removed from the groundwater-quality datasets. For organic constituents detected less frequently in blanks than in groundwater samples, the concentration corresponding to the 95th percentile of the cumulative frequency distribution of the field blanks, source-solution blanks, or laboratory blanks, whichever was highest, was defined as the SRL. For most constituents, the 95th percentiles of the cumulative frequency distributions were non-detections, thus, no SRLs were required.

Replicates

Sequential replicate samples were collected to assess the precision of the water-quality data. Estimates of data precision are needed to assess whether differences between concentrations in samples are due to differences in groundwater quality or to variability that may result from collecting, processing, and analyzing the samples.

Two methods for measuring variability were needed to adequately assess precision over the broad range of measured concentrations of most constituents. The variability between measured concentrations in the pairs of sequential replicate samples was represented by the standard deviation (SD) for low concentrations and by relative standard deviation (RSD) for high concentrations (Anderson, 1987; Mueller and Titus, 2005). The RSD is defined as the SD divided by the mean concentration for each replicate pair of samples, expressed as a percentage. The boundary between concentrations for which variability was assessed with SD and concentrations for which variability was assessed with RSD was defined as 5 times the LRL for each constituent.

For this study, acceptable precision for replicate sample pairs is defined as follows:

- For concentrations less than 5 times the LRL (<5 LRL), an SD less than ½ LRL is acceptable
- For concentrations greater than or equal to 5 times the LRL (≥5 LRL), an RSD less than 10 percent of the LRL is acceptable. For comparison, an RSD of 10 percent is equivalent to a relative percent difference (RPD) of 14 percent.
- For activities of radiochemical constituents (except tritium and carbon-14), replicate pairs with values that are statistically indistinguishable at a confidence level of $\alpha = 0.05$ are defined as acceptable.

If results from replicate sample pairs indicate that precision is unacceptable for a constituent and no specific reason can be identified, this greater variability must be considered when the data are used for the purposes of comparison. If measured concentrations are slightly greater than a water-quality benchmark, then actual concentrations could be slightly less than that benchmark. Similarly, if measured concentrations are slightly less than a water-quality benchmark, actual concentrations could be slightly greater than a water-quality benchmark. Also, if a constituent has high variability in replicate sample pairs, a larger difference between concentrations measured in two samples is required to conclude that the two samples have significantly different concentrations.

Replicate pairs of analyses of all constituents except for radiochemical constituents were evaluated as follows:

- If both values were reported as detections, the SD was calculated if the mean concentration was <5 LRL for the constituent or the RSD was calculated if the mean concentration was ≥5 LRL for the constituent.
- If both values were reported as nondetections, the variability was set to zero by definition.
- If one value was reported as a nondetection and the other value was reported as a detection less than the LRL or MRL, a value of zero was substituted for the nondetection and the SD was calculated. Substituting zero for the nondetection yielded the maximum estimate of variability for the replicate pair.
- For inorganic constituents, if one value for a sample pair was reported as a nondetection and the other value was reported as a ≤-coded value less than or equal to the SRL or if both values were reported as ≤-coded values less than or equal to the SRL, neither the SD nor the RSD was calculated, because the values may have been analytically identical. The ≤-code indicates that the value is a maximum potential concentration and that concentration may be low enough to be reported as a nondetection.
- If one value was reported as a nondetection and the other value was reported as a detection greater than the LRL, the variability for the pair was considered unacceptable.

Replicate pairs of analyses of radiochemical constituents were evaluated using the following equation (McCurdy and others, 2008):

$$z = \frac{\left|R_1 - R_2\right|}{\sqrt{\left(CSU_1^2 + CSU_2^2\right)}}$$

where

z is the test statistic,

R_1 and R_2 are the results for the two samples in the replicate pair and,

CSU_1 and CSU_2 are the combined standard uncertainties associated with the results.

Values of z less than 1.65 correspond to significant levels (p) less than α=0.05, and thus indicate replicate pairs with acceptable precision.

Matrix Spikes

Adding a known concentration of a constituent (”spike”) to a replicate environmental sample enables the analyzing laboratory to determine the effect of the matrix, in this case groundwater, on the analytical technique used to measure the constituent. The known compounds added to matrix spikes are the same as those being analyzed by the method. This enables matrix interferences to be analyzed compound by compound. Matrix spikes were added at the laboratory doing the analysis. Low matrix-spike recovery may indicate that the compound might not be detected in some samples if it was present at very low concentrations. Low and high matrix-spike recoveries may be a concern if the concentration of a compound in a groundwater sample is close to the MCL: a low recovery could falsely result in a measured concentration less than the MCL, whereas a high recovery could falsely result in a measured concentration greater than the MCL.

The GAMA program defined the data quality objective range for acceptable matrix-spike recoveries as 70 to 130 percent. For many constituents, an acceptable range of 70 to 130 percent for matrix spike recovery was more restrictive than the acceptable control limits for laboratory “set” spike recoveries. Laboratory set spikes are aliquots of laboratory blank water to which the same spike solution used for the matrix spikes has been added. One set spike is analyzed with each set of samples. Acceptable control limits for set spikes are defined relative to the long-term variability in recovery. For example, for many NWQL schedules, acceptable set spike recovery is within plus or minus two standard deviations of the mean recovery for a set of at least 30 set spikes (Conner and others, 1998; Furlong and others, 2008).

Matrix-spike recovery tests were done for VOCs, pesticides, pharmaceuticals, and NDMA because the analytical methods for these constituents are chromatographic methods that may be susceptible to matrix interferences. Replicate samples used for matrix-spike recovery tests were collected at approximately 10 percent of the wells sampled for the various analytical schedules.

Surrogate Compound Recoveries

Surrogate compounds are added to environmental samples in the laboratory before analysis in order to evaluate the recovery of similar constituents. Surrogate compounds were added in the laboratory to all groundwater and quality-control samples that were analyzed for VOCs, pesticides, and pharmaceuticals by the NWQL; pharmaceutical data will be presented in a subsequent report. Most of the surrogate compounds are deuterated analogs of compounds being analyzed. For example, the surrogate toluene-*d*8 used for the VOC analytical method has the same chemical structure as toluene, but the eight hydrogen-1 atoms on the molecule have been replaced by deuterium (hydrogen-2). Toluene-*d*8 and toluene behave very similarly in the analytical procedure, but the small mass difference between the two causes slightly different chromatographic retention times; thus, the use of a toluene-*d*8 surrogate does not interfere with the analysis of toluene (Grob, 1995). Only 0.015 percent of hydrogen atoms are deuterium (Firestone and others, 1996); thus, fully deuterated compounds like toluene-*d*8 do not occur naturally and are not found in environmental samples. Surrogates are used to identify general problems that may arise during sample analysis that could affect the analysis results for all compounds in that sample. Potential problems include matrix interferences (such as high levels of dissolved organic carbon) that produce a positive bias, or incomplete laboratory recovery (possibly due to improper maintenance and calibration of analytical equipment) that produces a negative bias. A 70- to 130-percent recovery of surrogates is generally considered acceptable; values outside this range indicate possible problems with processing and analyzing samples (Connor and others, 1998; Sandstrom and others, 2001).

Quality-Control Results

Detections in Field Blanks

Eight field blanks were analyzed for VOCs and there were no detections. Three of the VOCs detected in groundwater samples from the Sierra Nevada study unit were detected more frequently in field blanks than in groundwater samples in the previous 25 GAMA study units. Toluene was detected in 3 samples at a concentration of E0.03 µg/L; 1,2,4-trimethylbenzene was detected in 4 samples at concentrations ranging from E0.02 µg/L to 0.14 µg/L; tetrahydrofuran was detected in 1 sample at a concentration of E0.5 µg/L (table 5). These concentrations were within the ranges of concentrations detected in field blanks from the previous 25 GAMA study units. All detections of toluene, 1,2,4-trimethylbenzene, and tetrahydrofuran were removed from the groundwater-quality dataset presented in this report.

Seven field blanks were analyzed for pesticides and pesticide degradates and there were no detections. Three field blanks were analyzed for NDMA and there were no detections. Seven field blanks were analyzed for perchlorate and there were no detections.

Eight field blanks were analyzed for nutrients, and ammonia and orthophosphate were detected in one field blank each (table A3). GAMA SRLs based on the results for the eight field blanks collected for this study were used to determine which nutrient data should be flagged. Ammonia concentrations in eight groundwater samples were less than the highest and only concentration detected in the field blanks (E0.014 mg/L) and thus were flagged with a ≤ symbol (table 8). Orthophosphate was detected in a field blank at a concentration of E0.003 mg/L. The lowest concentration of orthophosphate in groundwater samples was E0.005 mg/L; thus, no groundwater samples were flagged with a ≤ symbol because all concentrations in groundwater samples were greater than the highest and only concentration detected in the field blank.

Eight field blanks were analyzed for major and minor ions, and no detections were reported.

Eight field blanks were analyzed for trace elements, and lead and silver each were detected in at least one field blank. Lead was detected in four field blanks collected at Sierra Nevada study unit sites; the concentrations were 0.46, E0.05, 0.50, and E0.03 µg/L, all of which are less than 0.65 µg/L, the SRL for lead assigned by Olsen and others (2010). Silver was detected in one field blank at a concentration of 1.08 µg/L and the source blank water certificate of analysis reported a nondetection of silver in the blank water. A SRL for silver was established on the basis of the detection in the field blank collected for this study. The only concentration of silver detected in groundwater samples was E0.005 µg/L and was in the groundwater sample collected at the same site as the field blank. It was flagged with a ≤ symbol (table 10).

GAMA SRLs from Olsen and others (2010) were used to flag data for aluminum, barium, chromium, copper, iron, lead, manganese, nickel, tungsten, vanadium, and zinc. Measured values that are less than the SRL are flagged with a ≤ symbol in table 10.

Eight field blanks were analyzed for arsenic and iron by the USGS Trace Metals laboratory in Boulder, Colorado, and iron (total) was detected at a concentration of 2 µg/L in one field blank (table A3). A SRL for iron (total) was established on the basis of the concentration in the field blank collected for this study. Concentrations of iron (total) equaling 2 µg/L were detected in five groundwater and were flagged with a ≤ symbol because the concentrations in the groundwater samples were not less than the maximum concentration detected in the field blanks (tables A3 and 11).

Field blanks were collected at approximately 10 percent of the wells sampled for gross alpha and gross beta particle activities, radium isotopes, and uranium isotopes. Results from field blanks were not used to define SRLs for radiochemical constituents because the low activities of these constituents occasionally reported in field blanks are thought to be an artifact of the algorithms used to convert instrument response to activities for blank samples, rather than to reflect presence of these constituents in blank samples (Sylvia Stork, USGS, written comm., 2010). Activities of radiochemical constituents reported in field blanks were all lower than most of the activities reported in groundwater samples, indicating that groundwater samples likely were not significantly contaminated by these constituents during collection, handling, or analysis. Eight field blanks were analyzed for gross alpha and gross beta particle activities. Gross alpha particle, 72-hour count (0.29 ± 0.20, ssL_C = 0.27), gross alpha particle, 30-day count (0.63 ± 0.25. ssL_C = 0.28), and gross beta particle, 72-hour count (0.56 ± 0.31, ssL_C = 0.48) activities each were reported in one field blank. Three field blanks were analyzed for radium activities. Radium-228 (0.51 ± 0.24, ssL_C = 0.25) was reported in one field blank, and radium-226 (0.034 ± 0.012, ssL_C = 0.016; 0.0214 ± 0.0077, ssL_C = 0.0095) was reported in two field blanks. One field blank was analyzed for uranium isotopes and uranium-234 (0.018 ± 0.010, ssL_C = 0.013) was reported.

Variability in Replicate Samples

Tables A4A–C summarize the results of replicate analyses for groundwater samples collected for the Sierra Nevada study unit study. Replicates of about 10 percent of the samples collected were analyzed. Of the 1,378 replicate pairs of individual constituents analyzed, 587 replicate pairs of constituents were detected in at least one groundwater sample. Of these 587 pairs, concentrations for 27 were outside the limits for acceptable precision. These 27 pairs are listed in tables A4A–C. Results for replicate pairs inside the limits for acceptable precision and results for constituents that were not detected are not reported.

Six replicate pairs of samples were analyzed for organic constituents and both results for nearly all pairs were reported as nondetections (table A4A). One replicate pair had an average concentration greater than five times the LRL, and the RSD for the pair was less than 10 percent. Four replicate pairs had average concentrations less than five times the LRLs, and the SDs for all four pairs were less than ½ the LRLs. These results indicated data for groundwater samples from the Sierra Nevada study unit varied within acceptable ranges.

Replicate pairs were analyzed for constituents of special interest at Weck Laboratories, Inc. (table A4). Three replicate pairs were analyzed for NDMA, and results are not reported because NDMA was not detected in any groundwater samples. Six replicate pairs were analyzed for perchlorate, and two yielded values reported as nondetections. Four perchlorate replicate pairs had concentrations less than 5 times the corresponding MRLs, and for all but one replicate pair, the SDs were less than ½ the MRL. These results indicated data for groundwater samples from the Sierra Nevada study unit varied within acceptable ranges.

Up to eight replicate pairs were analyzed for nutrients, major and minor ions, trace elements, arsenic and iron species, and isotope tracers. Over 97 percent of the pairs yielded two concentrations with a SD value less than ½ the LRL, MDL, or MRL (for concentrations less than 5 times the LRL, MDL, or MRL) or a RSD value less than 10 percent (for concentrations 5 times greater than or equal to the LRL, MDL, or MRL) or two nondetections (table A4B). These results indicated that data for groundwater samples from the Sierra Nevada study unit varied within acceptable ranges.

One replicate pair each of aluminum and beryllium, and three replicate pairs of copper had SD values greater than ½ the corresponding LRL, MDL, or MRL values when concentrations were less than five times the corresponding LRL, MDL, or MRL. One zinc replicate pair that had concentrations greater than five times the LRL had an RSD value greater than 10 percent. All concentrations of aluminum, beryllium, copper, and zinc detected in groundwater samples were less than one-tenth of the corresponding drinking water benchmarks (tables A4B, 11). The less than acceptable precision at this low concentration will not affect the assessments of groundwater quality being made by the GAMA Priority Basin Project.

Eight replicate pairs were analyzed for species of arsenic and iron by the USGS Trace Metals Laboratory in Boulder, Colorado. One replicate pair for iron (III) and two replicate pairs for iron (total) each yielded a detection with a concentration greater than the MRL and a nondetection, indicating unacceptable precision.

Six to eight replicate pairs were analyzed for isotope tracers (table A4B). All pairs, except for one pair for tritium, had variability within acceptable ranges.

Three to eight replicate pairs of samples were analyzed for radiochemical constituents (table A4C). Two of the 8 replicate pairs analyzed for gross alpha particle (72-hour count) activity, and one of the 8 replicate pairs analyzed for gross alpha particle (30-day count), and gross beta particle (72-hour and 30-day counts) activities had results that were statistically different, indicating unacceptable precision. One of the unacceptable replicate pairs for gross alpha particle (72-hour count) activity yielded results above and below 15 pCi/L, the MCL-US for gross alpha particle activity, suggesting that activities above and below the benchmark may not be reliably distinguished.

The agreement between results for total nitrogen concentration and the sum of the concentrations of the nitrogen species analyzed was evaluated using the same principles as used to evaluate agreement between replicate analyses. Total nitrogen concentration may be greater than the sum of the nitrogen species analyzed (ammonia, nitrate, and nitrite) because organic nitrogen is not analyzed as a separate species, but is included in the measurement of total nitrogen. Forty of the 84 samples had reported total nitrogen values that were less than the sum of the nitrogen species analyzed. In 23 of these 40 samples, the sum of nitrogen species analyzed was less than the LRL for total nitrogen (0.1 mg/L; total nitrogen reported as a non-detection or as an E-coded value below the LRL). Agreement between results is acceptable because they are equivalent. For 10 samples, the sum of the nitrogen species was less than 5 times the LRL for total nitrogen, thus agreement was evaluated using the SD of the results for the sum of nitrogen species and total nitrogen. SD was less than ½ the LRL (maximum SD = 0.026 mg/L) for all 10 samples, indicating acceptable agreement. For 7 samples, the sum of the nitrogen species was greater than 5 times the LRL for total nitrogen, thus agreement was evaluated used the RSD of the results for the sum of nitrogen species and total nitrogen. RSD was less than 10 percent (maximum RSD = 3.6 percent) for all 7 samples, indicating acceptable agreement.

Matrix-Spike Recoveries

Tables A5A–C present a summary of matrix-spike recoveries for the Sierra Nevada study unit study. Adding a spike or known concentration of a constituent to an environmental sample enables the analyzing laboratory to determine the effect of the matrix, in this case groundwater, on the analytical technique used to measure the constituent. Acceptable results for matrix-spike recovery tests were defined as median recoveries between 70 and 130 percent.

Eight environmental samples were spiked with VOCs to calculate matrix-spike recoveries (table A5A). The median recoveries for all VOC compounds were between 70 and 130 percent. Two VOC spike compounds had at least one matrix-spike recovery greater than 130 percent, bromomethane and CFC-11; CFC-11was detected in one groundwater sample (tables 5, A5A). No VOC spike compounds had any matrix-spike recoveries less than 70 percent.

Eight groundwater samples were spiked with pesticide and pesticide degradate compounds in order to calculate matrix-spike recoveries (table A5B). The median recoveries for 43 of the 63 compounds were between 70 and 130 percent. Twenty of the compounds had median recoveries less than 70 percent. Two of these compounds, deethylatrazine and hexazinone, were detected in groundwater samples, and their concentrations may have been biased low. For 11 compounds, all 8 matrix-spike recovery tests yielded recoveries less than 70 percent. (Note—low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations). A similar pattern of unusually low matrix-spike recoveries that started in March 2008 was noted in an assessment of method performance by the Organic Blind Sample Project of the Branch of Quality Systems (http://bqs.usgs.gov/OBSP/).

Four groundwater samples were spiked with NDMA in order to calculate matrix-spike recovery (table A5C). Results for matrix-spike recovery tests were between 70 and 130 percent.

Surrogate Compound Recoveries

Surrogate compounds were added to environmental samples in the laboratory and analyzed to evaluate the recoveries of similar constituents. Table A6 lists each surrogate, the analytical schedule in which it was used, the number of analyses of blank and of groundwater samples (environmental samples, replicates, and matrix-spike samples), and the numbers of surrogate recoveries less than 70 percent or greater than 130 percent for the blanks and the groundwater samples. Blank and groundwater samples were considered separately to assess whether the matrices in groundwater samples affected surrogate recoveries. The presence of sample matrices may increase the recovery of 1,2-Dichloroethane-*d*4 (table A6). However, because all of the median matrix-spike recoveries of VOCs were within acceptable ranges, this change in surrogate recovery did not noticeably affect the data. Seventy-nine percent of the surrogate recoveries for VOCs and 97 percent of the surrogate recoveries for pesticide compounds were in the acceptable ranges.

Table A1. Analytical methods used to determine organic, inorganic and radioactive constituents, and isotope tracers by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and additional contract laboratories.

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names]

Constituents	Analytical Method	Laboratory and analytical schedule	Citations
Field water-quality indicators			
Field parameters	Calibrated field meters and test kits	USGS field measurement	U.S. Geological Survey, variously dated
Organic constituents			
Volatile organic compounds (VOC)	Purge and trap capillary gas chromatography/mass spectrometry	NWQL, Schedule 2020	Connor and others, 1998
Pesticides and pesticide degradates	Solid-phase extraction and gas chromatography/mass spectrometry	NWQL, Schedule 2003	Zaugg and others, 1995; Lindley and others, 1996; Madsen and others, 2003; Sandstrom and others, 2001
Pharmaceuticals	Solid-phase extraction and high-performance liquid chromatography/mass spectrometry	NWQL, Schedule 2080	Kolpin and others, 2002; Furlong and others, 2008
Constituents of special interest			
N-Nitrosodimethylamine (NDMA)	Isotopic dilution chromatography/chemical ionization mass spectrometry	Weck Laboratories, Inc., standard operating procedure ORG065.R10	U.S. Environmental Protection Agency, 1989; Plomley and others, 1994
Perchlorate	Chromatography/mass spectrometry	Weck Laboratories, Inc., standard operating procedure ORG099.R01	U.S. Environmental Protection Agency, 2005
Inorganic constituents			
Nutrients	Alkaline persulfate digestion, Kjedahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
Major and minor ions, and trace elements	Atomic absorption spectrometry, colorimetry, ion-exchange chromatography, inductively-coupled plasma atomic emission spectrometry and mass spectrometry	NWQL, Schedule 1948	Fishman and Friedman, 1989; Fishman, 1993; Faires, 1993; McLain, 1993; Garbarino, 1999; Garbarino and Damrau, 2001; American Public Health Association, 1998; Garbarino and others, 2006
Arsenic and iron species	Various techniques of ultraviolet visible (UV-VIS) spectrophotometry and atomic absorbance spectroscopy	USGS Trace Metal Laboratory, Boulder, Colorado (USGSTMCO)	Stookey, 1970; To and others, 1998; Ball and McCleskey, 2003a,b; McCleskey and others, 2003

Table A1. Analytical methods used to determine organic, inorganic and radioactive constituents, and isotope tracers by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and additional contract laboratories.—Continued

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names]

Constituents	Analytical Method	Laboratory and analytical schedule	Citations
		Isotope tracers	
Stable isotopes of hydrogen and oxygen in water	Gaseous hydrogen and carbon dioxide-water equilibration and stable-isotope mass spectrometry	USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA), NWQL Schedule 1142	Epstein and Mayeda, 1953; Coplen and others, 1991; Coplen, 1994
Carbon isotopes	Accelerator mass spectrometry	University of Waterloo, Environmental Isotope Lab (CAN-UWIL); University of Arizona Accelerator Mass Spectrometry Laboratory (AZ-UAMSL), NWQL Schedule 2015	Donahue and others, 1990; Jull and others, 2004
Strontium isotopes	Chemical separations and thermal-ionization mass spectrometry	USGS Radiogenic Isotope Laboratory, Menlo Park, California	Bullen and others, 1996
Tritium	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA)	Thatcher and others, 1977
Tritium and noble gases	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory (CA-LLNL)	Moran and others, 2002; Eaton and others, 2004
		Radioactivity and gases	
Radon-222	Liquid scintillation counting	NWQL, Schedule 1369	American Society for Testing and Materials, 1998
Radium isotopes	Alpha activity counting	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1262	Krieger and Whittaker, 1980 (USEPA methods 903 and 904)
Uranium isotopes	Chemical separations and alpha-particle spectrometry	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1130	ASTM D3972
Gross alpha and gross beta particle activities	Alpha and beta activity counting	Eberline Analytical Services, NWQL Schedule 1792	Krieger and Whittaker, 1980 (USEPA method 900.0)

Table A2. Preferred analytical schedules for constituents appearing on multiple schedules for samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[LLNL, Lawrence Livermore National Laboratory; SITL, U.S. Geological Survey Stable Isotope and Tritium Laboratory; TML, U.S. Geological Survey Trace Metal Laboratory, Boulder, Colorado; VOC, volatile organic compound; np, no preference]

Constituent	Primary constituent classification	Analytical schedules	Preferred analytical schedule
	Results from both methods reported		
Alkalinity	Field water-quality indicator	field, 1948	field
Arsenic, total	Trace element	1948, TML	1948
Iron, total	Trace element	1948, TML	1948
pH	Field water-quality indicator	field, 1948	field
Specific conductance	Field water-quality indicator	field, 1948	field
Tritium	Radioactive isotopic tracer	LLNL, SITL	np

Table A3. Constituents detected in field blanks collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[**Sources of study reporting levels (SRL):** *SIERRA field blanks*, the SRL was assigned a value equal to the highest concentration in field blanks collected for this study unit; *report by Olsen and others (2010):* the SRL was defined on the basis of the examination of quality-control samples collected for the first 20 GAMA study units. **Abbreviations:** E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not detected; ≤, less than or equal to]

Constituent	Number of field blank detections/total number of field blanks	Concentrations detected in field blanks	SRL concentrations	Source of SRL	Number of groundwater samples ≤-coded
		Nutrients (mg/L)			
Ammonia (as nitrogen)	1/8	E0.014	0.014	SIERRA field blanks	8
Orthophosphate (as phosphorus)	1/8	E0.003	None [1]	None [1]	0
		Trace elements (µg/L)			
Aluminum	0/8	—	1.6	Olsen and others, 2010	10
Barium	0/8	—	0.36	Olsen and others, 2010	2
Chromium	0/8	—	0.42	Olsen and others, 2010	36
Copper	0/8	—	1.7	Olsen and others, 2010	30
Iron	0/8	—	6	Olsen and others, 2010	10
Lead	4/8	0.46, E0.05, 0.50, E0.03	0.65	Olsen and others, 2010	45
Manganese	0/8	—	0.2	Olsen and others, 2010	12
Nickel	0/8	—	0.36	Olsen and others, 2010	33
Silver	1/8	1.08	1.08	SIERRA field blanks	1
Tungsten	0/8	—	0.11	Olsen and others, 2010	16
Vanadium	0/8	—	0.1	Olsen and others, 2010	7
Zinc	0/8	—	4.8	Olsen and others, 2010	31
Iron (total, TML) [2]	1/8	2	2	SIERRA field blanks	5

[1] All concentrations of orthophosphate detected in groundwater samples are greater than the highest concentration detected in the field blanks collected for this study unit; therefore, no SRL is required.

[2] Total dissolved iron analyzed by the U.S. Geological Survey Trace Metal Laboratory in Boulder, Colorado.

Table A4A. Quality-control summary for replicate analyses of organic constituents and constituents of special interest in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[Results for replicate pairs with acceptable precision and results for constituents that were not detected are not reported. SD, standard deviation; RSD, relative standard deviation in percent; LRL, laboratory reporting limit; MRL, method reporting limit; µg/L, micrograms per liter; nv, no values in category; <, less than]

Constituent	Number of replicate pairs with detections/Total number of replicate pairs	Replicate pairs with average concentrations less than 5 times the LRL or MRL		Replicate pairs with average concentrations greater than 5 times the LRL or MRL	
		Number of pairs with SDs greater than ½ LRL or MRL/Total number of pairs	Concentrations for pairs with SDs greater than ½ LRL or MRL (environmental, replicate)	Number of pairs with RSDs greater than 10 percent/Total number of pairs	Concentrations for pairs with RSDs greater than 10 percent (environmental, replicate)
Volatile organic compounds (µg/L)					
Carbon disulfide	0/6	nv	nv	nv	nv
Chloroform	2/6	0/1	nv	0/1	nv
1,4-Dichlorobenzene	0/6	nv	nv	nv	nv
1,1-Dichloroethane	0/6	nv	nv	nv	nv
1,2-Dichloroethane	0/6	nv	nv	nv	nv
1,1-Dichloroethene	0/6	nv	nv	nv	nv
cis-1,2-Dichloroethene	0/6	nv	nv	nv	nv
Methyl *tert*-butyl ether	1/6	0/1	nv	nv	nv
1,1,1-Trichloroethane	1/6	0/1	nv	nv	nv
Trichloroethene	0/6	nv	nv	nv	nv
Trichlorofluoromethane	0/6	nv	nv	nv	nv
Tetrachloroethene	1/6	0/1	nv	nv	nv
Pesticides and pesticide degradates (µg/L)					
Atrazine	0/6	nv	nv	nv	nv
Deethylatrazine	0/6	nv	nv	nv	nv
3,4-Dichloroaniline	0/6	nv	nv	nv	nv
Desulfinylfipronil	0/6	nv	nv	nv	nv
Fipronil sulfone	0/6	nv	nv	nv	nv
Fipronil	0/6	nv	nv	nv	nv
Hexazinone	0/6	nv	nv	nv	nv
Simazine	0/6	nv	nv	nv	nv
Constituents of special interest (µg/L)					
Perchlorate	4/6	1/4	(0.11, <0.10)	nv	nv

Table A4B. Quality-control summary for replicate analyses of nutrients, major and minor ions, trace elements, and isotope tracers detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[δ^2H, delta hydrogen; $\delta^{18}O$, delta oxygen; $\delta^{13}C$, delta carbon; SD, standard deviation; RSD, percent relative standard deviation; LRL, laboratory reporting limit; µg/L, micrograms per liter; mg/L, milligrams per liter; pCi/L, picocuries per liter, nv, no values in category; ≤, less than or equal to; <, less than]

Constituent	Number of detections or ≤-coded replicate pairs/ Total number of replicate pairs	Replicate pairs with average concentrations less than 5 times the LRL, MDL, or MRL		Replicate pairs with average concentrations greater than 5 times the LRL, MDL, or MRL	
		Number of pairs with SDs greater than 1/2 the LRL, MDL, or MRL/ Total number of pairs	Concentrations or activities of pairs with SDs greater than ½ LRL, MDL, or MRL (environmental, replicate)	Number of pairs with RSDs greater than 10 percent/ Total number of pairs	Concentrations or activities of pairs with RSDs greater than 10 percent (environmental, replicate)
Nutrients (mg/L)					
Ammonia, as nitrogen	0/8	nv	nv	nv	nv
Nitrate plus nitrite, as nitrogen	8/8	0/4	nv	0/4	nv
Nitrite, as nitrogen	0/8	nv	nv	nv	nv
Orthophosphate, as phosphorus	8/8	0/6	nv	0/2	nv
Total nitrogen, as nitrogen	8/8	0/5	nv	0/3	nv
Major and minor ions (mg/L)					
Bromide	3/8	0/3	nv	nv	nv
Calcium	8/8	nv	nv	0/8	nv
Chloride	8/8	0/2	nv	0/6	nv
Fluoride	4/8	0/4	nv	nv	nv
Iodide	2/8	0/2	nv	nv	nv
Mangesium	8/8	nv	nv	0/8	nv
Potassium	8/8	nv	nv	0/8	nv
Silica	8/8	nv	nv	0/8	nv
Sodium	8/8	nv	nv	0/8	nv
Sulfate	8/8	0/3	nv	0/5	nv
Total dissolved solids	8/8	0/2	nv	0/6	nv
Trace elements (µg/L)					
Aluminum	2/8	1/1	(2.1, 4.0)	0/1	nv
Antimony	4/8	0/2	nv	0/2	nv
Arsenic	8/8	0/2	nv	0/6	nv
Barium	7/8	nv	nv	0/7	nv
Beryllium	1/8	1/1	(0.015, E0.007)	nv	nv
Boron	6/8	0/5	nv	0/1	nv
Cadmium	3/8	0/3	nv	nv	nv
Chromium	4/8	0/4	nv	nv	nv
Cobalt	3/8	0/3	nv	nv	nv
Copper	6/8	3/6	(3.2, 3.8); (≤1.7, 1.8); (1.9, ≤1.5)	nv	nv
Iron	2/8	0/2	nv	nv	nv
Lead	4/8	nv	nv	0/4	nv
Lithium	7/8	0/4	nv	0/3	nv
Manganese	3/8	0/2	nv	0/1	nv

Table A4B. Quality-control summary for replicate analyses of nutrients, major and minor ions, trace elements, and isotope tracers detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[δ^2H, delta hydrogen; $\delta^{18}O$, delta oxygen; $\delta^{13}C$, delta carbon; SD, standard deviation; RSD, percent relative standard deviation; LRL, laboratory reporting limit; mg/L, micrograms per liter; mg/L, milligrams per liter; pCi/L, picocuries per liter, nv, no values in category; ≤, less than or equal to; <, less than]

Constituent	Number of detections or ≤-coded replicate pairs/ Total number of replicate pairs	Replicate pairs with average concentrations less than 5 times the LRL, MDL, or MRL		Replicate pairs with average concentrations greater than 5 times the LRL, MDL, or MRL	
		Number of pairs with SDs greater than 1/2 the LRL, MDL, or MRL/ Total number of pairs	Concentrations or activities of pairs with SDs greater than ½ LRL, MDL, or MRL (environmental, replicate)	Number of pairs with RSDs greater than 10 percent/ Total number of pairs	Concentrations or activities of pairs with RSDs greater than 10 percent (environmental, replicate)
Mercury	1/8	0/1	nv	nv	nv
Molybdenum	6/8	0/2	nv	0/4	nv
Nickel	2/8	0/1	nv	0/1	nv
Selenium	4/8	0/3	nv	0/1	nv
Silver	0/8	nv	nv	nv	nv
Strontium	8/8	nv	nv	0/8	nv
Thallium	1/8	1/8	nv	nv	nv
Tungsten	4/8	0/2	nv	0/2	nv
Uranium	8/8	0/1	nv	0/7	nv
Vanadium	8/8	nv	nv	0/8	nv
Zinc	4/8	nv	nv	1/4	(10.1, 8.5)
Arsenic and iron species (µg/L)					
Arsenic (III)	0/8	nv	nv	nv	nv
Arsenic, total	3/8	nv	nv	0/3	nv
Iron (II)	2/8	1/2	(4, <2)	nv	nv
Iron, total	5/8	2/4	(<2, 3); (3, <2)	0/1	nv
Isotope tracers (units, as noted)					
δ^2H (per mil)	8/8	nv	nv	0/8	nv
$\delta^{18}O$ (per mil)	8/8	nv	nv	0/8	nv
$\delta^{13}C$ (per mil)	6/6	nv	nv	0/6	nv
Carbon-14 (percent modern)	6/6	nv	nv	0/6	nv
Tritium (pCi/L)	7/7	nv	nv	1/7	(9.2, 11.0)

Table A4C. Quality-control summary for replicate analyses of radiochemical constituents detected in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[For activities of radiochemical constituents, a replicate pair of analyses is defined as acceptable if the p-value for the normalized absolute difference is greater than the significance level, α = 0.5. pCi/L, picocuries per liter; —, not detected; nv, no values in category; <, less than]

Constituent	Number of pairs with $p < 0.05$/ Total number of replicate pairs	Activites for replicate pairs with $p < 0.05$ (environmental, replicate) (pCi/L)
Uranium-234	1/8	(1.12 ± 0.11, 0.812 ± 0.082)
Uranium-235	0/8	nv
Uranium-238	0/8	nv
Radon-222	0/4	nv
Radium-226	1/3	(0.0366 ± 0.0085, —)
Radium-228	0/3	nv
Gross alpha particle activity (72-hour count)	2/8	(10.7 ± 1.5, 16.1 ± 2.1); (19.0 ± 2.2, 27.2 ± 3.0)
Gross alpha particle activity (30-day count)	1/8	(4.88 ± 0.74, 2.88 ± 0.58)
Gross beta particle activity (72-hour count)	1/8	(1.27 ± 0.65, 9.50 ± 0.91)
Gross beta particle activity (30-day count)	1/8	(3.03 ± 0.52, 1.80 ± 0.50)

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOC) in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spiked samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetone	8	100	129	108
Acrylonitrile	8	101	117	110
tert-Amyl methyl ether (TAME)	8	95	122	108
Benzene	8	103	117	106
Bromobenzene	8	93	116	107
Bromochloromethane	8	94	123	109
Bromodichloromethane	8	88	113	109
Bromoform (Tribromomethane)	8	91	112	103
Bromomethane (Methyl bromide)	8	87	132	105
n-Butylbenzene	8	86	100	95
sec-Butylbenzene	8	92	118	107
tert-Butylbenzene	8	90	120	111
Carbon disulfide [1]	8	72	88	75
Carbon tetrachloride (Tetrachloromethane)	8	94	126	108
Chlorobenzene	8	97	119	106
Chloroethane	8	87	116	105
Chloroform (Trichloromethane) [1]	8	89	119	112
Chloromethane	8	81	115	95
3-Chloropropene	8	109	129	113
2-Chlorotoluene	8	95	123	105
4-Chlorotoluene	8	93	110	104
Dibromochloromethane	8	92	115	100
1,2-Dibromo-3-chloropropane (DBCP)	8	94	114	102
1,2-Dibromoethane (EDB)	8	101	121	107
Dibromomethane	8	80	119	108
1,2-Dichlorobenzene	8	93	121	105
1,3-Dichlorobenzene	8	99	111	103
1,4-Dichlorobenzene [1]	8	97	111	103
trans-1,4-Dichloro-2-butene	8	86	115	102
Dichlorodifluoromethane (CFC-12)	8	65	105	74
1,1-Dichloroethane (1,1-DCA) [1]	8	98	125	110
1,2-Dichloroethane (1,2-DCA) [1]	8	91	128	111
1,1-Dichloroethene (1,1-DCE) [1]	8	94	112	100
cis-1,2-Dichloroethene (*cis*-1,2-DCE) [1]	8	106	119	108
trans-1,2-Dichloroethene (*trans*-1,2-DCE)	8	102	125	109
1,2-Dichloropropane	8	102	122	111
1,3-Dichloropropane	8	103	117	109
2,2-Dichloropropane	8	87	115	93
1,1-Dichloropropene	8	96	110	104

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOC) in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spiked samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
cis-1,3-Dichloropropene	8	85	106	95
trans-1,3-Dichloropropene	8	87	101	95
Diethyl ether	8	105	129	114
Diisopropyl ether (DIPE)	8	103	114	110
Ethylbenzene	8	88	120	104
Ethyl *tert*-butyl ether (ETBE)	8	94	120	107
Ethyl methacrylate	8	94	117	103
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	8	88	113	100
Hexachlorobutadiene	8	79	103	88
Hexachloroethane	8	91	119	99
2-Hexanone (*n*-Butyl methyl ketone)	8	100	119	109
Iodomethane (Methyl iodide)	8	88	124	115
Isopropylbenzene	8	92	121	108
4-Isopropyl-1-methyl benzene	8	82	110	101
Methyl acrylate	8	102	118	107
Methyl acrylonitrile	8	106	126	113
Methyl *tert*-butyl ether (MTBE) [1]	8	96	121	111
Methyl *iso*-butyl ketone (MIBK)	8	96	117	105
Methylene chloride (Dichloromethane)	8	89	120	105
Methyl ethyl ketone (2-butanone, MEK)	8	103	114	107
Methyl methacrylate	8	91	116	103
Naphthalene	8	84	116	104
Perchloroethene (PCE, Tetrachloroethene) [1]	8	91	115	106
n-Propylbenzene	8	81	113	98
Styrene	8	88	115	104
1,1,1,2-Tetrachloroethane	8	94	120	112
1,1,2,2-Tetrachloroethane	8	88	119	109
Tetrahydrofuran	8	96	114	107
1,2,3,4-Tetramethylbenzene	8	81	116	102
1,2,3,5-Tetramethylbenzene	8	87	123	108
Toluene [1]	8	97	114	104
1,2,3-Trichlorobenzene	8	102	114	107
1,2,4-Trichlorobenzene	8	90	103	98
1,1,1-Trichloroethane (1,1,1-TCA) [1]	8	92	122	112
1,1,2-Trichloroethane (1,1,2-TCA)	8	88	117	108
Trichloroethene (TCE) [1]	8	101	116	103
Trichlorofluoromethane (CFC-11) [1]	8	86	132	102
1,2,3-Trichloropropane (1,2,3-TCP)	8	83	118	105
Trichlorotrifluoroethane (CFC-113)	8	77	96	89

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOC) in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spiked samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
1,2,3-Trimethylbenzene	8	93	123	111
1,2,4-Trimethylbenzene [1]	8	91	121	109
1,3,5-Trimethylbenzene	8	88	114	104
Vinyl bromide (Bromoethene)	8	94	114	100
Vinyl chloride (Chloroethene)	8	94	123	108
m- and *p*-Xylene	8	91	119	107
o-Xylene	8	89	120	103

[1] Constituents detected in groundwater samples.

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spiked samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetochlor	8	82	118	99
Alachlor	8	89	119	98
Atrazine [1]	8	82	110	99
Azinphos-methyl	8	84	112	96
Azinphos-methyl-oxon	8	61	96	71
Benfluralin	8	42	78	58
Carbaryl	8	90	120	108
2-Chloro-2,6-diethylacetanilide	8	79	109	92
4-Chloro-2-methylphenol	8	54	78	69
Chlorpyrifos	8	57	105	82
Chlorpyrifos, oxygen analog	7	24	54	34
Cyfluthrin	8	35	63	52
Cypermethrin	8	38	65	53
Dacthal (DCPA)	8	91	112	107
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine) [1]	8	49	73	65
Desulfinylfipronil [1]	8	80	114	103
Desulfinylfipronil amide	8	86	127	91
Diazinon	8	73	100	88
3,4-Dichloroaniline [1]	8	78	99	84
Dichlorvos	8	5	37	20
Dicrotophos	8	15	37	30
Dieldrin	8	63	127	86
2,6-Diethylaniline	8	81	101	93
Dimethoate	8	37	55	47
Ethion	8	51	107	70
Ethion monoxon	8	63	85	69
2-Ethyl-6-methylaniline	8	81	99	91
Fenamiphos	8	52	106	76
Fenamiphos sulfone	8	66	116	87
Fenamiphos sulfoxide	8	8	27	18
Fipronil [1]	8	78	124	100
Fipronil sulfide	8	70	118	95
Fipronil sulfone [1]	8	60	101	73
Fonofos	8	79	95	85
Hexazinone [1]	8	47	87	66
Iprodione	8	61	89	76
Isofenphos	8	77	122	101
Malaoxon	8	60	98	83
Malathion	8	72	108	84
Metalaxyl	8	89	121	99
Methidathion	8	76	104	85

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spiked samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Metolachlor	8	85	112	97
Metribuzin	8	72	103	87
Myclobutanil	8	69	113	84
1-Naphthol	8	33	62	53
Paraoxon-methyl	8	34	80	60
Parathion-methyl	8	66	93	74
Pendimethalin	8	68	126	95
cis-Permethrin	8	38	82	55
Phorate	8	56	88	66
Phorate oxon	8	74	115	92
Phosmet	8	9	31	19
Phosmet oxon	8	16	63	23
Prometon	8	75	104	85
Prometryn	8	79	112	100
Propyzamide	8	78	111	95
Simazine [1]	8	83	109	93
Tebuthiuron	8	73	144	111
Terbufos	8	57	92	75
Terbufos oxon sulfone	8	59	92	82
Terbuthylazine	8	87	111	99
Tribufos	8	34	64	48
Trifluralin	8	47	85	64

[1]Constituents detected in groundwater samples.

Table A5C. Quality-control summary for matrix-spike recoveries of *N*-Nitrosodimethylamine (NDMA) in groundwater samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spiked samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
N-Nitrosdimethylamine (NDMA)	4	77	115	89

Table A6. Quality-control summary for surrogate recoveries of volatile organic compounds and pesticides and pesticide degradates in samples collected for the Sierra Nevada Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June through October 2008.

[VOC, volatile organic compound]

Surrogate	Analytical schedule	Constitutent class analyzed	Number of analyses	Median recovery (percent)	Number of surrogate recoveries below 70 percent	Number of surrogate recoveries above 130 percent
Blanks						
1-Bromo-4-fluorobenzene	2020	VOC	8	82	0	0
1,2-Dichloroethane-*d*4	2020	VOC	8	128	0	4
Toluene-*d*8	2020	VOC	8	95	0	0
Diazinon-*d*10	2003	Pesticide	7	87	0	0
α-HCH-*d*6	2003	Pesticide	7	86	0	0
Groundwater, replicate, and matrix-spike test samples						
1-Bromo-4-fluorobenzene	2020	VOC	83	80	5	0
1,2-Dichloroethane-*d*4	2020	VOC	83	133	0	49
Toluene-*d*8	2020	VOC	83	94	0	0
Diazinon-*d*10	2003	Pesticide	83	86	3	0
α-HCH-*d*6	2003	Pesticide	83	86	2	0

This page intentionally left blank.

USGS

Shelton and others—**Groundwater-Quality Data for the Sierra Nevada Study Unit, 2008: Results from the California GAMA Program**—Data Series 534

Printed on recycled paper