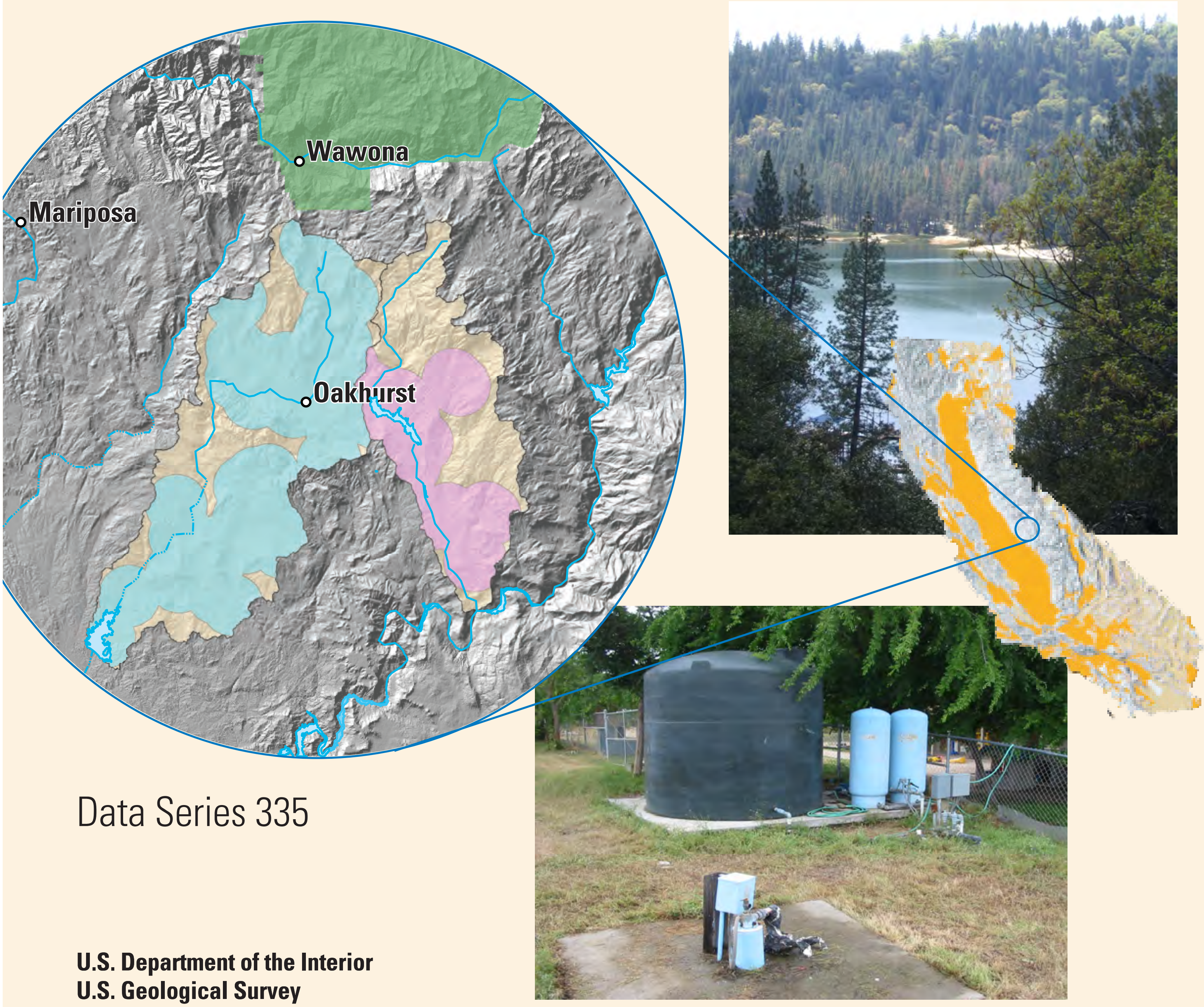
In cooperation with the California State Water Resources Control Board

Ground-Water Quality Data in the Central Sierra Study Unit, 2006—Results from the California GAMA Program



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Conversion Factors, Datum, Abbreviations and Acronyms, Chemical and Microbial Names, Organizations, and Units of Measure

Conversion Factors

Multiply	By	To obtain
foot (ft)	0.3048	meter
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
square mile (mi^2)	2.590	square kilometer (km^2)

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

°C = (°F-32)/1.8

Datum

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1988 (NGVD 88).

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).

Conversion Factors, Datum, Abbreviations and Acronyms, Chemical and Microbial Names, Organizations, and Units of Measure—Continued

Abbreviations and Acronyms

Abbreviations and Acronyms	Definition
AB	Assembly Bill (through the California State Assembly)
AL-US	U.S. Environmental Protection Agency action level
AMCL	Alternative Maximum Contaminant Level
CAS	Chemical Abstract Service (American Chemical Society)
CENSIE	Central Sierra study unit
CGOLD	Central Sierra Coarse Gold study area
CGOLDU	Central Sierra Coarse Gold study area understanding well
CSU	one-sigma combined standard uncertainty
CWISH	Central Sierra Wishon study area
CWISHU	Central Sierra Wishon study area understanding well
D	detected
E	estimated or having a higher degree of uncertainty
GAMA	Groundwater Ambient Monitoring and Assessment program
GC/MS	gas chromatography/mass spectrometry
GPS	Global Positioning System
HAL-US	U.S. Environmental Protection Agency lifetime health advisory level
HPLC	high-performance liquid chromatography
ICP-MS	inductively-coupled-plasma mass spectrometry
ID	inside diameter
IRL	interim reporting levels
LRL	laboratory reporting level
LSD	land-surface datum
LT-MDL	long-term method detection level
LUFT	leaking underground fuel tank
MCL-CA	California Department of Public Health maximum contaminant level
MCL-US	U.S. Environmental Protection Agency maximum contaminant level
MRL	minimum reporting level
MU	method uncertainty
N	Normal (1-gram-equivalent per liter of solution)
na	not available
NL-CA	California Department of Public Health notification level
nc	sample not collected
NWIS	National Water Information System (USGS)
QC	quality control
QPC	Quaternary Pleistocene age semiconsolidated deposits
RSD	relative standard deviation
RSD5-US	U.S. Environmental Protection Agency risk-specific dose at a risk factor of 10^{-5}
SMCL-CA	California Department of Public Health secondary maximum contaminant level
SSMDC	sample-specific minimum detectable concentration
TT-US	U.S. Environmental Protection Agency Treatment Technique
UV-VIS	ultraviolet
V	value flagged due to possible contamination

Conversion Factors, Datum, Abbreviations and Acronyms, Chemical and Microbial Names, Organizations, and Units of Measure—Continued

Organizations

Abbreviations and Acronyms	Definition
CDPH	California Department of Public Health (was formerly California Department of Health Services prior to July 1, 2007)
CDWR	California Department of Water Resources
LLNL	Lawrence Livermore National Laboratory
MWH	Montgomery Watson-Harza Laboratory
NAWQA	National Water Quality Assessment (USGS)
NELAP	National Environmental Laboratory Accreditation Program
NIST	National Institute for Standards and Technology
NRP	National Research Program (USGS)
NWQL	National Water Quality Laboratory (USGS)
RSIL	Reston Stable Isotope Laboratory (USGS)
SITL	Stable Isotope and Tritium Laboratory (USGS)
SWRCB	California State Water Resources Control Board
TML	Trace Metal Laboratory (USGS)
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Chemical and Microbial Names

Abbreviations and Acronyms	Definition
$CaCO_3$	calcium carbonate
CO_3^{2-}	carbonate
Cr(VI)	hexavalent chromium
CFC	chlorofluorocarbon
CFC-11	trichlorofluoromethane
CFC-12	dichlorodifluoromethane
CFC-113	1,1,2-trichlorotrifluoroethane
DBCP	1,2-dibromo-3-chloropropane
DCE	1,1-dichloroethene
DIPE	diisopropyl ether
DO	dissolved oxygen
DOC	dissolved organic carbon
E. coli	*Escherichia coli*
EDB	1,2-dibromoethane
ETBE	ethyl-tert butyl ether
HCl	hydrochloric acid
HCO_3^-	bicarbonate
MTBE	methyl *tert*-butyl ether
NDMA	*N*-nitrosodimethylamine
PCE	tetrachloroethylene
PVC	polyvinyl chloride
SC	specific conductance
TBA	*tert*-butyl alcohol
1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
TCE	trichloroethene

Conversion Factors, Datum, Abbreviations and Acronyms, Chemical and Microbial Names, Organizations, and Units of Measure—Continued

Chemical and Microbial Names—Continued

Abbreviations and Acronyms	Definition
1,2,3-TCP	1,2,3-trichloropropane
TDS	total dissolved solids
THM	trihalomethane
TIC	tentatively identified compound
VOC	volatile organic compound

Units of Measurement

Abbreviations and Acronyms	Definition
δ	delta
°C	degrees Celsius
cm^3 STP	cubic centimeters at standard temperature and pressure (0°C and 1 atmosphere of pressure)
km	kilometer
km^2	square kilometer
L	liter
mg	milligram
mg/L	milligrams per liter (parts per million)
mi2	square mile
mL	milliliter
µg	microgram
µg/L	micrograms per liter (parts per billion)
µL	microliter
µm	micrometer
µS/cm	microsiemens per centimeter
pCi/L	picocuries per liter
VPDB	Vienna Peedee Belemnite
VSMOW	Vienna Standard Mean Ocean Water

Ground-Water Quality Data in the Central Sierra Study Unit, 2006–Results from the California GAMA Program

By Matthew J. Ferrari, Miranda S. Fram, and Kenneth Belitz

Abstract

Ground-water quality in the approximately 950 square kilometer (370 square mile) Central Sierra study unit (CENSIE) was investigated in May 2006 as part of the Priority Basin Assessment project of the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA Priority Basin Assessment project was developed in response to the Ground-Water Quality Monitoring Act of 2001, and is being conducted by the U.S. Geological Survey (USGS) in cooperation with the California State Water Resources Control Board (SWRCB).

This study was designed to provide a spatially unbiased assessment of the quality of raw ground water used for drinking-water supplies within CENSIE, and to facilitate statistically consistent comparisons of ground-water quality throughout California. Samples were collected from thirty wells in Madera County. Twenty-seven of the wells were selected using a spatially distributed, randomized grid-based method to provide statistical representation of the study area (grid wells), and three were selected to aid in evaluation of specific water-quality issues (understanding wells).

Ground-water samples were analyzed for a large number of synthetic organic constituents (volatile organic compounds [VOCs], gasoline oxygenates and degradates, pesticides and pesticide degradates), constituents of special interest (*N*-nitrosodimethylamine, perchlorate, and 1,2,3-trichloropropane), naturally occurring inorganic constituents [nutrients, major and minor ions, and trace elements], radioactive constituents, and microbial indicators. Naturally occurring isotopes [tritium, and carbon-14, and stable isotopes of hydrogen, oxygen, nitrogen, and carbon], and dissolved noble gases also were measured to help identify the sources and ages of the sampled ground water. In total, over 250 constituents and water-quality indicators were investigated.

Quality-control samples (blanks, replicates, and samples for matrix spikes) were collected at approximately one-sixth of the wells, and the results for these samples were used to evaluate the quality of the data for the ground-water samples. Results from field blanks indicated contamination was not a noticeable source of bias in the data for ground-water samples. Differences between replicate samples were within acceptable ranges, indicating acceptably low variability. Matrix spike recoveries were within acceptable ranges for most constituents.

This study did not attempt to evaluate the quality of water delivered to consumers; after withdrawal from the ground, water typically is treated, disinfected, or blended with other waters to maintain water quality. Regulatory thresholds apply to water that is served to the consumer, not to raw ground water. However, to provide some context for the results, concentrations of constituents measured in the raw ground water were compared with health-based thresholds established by the U.S. Environmental Protection Agency (USEPA) and California Department of Public Health (CDPH), and thresholds established for aesthetic concerns (Secondary Maximum Contaminant Levels, SMCL-CA) by CDPH. Therefore, any comparisons of the results of this study to drinking-water standards only is for illustrative purposes and is not indicative of compliance or non-compliance to those standards.

Most constituents that were detected in ground-water samples were found at concentrations below drinking-water standards or thresholds. Six constituents— fluoride, arsenic, molybdenum, uranium, gross-alpha radioactivity, and radon-222—were detected at concentrations higher than thresholds set for health-based regulatory purposes. Three additional constituents—pH, iron and manganese—were detected at concentrations above thresholds set for aesthetic concerns. Volatile organic compounds (VOCs) and pesticides, were detected in less than one-third of the samples and generally at less than one one-hundredth of a health-based threshold.

Introduction

Ground water comprises nearly half of the water used for public supply in California (Hutson and others, 2004). To assess the quality of ground water in aquifers used for drinking water supply and to establish a program for monitoring trends in ground-water quality, the 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/index.html). The GAMA program consists of three projects: Priority Basin Assessment, conducted by the USGS (http://ca.water.usgs.gov/gama/); Voluntary Domestic Well Assessment, conducted by the SWRCB; and Special Studies, conducted by LLNL.

The GAMA Priority Basin Assessment project was developed in response to the Ground-Water Quality Monitoring Act of 2001 (California Water Code, Section §§10780-10782.3). AB 599 is a public mandate to assess and monitor the quality of ground water used as public supply for municipalities in California. The project is a comprehensive assessment of statewide ground-water quality designed to help better understand and identify risks to ground-water resources, and to increase the availability of information about ground-water quality to the public. The USGS, as part of the AB 599 process and in collaboration with the SWRCB, developed the monitoring plan for the project (Belitz and others, 2003; http://water.usgs.gov/pubs/wri/wri034166/). A key aspect of the project is interagency collaboration and cooperation with local water agencies and well owners. Local participation in the project is entirely voluntary.

The GAMA Priority Basin Assessment project is unique because the data collected during the study include analyses for an extensive number of chemical constituents at very low concentrations, analyses that normally are not available. A broader understanding of ground-water composition will be especially useful for providing an early indication of changes in water quality, and for identifying the natural and human factors affecting water quality. Additionally, the GAMA Priority Basin Assessment project will analyze a broader suite of constituents than required by the California Department of Public Health (CDPH, formerly California Department of Health Services). An understanding of the occurrence and distribution of these constituents is important for the long-term management and protection of ground-water resources.

The range of hydrologic, geologic, and climatic conditions that exist in California must be considered in an assessment of ground-water quality. Belitz and others (2003) partitioned the state into ten hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics (fig. 1), and representative regions in all ten provinces were included in the project design. Eighty percent of California's approximately 16,000 public-supply wells are located in ground-water basins within these hydrologic provinces. These ground-water basins, defined by the California Department of Water Resources (CDWR), generally consist of relatively permeable, unconsolidated deposits of alluvial or volcanic origin (California Department of Water Resources, 2003). Ground-water basins were prioritized for sampling on the basis of the number of public-supply wells in the basin, with secondary consideration given to municipal ground-water use, agricultural pumping, the number of leaking underground fuel tanks, and pesticide applications within the basins (Belitz and others, 2003). In addition, some ground-water basins, or groups of adjacent similar basins, with relatively few public-supply wells were assigned high priority so that all hydrogeologic provinces would be represented in the subset of basins sampled. The 116 priority basins were grouped into 35 study units. Some areas not in the defined ground-water basins were included in several of the study units, including the Central Sierra GAMA study unit, to achieve representation of the 20 percent of public-supply wells not located in the defined ground-water basins.

Within the Sierra Nevada Hydrogeologic Province, 97 percent of the total area, 84 percent of the LUFTs, and 96 percent of the section with pesticide applications are located outside of the defined priority ground-water basins. (Belitz and others, 2003). Therefore, the Central Sierra GAMA study unit, hereafter referred to as CENSIE, was delineated on the basis of two watersheds (surface-water drainage areas), rather than defined ground-water basins. CENSIE was considered high priority for sampling to provide adequate representation of the Sierra Nevada Hydrogeologic Province.

Previous studies have identified several water-quality concerns in eastern Madera County, which includes CENSIE (California Department of Water Resources, 1966, 1990; Mack and Ferrell, 1979; Todd Engineers, 2002; Gardner, 2005; and Schmidt and Associates, 2005). Most of the known water-quality concerns are caused by naturally occurring constituents including uranium, arsenic, chloride, iron, manganese, hydrogen sulfide, and total dissolved solids. Other constituents, such as nitrate, total coliform, and methyl tert-butyl ether (MTBE), have been found as local occurrences in ground-water samples from eastern Madera County.

Three types of water-quality assessments are being conducted with the data collected in each study unit: (1) Status: assessment of the current quality of the ground-water resource, (2) Trends: detection of changes in ground-water quality and (3) Understanding: identification the natural and human factors affecting ground-water quality (Kulongoski and Belitz, 2004). This report is one of a series of reports presenting the status of current water-quality conditions in each study unit; previous reports in this series include Wright and others (2005), Kulongoski and others (2006), Bennett and others (2006), Kulongoski and Belitz (2007), Fram and Belitz (2007), and Dawson and others (2008), and. Subsequent reports will address the trends and understanding aspects of the water-quality assessments.

Base from U.S. Geological Survey digital elevation data, 1999, Albers Equal Area Conic Projection

Provinces from Belitz and others, 2004

Figure 1. Hydrogeologic provinces of California and the location of the Central Sierra Ground-Water Ambient Monitoring and Assessment (GAMA) study unit.

Purpose and Scope

The purposes of this report are: (1) to describe the study design and study methods; (2) to present the results of quality-control tests; and (3) to present the analytical results for ground-water samples collected in CENSIE. Ground-water samples were analyzed for field parameters, organic, inorganic, and microbial constituents, and chemical tracers. The chemical and microbial data presented in this report were evaluated by comparison to Federal and State drinking-water regulatory thresholds and other health-based standards that are applied to treated drinking water. Regulatory thresholds have been established by the U.S. Environmental Protection Agency (USEPA) and the California Department of Public Health (CDPH) (U.S. Environmental Protection Agency, 2008a, 2008b, 2008c; California Department of Public Health, 2008a, 2008b). The data presented in this report are intended to characterize the quality of untreated ground-water resources within the study unit, not the treated drinking water delivered to consumers by water purveyors. Discussions of the factors that influence the distribution and occurrence of the constituents detected in ground-water samples will be the subject of subsequent publications.

Acknowledgements

The authors thank the following agencies for their support: the California State Water Resources Control Board, California Department of Public Health, California Department of Water Resources, and Lawrence Livermore National Laboratory. We also thank the cooperating well owners and water purveyors for their generosity in allowing the USGS to collect samples from their wells. In addition, three reviewers—Jonathan J.A. Dillow and Matthew K. Landon of the USGS, and Jan Stepek of the SWRCB—provided technical reviews for this report. Funding for this work was provided by State bonds authorized by Proposition 50 and administered by the SWRCB.

Hydrogeologic Setting

Knowledge of the hydrologeologic setting is important in the design of a ground-water quality investigation. The Central Sierra GAMA study unit (CENSIE) lies entirely within the Sierra Nevada Hydrogeologic Province described by Belitz and others (2003) (fig. 1). However, unlike most of the other thirty-five study units, CENSIE is not comprised of ground-water basins defined by the CDWR (California Department of Water Resources, 2003). The boundaries of CENSIE are defined by surface-water watershed boundaries.

The CENSIE study unit is located in Madera and Mariposa counties, west of Merced and south of Yosemite National Park (fig. 2). The study unit consists of two watersheds: Fresno River and North Fork Willow Creek, referred to in this report by the largest hydrologic sub-areas within each watershed, the Coarse Gold and Wishon study areas, respectively (fig. 2) (California Department of Water Resources, 2006a; 2006b). The two watersheds combined cover an area of approximately 975 square kilometers (km^2) in central Madera County and a small portion of Mariposa County. Both watersheds eventually drain into the San Joaquin River.

The climate within the Central Sierra region generally is hot and dry in the summer and cold and wet in the winter. Precipitation, which usually is rain in the lower elevations and rain or snow in the higher elevations, falls mainly from late fall to early spring. Average annual precipitation ranges from less than 20 inches per year (in/yr) near Hensley Lake in the foothills to over 70 in/yr in the highest elevations within the study unit (Todd Engineers, 2002). Over half of the average annual precipitation falls in the months of December, January, and February (California Department of Water Resources, 2006c). Ground-water recharge is estimated to be 10-20 percent of the average precipitation in the Oakhurst area (Schmidt and Associates, 2005). This estimate is calculated from the amount of precipitation minus the amount of runoff, minus the amount of evapotranspiration, plus the amount of streambed or lakebed infiltration (ignoring any artificial recharge or recharge from irrigation).

Most of the study unit is underlain by granite, with a few areas underlain by gabbro or metamorphic rocks. The granite has been weathered and has decomposed partially to depths of as much as 100 feet (ft) in places. Metamorphic rocks have been weathered to depths of as much as 50 ft. Movement of ground water occurs primarily through fractures in the bedrock. These fractures generally are more extensive in size and number in the upper few hundred feet and typically decrease with depth (Borchers, 1996; Todd Engineers, 2002). Several mapped or inferred faults, which may be part of the Melones fault zone, also occur within the study unit. These faults and lineaments, especially in the Oakhurst–Bass Lake area, may affect infiltration of precipitation and movement of ground water and solutes (Mack and Ferrell, 1979; Mack and Schmidt, 1981; and California Department of Water Resources, 1990). Historic mining operations and identified deposits in Madera County include copper, gold, iron, molybdenum, silver, tungsten, pumice, and building stone (Bradley, 1920; and Madera County, 2001).

Land use in the CENSIE region mainly is forested in the higher elevations, and woodland or grassland in the lower elevations. Very little cultivated agriculture occurs within the study unit itself, but there is some cultivated agriculture (mainly orchards and vineyards) and pasture in the foothills region south and west of CENSIE. Residential and commercial development has been increasing at a moderate pace along the major highways, mostly around existing communities, and tourism and recreation also are important (Todd Engineers, 2002; Oakhurst Area Chamber of Commerce, 2005).

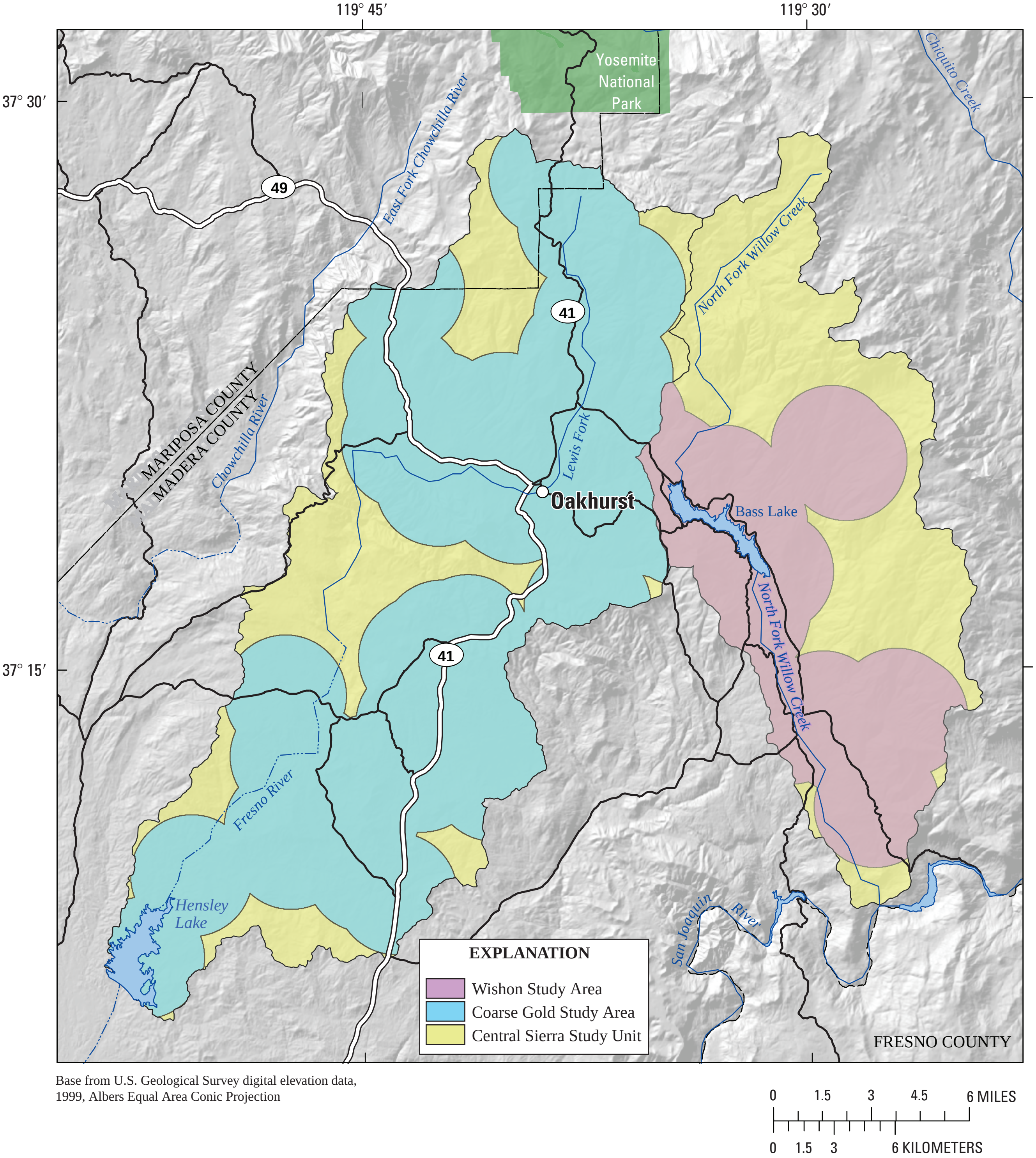


Figure 2. The Central Sierra Ground-Water Ambient Monitoring and Assessment (GAMA) study unit showing the two watersheds within the study unit and major hydrologic features.

Population in eastern Madera County has increased from 5,853 in 1970 to 36,376 in 1997, which has increased demand on the ground-water resources (Oakhurst Area Chamber of Commerce, 2006).

The Coarse Gold study area is defined as the Fresno River watershed above Hidden Dam at Hensley Lake (fig. 2). The watershed covers an area of 620 km^2 above Hidden Dam and ranges in elevation from approximately 400 ft at the Fresno River near the base of Hidden Dam to 6,586 ft at the summit of Hogan Mountain. Major surface hydrologic features include the upper Fresno River, Coarse Gold Creek, Lewis Fork, and Hensley Lake. Most of the watershed is underlain by Mesozoic granite, although parts of the central and western portions of the watershed are underlain by metamorphic rocks, known as the Oakhurst Metamorphic Belt (Jennings, 1977; Mack and Schmidt, 1981; Todd Engineers, 2002; and Schmidt and Associates, 2005).

The Wishon study area is defined as the North Fork Willow Creek watershed above the confluence with the San Joaquin River. The watershed covers an area of 337 km^2, and ranges in elevation from approximately 1,180 ft at the confluence of Willow Creek and San Joaquin River to 9,158 ft at the summit of Iron Mountain. Major surface hydrologic features include Willow Creek, Bass Lake, Manzanita Lake, and Chilkoot Lake. Almost all of the Wishon study area is underlain by Mesozoic granite except for a few small areas of metamorphic and metavolcanic rocks (Jennings, 1977; Todd Engineers, 2002; and Schmidt and Associates, 2005).

Methods

Methods used for the GAMA program were selected to achieve the following objectives: (1) design a sampling plan suitable for statistical analysis, (2) ensure sample collection in a consistent manner, (3) analyze samples using proven and reliable laboratory methods, (4) assure the quality of the ground-water 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 plan, and the results of analyses of quality-control samples.

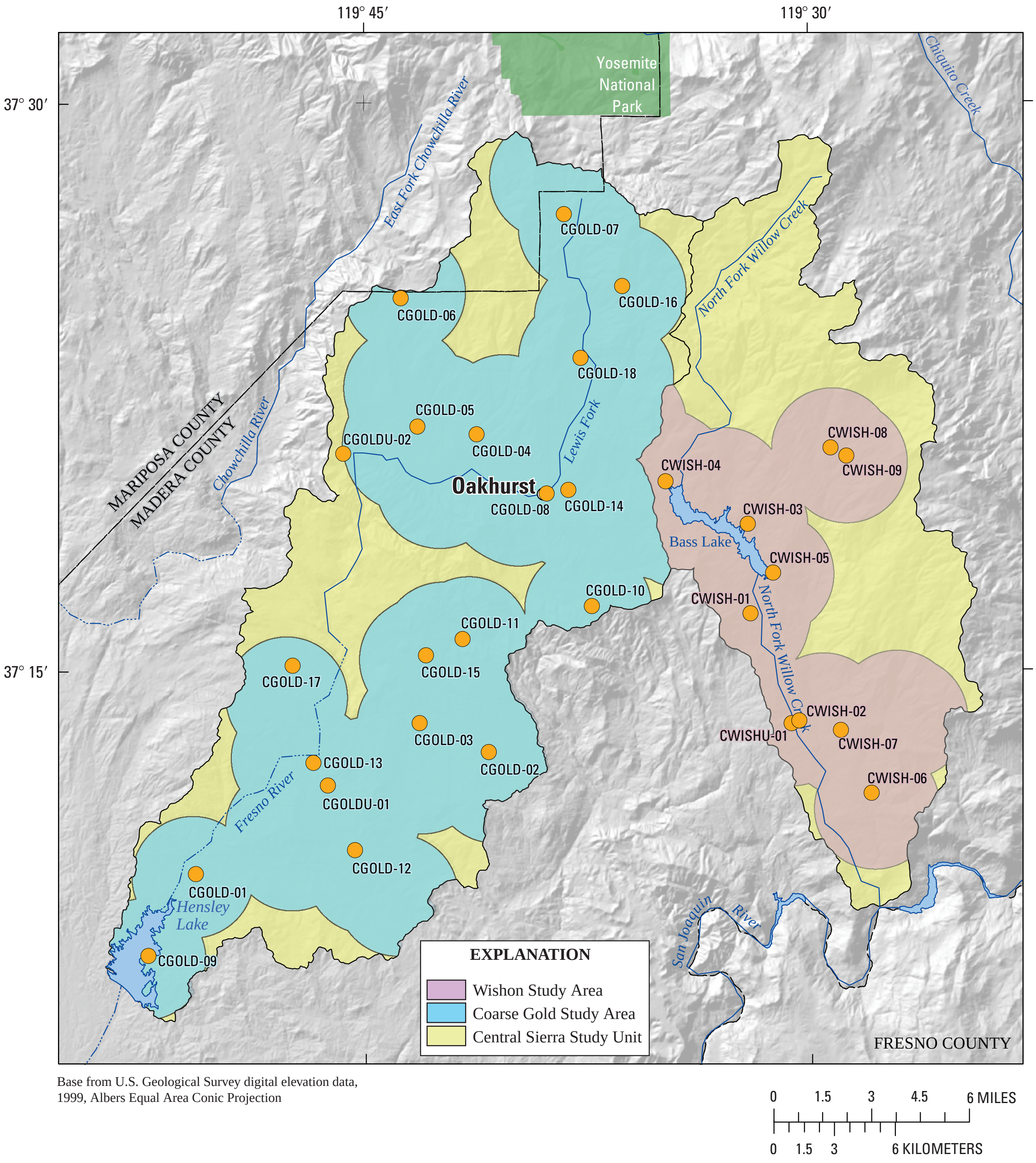
Study Design

Most other GAMA Priority Basin Assessment project study units have boundaries that coincide with the ground-water basin boundaries identified by the CDWR (California Department of Water Resources, 2003.) However, the boundary of the CENSIE study unit does not encompass mapped ground-water basins and, instead, is based on surface-water drainage areas. Just 3 percent of the Sierra Nevada Hydrogeologic Province is comprised of ground-water basins identified by CDWR. However, approximately 20 percent of the public-supply wells in the CDPH database are located outside of CDWR basins, primarily in the Sierra Nevada. To provide coverage of the full range of hydrogeologic settings of aquifers used for public supply, several study units, including CENSIE, were designed to include areas outside of defined ground-water basins (Belitz and others, 2003).

CENSIE utilized the upper Fresno River (Coarse Gold) and North Fork Willow Creek (Wishon) watersheds for the study-area boundaries (fig. 2). These two watersheds are sparsely populated and, therefore, public-supply wells are not distributed evenly throughout the watersheds. To minimize inclusion of areas within each watershed with no public-supply wells in the spatially distributed, randomized well-selection process, a 3-kilometer (km)-radius buffer was placed around each public-supply well. The collective area within these 3-km buffers in each of the two watersheds defined the study areas. Each of the buffered study areas was subdivided into grid cells to provide a spatially unbiased assessment of ground-water quality (Scott, 1990) (fig. 3). The number of grid cells was determined by the total buffered area in each watershed, divided by 25 km^2, and the resulting number was rounded up. The objective was to randomly select one public-supply well per grid cell. For the Wishon study area, this procedure resulted in only 8 grid cells, so this number was increased to 10 for statistical purposes. For the Coarse Gold study area, the buffered area was divided into 20 grid cells.

Initial candidate wells were obtained from statewide databases maintained by CDPH and the USGS. An attempt was made to select one public-supply well per grid cell. If a grid cell contained more than one public-supply well, each well in that grid cell was randomly assigned a rank, and the highest ranked well was given priority for sampling. If a grid cell did not contain accessible or active public-supply wells, a domestic well within the cell was chosen. In this fashion, a public-supply well or domestic well was selected for twenty-seven of the thirty cells to provide a spatially distributed, randomized monitoring network for each study area (fig. 3). Wells sampled as part of the grid-cell network hereafter are referred to as grid wells. Three additional wells were selected to provide additional spatial coverage for understanding of particular water-quality issues. These wells are referred to as understanding wells and are not included in the assessment of the status of water-quality in CENSIE.

Grid wells sampled as part of CENSIE were assigned unique alphanumeric identification numbers with the following prefixes based on study area: the Coarse Gold study area (CGOLD), and the Wishon study area (CWISH). Wells were numbered in the order of sample collection. Understanding wells in the Coarse Gold and Wishon study areas were numbered with the prefixes CGOLDU and CWISHU, respectively. Table 1 (at back of report) provides the GAMA identification number for each well, along with the sampling schedule, time and date sampled, and well-construction information. Ground-water samples were collected from 27 public-supply wells and 3 domestic wells in May 2006.



Base from U.S. Geological Survey digital elevation data, 1999, Albers Equal Area Conic Projection

Figure 3. The Central Sierra Ground-Water Ambient Monitoring and Assessment (GAMA) study unit showing the 1.86-mile (3-kilometer) buffer zones around all public-supply wells, the distribution of study area grid cells, and the location of sampled wells.

Well locations and identifications were verified using GPS, 1:24,000-scale USGS topographic maps, comparison with 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 uploaded into the USGS National Water Information System (NWIS). Well owner information is confidential. Well location and all chemical data are currently inaccessible from NWIS's public website.

The wells in CENSIE were sampled using a tiered analytical approach. All wells were sampled for a standard set of water-quality constituents and environmental tracers. The classes of water-quality constituents in the standard set included: organic constituents [volatile organic compounds (VOCs), gasoline oxygenates and degradates, pesticides and pesticide degradates, and pharmaceutical compounds]; constituents of special interest [perchlorate, *N*-nitrosodimethylamine (NDMA), and 1,2,3-trichloropropane (1,2,3-TCP)]; inorganic constituents [nutrients and dissolved organic carbon, major and minor ions, and trace elements]; and uranium isotopes. The environmental tracers in the standard set included: stable isotopes of water and nitrate; boron and strontium isotopic ratios; and age-dating tracers (carbon-14, tritium, and tritium/helium). The standard set of constituents was termed the "intermediate" schedule (table 2; at back of report). Wells on the "slow" schedule were sampled for all the constituents on the intermediate schedule, plus gross-alpha and gross-beta radiation, radium isotopes, radon-222, and microbial constituents (table 2). Intermediate and slow refer to the time required to sample the well for all of the analytes on the schedule. A third schedule, "fast" was used in many of the other GAMA study units. Generally, one slow or one or two intermediate wells could be sampled per day. In CENSIE, sixteen of the ground-water wells were sampled on the intermediate schedule and fourteen on the slow schedule (table 1).

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 ground water is collected at each site, and that the samples are collected and handled in a way that minimizes the potential for contamination of samples or cross contamination between samples collected at wells. The methods used for sample collection are described in the Appendix.

Tables 3A–J (at back of report) list the compounds analyzed in each constituent class. Raw (untreated) ground-water samples were analyzed for 85 VOCs (table 3A), 8 gasoline additives and oxygenates (table 3B), 83 pesticide and pesticide degradates (table 3C), 3 constituents of special interest (NDMA, 1,2,3-TCP, and perchlorate) (table 3D), 5 nutrients and dissolved organic carbon (DOC) (table 3E), 10 major and minor ions and TDS (table 3F), 25 trace elements (table 3F), arsenic, iron, and chromium species (table 3G), 11 radioactive constituents (table 3H), 7 isotope constituents (table 3H), 6 dissolved noble gases and helium rations used for age dating (table 3I), and 4 microbial constituents (table 3J). General water-quality indicators that were determined in the field were DO, pH, SC, alkalinity, turbidity, and water temperature. The methods used for sample analysis are described in the Appendix.

Data Reporting

The methods and conventions used for reporting the data are described in the Appendix. Five constituents analyzed in this study were measured by more than one method at the USGS National Water Quality Laboratory (NWQL), but only the results from the preferred method are reported. Eight constituents were analyzed by more than one laboratory, or in the field and in the laboratory; both sets of results are reported for these constituents.

Quality-Assurance and Quality-Control Procedures

Quality-assurance and quality-control procedures for this study follow the protocols described in the USGS National Field Manual (U.S. Geological Survey, variously dated) and the protocols used by the USGS NAWQA program (Koterba and others, 1995). Standard quality-control procedures were followed at the USGS NWQL (Pirkey and Glodt, 1998; Maloney, 2005). Quality-control (QC) samples collected in the CENSIE study include source-solution blanks, field blanks, replicates, and matrix and surrogate spikes. QC samples were collected to evaluate bias and variability of the water-quality data that may have resulted from sample collection, processing, storage, transportation, and laboratory analysis. Quality-control procedures and quality-control sample results are described in the Appendix.

Quality-Control Sample Results

Results of quality-control analyses (blanks, replicates, matrix spikes, and surrogates) were used to evaluate the quality of the data for the ground-water samples (see Appendix). Of the 250 constituents analyzed, fifteen were detected in at least one field blank. Some reported detections for six constituents in ground-water samples were flagged with "V" codes in tables 4-13 (at back of report), as potentially due to contamination, and were not considered to be detections in assessments of water quality. Data from replicates indicated that variability between measurements generally was low, with a relative standard deviation (RSD) below 5 percent in most samples and above 20 percent in only 15 pairs of replicate samples. Most of the replicate pairs with RSDs above 20 percent had concentrations near the LRL for those constituents, and at these low concentrations, small differences in the measured values in the replicate pairs account for the large RSDs. These results from the replicates confirm that the procedures used to collect the samples were consistent. Matrix-spike recoveries for a number of organic constituents were lower than the acceptable limits, which may indicate that these constituents might not have been detected in some samples if they were present at very low concentrations. More than 90 percent of the samples had surrogate recoveries within acceptable limits for the analyses that use surrogates. The quality-control results are described in the Appendix.

Comparison Thresholds

Water-quality results from ground-water sampling were compared with CDPH and USEPA drinking-water health-based thresholds and thresholds established for aesthetic purposes (California Department of Public Health, 2008a, 2008b; U.S. Environmental Protection Agency, 2008a, 2008b, 2008c). CDPH replaced California Department of Health Services (CDHS) on July 1, 2007. The chemical and microbial data presented in this report are meant to characterize the quality of the untreated ground-water resources within CENSIE, and are not intended to represent the treated drinking water delivered to consumers by water purveyors. The chemical and microbial composition of treated drinking water may differ from untreated ground water because treated drinking water may be subjected to disinfection, filtration, mixing with other waters, and exposure to the atmosphere prior to its delivery to consumers. Comparisons of raw (untreated) ground water to thresholds are for illustrative purposes only, and are not indicative of compliance or non-compliance with drinking-water regulations.

Explanations of the threshold levels used in this report are provided as follows:

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 (U.S. Environmental Protection Agency, 1974). National MCLs are established by USEPA and individual states may choose to set more stringent standards. CDPH has established MCLs for additional constituents not regulated by the USEPA, as well as lowered the threshold concentrations for a number of constituents with MCLs established by the USEPA. In this report, a threshold set by the USEPA is labeled “MCL-US”, and one set by CDPH that is different from the MCL-US is labeled “MCL-CA”. CDPH is notified when constituents are detected at concentrations above MCL-US or MCL-CA thresholds in samples collected for the GAMA Priority Basin Assessment.

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 above thresholds trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and CDHS are the same, thus, the thresholds are labeled “AL-US” in this report.

TT – Treatment Technique. Legally enforceable standards that apply to public-water systems and are designed to protect public health by limiting the levels of turbidity and microbial constituents in drinking water. Detections of turbidity or microbial constituents above specified action levels trigger requirements for mandatory additional disinfection and filtration during water treatment. The action levels established by the USEPA and CDPH are the same, thus, these thresholds are labeled “TT-US” in this report.

SMCL – Secondary Maximum Contaminant Level. Non-enforceable standards applied to constituents that affect the aesthetic qualities of drinking water, such as taste, odor, and color. 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.

NL – Notification Level. Health-based advisory levels established by CDPH for some of the constituents in drinking water that lack MCLs (NL-CA). If a constituent is detected above its NL-CA, State law requires timely notification of the local governing bodies and recommends consumer notification.

HAL – Lifetime Health Advisory Level. The concentration of a constituent in drinking water that 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 of water per day over a 70-year lifetime by a 70-kilogram 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 excess estimated lifetime cancer risk of 1 in 100,000. RSD5s are calculated by dividing the RSD4 established by the USEPA by ten (RSD5–US).

For constituents with MCLs, detections in ground-water samples were compared to 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; detections of these constituents in ground-water samples were compared with both levels. The SMCL–US for these constituents corresponds to the recommended SMCL–CA. Detected concentrations of constituents that lack an MCL or SMCL were compared to the NL-CA. For constituents that lack an MCL, SMCL, or

NL–CA, detected concentrations were compared with the HAL–US. For constituents that lack an MCL, SMCL, NL–CA, or HAL–CA, detected concentrations were compared with the RSD5–US. Note that this hierarchy of selection of comparison thresholds means that for constituents that have multiple types of established thresholds, the threshold used for comparison purposes may not be the one with the lowest concentration. The comparison thresholds used in this report are listed in tables 3A–J for all constituents and in tables 4–13 for constituents detected in ground-water samples from CENSIE. Not all constituents analyzed for this study have available established thresholds.

Concentrations greater than their comparison thresholds are marked with an asterisk in tables 4–13. In this study, six constituents (arsenic, fluoride, molybdenum, uranium, gross alpha radioactivity, and radon-222) were detected at concentrations higher than health-based thresholds. Three constituents (pH, iron, and manganese) were detected at concentrations above SMCLs set for aesthetic concerns.

Ground-Water-Quality Data

Table 4 includes water-quality indicators measured in the field and at the NWQL, and tables 5–13 present the results of ground-water analyses organized by compound classes:

- Organic constituents
    - Volatile organic compounds (VOCs), and gasoline oxygenates and degradates (table 5)
    - Pesticides and pesticide degradates (table 6)
- Inorganic constituents
    - Nutrients and dissolved organic carbon (table 7)
    - Major and minor ions and total dissolved solids (table 8)
    - Trace elements (table 9)
- Species of inorganic arsenic, iron, and chromium (table 10)
- Radioactive constituents (table 11)
- Isotopic tracers (table 12)
- Microbial indicators (table 13)

The constituents of special interest have no summary table because there were no detections of these constituents. Results for pharmaceutical compounds, and dissolved noble gases and tritium/helium age dates are not presented in this report; they will be included in subsequent publications.

Field Parameters

Field and laboratory measurements including pH, specific conductance, alkalinity, and other parameters are presented in table 4. Turbidity is a measure of the cloudiness of water and is used to indicate filtration effectiveness. Higher turbidity levels may be associated with higher levels of disease-causing microorganisms. One well had a turbidity value above the TT-US maximum value of 5 NTU, and three other wells had turbidity values between 0.3 and 5 NTU. The pH value indicates the acidity or basicity of the water. Eight wells had pH values outside of the SMCL-US range for pH. Specific conductance is a measure of electrical conductivity of the water, and is proportional to amount of dissolved salts in the water. Alkalinity is used as an indicator of natural processes that control water chemistry. Alkalinity also is useful in determining the geochemical evolution of the water and to evaluate the potential of certain water-rock interactions (Hem, 1985).

Organic Constituents

Volatile organic compounds (VOCs) can be present in paints, solvents, fuels, fuel additives, refrigerants, fumigants, and disinfected water and are characterized by their tendency to evaporate. VOCs generally persist longer in ground water than in surface water because ground water is isolated from the atmosphere. Of the 88 VOCs analyzed, 5 were detected in ground-water samples; all detections were below health-based thresholds, and most were less than one one-hundredth of the threshold values (table 5). Chloroform, a byproduct of drinking water disinfection, was detected in more than 10 percent of the grid wells. Chloroform is among the most commonly detected VOCs in ground water nationally (Zogorski and others, 2006). One or two VOCs were detected in 8 of the 27 grid wells sampled.

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 83 pesticides and pesticide degradates analyzed, 4 were detected in ground-water samples; all detections were below health-based thresholds, and all were less than one one-hundredth of the threshold values (table 6). Simazine, an herbicide, was detected in more than 10 percent of the grid wells. Simazine is among the most commonly detected pesticides in ground water nationally (Gilliom and others, 2006). One or more pesticide compounds were detected in 6 of the 26 grid wells sampled.

Inorganic Constituents

Unlike the organic constituents and the constituents of special interest, most of the inorganic constituents naturally can be present in ground water, although their concentrations may be affected by human activities.

The nutrients, nitrogen and phosphorus, and the dissolved organic carbon present in ground water can affect biological activity in aquifers and in surface-water bodies that receive ground-water discharge (Mueller and Helsel, 1996). Nitrogen may be present in the form of ammonia, nitrite, or nitrate, depending on the oxidation-reduction state of the ground water (Hallberg and Keeney, 1993). High concentrations of nitrate can adversely affect human health, particularly the health of infants (Ward and others, 2005). All concentrations of ammonia, nitrite, and nitrate measured in samples from CENSIE wells were below health-based thresholds (table 7). Concentrations of orthophosphate and dissolved organic carbon also were low.

The major-ion composition, total dissolved solids (TDS) content, and levels of certain trace elements in ground water may produce undesirable effects on the aesthetic or technical properties of the water. Undesirable aesthetic properties include poor taste, color, or odor, and staining. Undesirable technical properties include scaling, and reduced effectiveness of treatment for other contaminants. CDPH and USEPA have established non-enforceable thresholds (SMCLs) that are based on these aesthetic and technical concerns, rather than the MCLs based on health concerns. Although there are no adverse health effects associated with concentrations at any SMCL, concentrations above an SMCL may reduce consumer satisfaction with the water or may have economic impacts. Health implications also may exist at concentrations in drinking water higher than the SMCLs (Code of Federal Regulations, 40 CFR 143.1).

The concentrations of chloride, sulfate, and TDS (table 8), and zinc (table 9) measured in samples from CENSIE wells were all below the recommended SMCL-CAs. Precipitation of minerals containing iron or manganese may cause orange or black staining of surfaces. Manganese was detected above the SMCL-CA in nine of the twenty-seven grid wells, and iron also was detected above the SMCL-CA in three of these wells.

Eighteen of the 25 trace elements (table 9), and one of the three minor ions (table 8) analyzed in this study, have health-based thresholds. Of the 19 constituents with health-based thresholds, one trace element was not detected, and all detections of 15 trace elements were below health-based thresholds (table 9). Samples from 10 of the 27 grid wells had concentrations of at least one trace element or minor ion above a health-based threshold. Samples from five grid wells had arsenic concentrations above the MCL-US (table 9), five had uranium concentrations above the MCL-US (table 9), three had molybdenum concentrations above the HAL-US, and two had fluoride concentrations above the MCL-CA (table 8).

Arsenic, chromium, and iron occur in different species, depending on the oxidation-reduction state of the ground water. The oxidized and reduced species have different solubilities in ground water and may have different effects on human health. The relative proportions of the oxidized and reduced species of each element also are used to aid in interpretation of the oxidation-reduction state of the aquifer. Concentrations of total arsenic and iron, and chromium, and the concentrations of either the reduced or the oxidized species of each element are reported in table 10. The concentration of the other species can be calculated by difference. The concentrations of arsenic, iron, and chromium reported in table 10 may be different than those reported in table 9 because different analytical methods were used (see Appendix). The concentrations reported in table 9 are considered to be more accurate than those reported in table 10.

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 ground water comes from decay of naturally occurring isotopes of uranium and thorium that are present in minerals in the sediments or fractured rocks of an aquifer. Both uranium and thorium decay in a series of steps, eventually forming stable isotopes of lead. Radium-226, radium-228, and radon-222 are radioactive isotopes formed during the uranium and 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, hence, becomes radon-222. Radium-228 decays to form actinium-228 by emission of 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 ground water is measured in units of picocuries per liter (pCi/L), and one picocurie is approximately equal to 2.2 atoms decaying per minute. The number of atoms decaying is equal to the number of alpha or beta particles emitted.

Five of the 27 grid wells had combined activities of the three uranium isotopes above the MCL-CA (table 11). The same samples also had uranium concentrations above the MCL-US (table 9), and all five were from the Wishon study area. Of the 14 grid well samples analyzed for radioactive constituents, 3 had activities of gross-alpha radiation (72-hour count) above the MCL-US, and 6 had activities of radon-222 above the proposed alternative MCL-US.

Inorganic Tracer Constituents

Isotopic ratios of constituents, tritium and carbon-14 activities, and noble gas concentrations may be used as tracers of natural processes affecting ground-water composition. Hydrogen and oxygen stable isotopic ratios of water (table 12) may aid in identification of ground-water recharge sources. The stable isotopic ratios of water depend on the altitude, latitude, and temperature of precipitation, and on the extent of evaporation of surface water or soil water (Kendall and Caldwell, 1998). The nitrogen and oxygen stable isotope ratios of nitrate (table 12) may aid in identification of processes affecting nitrate concentrations in ground water, such as denitrification. Nitrate derived from natural, agricultural, and wastewater sources may have distinct stable isotope ratios. Strontium and boron isotopic ratios may aid in identification of the sources of inorganic constituents in ground water; results will be presented in a subsequent publication. Noble gas concentrations may aid in estimation of ground-water recharge sources because the concentrations of the different noble gases depend on water temperature. Noble gas analyses were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

Tritium activities and carbon-14 activities (table 12), and helium isotope ratios also provide information about the age (time since recharge) of the ground water. 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 above background generally indicate the presence of water recharged since the early 1950s. All measured tritium activities in samples from CENSIE wells were less than one one-thousandth of the MCL-CA (tables 12). Helium isotope ratios are used in conjunction with tritium concentrations to estimate ages for young ground water. Helium isotope ratio analyses were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

Carbon-14 (table 12) 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 incorporated into atmospheric carbon dioxide. The carbon dioxide dissolves in precipitation, surface water, and ground water 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 presence of ground water that is several thousand years old.

Microbial Constituents

Water is disinfected during drinking water treatment to prevent diseases that may be spread by water-borne microbial constituents derived from human or animal wastes. The specific viruses and bacteria responsible for diseases generally are not measured because routine analytical methods are not available. Measurements are made of more easily analyzed microbial constituents that serve as indicators of the presence of human or animal waste in water. Drinking-water purveyors respond to detections of microbial indicators by applying additional disinfection techniques to the water.

Samples from 14 CENSIE grid wells were analyzed for microbial indicators. No samples contained the bacterial indicators *Escherichia coli* (*E. coli*) or total coliforms, or the viral indicator somatic coliphage, but there were two detections of low levels of the viral indicator F-specific coliphage (table 13).

Future Work

Subsequent reports will be focused on assessment of the data shown presented in this report using a variety of statistical, qualitative, and quantitative approaches to evaluate the natural and human factors affecting ground-water quality. Water-quality data contained in the CDPH and 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 that is presented in this report; the results of these future efforts will appear in one or more subsequent reports.

Summary

Ground-water quality in the Central Sierra study unit (CENSIE) was investigated in May 2006 as part of the Priority Basin Assessment project of Ground-Water Ambient Monitoring and Assessment (GAMA) program. The California State Water Resources Control Board (SWRCB), in collaboration with the U.S. Geological Survey (USGS) and the Lawrence Livermore National Laboratory, is implementing the GAMA Program (http://www.waterboards.ca.gov/gama/). The Priority Basin Assessment Project was designed by the SWRCB and the USGS in response to the Ground-Water Quality Monitoring Act of 2001 (Belitz and others, 2003; State Water Resources Control Board, 2003). The project is a comprehensive assessment of statewide ground-water quality designed to identify and characterize risks to ground-water resources, and to increase the availability of information about ground-water quality to the public. CENSIE was the tenth study unit sampled as part of the project.

CENSIE lies within the Sierra Nevada Physiographic Province in Madera and Mariposa counties, and consists of two study areas that are defined on the basis of two surface-water drainage areas: the Fresno River (Coarse Gold) and the North Fork Willow Creek (Wishon) study areas. The CENSIE study included assessment of the ground-water quality from thirty wells located within the approximately 960 km^2 (370 mi^2) study unit. Twenty-seven of the wells were selected using a spatially distributed, randomized grid-based method to achieve statistically unbiased representation of ground water used for public drinking water supplies. Three of the wells were selected to provide additional sampling density to aid in understanding processes affecting ground-water quality.

Ground-water samples were analyzed for VOCs, gasoline oxygenates and degradates, pesticides and pesticide degradates, pharmaceutical compounds, constituents of special interest (NDMA, perchlorate, and 1,2,3-TCP), nutrients and dissolved organic carbon, major and minor ions, trace elements, radioactive constituents, and microbial indicators. Concentrations of naturally occurring isotopes (stable isotopic ratios of hydrogen, oxygen, nitrogen, and carbon, activities of tritium and carbon-14) and dissolved noble gases also were measured to provide a data set that will be used to help interpret the source and age of the sampled ground water. In total, over 250 constituents and water-quality indicators were investigated for this study. This report describes the hydrogeologic setting of the CENSIE region, details the sampling, analytical, and quality-assurance methods that were used in the study, and presents the results of the chemical and microbial analyses made of the ground-water samples collected during May 2006.

Quality-control samples (blanks, replicates, and samples for matrix spikes) were collected at 10–20 percent of the wells, and the results for these samples were used to evaluate the quality of the data for the ground-water samples. Assessment of the quality-control data showed that the environmental data were of good quality; less than 0.6 percent of the detections may have been due to contamination.

This study did not attempt to evaluate the quality of water delivered to consumers; after withdrawal from the ground, water typically is treated, disinfected, or blended with other waters to maintain acceptable water quality. Regulatory thresholds apply to treated water that is served to the consumer, not to raw ground water. However, to provide some context for the results, concentrations of constituents measured in the raw ground water were compared with health-based thresholds established by the U.S. Environmental Protection Agency (USEPA) and the California Department of Public Health (CDPH).

All detections of VOCs and pesticides were below health-based thresholds, and most were less than one one-hundredth of the threshold values. Six constituents—arsenic, fluoride, molybdenum, uranium, gross-alpha radioactivity, and radon-222—were detected at concentrations above a maximum contaminant level (MCL-US or MCL-CA), proposed MCL-US, or lifetime health advisory (HAL-US). Three additional constituents—pH, iron, and manganese—were detected at concentrations above secondary maximum contaminant levels (SMCL-CAs), non-enforceable thresholds set for aesthetic concerns. Future work will evaluate the data presented in this report using a variety of statistical, qualitative, and quantitative approaches to assess the natural and human factors affecting ground-water quality.

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Table 1. Identification, sampling, and construction information for wells sampled for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[Sampling schedules are described in table 2. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well; CGOLDU, Central Sierra Coarse Gold study area understanding well; CWISHU, Central Sierra Wishon study area understanding well. **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 (NAVD88). **Abbreviations:** ft, foot; LSD, land-surface datum; –, no data]

Sampling information			Construction information				
GAMA Identification No.	Date	Sampling schedule	Elevation of LSD (feet above NAVD88)	Well depth (feet below LSD)	Perforation (feet below LSD)		Total open length (feet)
					Top	Bottom	
Grid wells							
CGOLD-01	05-08-06	Slow	760	1,007	100	1,007	907
CGOLD-02	05-09-06	Slow	2,220	750	100	750	650
CGOLD-03	05-09-06	Slow	1,900	680	50	680	630
CGOLD-04	05-10-06	Slow	2,300	500	55	500	445
CGOLD-05	05-12-06	Intermediate	2,200	140	–	–	–
CGOLD-06	05-15-06	Slow	3,240	–	–	–	–
CGOLD-07	05-16-06	Slow	4,400	462	60	462	402
CGOLD-08	05-16-06	Slow	2,310	225	–	–	–
CGOLD-09	05-17-06	Slow	660	–	–	–	–
CGOLD-10	05-18-06	Slow	3,680	1,025	50	1,025	975
CGOLD-11	05-18-06	Intermediate	2,200	–	–	–	–
CGOLD-12	05-23-06	Intermediate	1,300	880	100	880	780
CGOLD-13	05-23-06	Intermediate	1,090	302	60	302	242
CGOLD-14	05-23-06	Intermediate	2,280	–	–	–	–
CGOLD-15	05-23-06	Intermediate	2,200	355	50	355	305
CGOLD-16	05-24-06	Intermediate	4,800	500	220	500	280
CGOLD-17	05-25-06	Intermediate	1,200	300	200	300	100
CGOLD-18	05-31-06	Intermediate	3,030	631	56	631	575
CWISH-01	05-08-06	Slow	3,360	608	52	608	556
CWISH-02	05-11-06	Slow	2,660	520	70	520	450
CWISH-03	05-11-06	Slow	3,500	472	50	472	422
CWISH-04	05-15-06	Slow	3,400	700	52	700	648
CWISH-05	05-17-06	Slow	3,480	202	85	202	117
CWISH-06	05-22-06	Intermediate	1,800	900	20	200	180
CWISH-07	05-22-06	Intermediate	2,900	900	100	900	800
CWISH-08	05-25-06	Intermediate	5,400	925	81	925	844
CWISH-09	05-25-06	Intermediate	5,390	700	70	700	630
Understanding wells							
CGOLDU-01	05-24-06	Intermediate	1,300	675	20	675	655
CGOLDU-02	05-24-06	Intermediate	1,950	100	30	100	70
CWISHU-01	05-22-06	Intermediate	2,560	74	23	74	51

Table 2. Classes of chemical and microbial constituents and water-quality indicators collected for the slow and intermediate well sampling schedules in the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

Analyte classes	Analyte list table	Schedule	
		Slow	Intermediate
Water-quality indicators			
Alkalinity, dissolved oxygen, pH		X	X
Specific conductance, temperature		X	X
Turbidity		X	
Organic constituents			
Volatile organic compounds (VOCs)	3A	X	X
Gasoline, oxygenates and degradates	3B	X	X
Pesticides and pesticide degredates	3C	X	X
Constituents of special interest			
Perchlorate	3D	X	X
N-nitrosodimethylamine (NDMA)	3D	X	X
1,2,3-Trichloropropane (1,2,3-TCP)	3D	X	X
Inorganic constituents			
Nutrients and dissolved organic carbon	3E	X	X
Major and minor ions and trace elements	3F	X	X
Chromium abundance and speciation	3G	X	X
Arsenic and iron abundances and speciation	3G	X	X
Radioactivity and gases			
Gross alpha and beta radiation	3H	X	
Radium isotopes (Ra-226 and -228)	3H	X	
Radon-222	3H	X	
Tritium	3H	X	X
Uranium isotopes (U-234, -235, and -238)	3H	X	X
Tritium and noble gases	3I	X	X
Isotopic ratios			
Stable isotopes of carbon and carbon-14 abundance	3H	X	X
Stable isotopes of hydrogen and oxygen in water	3H	X	X
Stable isotopes of nitrogen and oxygen in nitrate	3H	X	X
Microbial constituents			
Escherichia coli and total coliform	3J	X	
F-specific and somatic coliphage	3J	X	
Additional analytes collected, but not included in this report			
Pharmaceutical compounds		X	X
Boron isotopic composition		X	X
Strontium isotopic composition		X	X

Table 3A. Volatile organic compounds and gasoline additives, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey National Water Quality Laboratory Schedule 2020.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. CAS number: 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$^{\text{SM}}$. **Thresholds** and threshold values as of March 1, 2008. **Threshold type:** Maximum contaminant level thresholds 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. HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; 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; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Abbreviations:** LRL, laboratory reporting level. USGS, U.S. Geological Survey; THM, trihalomethane; D, detected in ground-water samples (table 5); na, not available; µg/L, micrograms per liter; –, not detected]

Constituent (common name)	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold		Detection
					Type	Value (µg/L)	
Acetone	Solvent	81552	67-64-1	6	na	na	–
Acrylonitrile	Organic synthesis	34215	107-13-1	.8	RSD5-US	0.6	–
tert-Amyl methyl ether (TAME)	Gasoline oxygenate	50005	994-05-8	.04	na	na	–
Benzene	Gasoline hydrocarbon	34030	71-43-2	.021	MCL-CA	1	D
Bromobenzene	Solvent	81555	108-86-1	.028	na	na	–
Bromochloromethane	Fire retardant	77297	74-97-5	.12	HAL-US	90	–
Bromodichloromethane	Disinfection by-product (THM)	32101	75-27-4	.028	MCL-US	[1]80	–
Bromoform (Tribromomethane)	Disinfection by-product (THM)	32104	75-25-2	.10	MCL-US	[1]80	–
Bromomethane (Methyl bromide)	Fumigant	34413	74-83-9	.33	HAL-US	10	–
n-Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	.12	NL-CA	260	–
sec-Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	.06	NL-CA	260	–
tert-Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	.06	NL-CA	260	–
Carbon disulfide	Organic synthesis	77041	75-15-0	.038	NL-CA	160	D
Carbon tetrachloride (Tetrachloromethane)	Solvent	32102	56-23-5	.06	MCL-CA	0.5	–
Chlorobenzene	Solvent	34301	108-90-7	.028	MCL-CA	70	–
Chloroethane	Solvent	34311	75-00-3	.12	na	na	–
Chloroform (Trichloromethane)	Disinfection by-product (THM)	32106	67-66-3	.024	MCL-US	[1]80	D
Chloromethane	Solvent	34418	74-87-3	.17	HAL-US	30	–
3-Chloropropene	Organic synthesis	78109	107-05-1	.5	na	na	–
2-Chlorotoluene	Solvent	77275	95-49-8	.04	NL-CA	140	–
4-Chlorotoluene	Solvent	77277	106-43-4	.05	NL-CA	140	–
Dibromochloromethane	Disinfection by-product (THM)	32105	124-48-1	.10	MCL-US	[1]80	–
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	.51	MCL-US	0.2	–
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	.036	MCL-US	0.05	–
Dibromomethane	Solvent	30217	74-95-3	.050	na	na	–
1,2-Dichlorobenzene	Solvent	34536	95-50-1	.048	MCL-CA	600	–
1,3-Dichlorobenzene	Solvent	34566	541-73-1	.03	HAL-US	600	–
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	.034	MCL-CA	5	–
trans-1,4-Dichloro-2-butene	Organic synthesis	73547	110-57-6	.70	na	na	–
Dichlorodifluoromethane (CFC-12)	Refrigerant	34668	75-71-8	.18	NL-CA	1,000	–
1,1-Dichloroethane (1,1-DCA)	Solvent	34496	75-34-3	.035	MCL-CA	5	–
1,2-Dichloroethane (1,2-DCA)	Solvent	32103	107-06-2	.13	MCL-CA	0.5	–
1,1-Dichloroethene (1,1-DCE)	Organic synthesis	34501	75-35-4	.024	MCL-CA	6	–
cis-1,2-Dichloroethene (cis-1,2-DCE)	Solvent	77093	156-59-2	.024	MCL-CA	6	–
trans-1,2-Dichloroethene (trans-1,2-DCE)	Solvent	34546	156-60-5	.032	MCL-CA	10	–
1,2-Dichloropropane	Fumigant	34541	78-87-5	.029	MCL-US	5	–
1,3-Dichloropropane	Fumigant	77173	142-28-9	.06	na	na	–
2,2-Dichloropropane	Fumigant	77170	594-20-7	.05	na	na	–
1,1-Dichloropropene	Organic synthesis	77168	563-58-6	.026	na	na	–
cis-1,3-Dichloropropene	Fumigant	34704	10061-01-5	.05	RSD5-US	[2]4	–
trans-1,3-Dichloropropene	Fumigant	34699	10061-02-6	.09	RSD5-US	[2]4	–
Diethyl ether	Solvent	81576	60-29-7	.08	na	na	–

Table 3A. Volatile organic compounds and gasoline additives, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey National Water Quality Laboratory Schedule 2020.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. CAS number: 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}. **Thresholds** and threshold values as of March 1, 2008. **Threshold type:** Maximum contaminant level thresholds 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. HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; 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; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of $10E^{-5}$. **Abbreviations:** LRL, laboratory reporting level. USGS, U.S. Geological Survey; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; –, not detected]

Constituent (common name)	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold		Detection
					Type	Value (µg/L)	
Diisopropyl ether (DIPE)	Gasoline oxygenate	81577	108-20-3	0.10	na	na	–
Ethylbenzene	Gasoline hydrocarbon	34371	100-41-4	.030	MCL-CA	300	–
Ethyl *tert*-butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	.030	na	na	–
Ethyl methacrylate	Organic synthesis	73570	97-63-2	.18	na	na	–
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	Gasoline hydrocarbon	77220	611-14-3	.06	na	na	–
Hexachlorobutadiene	Organic synthesis	39702	87-68-3	.14	RSD5-US	9	–
Hexachloroethane	Solvent	34396	67-72-1	.14	HAL-US	1	–
2-Hexanone (*n*-Butyl methyl ketone)	Solvent	77103	591-78-6	.4	na	na	–
Iodomethane (Methyl iodide)	Organic synthesis	77424	74-88-4	.50	na	na	–
Isopropylbenzene	Gasoline hydrocarbon	77223	98-82-8	.038	NL-CA	770	–
4-Isopropyl-1-methyl benzene	Gasoline hydrocarbon	77356	99-87-6	.08	na	na	–
Methyl acrylate	Organic synthesis	49991	96-33-3	1.0	na	na	–
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	.40	na	na	–
Methyl *tert*-butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	.10	MCL-CA	13	D
Methyl *iso*-butyl ketone (MIBK)	Solvent	78133	108-10-1	.37	NL-CA	120	–
Methylene chloride (Dichloromethane)	Solvent	34423	75-09-2	.06	MCL-US	5	–[3]
Methyl ethyl ketone (2-butanone, MEK)	Solvent	81595	78-93-3	2	HAL-US	4,000	–
Methyl methacrylate	Organic synthesis	81597	80-62-6	.20	na	na	–
Naphthalene	Gasoline hydrocarbon	34696	91-20-3	.52	NL-CA	17	–
Perchloroethene (PCE)	Solvent	34475	127-18-4	.030	MCL-US	5	D
n-Propylbenzene	Solvent	77224	103-65-1	.042	NL-CA	260	–
Styrene	Gasoline hydrocarbon	77128	100-42-5	.042	MCL-US	100	–
1,1,1,2-Tetrachloroethane	Solvent	77562	630-20-6	.03	HAL-US	70	–
1,1,2,2-Tetrachloroethane	Solvent	34516	79-34-5	.08	MCL-CA	1	–
Tetrahydrofuran	Solvent	81607	109-99-9	1.2	na	na	–
1,2,3,4-Tetramethylbenzene	Gasoline hydrocarbon	49999	488-23-3	.14	na	na	–[3]
1,2,3,5-Tetramethylbenzene	Gasoline hydrocarbon	50000	527-53-7	.18	na	na	–[3]
Toluene	Gasoline hydrocarbon	34010	108-88-3	.02	MCL-CA	150	–
1,2,3-Trichlorobenzene	Organic synthesis	77613	87-61-6	.18	na	na	–[3]
1,2,4-Trichlorobenzene	Solvent	34551	120-82-1	.12	MCL-CA	5	–
1,1,1-Trichloroethane (TCA)	Solvent	34506	71-55-6	.032	MCL-CA	200	–
1,1,2-Trichloroethane	Solvent	34511	79-00-5	.04	MCL-CA	5	–
Trichloroethene (TCE)	Solvent	39180	79-01-6	.038	MCL-US	5	–
Trichlorofluoromethane (CFC-11)	Refrigerant	34488	75-69-4	.08	MCL-CA	150	–
1,2,3-Trichloropropane (1,2,3-TCP)	Solvent/organic synthesis	77443	96-18-4	.18	HAL-US[4]	40	–
Trichlorotrifluoroethane (CFC-113)	Refrigerant	77652	76-13-1	.038	MCL-CA	1,200	–
1,2,3-Trimethylbenzene	Gasoline hydrocarbon	77221	526-73-8	.09	na	na	–
1,2,4-Trimethylbenzene	Gasoline hydrocarbon	77222	95-63-6	.056	NL-CA	330	–
1,3,5-Trimethylbenzene	Organic synthesis	77226	108-67-8	.044	NL-CA	330	–
Vinyl bromide (Bromoethene)	Fire retardant	50002	593-60-2	.10	na	na	–
Vinyl chloride (Chloroethene)	Organic synthesis	39175	75-01-4	.08	MCL-CA	0.5	–
m- and *p*-Xylene	Gasoline hydrocarbon	85795	108-38-3/106-42-3	.06	MCL-CA	1750	–
o-Xylene	Gasoline hydrocarbon	77135	95-47-6	.038	MCL-CA	1750	–

[1] The MCL-US thresholds for trihalomethanes is the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

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

[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.

[4] In earlier reports in this series, the NL-CA (0.005 µg/L) was used as the comparison threshold for 1,2,3-TCP.

Table 3B. Gasoline oxygenates and degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey National Water Quality Laboratory Schedule 4024.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and threshold values** as of March 1, 2008. Maximum contaminant level thresholds 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; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level. **Abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; USGS, U.S. Geological Survey; D, detected in ground-water samples (table 5); na, not available; µg/L, micrograms per liter; –, not detected]

Constituent (common name)	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold Type	Threshold Value (µg/L)	Detection
Acetone	Degradate	81552	67-64-1	1.2	na	na	–
tert-Amyl alcohol	Oxygenate	77073	75-85-4	1.0	na	na	–
tert-Amyl methyl ether (TAME)	Oxygenate	50005	994-05-8	.05	na	na	–
tert-Butyl alcohol (TBA)	Degradate	77035	75-65-0	1	NL-CA	12	–
Diisopropyl ether (DIPE)	Oxygenate	81577	108-20-3	.06	na	na	–
Ethyl *tert*-butyl ether (ETBE)	Oxygenate	50004	637-92-3	.06	na	na	–
Methyl acetate	Degradate	77032	79-20-9	.43	na	na	–
Methyl *tert*-butyl ether (MTBE)	Oxygenate	78032	1634-04-4	.05	MCL-CA	13	D

Table 3C. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey National Water Quality Laboratory Schedule 2033.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and thresholds values** as of March 1, 2008.**Threshold type:** Maximum contaminant level thresholds 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; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; 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 $10E^{-5}$. **Abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; USGS, U.S. Geological Survey; D, detected; na, not available; µg/L, micrograms per liter; –, not detected]

Constituent (common name)	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold		Detection
					Type	Value (µg/L)	
Acetochlor	Herbicide	49260	34256-82-1	0.006	na	na	–
Alachlor	Herbicide	46342	15972-60-8	.005	MCL-US	2	–
Atrazine	Herbicide	39632	1912-24-9	.007	MCL-CA	1	D
Azinphos-methyl	Insecticide	82686	86-50-0	.05	na	na	–
Azinphos-methyl oxygen analog	Insecticide degradate	61635	961-22-8	.07	na	na	–
Benfluralin	Herbicide	82673	1861-40-1	.01	na	na	–
Carbaryl	Insecticide	82680	63-25-2	.041	RSD5-US	400	–
Carbofuran	Insecticide	82674	1563-66-2	.016	MCL-CA	18	–
2-Chloro-2,6-diethylacetanilide	Herbicide degradate	61618	6967-29-9	.005	na	na	–
4-Chloro-2-methylphenol	Herbicide degradate	61633	1570-64-5	.0056	na	na	–
Chlorpyrifos	Insecticide	38933	2921-88-2	.005	HAL-US	2	–
Chlorpyrofos, oxygen analog	Insecticide degradate	61636	5598-15-2	.0562	na	na	–[1]
Cyanazine	Herbicide	04041	21725-46-2	.018	HAL-US	1	–
Cyfluthrin	Insecticide	61585	68359-37-5	.0267	na	na	–
λ-Cyhalothrin	Insecticide	61595	91465-08-6	.0089	na	na	–[1]
Cypermethrin	Insecticide	61586	52315-07-8	.0086	na	na	–
DCPA (Dacthal)	Herbicide	82682	1861-32-1	.003	HAL-US	70	–
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	Herbicide degradate	04040	6190-65-4	.028	na	na	D[1]
Desulfinylfipronil	Insecticide degradate	62170	na	.012	na	na	–[1]
Desulfinylfipronil amide	Insecticide degradate	62169	na	.029	na	na	–[1]
Diazinon	Insecticide	39572	333-41-5	.005	HAL-US	1	–
Diazinon, oxygen analog	Insecticide degradate	61638	962-58-3	.01	na	na	–
3,4-Dichloroaniline	Herbicide degradate	61625	95-76-1	.0045	na	na	D
3,5-Dichloroaniline	Herbicide degradate	61627	626-43-7	.0043	na	na	–
Dichlorvos	Insecticide	38775	62-73-7	.0118	na	na	–[1]
Dicrotophos	Insecticide	38454	141-66-2	.0843	na	na	–[1]
Dieldrin	Insecticide	39381	60-57-1	.009	RSD5-US	0.02	–
2,6-Diethylaniline	Herbicide degradate	82660	579-66-8	.006	na	na	–
Dimethoate	Insecticide	82662	60-51-5	.0061	na	na	–[1]
Disulfoton	Insecticide	82677	298-04-4	.021	HAL-US	0.7	–
Disulfoton sulfone	Insecticide degradate	61640	2497-06-5	.0059	na	na	–
α-Endosulfan	Insecticide	34362	959-98-8	.0047	na	na	–
Endosulfan sulfate	Insecticide degradate	61590	1031-07-8	.0138	na	na	–
EPTC	Herbicide	82668	759-94-4	.004	na	na	–
Ethion	Insecticide	82346	563-12-2	.004	na	na	–
Ethion monoxon	Insecticide degradate	61644	17356-42-2	.002	na	na	–
Ethoprop	Herbicide	82672	13194-48-4	.005	na	na	–
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	.0045	na	na	–
Fenamiphos	Insecticide	61591	22224-92-6	.029	HAL-US	0.7	–
Fenamiphos sulfone	Insecticide degradate	61645	31972-44-8	.0491	na	na	–
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	.0387	na	na	–[1]
Fipronil	Insecticide	62166	120068-37-3	.016	na	na	–
Fipronil sulfide	Insecticide degradate	62167	120067-83-6	.013	na	na	–[1]
Fipronil sulfone	Insecticide degradate	62168	120068-36-2	.024	na	na	–[1]
Fonofos	Insecticide	04095	944-22-9	.003	HAL-US	10	–
Hexazinone	Herbicide	04025	51235-04-2	.0129	HAL-US	400	–
Iprodione	Fungicide	61593	36734-19-7	.538	na	na	–[1]

Table 3C. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey National Water Quality Laboratory Schedule 2033.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and thresholds values** as of March 1, 2008.**Threshold type:** Maximum contaminant level thresholds 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; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; 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 $10E^{-5}$. **Abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; USGS, U.S. Geological Survey; D, detected; na, not available; µg/L, micrograms per liter; –, not detected]

Constituent (common name)	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold		Detection
					Type	Value (µg/L)	
Isofenphos	Insecticide	61594	25311-71-1	0.0034	na	na	–
Malaoxon	Insecticide degradate	61652	1634-78-2	.0298	na	na	–
Malathion	Insecticide	39532	121-75-5	.027	HAL-US	100	–
Metalaxyl	Fungicide	61596	57837-19-1	.0051	na	na	–
Methidathion	Insecticide	61598	950-37-8	.0058	na	na	–
Metolachlor	Herbicide	39415	51218-45-2	.006	HAL-US	700	–
Metribuzin	Herbicide	82630	21087-64-9	.006	HAL-US	70	–
Molinate	Herbicide	82671	2212-67-1	.0016	MCL-CA	20	–
Myclobutanil	Fungicide	61599	88671-89-0	.008	na	na	–
1-Naphthol	Insecticide degradate	49295	90-15-3	.0882	na	na	–[1]
Oxyfluorfen	Herbicide	61600	42874-03-3	.0073	na	na	–[1]
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	.0299	na	na	–[1]
Parathion-methyl	Insecticide	82667	298-00-0	.015	HAL-US	1	–
Pendimethalin	Herbicide	82683	40487-42-1	.022	na	na	–
cis-Permethrin	Insecticide	82687	54774-45-7	.006	na	na	–[1]
Phorate	Insecticide	82664	298-02-2	.011	na	na	–
Phorate oxygen analog	Insecticide degradate	61666	2600-69-3	.1048	na	na	–
Phosmet	Insecticide	61601	732-11-6	.0079	na	na	–[1]
Phosmet oxon	Insecticide degradate	61668	3735-33-9	.0511	na	na	–[1]
Prometon	Herbicide	04037	1610-18-0	.01	HAL-US	100	–
Prometryn	Herbicide	04036	7287-19-6	.0054	na	na	–
Pronamide	Herbicide	82676	23950-58-5	.004	RSD5-US	20	–
Propanil	Herbicide	82679	709-98-8	.011	na	na	–
Propargite	Insecticide	82685	2312-35-8	.023	na	na	–
cis-Propiconazole	Fungicide	79846	60207-90-1	.008	na	na	–
trans-Propiconazole	Fungicide	79847	60207-90-1	.0133	na	na	–
Simazine	Herbicide	04035	122-34-9	.005	MCL-US	4	D
Tebuconazole	Fungicide	62852	107534-96-3	.0136	na	na	–
Tebuthiuron	Herbicide	82670	34014-18-1	.016	HAL-US	500	–
Tefluthrin	Insecticide	61606	79538-32-2	.0077	na	na	–[1]
Terbufos	Insecticide	82675	13071-79-9	.017	HAL-US	.4	–
Terbufos oxygen analog sulfone	Insecticide degradate	61674	56070-15-6	.0676	na	na	–
Terbuthylazine	Herbicide	04022	5915-41-3	.0102	na	na	–
Thiobencarb	Herbicide	82681	28249-77-6	.01	MCL-CA	70	–
Tribufos	Herbicide	61610	78-48-8	.0044	na	na	–
Trifluralin	Herbicide	82661	1582-09-8	.009	HAL-US	10	–

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[1] 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 3D. Constituents of special interest, primary uses or sources, comparative thresholds, and reporting information for the Montgomery Watson-Harza Laboratory.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and thresholds values** as of March 1, 2008.**Threshold type:** Maximum contaminant level thresholds 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; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; 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. **Abbreviations:** CAS, Chemical Abstract Service; MRL, minimum reporting level; USGS, U.S. Geological Survey; D, detected; na, not available; µg/L, micrograms per liter; –, not detected]

Constituent (common name)	Primary use or source	USGS parameter code	CAS number	MRL (µg/L)	Threshold		Detection
					Type	Value (µg/L)	
Perchlorate	Rocket fuel, fireworks, flares	61209	14797-73-0	0.5	MCL-CA	6	–
1,2,3-Trichloropropane (TCP)	Fumigant, solvent	77443	96-18-4	.005	HAL-US[1]	40	–
N-Nitrosodimethylamine (NDMA)	Rocket fuel, plasticizer	34438	62-75-9	.002	NL-CA	.010	–

[1] Earlier reports in this series used the California Department of Public Health notification level of 0.005 microgram per liter as the comparison threshold.

Table 3E. Nutrients and dissolved organic carbon, comparative thresholds, and reporting information for the USGS National Water Quality Laboratory Schedule 2755 and lab code 2613.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and thresholds values** as of March 1, 2008.**Threshold type:** Maximum contaminant level thresholds 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; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; 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. **Abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; USGS, U.S. Geological Survey; D, detected in ground-water samples (table 7); na, not available; mg/L, milligrams per liter]

Constituent	USGS parameter code	CAS number	LRL (mg/L)	Threshold		Detection
				Type	Value (pCi/L)	
Ammonia (as nitrogen)	00608	7664-41-7	0.010	HAL-US	30	D
Nitrite (as nitrogen)	00613	14797-65-0	.002	MCL-US	1	D
Nitrate plus nitrite (as nitrogen)	00631	na	.060	MCL-US	10	D
Total nitrogen (ammonia, nitrite, nitrate, organic nitrogen)	62854	17778-88-0	.06	na	na	D
Orthophosphate (as phosphorus)	00671	14265-44-2	.006	na	na	D
Dissolved organic carbon (DOC)	00681	na	.33	na	na	D

Table 3F. Major and minor ions and trace elements, comparative thresholds, and reporting information for the U.S. Geological Survey National Water Quality Laboratory Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and thresholds values** as of March 1, 2008.**Threshold type:** Maximum contaminant level thresholds 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; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; 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; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; USGS, U.S. Geological Survey; D, detected in ground-water samples (tables 8 and 9); na, not available; µg/L, micrograms per liter]

Constituent (common name)	USGS parameter code	CAS number	LRL (µg/L)	Threshold		Detection
				Type	Value (µg/L)	
Major and minor ions (mg/L)						
Bromide	71870	24959-67-9	0.02	na	na	D
Calcium	00915	7440-70-2	.02	na	na	D
Chloride	00940	16887-00-6	.2	SMCL-CA	[1]250 (500)	D
Fluoride	00950	16984-48-8	.10	MCL-CA	2	D
Iodide	78165	7553-56-2	.002	na	na	D
Magnesium	00925	7439-95-4	.008	na	na	D
Potassium	00935	7440-09-7	.16	na	na	D
Silica	00955	7631-86-9	.04	na	na	D
Sodium	00930	7440-23-5	.20	na	na	D
Sulfate	00945	14808-79-8	.18	SMCL-CA	[1]250 (500)	D
Residue on evaporation (total dissolved solids, TDS)	70300	na	10	SMCL-US	[1]500 (1,000)	D
Trace elements (µg/L)						
Aluminum	01106	7429-90-5	1.6	MCL-CA	1,000	D
Antimony	01095	7440-36-0	.2	MCL-US	6	D
Arsenic	01000	7440-38-2	.12	MCL-US	10	D
Barium	01005	7440-39-3	.2	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	.06	MCL-US	4	D
Boron	01020	7440-42-8	8	NL-CA	1,000	D
Cadmium	01025	7440-43-9	.04	MCL-US	5	D
Chromium	01030	7440-47-3	.04	MCL-CA	50	D
Cobalt	01035	7440-48-4	.04	na	na	D
Copper	01040	7440-50-8	.4	AL-US	1,300	D
Iron	01046	7439-89-6	6	SMCL-CA	300	D
Lead	01049	7439-92-1	.08	AL-US	15	D
Lithium	01130	7439-93-2	.6	na	na	D
Manganese	01056	7439-96-5	.2	SMCL-CA	50	D
Mercury	71890	7439-97-6	.010	MCL-US	2	D
Molybdenum	01060	7439-98-7	.4	HAL-US	40	D
Nickel	01065	7440-02-0	.06	MCL-CA	100	D
Selenium	01145	7782-49-2	.08	MCL-US	50	D
Silver	01075	7440-22-4	.20	SMCL-CA	100	--
Strontium	01080	7440-24-6	.4	HAL-US	4,000	D
Thallium	01057	7440-28-0	.04	MCL-US	2	--
Tungsten	01155	7440-33-7	.06	na	na	D
Uranium	22703	7440-61-1	.04	MCL-US	30	D
Vanadium	01085	7440-62-2	.10	NL-CA	50	D
Zinc	01090	7440-66-6	.6	HAL-US	2,000	D

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

Table 3G. Arsenic, chromium, and iron species, comparative thresholds, and reporting information for the U.S. Geological Survey Trace Metal Laboratory, Boulder, Colorado.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and thresholds values** as of March 1, 2008.**Threshold type:** Maximum contaminant level thresholds 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; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Abbreviations:** CAS, Chemical Abstract Service; MDL, method detection level; USGS, U.S. Geological Survey; D, detected in ground-water samples (table 10); na, not available; µg/L, micrograms per liter; –, not detected]

Constituent	USGS parameter code	CAS number	MDL (µg/L)	Threshold		Detection
				Type	Value (µg/L)	
Arsenic (III)	99034	22569-72-8	1	na	na	D
Arsenic (total)	99033	7440-38-2	.5	MCL-US	10	D
Chromium (VI), hexavalent	01032	18540-29-9	1	na	na	–
Chromium (total)	01030	7440-47-3	1	MCL-CA	50	–
Iron (II)	01047	7439-89-6	2	na	na	D
Iron (total)	01046	7439-89-6	2	SMCL-CA	300	D

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and thresholds values** as of March 1, 2008. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. **Threshold type:** Maximum contaminant level thresholds 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; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant leve; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Abbreviations:** CAS, Chemical Abstract Service; CV, critical value; D, detected in ground-water samples (tables 11 and 12); MRL, minimum reporting level; MU, method uncertainty; na, not available; pCi/L, picocuries per liter; SSMDC, sample specific minimum detectable concentration USGS, U.S. Geological Survey]

Constituent	USGS parameter code	CAS number	Reporting level type	Reporting level or uncertainty	Threshold		Detection
					Type	Value (pCi/L)	
Stable isotope ratios (per mil)							
δ^{2}H of water[1]	82082	na	MU	2	na	na	D
δ^{18}O of water[1]	82085	na	MU	0.20	na	na	D
δ^{15}N of nitrate[2]	82690	na	MU	0.30	na	na	D
δ^{18}O of nitrate[2]	63041	na	MU	0.50	na	na	D
δ^{13}C of dissolved carbonates[3]	82081	na	1 sigma	0.05	na	na	D
Radioactive constituents (percent modern)							
Carbon-14[4]	49933	14762-75-5	1 sigma	0.0015	na	na	D
Radioactive constituents (pCi/L)							
Radon-222[5]	82303	14859-67-7	SSMDC	CSU and CV	Prop. MCL-US	7,300 (4,000)	D
Tritium[2, 7]	07000	10028-17-8	MRL	1	MCL-CA	20,000	D
Gross-alpha radioactivity, 72-hour and 30-day counts[8]	62636, 62639	12587-46-1	SSMDC	CSU and CV	MCL-US	15	D
Gross-beta radioactivity, 72-hour and 30-day counts[8]	62642, 62645	12587-47-2	SSMDC	CSU and CV	MCL-CA	50	D
Radium-226[8]	09511	13982-63-3	SSMDC	CSU and CV	MCL-US	[9]5	D
Radium-228[8]	81366	15262-20-1	SSMDC	CSU and CV	MCL-US	[9]5	D
Uranium-234[8]	22610	13966-29-5	SSMDC	CSU and CV	MCL-CA	[10]20	D
Uranium-235[8]	22620	15117-96-1	SSMDC	CSU and CV	MCL-CA	[10]20	D
Uranium-238[8]	22603	7440-61-1	SSMDC	CSU and CV	MCL-CA	[10]20	D

[1] U.S. Geological Survey Stable Isotope Laboratory, Reston, Virginia.

[2] University of Waterloo (contract laboratory).

[3] University of Arizona, Accelerator Mass Spectrometry Laboratory (contract laboratory).

[4] U.S. Geological Survey National Water Quality Laboratory.

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

[6] U.S. Geological Survey Stable Isotope and Tritium Laboratory, Menlo Park, California.

[7] Lawrence Livermore National Laboratory.

[8] Eberline Analytical Services (contract laboratory).

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

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and thresholds values** as of February 10, 2007. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. **Threshold type:** Maximum contaminant level thresholds 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; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Abbreviations:** CAS, Chemical Abstract Service; cm^3 STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water; D, detected in ground-water samples; MU, method uncertainty; na, not available; pCi/L, picocuries per liter; USGS, U.S. Geological Survey]

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

Table 3J. Microbial constituents, comparison thresholds, and reporting information for the USGS Ohio Microbiology Laboratory parameter codes 90901, 90900, 99335 and 99332.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Thresholds and thresholds values** as of March 1, 2008. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; TT-US, U.S. Environmental Protection Agency treatment technique—a required process intended to reduce the level of contamination in drinking water. **Abbreviations:** D, detected in ground-water samples (table 13); mL, milliliters; MDL, method detection level; na, not available; USGS, U.S. Geological Survey]

Constituent	USGS parameter code	Primary source	MDL	Threshold		Detection
				Type	Value	
Escherichia coli[1]	90901	Sewage and animal waste indicator	1 colony/ 100 mL	TT-US	Zero	–
Total coliform - including fecal coliform and *E. coli*[2]	90900	Sewage and animal waste indicator	1 colony/ 100 mL	MCL-US	5 percent of samples positive per month	D
F-specific coliphage	99335	Sewage and animal waste indicator	na	TT-US	99.99 percent killed/ inactivated	–
Somatic coliphage	99332	Sewage and animal waste indicator	na	TT-US	99.99 percent killed/ inactivated	–

[1] Maximum contaminant level thresholds 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] Analyzed in the field.

Table 4. Water-quality indicators in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[The five digit number below the conctituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific conctituent or property. **Thresholds and thresholds values** as of March 1, 2008. **Threshold type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well; CGOLDU, Central Sierra Coarse Gold study area understanding well; CWISHU, Central Sierra Wishon study area understanding well. **Abbreviationc:** $CaCO_3$, calcium carbonate; E, estimated value; mg/L, milligrams per liter; mm, millimeter; nc, sample not collected; na, not available; NTU, nephelometric turbidity unit; RL, reporting limit or range; °C, degrees Celsius; µS/cm, microsiemenc per centimeter; <, less than; –, not detected]

GAMA identification No.	Turbidity, field (NTU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25°C) (90095)	Specific conductance, field (µS/cm at 25°C) (00095)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)
Threshold type	na	na	na	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	na	na
Threshold level	na	na	na	6.5 - 8.5	6.5 - 8.5	[1] 900 (1,600)	[1] 900 (1,600)	na	na
RL	[0.1]	[0.2]	[0.0 - 38.5]	[0-14]	[0-14]	[5]	[5]	[1]	[1]
Grid wells									
CGOLD-01	0.1	0.8	23.0	7.3	7.4	424	420	143	137
CGOLD-02	nc	0.1	19.0	7.0	6.9	422	416	154	166
CGOLD-03	–	0.2	21.0	7.1	7.1	271	267	126	126
CGOLD-04	*3.0	5.4	19.5	6.9	*6.2	149	145	73	72.8
CGOLD-05	nc	1.4	19.0	7.9	8.0	509	519	94	nc
CGOLD-06	nc	0.8	17.0	6.6	*6.4	242	230	99	100
CGOLD-07	0.1	–	11.5	*9.4	*9.4	162	158	36	35.8
CGOLD-08	*0.6	1.6	16.5	*6.4	*6.0	272	267	81	83.4
CGOLD-09	nc	1.1	24.5	8.5	8.7	257	250	82	84.2
CGOLD-10	*120	1.5	15.5	*6.4	*6.0	178	174	71	72.6
CGOLD-11	0.2	0.1	19.0	7.0	6.7	481	479	159	nc
CGOLD-12	nc	0.1	23.0	7.5	nc	279	282	123	nc
CGOLD-13	nc	8.4	19.5	7.2	7.2	533	534	158	nc
CGOLD-14	nc	1.1	16.0	6.9	nc	780	782	141	nc
CGOLD-15	nc	0.2	20.0	7.5	7.6	556	565	227	nc
CGOLD-16	nc	9.3	11.0	6.8	nc	128	124	60	nc
CGOLD-17	nc	2.2	20.0	7.3	nc	273	269	122	nc
CGOLD-18	nc	3.4	18.0	*8.6	8.5	286	284	98	nc
CWISH-01	–	0.4	16.0	7.2	6.9	626	619	206	203
CWISH-02	–	0.1	18.5	8.4	8.3	250	242	65	64.7
CWISH-03	nc	0.3	16.0	7.4	7.2	526	511	182	184
CWISH-04	*2.3	2.2	15.0	*6.4	*5.7	201	197	86	nc
CWISH-05	0.2	1.0	15.0	6.6	*6.0	323	322	128	130
CWISH-06	nc	nc	16.0	*9.3	nc	218	219	76	nc
CWISH-07	nc	1.3	18.0	7.8	nc	258	252	123	nc
CWISH-08	nc	2.1	11.0	7.0	6.5	166	160	81	nc
CWISH-09	nc	3.2	12.0	*6.4	*5.3	45	41	22	nc
Understanding wells									
CGOLDU-01	nc	–	21.5	7.5	7.2	457	453	156	nc
CGOLDU-02	nc	6.3	18.0	6.8	nc	480	484	165	nc
CWISHU-01	nc	12.2	18.5	8.4	8.3	216	215	65	nc

*Value above threshold level.

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

Table 5. Volatile organic compounds (VOCs), and gasoline oxygenates and degradates detected in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[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. **Thresholds and thresholds values** as of March 1, 2008. Samples from all 30 wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the 27 grid wells. All analytes are listed in tables 3A and 3B **Threshold type:** Maximum contaminant level thresholds 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 HAL-US, U.S. Environmental Protection Agency lifetime health advisory; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well. **Abbreviations:** E, estimated value; V, analyte detected in sample and blanks thus result is not considered a detection in ground-water quality assessment; μg/L, microgram per liter; –, not detected]

GAMA well identification No.	Trihalomethane	Gasoline	Solvent	Gasoline	Synthesis	Solvent				VOC detections per well
	Chloroform, (μg/L) (32106)	Methyl *tert*-butyl ether (MTBE) (μg/L) (78032)	Perchloroethene (PCE) (μg/L) (34475)	Benzene, (μg/L) (34030)	Carbon disulfide, (μg/L) (77041)	Toluene (μg/L) (34010)	Ethyl methyl ketone, (μg/L) (81595)	Tetrahydrofuran, (μg/L) (81607)	Acetone (μg/L) (81552)	
[LRL]	[0.024]	[0.05]	[0.03]	[0.021]	[0.038]	[0.02]	[2]	[1.2]	[1.8]	
Threshold type	MCL-US	MCL-CA	MCL-US	MCL-CA	NL-CA	MCL-CA	HAL-US	na	na	
Threshold level	[1]80	13	5	1	160	150	4000	na	na	
Grid wells										
CGOLD-02	–	–	–	–	E0.03	–	–	–	–	1
CGOLD-06	0.35	–	–	–	–	–	–	–	–	1
CGOLD-08	E.01	–	–	–	–	–	–	–	–	1
CGOLD-09	–	–	–	–	–	–	V154	V495	V80	0
CGOLD-10	–	–	–	0.17	–	–	–	–	–	1
CGOLD-11	E.04	–	–	–	–	–	–	–	–	1
CGOLD-14	–	0.2	0.11	–	–	V0.02	–	–	–	2
CWISH-04	.43	E.1	–	–	–	–	–	–	–	2
CWISH-08	E.08	–	–	–	–	–	–	–	–	1
CWISH-09	–	–	–	–	–	V.04	–	–	–	0
Number of detections	5	2	1	1	1	0	0	0	0	
Detection frequency (percent)	19	7	4	4	4	0	0	0	0	[2]30

[1] The MCL-US threshold for trihalomethanes is the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

[2] Frequency of detection of at least one VOC in the grid wells. Detections with V remark codes are not included.

Table 6. Pesticides and pesticide degradates detected in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[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. **Thresholds and thresholds values** as of March 1, 2008. Samples from 29 wells were analyzed. (CGOLD-12 was not analyzed), but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the 26 grid wells analyzed. All analytes are listed in table 3C. **Threshold type:** Maximum contaminant level thresholds 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. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well. **Abbreviations:** E, estimated value; LRL, laboratory reporting level; µg/L, microgram per liter; –, not detected]

GAMA well identification No.	Simazine (µg/L) (04035)	3,4-Dichloro-aniline (µg/L) (61625)	Deethyla-trazine (µg/L) (04040)	Atrazine, (µg/L) (39632)	Pesticide detections per well
[LRL]	[0.005]	[0.0045]	[0.014]	[0.007]	
Threshold type[1]	MCL-US	na	na	MCL-CA	
Threshold level	4	na	na	1	
		Grid wells			
CGOLD-01	E0.005	–	–	–	2
CGOLD-08	E.004	–	–	–	1
CGOLD-09	–	E0.006	E0.007	–	2
CGOLD-11	E.004	E.005	–	E0.004	3
CGOLD-14	E.008	–	–	–	1
CWISH-05	–	–	E.006	–	1
Number of detections	4	2	2	1	
Detection frequency (percent)	15	8	8	4	[1]22

[1] Frequency of detection of at least one pesticide or pesticide degradate in the grid wells.

Table 7. Nutrients and dissolved organic carbon detected in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[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. **Thresholds and thresholds values** as of March 1, 2008. Samples from all 30 wells were analyzed. Information about the analytes given in table 3E. **Threshold type:** Maximum contaminant level thresholds 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. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well; CGOLDU, Central Sierra Coarse Gold study area understanding well; CWISHU, Central Sierra Wishon study area understanding well. **Abbreviations:** E, estimated value; LRL, laboratory reporting level; mg/L, milligram per liter; na, not available; –, not detected]

GAMA well identification No.	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)	Dissolved organic carbon (DOC) (mg/L) (00681)
[LRL]	[0.01]	[0.06]	[0.002]	[0.06]	[0.006]	[0.33]
Threshold type[1]	HAL-US	MCL-US	MCL-US	na	na	na
Threshold level	30	10	1	na	na	na
Grid wells						
CGOLD-01	–	0.62	–	0.66	0.009	0.6
CGOLD-02	–	–	–	–	V.006	.4
CGOLD-03	–	–	–	–	.052	E.2
CGOLD-04	–	.39	–	.43	.013	E.3
CGOLD-05	–	1.44	–	[1]1.41	–	E.2
CGOLD-06	–	.75	–	[1].74	.011	E.3
CGOLD-07	–	–	–	–	–	–
CGOLD-08	–	2.39	–	2.5	.02	.8
CGOLD-09	–	1.88	0.031	1.94	.023	.9
CGOLD-10	E0.02	–	–	–	.011	E.3
CGOLD-11	–	E.04	–	E.05	E.003	1.3
CGOLD-12	–	–	–	–	.04	.4
CGOLD-13	–	–	–	–	–	.7
CGOLD-14	–	3.66	–	3.41	.014	–
CGOLD-15	–	.07	–	E.04	1.04	.9
CGOLD-16	–	.07	–	E.04	.044	E.2
CGOLD-17	–	.79	–	.83	.014	E.3
CGOLD-18	–	–	–	–	.009	.4
CWISH-01	–	–	–	–	V.008	na
CWISH-02	–	–	–	–	–	E.2
CWISH-03	–	–	–	–	E.003	–
CWISH-04	–	.51	–	.54	.023	.7
CWISH-05	–	E.03	–	–	.019	.6
CWISH-06	–	–	–	E.03	–	E.3
CWISH-07	–	–	–	–	–	E.3
CWISH-08	–	E.04	–	–	.019	E.3
CWISH-09	–	–	–	–	.019	E.2
Understanding wells						
CGOLDU-01	–	–	–	–	E.005	0.7
CGOLDU-02	–	5.75	–	5.81	.019	.9
CWISHU-01	–	E.03	–	–	–	–

[1] Total nitrogen in these samples is less than the sum of the filtered nitrogen analytes, but falls within the U.S. Geological Survey National Water Quality Laboratory acceptance criteria of a 10 percent relative percent difference.

Table 8. Major and minor ions and dissolved solids detected in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[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. **Thresholds and thresholds values** as of March 1, 2008. Samples from all 30 wells were analyzed. Information about the analytes given in table 3F. **Threshold type:** Maximum contaminant level thresholds 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. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well; CGOLDU, Central Sierra Coarse Gold study area understanding well; CWISHU, Central Sierra Wishon study area understanding well. **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 $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_W = 14$. **Abbreviations:** E, estimated value; LRL, laboratory reporting level; mg/L, milligram per liter; na, not available; –, not detected]

GAMA well identification No.	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Bicarbonate (mg/L)	Carbonate (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 solits (mg/L) (70300)
[LRL]	[0.02]	[0.008]	[0.16]	[0.2]	[1]	[1]	[0.02]	[0.20]	[0.10]	[0.002]	[0.04]	[0.18]	[10]
Threshold type	na	na	na	na	na	na	na	SMCL-CA[1]	MCL-CA	na	na	SMCL-CA[1]	SMCL-CA[1]
Threshold level	na	na	na	na	na	na	na	250 (500)	2	na	na	250 (500)	500 (1,000)
Grid wells													
CGOLD-01	44.5	1.80	0.87	41.2	174	–	0.09	24.9	1.70	0.029	28.8	24.3	266
CGOLD-02	47.2	12.0	6.21	19.1	188	–	.07	10.1	.19	.013	42.2	48.2	283
CGOLD-03	27.7	5.20	3.15	20.4	154	–	.03	5.22	.35	.008	53.1	7.29	198
CGOLD-04	13.9	3.04	2.58	12.0	89	–	–	2.29	.16	–	50.9	.47	118
CGOLD-05	30.5	2.75	2.63	67.5	114	–	.18	96.4	.22	.074	26.2	5.74	303
CGOLD-06	28.5	4.47	2.30	13.9	121	–	.03	5.30	.18	.003	41.8	10.6	170
CGOLD-07	3.44	.07	1.06	27.0	34	4	.04	19.2	.27	.040	19.6	7.15	100
CGOLD-08	21.9	4.92	3.20	22.6	99	–	.04	20.0	.11	.003	40.5	8.66	197
CGOLD-09	7.41	2.73	3.15	39.8	97	1	.05	11.0	[*]3.32	.016	21.1	8.29	154
CGOLD-10	18.3	6.47	2.71	6.60	87	–	–	1.76	.09	E.001	41.7	16.5	137
CGOLD-11	59.5	8.97	3.78	25.3	194	–	.04	15.3	.21	.007	36.5	54.8	317
CGOLD-12	26.8	3.94	1.66	26.2	150	–	.04	6.27	.52	.009	45.6	7.80	203
CGOLD-13	52.1	11.2	4.57	35.7	192	–	.12	54.7	.43	.086	34.6	22.7	331
CGOLD-14	41.6	5.76	4.32	98.8	172	–	.27	132	.50	.049	37.9	23.0	466
CGOLD-15	22.9	51.5	13.5	13.9	276	–	.04	12.3	.20	.007	48.5	48.6	361
CGOLD-16	14.5	4.20	1.49	5.32	73	–	E.01	0.75	.05	–	38.8	3.05	104
CGOLD-17	25.9	7.88	4.16	16.6	149	–	.03	5.65	.14	E.001	32.9	4.18	175
CGOLD-18	10.3	.57	.64	49.6	115	2	.05	22.7	.42	.039	22.0	7.09	186
CWISH-01	79.2	3.95	1.17	43.0	251	–	.13	66.9	.53	.066	40.1	14.0	387
CWISH-02	14.9	.46	.90	34.4	77	1	.06	29.3	1.03	.052	21.6	6.53	161
CWISH-03	59.3	4.07	1.97	46.6	222	–	.09	47.5	.75	.090	32.1	9.42	323
CWISH-04	20.9	4.85	2.90	13.1	105	–	E.02	5.26	.09	.003	48.4	5.01	158
CWISH-05	38.2	4.86	2.93	21.1	156	–	.03	15.0	.15	.008	42.3	10.1	212
CWISH-06	2.93	.04	.21	44.1	77	7	.03	11.4	[*]3.61	.014	16.9	2.70	139
CWISH-07	28.6	1.62	.71	26.0	149	–	–	3.78	.51	.004	25.4	2.50	172
CWISH-08	18.5	2.45	2.04	9.01	99	–	–	.43	–	–	31.1	2.44	124
CWISH-09	4.43	.52	.92	2.88	27	–	–	.31	–	–	21.0	E.1	40
Understanding wells													
CGOLDU-01	50.7	8.94	4.45	28.0	190	–	0.05	14.7	0.29	0.019	36.2	46.8	292
CGOLDU-02	47.4	20.8	4.86	16.5	201	–	.06	27.4	.14	E.002	49.5	15.3	312
CWISHU-01	12.9	.38	.85	31.1	77	1	.04	20.4	1.08	.003	21.8	5.6	141

[1] The SMCL-CAs for chloride, sulfate, and TDS have recommended and upper threshold values. The upper value is shown in parentheses.

[*] Value above threshold level.

Table 9. Trace elements detected in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[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. **Thresholds and thresholds values** as of March 1, 2008. Samples from all 30 wells were analyzed. All analytes are listed in table 3F. **Threshold type:** Maximum contaminant level thresholds 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. AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; 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; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well; CGOLDU, Central Sierra Coarse Gold study area understanding well; CWISHU, Central Sierra Wishon study area understanding well. **Abbreviations:** E, estimated value; LRL, laboratory reporting level; mg/L, milligram per liter; na, not available; V, analyte detected in sample and blanks thus result is not considered a detection in ground-water quality analyses;–, not detected]

GAMA well identification No.	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)
[LRL]	[1.6]	[0.20]	[0.12]	[0.2]	[0.06]	[8]	[0.04]	[0.04]	[0.040]	[0.4]	[6]	[0.08]
Threshold type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Threshold level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
Grid wells												
CGOLD-01	E0.9	0.27	5.8	3	–	57	–	–	0.143	0.6	V6	3.73
CGOLD-02	–	–	.86	5	E0.04	25	–	–	.260	E.3	*1,220	–
CGOLD-03	–	–	.47	–	E.05	36	–	–	.100	E.3	*412	E.08
CGOLD-04	–	–	1.2	4	–	13	–	–	.075	13.9	81	.35
CGOLD-05	E.8	–	5.2	1	–	275	–	V0.05	.073	1.1	–	.49
CGOLD-06	–	.45	1.30	20	–	17	0.30	V.04	1.710	9.0	V4	1.93
CGOLD-07	1.8	–	7.0	–	–	82	.12	–	–	.4	–	E.08
CGOLD-08	–	–	.31	96	–	43	–	V.04	.079	2.2	V11	E.05
CGOLD-09	3.6	.9	*12.8	6	–	162	.06	V.04	E.021	E.3	–	.26
CGOLD-10	E.8	–	.60	44	–	–	–	.08	.293	2.6	92	.47
CGOLD-11	–	E.1	1.1	11	E.05	131	–	V.03	1.040	1.1	*330	.50
CGOLD-12	–	–	1.5	–	–	16	–	V.02	.077	E.3	41	E.05
CGOLD-13	–	–	1.9	10	–	108	.24	V.03	.214	.5	28	.15
CGOLD-14	–	–	1.1	17	–	582	E.03	.06	.134	6.2	V4	1.83
CGOLD-15	E1.3	–	5.7	51	–	35	E.02	V.04	.203	.9	113	.10
CGOLD-16	–	–	.15	38	–	–	–	.60	E.038	9.0	V17	5.53
CGOLD-17	E.8	–	2.4	33	–	E7	.08	V.05	.105	3.5	–	1.41
CGOLD-18	3.0	–	8.7	2	–	318	.10	V.04	E.028	E.2	–	–
CWISH-01	–	.43	*34.5	2	E.06	744	.30	–	.259	.5	V6	1.01
CWISH-02	E1.3	–	*12.4	–	–	170	.05	–	E.038	–	V8	.19
CWISH-03	–	–	*40.5	–	–	568	.06	–	.157	1.0	47	.59
CWISH-04	–	–	.27	24	–	–	.04	.08	.062	2.2	262	.52
CWISH-05	–	–	.90	25	–	59	.06	–	.124	2.2	V8	.71
CWISH-06	12	–	3.0	–	–	906	E.04	V.03	–	–	–	.13
CWISH-07	3.1	–	*17.6	3	–	204	.06	V.03	.089	5.8	–	1.24
CWISH-08	–	–	.82	7	–	31	.06	.06	.072	.9	–	.14
CWISH-09	–	–	E.08	4	–	–	–	.06	E.036	8.9	V20	10.0
Understanding wells												
CGOLDU-01	–	–	2.1	2	–	56	0.08	V0.05	0.303	0.8	45	0.10
CGOLDU-02	–	–	1.4	151	–	11	E.03	.55	.187	9.3	V3	8.13
CWISHU-01	2.4	–	*11.8	2	–	157	.08	.39	.049	.9	V8	.54

Table 9. Trace elements detected in ground-water samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.—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. **Thresholds and thresholds values** as of March 1, 2008. Samples from all 30 wells were analyzed. All analytes are listed in table 3F. **Threshold type:** Maximum contaminant level thresholds 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. AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; 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; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well; CGOLDU, Central Sierra Coarse Gold study area understanding well; CWISHU, Central Sierra Wishon study area understanding well. **Abbreviations:** E, estimated value; LRL, laboratory reporting level; mg/L, milligram per liter; na, not available; V, analyte detected in sample and blanks thus result is not considered a detection in ground-water quality analyses;–, not detected]

GAMA well identification No.	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Strontium (µg/L) (01080)	Tungsten (µg/L) (01155)	Uranium (natural) (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
[LRL]	[0.6]	[0.2]	[0.01]	[0.4]	[0.06]	[0.08]	[0.4]	[0.06]	[0.04]	[0.1]	[0.6]
Threshold type	na	SMCL-CA	MCL-US	HAL-US	MCL-CA	MCL-US	HAL-US	na	MCL-US	NL-CA	SMCL-CA
Threshold level	na	50	2	40	100	50	4000	na	30	50	5000
Grid wells											
CGOLD-01	123	1.5	–	7.1	2.81	0.15	163	0.06	5.55	0.25	103
CGOLD-02	47.7	*220	–	2.2	3.28	.08	102	.13	3.96	.12	4
CGOLD-03	67.3	*168	–	1.4	1.88	–	92.5	.28	–	–	2.4
CGOLD-04	30.7	4.3	–	2.4	1.20	E.07	64.1	E.05	23.2	3.3	284
CGOLD-05	109	0.2	–	20.2	.90	.31	117	7.3	13.6	3.0	14.8
CGOLD-06	20.7	*53.9	–	31.7	1.44	E.07	109	.57	11.0	1.6	43.4
CGOLD-07	7.3	E.2	–	*52.6	.13	–	16.0	19.9	.47	1.3	2.1
CGOLD-08	26.1	1.3	–	0.9	.87	.20	179	.38	9.65	2.2	1.4
CGOLD-09	17.3	E.2	–	23.4	.34	.33	42.1	.68	15.7	8.1	35.3
CGOLD-10	4.7	*108	–	0.5	2.37	.35	92.0	–	.07	.25	2,690
CGOLD-11	29.7	*157	–	1.9	5.20	E.07	101	4.7	1.49	.15	1.1
CGOLD-12	67.5	[1]94	–	10.8	1.63	–	104	.06	.13	–	25.5
CGOLD-13	46.9	*111	–	*84.7	2.98	E.04	180	.83	2.33	.33	5.9
CGOLD-14	96.8	E.2	–		2.60	.11	192	13.1	19.8	5.7	8.2
CGOLD-15	34.7	45.0	–	4.3	2.02	.58	77.1	1.6	1.33	.48	2.6
CGOLD-16	3.3	1.1	–	2.7	.67	.30	117	–	.11	2.8	10.9
CGOLD-17	46.4	2.4	–	22.8	1.55	.21	109	–	8.35	3.6	254
CGOLD-18	40.3	.8	–	35.1	.46	–	16.0	27.9	1.48	.24	2.1
CWISH-01	95.7	*87.4	–	29.7	5.26	–	58.0	.81	*153	.64	12.3
CWISH-02	23.6	2.2	–	29.2	.90	–	35.7	19.4	1.81	–	1.9
CWISH-03	100	*137	–	*41.2	3.42	E.04	111	10.7	*655	.14	252
CWISH-04	48.1	4.9	–	E0.2	.97	.11	212	–	5.24	4.6	128
CWISH-05	48.3	.8	–	17.2	1.92	.11	121	.43	*434	2.4	42.6
CWISH-06	7.1	.3	–	12	.37	–	4.02	111	.13	–	0.6
CWISH-07	23.6	3.0	–	21.5	1.76	–	17.5	12.4	*39.4	.63	49
CWISH-08	17.7	11.7	0.02	7.0	1.00	–	97.0	1.7	*58.7	2.5	3,820
CWISH-09	1.5	1.8	–	E.3	12.6	–	45.5	–	1.47	0.55	343
Understanding wells											
CGOLDU-01	75.0	*132	–	24	3.29	–	236	0.26	2.7	–	28
CGOLDU-02	19.5	–	–	2.5	4.71	0.59	409	E.03	2.41	21.4	21.8
CWISHU-01	18.8	.6	–	26.7	1.11	–	29.9	21.2	2.96	.21	19.8

*Value above threshold value.

Table 10. Species of inorganic arsenic, iron, and chromium in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[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. **Thresholds and thresholds values** as of March 1, 2008. Information about analytes given in table 3G. Samples from all 30 wells were analyzed; only wells with at least one detection are listed. **Threshold type:** Maximum contaminant level thresholds 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. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well. **Abbreviations:** E, estimated value; MDL, method detection limit; na, not available; µg/L, microgram per liter; –, not detected]

GAMA well identification No.	Arsenic (µg/L) (99033)	Arsenic (III) (µg/L) (99034)	Iron (µg/L) (01046)	Iron (II) (µg/L) (01047)	Chromium (µg/L) (01030)	Chromium (VI) (µg/L) (01032)
[MDL]	[0.5]	[1]	[2]	[2]	[1]	[1]
Threshold type[1]	MCL-US	na	SMCL-CA	na	MCL-CA	na
Threshold level	10	na	300	na	50	na
Grid wells						
CGOLD-01	5.2	–	4	–	–	–
CGOLD-02	.5	–	*1,150	1,140	–	–
CGOLD-03	–	–	*383	373	–	–
CGOLD-04	1	–	71	56	–	–
CGOLD-05	4.8	1	–	–	–	–
CGOLD-06	1	–	3	–	–	–
CGOLD-07	5.9	–	–	–	–	–
CGOLD-08	–	–	6	3	–	–
CGOLD-09	*11	1	–	–	–	–
CGOLD-10	.6	–	58	17	–	–
CGOLD-11	1	–	*319	299	–	–
CGOLD-12	1.3	–	34	24	–	–
CGOLD-13	1.6	–	27	16	–	–
CGOLD-14	.6	–	5	3	–	–
CGOLD-15	5	–	54	27	–	–
CGOLD-16	–	–	18	12	–	–
CGOLD-17	1.8	–	3	–	–	–
CGOLD-18	9	2	2	–	–	–
CWISH-01	*31	–	5	–	–	–
CWISH-02	*11	10	–	–	–	–
CWISH-03	*37	*14	45	14	–	–
CWISH-04	–	–	233	225	–	–
CWISH-05	.9	–	7	3	–	–
CWISH-06	2.3	1.2	–	–	–	–
CWISH-07	*15	1.6	–	–	–	–
CWISH-08	–	–	–	–	–	–
CWISH-09	–	–	18	4	–	–
Understanding wells						
CGOLDU-01	1.6	–	43	33	–	–
CGOLDU-02	.8	–	–	–	–	–
CWISHU-01	10	–	6	–	–	–

*Value above threshold level.

Table 11. Radioactive constituents detected in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[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. **Thresholds and thresholds values** as of March 1, 2008. Information about analytes given in table 3H. Samples from the 13 slow wells were analyzed for radium, radon, and alpha and beta radioactivity; all 30 samples were analyzed for uranium. The MCL-US threshold for radium is the sum of radium-226 and radium-228. Two MCLs have been proposed for Radon-222. The proposed Alternaltive MCL is in parentheses. The MCL-CA threshold for uranium is the sum of uranium-234, uranium-235, and uranium-238. **Threshold type:** Maximum contaminant level thresholds 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. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well; CGOLDU, Central Sierra Coarse Gold study area understanding well; CWISHU, Central Sierra Wishon study area understanding well. **Abbreviations:** E, estimated value; pCi/L, picocuries per liter; nc, sample not collected; <, less than]

GAMA well identification No.	Radium-226 (pCi/L) (09511)	Radium-228 (pCi/L) (81366)	Radon-222 (pCi/L) (82303)	Alpha radioacitvity (pCi/L)		Beta radioacitvity (pCi/L)		Uranium-234 (pCi/L) (22610)	Uranium-235 (pCi/L) (22620)	Uranium-238 (pCi/L) (22603)
				72-hour count (62636)	30-day count (62639)	72-hour count (62642)	30-day count (62645)			
Threshold type	MCL-US	MCL-US	Proposed MCL-US	MCL-US	MCL-US	MCL-CA	MCL-CA	MCL-CA	MCL-CA	MCL-CA
Threshold value			300 (4,000)	15	15	50	50	20	20	20
Grid wells										
CGOLD-01	E0.05	< 0.50	*700	E 3.4	E 2.4	< 1.7	E 2.6	2.2	E 0.12	1.9
CGOLD-02	.47	E .43	*2,900	5.5	E 2.9	8.3	7.6	1.8	E .06	1.4
CGOLD-03	.29	< .52	*1,400	E .99	< 1.4	E 3.8	E 2.4	E .04	< .02	E .01
CGOLD-04	.11	< .47	*5,700	14	12	E 3.2	9.3	8.6	.47	7.7
CGOLD-05	nc	nc	nc	nc	nc	nc	nc	5.3	.2	4.2
CGOLD-06	.12	E.37	*3,400	11	E 5.4	5.3	E 5.9	4.4	.26	3.7
CGOLD-07	E.02	< .53	*2,000	< 2.1	< 2.9	E 1.3	E 1.3	0.37	E .02	0.15
CGOLD-08	.22	E .51	**5,700	8.1	E 6.6	E 3.1	6.5	3.4	E .11	3.4
CGOLD-09	E.05	< .39	*1,100	* 16	14	E 3.2	7.3	6.8	.28	5.7
CGOLD-10	.08	< .40	*1,000	< 2.3	E 1.1	E 2.2	E 3.3	E .06	< .03	E .04
CGOLD-11	nc	nc	nc	nc	nc	nc	nc	.88	E .02	0.6
CGOLD-12	nc	nc	nc	nc	nc	nc	nc	.1	E .02	E .05
CGOLD-13	nc	nc	nc	nc	nc	nc	nc	1.1	E .04	.79
CGOLD-14	nc	nc	nc	nc	nc	nc	nc	7.7	E .20	7.3
CGOLD-15	nc	nc	nc	nc	nc	nc	nc	.69	E .04	.41
CGOLD-16	nc	nc	nc	nc	nc	nc	nc	E .08	< .03	E .03
CGOLD-17	nc	nc	nc	nc	nc	nc	nc	3.1	E .17	2.5
CGOLD-18	nc	nc	nc	nc	nc	nc	nc	.68	< .03	.49
CWISH-01	1.2	< .58	**14,000	*110	*120	16	*50	*78	2.5	*52
CWISH-02	.14	< .56	**6,000	E 5.5	3.2	E 3.7	1.9	1.2	E .02	.63
CWISH-03	2.6	E .47	**41,000	*850	*850	E 8.0	*180	*310	36	*230
CWISH-04	E.06	< .48	**4,500	E 4.8	E 3.6	E 2.7	4.6	2.0	E .08	1.8
CWISH-05	.35	E .43	**25,000	270	*280	12	*120	*130	3.2	*140
CWISH-06	nc	nc	nc	nc	nc	nc	nc	.12	< .04	E .04
CWISH-07	nc	nc	nc	nc	nc	nc	nc	*25	.76	14
CWISH-08	nc	nc	nc	nc	nc	nc	nc	*24	.97	18
CWISH-09	nc	nc	nc	nc	nc	nc	nc	.61	< .04	.36
Understanding wells										
CGOLDU-01	nc	nc	nc	nc	nc	nc	nc	2.1	E 0.07	0.87
CGOLDU-02	nc	nc	nc	nc	nc	nc	nc	.97	E .02	083
CWISHU-01	nc	nc	nc	nc	nc	nc	nc	2.3	E .06	1.0

*Value above lower threshold level.

**Value above upper threshold level.

Table 12. Species of inorganic arsenic, iron, and chromium in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[The five digit number below the conctituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific conctituent or property. **Thresholds and thresholds values** as of March 1, 2008. Information about analytes given in table 3H. Samples from all 30 wells were analyzed. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. **Threshold type:** Maximum contaminant level thresholds 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. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well; CGOLDU, Central Sierra Coarse Gold study area understanding well; CWISHU, Central Sierra Wishon study area understanding well. **Abbreviationc:** E, estimated value; na, not available; nc, not collected; pCi/L, picocuries per liter; <, less than; –, nitrate not detected]

GAMA well identification No.	δ^{2}H of water (per mil) (82082)	δ^{18}O of water (per mil) (82085)	Tritium (pCi/L) (07000)	δ^{13}C (per mil) (82081)	Carbon-14 (percent modern) (49933)	δ^{15}N of nitrate (per mil) (82082)	δ^{18}O of nitrate (per mil) (82085)
Threshold type	na	na	MCL-CA	na	na	na	na
Threshold level	na	na	20,000	na	na	na	na
			Grid wells				
CGOLD-01	-63.1	-8.73	3.2	-17.80	63	9.63	5.56
CGOLD-02	-66.2	-9.49	3.2	-18.10	86	–	–
CGOLD-03	-67.9	-9.64	<1	-18.25	78	–	–
CGOLD-04	-70.6	-10.06	5.8	-19.18	109	5.46	-.60
CGOLD-05	-78.1	-11.24	1.6	-19.24	78	nc	nc
CGOLD-06	-71.7	-10.48	6.1	-18.22	96	8.56	2.22
CGOLD-07	-90.2	-12.93	<1	-19.37	59	–	–
CGOLD-08	-67.3	-9.55	9.6	-20.58	108	7.96	.22
CGOLD-09	-66.5	-8.94	2.2	-17.56	53	8.25	5.44
CGOLD-10	-71.3	-10.66	9.9	-21.54	109	–	–
CGOLD-11	-65.3	-9.35	7.4	-17.79	98	8.22	8.87
CGOLD-12	-64.9	-9.08	<1	-18.32	71	–	–
CGOLD-13	-61.5	-8.60	5.1	-17.10	97	–	–
CGOLD-14	-72.4	-10.16	7.4	-19.10	83	7.29	.75
CGOLD-15	-66.7	-9.35	5.8	-16.98	92	5.66	4.59
CGOLD-16	-80.2	-11.59	17.9	nc	nc	5.70	3.06
CGOLD-17	-61.4	-8.64	10.9	-17.70	104	2.99	2.22
CGOLD-18	-83.9	-11.95	6.4	nc	nc	–	–
CWISH-01	-77.0	-11.19	3.5	-12.81	37	–	–
CWISH-02	-82.5	-11.92	<1	-18.44	61	6.65	-.42
CWISH-03	-85.3	-12.24	<1	-9.92	17	--	–
CWISH-04	-73.0	-10.58	11.2	-21.68	108	5.90	.68
CWISH-05	-73.2	-10.78	9	-20.26	103	–	–
CWISH-06	-83.9	-11.94	<1	-15.40	18	–	–
CWISH-07	-76.4	-11.02	3.5	-17.70	64	–	–
CWISH-08	-82.1	-11.94	4.5	-20.00	90	–	–
CWISH-09	-78.2	-11.64	9.3	-21.40	100	–	–
			Understanding wells				
CGOLDU-01	-62.7	-8.63	nc	-17.50	82	–	–
CGOLDU-02	-65.2	-9.22	11.2	-17.82	114	6.11	2.49
CWISHU-01	-81.9	-11.92	1	-18.50	61	5.16	1.10

Table 13. Microbial indicators detected in samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[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. **Thresholds and thresholds values** as of March 1, 2008. Samples from all 14 slow wells were analyzed, except that CGOLD-10 was not analyzed for coliphage and CWISH-04, and -05 were not analyzed for coliforms. All analytes are listed in table 3J. **Threshold type:** TT-US, U.S. Environmental Protection Agency treatment technique. **GAMA identification No.:** CGOLD, Central Sierra Coarse Gold study area grid well; CWISH, Central Sierra Wishon study area grid well. **Abbreviations:** E, estimated value; TT-US, U.S. Environmental Protection Agency treatment technique]

GAMA well identification No.	F-specific coliphage (units) (99335)
Threshold type	TT-US
Threshold level	99.99 percent killed/ deactivated
CGOLD-09	E 2
CWISH-05	E 2

Appendix. Sample Collection and Analysis, Data Reporting, Quality-Assurance and Quality-Control Procedures, and Quality-Control Sample Results

This appendix includes discussions the methods used to collect and analyze ground-water samples and report the resulting water-quality data. The methods used were selected to obtain representative samples of the ground water used for drinking-water supplies in the study area and to minimize potential bias to the data. Procedures used to collect and assess quality-control data, and the application of results from quality-control data to the ground-water quality data, are then discussed.

Sample Collection and Analysis

Ground-water 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). Samples were also collected using protocols described by Weiss, 1968; Shelton and others, 2001; Ball and McClesky, 2003a,b; and Wright and others, 2005.

Field Methods

Prior to sampling, each well was pumped continuously to purge at least three casing-volumes of water from the well and field parameters were monitored for stability. Samples were collected before filtration or chemical treatment, such as chlorination. If a chlorinating system was attached to the well prior to the sampling point, the chlorinator was shut off at least 24 hours prior to purging and sampling the well in order to purge the system of extraneous chlorine. Samples were collected inside an enclosed chamber located inside a mobile laboratory and connected to the well head by a 10- to 50-ft length of the TeflonTM tubing (Lane and others, 2003). All fittings and lengths of tubing were cleaned between samples (Wilde, 2004).

For the field measurements, ground water was pumped through a flow-through chamber fitted with a multi-probe meter that simultaneously measures the water-quality indicators dissolved oxygen, pH, specific conductance, turbidity, and water 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. Turbidity was measured using a dedicated turbidimeter; a calibration check of the turbidimeter was performed daily, and the turbidimeter was calibrated periodically as needed. Measured dissolved oxygen, pH, specific conductance, temperature, and turbidity values were recorded at 3- to 5-minute intervals for at least 30 minutes. Water samples for laboratory analyses were collected after water-quality indicators remained stable for 15–20 minutes. Field measurements and instrument calibrations were recorded by hand on field record sheets and electronically in PCFF-GAMA, a software package designed by the USGS with support from the GAMA program. Analytical service requests were also managed by PCFF-GAMA. Information from PCFF-GAMA was uploaded directly into NWIS at the end of every week of sample collection.

For analyses requiring filtered water, ground water was diverted through a 0.45-micrometer (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). Prior to sample collection, polyethylene sample bottles were pre-rinsed using deionized water three times, and once with native water before sample collection. Baked glass bottles were not pre-rinsed with either deionized or native water. 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).

Temperature-sensitive samples (volatile organic compounds, pesticides, compounds of special interest, dissolved organic carbon,) were stored on ice prior to daily shipping to the various laboratories; other samples that were not temperature-sensitive but required rapid analysis (radium isotopes, gross-alpha and -beta, and radon-222) also were shipped daily. The non-temperature-sensitive samples for tritium, noble gases, chromium speciation, uranium isotopes, strontium and boron isotopes, and stable isotopes were shipped monthly.

Detailed sampling protocols for individual analyses and groups of analytes are described in Koterba and others (2005) and the USGS National Field Manual (Wilde and others, 1999; Wilde and others, 2004) and in the references for analytical methods listed in table A1; only brief descriptions are given here. Volatile organic compounds (VOCs) and gasoline additives, 1,2,3-trichloropropane (1,2,3-TCP), and dissolved nitrogen samples were collected in 40-milliliter (mL) baked amber glass sample vials that were purged with three vial volumes of sample water before bottom-filling to eliminate atmospheric contamination. Six normal (6N) hydrochloric acid (HCl) was added as a preservative to the VOC samples, but not to the gasoline additives and oxygenate samples, or the 1,2,3-TCP samples. Perchlorate samples were collected in 125-mL polyethylene bottles. Tritium samples were collected by bottom-filling two 1-L polyethylene bottles with unfiltered ground water after first overfilling the bottle with three volumes of water. Stable isotopes of water were collected in 60-mL clear glass bottles filled with unfiltered water, sealed with a conical cap, and secured with electrical tape to prevent leakage and evaporation.

Pesticides and pesticide degradation products, pharmaceutical compounds, and N-nitrosodimethylamine (NDMA) were collected in 1-liter (L) baked amber bottles. Pesticide and pharmaceutical samples were filtered with a glass-fiber filter, while the NDMA samples were filtered at the Montgomery Watson Harza Laboratory prior to analysis.

Ground-water samples for major and minor ions, and trace element, alkalinity, and total dissolved solids analyses required filling one 250-mL polyethylene bottle with raw ground water and one 500-mL and one 250-mL polyethylene bottle with filtered ground water (Wilde and others, 2004). Filtration was done using a Whatman 0.45-µm vented capsule filter. The 250-mL filtered sample then was preserved with 7.5N nitric acid. Mercury samples were collected by filtering ground water into a 250-mL glass bottle and preserving with 6 N HCl. Arsenic and iron speciation samples were filtered into a 250-mL polyethylene bottle that was covered with dark-colored plastic to prevent light exposure and preserved with 6N HCl. Nutrient samples were filtered into 125-mL brown polyethylene bottles. The nitrate isotopes samples were filtered into 1-L polyethylene bottles. Radium isotopes, gross-alpha and -beta radiation, and uranium isotope samples were filtered into 1-L polyethylene bottles and acidified to a pH less than 2 with 7.5N nitric acid. Strontium and boron isotope samples were filtered into a 250-mL polyethylene bottle and the bottle cap was taped to seal. Carbon isotope samples were filtered and bottom-filled into two 500-mL glass bottles that were first overfilled with three bottle volumes of ground water. These samples had no headspace and were sealed with a conical cap to avoid atmospheric contamination. Tritium and carbon isotope samples had no headspace, whereas stable isotope samples (to avoid bottle breakage) and radium gross-alpha and -beta samples (to permit sample acidification) had headspace, and all were sealed with a conical cap to avoid atmospheric contamination. Samples for alkalinity titrations were collected by filtering ground water into 500-mL polyethylene bottles.

DOC, chromium, radon-222, dissolved gases, and microbial constituents were collected from the hose bib at the well head, regardless of the sampling schedule (intermediate or slow). DOC was collected after rinsing the sampling equipment with universal blank water (Wilde and others, 2004). Using a 50-mL syringe and 0.45-µm disk filter, each ground-water sample then was filtered into a 125-mL baked amber glass bottle and preserved with 4.5N sulfuric acid. Chromium-speciation samples were collected using a 10-mL syringe with an attached 0.45-µm disk filter. After the syringe was rinsed thoroughly and filled with ground water, 4 mL was forced through the disk filter and the next 2 mL of the ground water was filtered slowly into a small centrifuge vial for analysis of total chromium. Hexavalent chromium, Cr(VI), then was collected by attaching a small cation-exchange column to the syringe filter, and after conditioning the column with 2 mL of sample water, 2 mL was collected in a second centrifuge vial. Both vials were preserved with 10 microliters (µL) of 7.5N nitric acid (Ball and McClesky, 2003).

For the collection of radon-222, a stainless-steel and Teflon valve assembly was attached to the sampling port at the well head (Wilde and others, 2004). The valve was closed partially to create back pressure, and a 10-mL sample was taken through a Teflon septum on the value assembly using a glass syringe affixed with a stainless-steel needle. The sample then was injected into a 25-mL vial partially filled with scintillation mixture (mineral oil) and shaken. The vial then was placed in a cardboard tube to shield it from light during shipping.

Noble gas samples were collected in 3/8-inch inside diameter (ID) copper tubes using reinforced nylon tubing connected to the hose bib at the wellhead (table 3J). Ground water 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 ground water for analyses of noble gases (Weiss, 1968).

Samples for analysis of microbial constituents also were collected at the well head (Bushon, 2003; Myers, 2004). Prior to the collection of samples, the sampling port was sterilized using isopropyl alcohol, and ground water was run through the sampling port for at least 3 minutes to remove any traces of the sterilizing agent. Two sterilized 250-mL bottles were then filled with ground water for coliform analyses (E. coli and total coliform determinations), and one sterilized 3-L carboy was filled for coliphage analyses (F-specific and somatic coliphage determinations).

Alkalinity, *Escherichia coliform* (*E. coli*), and total coliforms were measured in the mobile laboratory at the well site. Alkalinity and the concentrations of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) were measured on filtered samples by Gran's titration method (Rounds, 2006). *E. coli* and total coliforms plates were prepared using sterilized equipment and reagents (Myers, 2004). Plates were counted under an ultraviolet light, following a 22–24 hour incubation time.

Laboratory Methods

Ten laboratories performed chemical and microbial analyses for this study (table A1; at back of report), Most of the analyses were performed 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 (Friedman and Erdmann, 1982). Method detection limits are tested continuously and laboratory reporting levels updated accordingly. NWQL maintains National Environmental Laboratory Accreditation Program (NELAP) and other certifications (http://nwql.usgs.gov/Public/Performance/publiclabcertcoverpage.html). In addition, the Branch of Quality Systems within the USGS Office of Water Quality maintains independent oversight of quality assurance at the NWQL and laboratories contracted by the NWQL. The Branch of Quality Systems also runs a National Field Quality Assurance program that includes annual testing of all USGS field personnel for proficiency in making field water-quality measurements (http://nfqa.cr.usgs.gov/). Results for analyses made at the NWQL or by laboratories contracted by the NWQL are uploaded directly into NWIS by the NWQL. Laboratory quality-control data also are stored in NWIS.

Concentrations of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) also were calculated from the laboratory alkalinity and pH measurements. Calculations were made using the advanced speciation method (http://or.water.usgs.gov/alk/methods.html) with pK_1 ($-\log_{10}$ of the first acid dissociation constant for H_2CO_3) = 6.35, pK_2 ($-\log_{10}$ of the second acid dissociation constant for H_2CO_3) = 10.33, and pK_W ($-\log_{10}$ of the acid dissociation constant for water) = 14.

Data Reporting

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

Laboratory Reporting Conventions

The USGS NWQL uses the laboratory reporting level (LRL) as a threshold for reporting analytical results. The LRL is set to minimize the reporting of false negatives (not detecting a compound when it actually is present in a sample) to less than 1 percent (Childress and others, 1999). The LRL is set at two-times the long-term method detection limit (LT-MDL). The LT-MDL is derived from the standard deviation of at least 24 MDL determinations made over an extended period of time. LT-MDLs are monitored and updated continually. The method detection limit (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 MDL there is less than 1 percent chance of a false positive) (Childress and others, 1999; U.S. Environmental Protection Agency, 2002a). The USGS NWQL updates LRL values regularly, and the values listed in this report were in effect during the period that analyses were made for ground-water samples from the CENSIE study (May, 2006). Interim reporting levels (IRL) are used as a temporary reporting level for new or custom schedules when LT-MDL data are unavailable and a LRL has not been established (U.S. Geological Survey, 2005).

Detections between the LRL and the LT-MDL are reported as estimated concentrations (designated with an “E” before the value in the tables and text). For information-rich methods, detections below the LT-MDL have 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 (VOCs; gasoline oxygenates, and degradates; pesticides; and pharmaceuticals). Compounds are identified by the 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 outside the range of calibration standards, for detections that did not meet all laboratory quality-control criteria, and for samples that were diluted prior to analysis.

Some concentrations 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 reported reliably 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.

Detections that could have resulted from sample contamination are reported with a “V” before the values in the tables. The potential for sample contamination was assessed using results from field, source-solution, and laboratory blanks.

The reporting levels for radiochemical constituents (gross-alpha radioactivity, gross-beta radioactivity, radium-226, and radium-228) are based on a sample-specific minimum detectable concentration (SSMDC), a sample-specific critical value, and the combined standard uncertainty (CSU) (U.S. Environmental Protection Agency, 2004; Bennett and others, 2006). A result above the critical value represents a greater-than-95-percent certainty that the result is greater than zero (significantly different from the instrument's background response to a blank sample), and a result above the SSMDC represents a greater-than-95-percent certainty that the result is greater than the critical value. Using these reporting level elements, three unique cases are possible when screening the raw analytical data. If the analytical result is less than the critical value (case 1), the analyte is considered not detected, and the concentration is reported as less than the SSMDC. If the analytical result is greater than the critical value, the ratio of the CSU to the analytical result is calculated as a percent (percent-relative CSU). For those samples with percent-relative CSU greater than 20 percent, concentrations are reported as estimated values (designated by an "E" preceding the value) (case 2). For those samples with percent-relative CSU less than 20 percent, concentrations are reported as given (case 3).

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

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

where

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

E is the element (O for oxygen, C for carbon, H for hydrogen, N for nitrogen, or B for Boron),

R_{sample} is the ratio of the abundance of the heavier isotope isotope of the element (^{18}O, ^{12}C, ^{1}H, ^{15}N, or ^{10}B) in the sample, and

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

Information about reference materials for isotope analysis is compiled in Coplen and others (2002).The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned δ^{18}O and δ^{2}H values of 0 per mil (note than δ^{2}H also is written as δD because the common name of the heavier isotope of hydrogen, ^{2}H, is deuterium). The reference material for carbon is Vienna Peedee Belemnite (VPDB), which is assigned a δ^{13}C value of 0 per mil. The reference material for nitrogen is atmospheric nitrogen gas, which is assigned a δ^{15}N 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

Thirteen constituents targeted in this study were determined by more than one analytical schedule or more than one laboratory (table A2, at back of report). The preferred methods for these constituents were selected based on the procedure recommended by the NWQL (U.S. Geological Survey, 2004). Methods with full approval are preferred over those with provisional approval and approved methods are favored over research methods. The method with greater accuracy and precision and lower LRLs for the overlapping constituents is preferred. A method may be selected as the preferred method to provide consistency with historical data analyzed by the same method.

Five of the constituents appear on NWQL schedules 2020 and 4024. The preferred method was Schedule 2020 to provide consistency (all samples collected for the GAMA Priority Basin Assessment project are analyzed using Schedule 2020).

The 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 are reported because laboratory pH and alkalinity measurements were made on a greater number of samples.

The field and laboratory data were compared using the paired t-test (Helsel and Hirsch, 2002). The paired t-test evaluates the null hypothesis that the median of the paired differences between the two data sets is zero. Results are reported as the probability, P, of obtaining the observed distribution of data, or one even less likely, when the null hypothesis is true. Therefore, a P value of 0.01 indicates 99 percent confidence that the two data sets are different.

Alkalinity was measured in both the field and the laboratory for 13 samples, and there was no difference between the two data sets (P = 0.4). Specific conductance was measured in both the field and the laboratory for all 30 samples, and the two data sets were systematically different (P = 0.004). The specific conductance measured in the laboratory was greater than that measured in the field by an average of 3 µS/cm. The reason for this difference is unknown. Both laboratory and field pH measurements were made for 23 samples, and the two data sets were systematically different (P = 0.001). Lab pH values were higher by a median of 0.2 pH units, and there was an inverse correlation between the field pH value and the magnitude of the difference between the field and lab pH values. The increase in pH between field and laboratory measurement may be explained by equilibration of the sample with the atmosphere after collection.

For arsenic, chromium, and iron concentrations, the approved method, Schedule 1948, used by the NWQL are preferred over the research methods used by the USGS Trace Metal Laboratory. The concentrations measured by the Trace Metal Laboratory used are only to calculated ratios of redox species for each element, $\frac{\mathrm{As(V)}}{\mathrm{As(III)}}$ for arsenic, $\frac{\mathrm{Cr(VI)}}{\mathrm{Cr(III)}}$ for chromium, and $\frac{\mathrm{Fe(III)}}{\mathrm{Fe(II)}}$ for iron. For example:

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

where

Fe(T) is the total iron concentration (measured),
Fe(II) is the concentration of ferrous iron (measure
and,
Fe(III) is the concentration of ferric iron (calculated

Quality-Assurance

The purpose of quality-assurance is to identify which data best represent environmental conditions and which data may have been affected by contamination or bias during sample collection, processing, storage, transportation, or laboratory analysis. Four types of quality-control (QC) tests were used in this study: blank samples were collected to assess contamination; replicate samples were collected to assess reproducibility; matrix spike tests were done to assess accuracy of laboratory analytical methods; and surrogate compounds were added to samples analyzed for organic constituents to assess bias of laboratory analytical methods. In this report, detections of analytes in ground-water samples that may have resulted from contamination were marked with a “V” remark code before the value in the data tables, and are not considered detections in assessments of ground-water quality. The evaluation of QC data presented in this report primarily was based on results for QC samples collected for CENSIE. A holistic evaluation using results from QC samples collected from many study units will be presented in a subsequent report.

The quality-assurance 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 in Maloney (2005) and Pirkey and Glodt (1998).

Blanks

Two types of blank samples (blanks) were collected for the Central Sierra GAMA study: field and source-solution blanks. Field blanks and source-solution blanks were collected at 12 percent of the wells sampled to determine if equipment or procedures used in the field or laboratory introduced contamination. Blanks were collected using water (commercially available pesticide-grade blank water that was screened for inorganic analytes) certified by the NWQL to contain less than the LRL of the analytes investigated in the study. Source-solution blanks were collected to verify that the blank water used for the field blanks was free of analytes. Field blanks were analyzed for VOCs, gasoline additives, pesticides, NDMA, perchlorate, 1,2,3-TCP, nutrients, dissolved organic carbon, major and minor ions, trace elements, iron, arsenic, and chromium speciation, and radioactive constituents. Commercially available blank water has not been certified as being free of tritium or noble gases, thus field blanks were not collected for these constituents.

Source-solution blanks were collected at the sampling site by pouring blank water directly into sample containers that were preserved, stored, shipped, and analyzed in the same manner as the ground-water samples. For field blanks, blank water either was pumped or poured through the sampling equipment (fittings and tubing) used to collect ground water, then processed and transported using the same protocols for the ground-water samples.

If a constituent was detected in field or source-solution blanks, the data for that constituent in ground-water samples were examined for potential contamination. Detections in ground-water samples with concentrations less than the highest concentration measured in a blank plus the LT-MDL were marked with a “V” in the data tables (LRL equals twice the LT-MDL). The highest concentration measured in a blank was assumed to represent the highest potential amount of contamination. Thus, the V remark code flags results that could have changed from a non-detection to a detection relative to the LT-MDL due to contamination. For example, if the LT-MDL for a constituent is 0.10 µg/L, the measured concentration in a ground-water sample with a true concentration of 0.05 µg/L would be reported as a non-detection. But, if the ground-water sample was contaminated with 0.20 µg/L of the constituent, the measured concentration would be reported as 0.25 µg/L, a detection. If the maximum potential amount of contamination is 0.20 µg/L, then ground-water samples with measured concentrations less than 0.30 µg/L may actually have true concentrations less than the LT-MDL. For organic constituents, results with V codes are not considered to be detections of the constituent when calculating detection frequencies for ground-water quality assessments. For inorganic constituents, results with V codes are considered to have concentrations less than the reported value (including the possibility of the concentration being less than the LT-MDL).

Replicates

Sequential replicate samples were used to assess variability that may result from the processing and analyses of inorganic and organic constituents. Relative standard deviation (RSD) of the measured values was used to express the variability between replicate pairs for each compound (tables A4A-D, at back of report). The RSD is defined as the standard deviation divided by the mean concentration for each replicate pair of samples, multiplied by 100 percent. If one value in a sample pair was reported as a non-detection and the other value was reported as an estimate below the LRL or MRL, the RSD was set to zero because the values are analytically identical. If one value in a sample pair was reported as a non-detection and the other value was greater than the LRL or MRL, then the non-detection value was set equal to one-quarter of the LRL and the RSD was calculated (Hamlin and others, 2002). Values of RSD less than 20 percent are considered acceptable in this study. An RSD value of 20 percent corresponds to a relative percent difference (RPD) value of 29 percent. High RSD values for a compound may indicate analytical uncertainty at low concentrations, particularly for concentrations within an order of magnitude of LT-MDL or MDL. Sequential replicate samples were collected at 17 percent of the wells sampled.

Matrix Spikes

Addition of a spike, or known concentration of a constituent, to a replicate environmental sample enables the laboratory to determine the effect of the matrix, in this case ground water, on the analytical technique used to measure the constituent. Laboratory matrix spikes are prepared by adding a specific volume of a solution containing known concentrations of target analytes to replicate ground-water samples prior to sample preparation and analysis. The constituents added in matrix spikes are identical to those being analyzed in a given method, allowing for an analysis of matrix effects on individual compounds. Matrix spikes were added at the laboratory performing the analysis. Compounds with low recoveries (less than 70 percent) are of particular concern if environmental concentrations are close to the MCLs; a low recovery could falsely indicate a concentration below the MCL (tables A5A, B, at back of report). Conversely, compounds with high recoveries (greater than 130 percent) are of potential concern if the environmental concentrations are greater than the MCLs: a high recovery could falsely indicate a concentration above the MCL. Acceptable ranges for set spike recoveries are 70 to 130 percent for NWQL schedules 2020 and 4024 (VOC's and gasoline compounds; Connor and others, 1998; Rose and Sandstrom, 2003), and 60 to 120 percent for NWQL schedule 2033 (pesticides; Sandstrom and others, 2001). Based on these ranges, we defined 70–130 percent as the acceptable range for matrix-spike recoveries for organic compounds in this study.

Matrix spike tests were done for VOCs, gasoline additives, pesticide compounds, NDMA, and 1,2,3-TCP, because the analytical methods for these constituents are chromatographic methods which may be susceptible to matrix interferences. Replicate samples for matrix spike additions were collected at 17 percent of the wells sampled, although not all analyte classes were tested at every well (tables A5A,B).

Surrogates

Surrogate compounds are added to environmental samples in the laboratory prior to analysis to evaluate the recovery of similar constituents. Surrogate compounds were added to all of the ground-water and quality-control samples that were analyzed for VOCs and gasoline additives, pesticides, NDMA, and 1,2,3-TCP (table A6, at back of report). Most of the surrogate compounds are deuterated analogs of compounds being analyzed. For example, the surrogate toluene-d8 used for the VOC analytical method has the same chemical structure as toluene, except that the eight hydrogen-1 atoms on the molecule have been replaced by deuterium (^{2}H). Toluene-d8 and toluene behave very similarly in the analytical procedure, but the small mass difference between the two results in slightly different chromatographic retention times, thus the use of a toluene-d8 surrogate does not interfere with the analysis of toluene. Only 0.0156 percent of hydrogen atoms are deuterium, thus deuterated compounds like toluene-d8 do not occur naturally and are not found in environmental samples (Firestone and others, 1996). Surrogates are used to identify potential 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 70-130 percent recovery of surrogates generally is considered acceptable. Values outside this range indicate possible problems with the processing and analysis of samples (table A6) (Connor and others, 1998; Sandstrom and others, 2001).

Quality-Control Sample Results

Four types of QC samples were collected and analyzed: blanks, field replicates, laboratory surrogates, and laboratory matrix spikes. QC samples collected in the field were collected concurrently with approximately 10 percent of the environmental samples in the Central Sierra GAMA study. Results of QC sampling are discussed in the following sections.

Detections in Field and Source-Solution Blanks

Field blanks were collected at approximately 12 percent of the sites sampled in CENSIE and are summarized in table A3.

Seven VOCs were detected in field blanks, however, one field blank contained all of the detections for six of the compounds. Only one compound, toluene, was detected in more than one field blank (table A3). Toluene was detected in three of the four field blanks at a maximum concentration of E0.04 µg/L, and also was detected in an associated source-solution blank. Low levels of toluene were detected in nearly half of the source-solution and field blanks collected using all equipment sets in earlier study units (Wright and others, 2005; Bennett and others, 2006; Kulongoski and others, 2006; Kulongoski and Belitz, 2007; Fram and Belitz, 2007; Dawson and others, 2008). Because toluene detections in field and source-solution blanks did not necessarily occur in pairs of blanks collected at the same sites, the source blank water was not considered the source of the contamination. Due to the frequent detection of toluene in both source-solution and field blanks, all toluene detections with concentrations less than 0.05 µg/L (0.04 µg/L plus one-half the LRL) were V-coded. Toluene was detected in two ground-water samples at concentrations of E0.04 and E0.02 µg/L; both of these detections were V-coded (tables 5 and A3).

Methylene chloride, ethylbenzene, styrene, o-xylene, and m- and p-xylene were detected on one field blank (table A3), but were not detected in any ground-water samples. Methyl ethyl ketone also was detected in the same field blank, and in one ground-water sample that was collected at a different site than the field blank. The sample for CGOLD-09 contained high concentrations of methyl ethyl ketone, tetrahydrofuran, and acetone (table 5). These detections were V-coded because the contamination came from a known source–pieces of PVC piping was attached to the well to create the sampling port, and the primary ingredients of PVC cement are methyl ethyl ketone, tetrahydrofuran, and acetone. A strong odor of PVC cement had been recorded in the field notes for that well site.

Field blanks analyzed for pesticides and pesticide degradates, pharmaceutical compounds, and compounds of special interest contained no detectable concentrations of any of those analytes, and therefore no data for these analytical schedules were V-coded.

Orthophosphate was the only nutrient detected in field blanks (table A3). Based on the LRL for orthophosphate, as well as the maximum concentration detected in the field blanks and the minimum concentration detected in the associated ground-water samples, detections of orthophosphate in two of the ground-water samples have been flagged (V-coded in table 7) due to possible contamination of the sample.

Calcium was detected in one field blank and silica in three field blanks, but the concentrations measured in ground-water samples (table 8) were at least 300 times greater than the concentrations measured in the field blanks (table A3). No calcium or silica data were V-coded.

Five trace elements were detected in field blanks. One field blank had detections of chromium, silver, strontium, and uranium, and another field blank had a detection of iron (table A3). These detections resulted in V-coding of chromium in 13 samples, iron in 11 samples, and silver in 1 sample (table 9). No detections of uranium or strontium in ground-water were V-coded because all of the measured concentrations were significantly greater than the concentration measured in the field blank.

Variability in Replicate Samples

Tables A4A-D summarize the results of replicate sample pairs for analytes detected in ground-water samples collected in the CENSIE study. Most replicate sample pairs collected during the CENSIE study had relative standard deviations (RSDs) of less than 5 percent and only 15 pairs had RSD values greater than the acceptable limit of 20 percent. Measured concentrations in the environmental and replicate samples are reported for all replicate sample pairs with RSD values greater than zero. RSD values for replicate pairs for VOCs, gasoline oxygenates and degradates, pesticides and pesticide degradates, and the compounds of special interest were all zero with the exception of a single replicate pair for 3,4-dichloroanaline, which had an RSD value of approximately 13 percent (table A4A). Constituents with replicate sample pairs with RSD values greater than 20 percent include: five minor ions and nutrients [bromide, fluoride, nitrite plus nitrate, orthophosphate, and total nitrogen (table A4B)]; nine trace elements [antimony, cadmium, chromium, iron, and zinc on Schedule 1948; and arsenic(T), arsenic(III), iron(T), and iron(II) by the USGS Traces Metals laboratory (table A4C)]; and one radioactive constituent [uranium-235 (table A4D)]. Most of the replicate sample pairs with high RSDs had concentrations near the LRL for those constituents, and at these low concentrations, small differences in the measured values in the replicate pairs account for the large RSDs. Because of this variability in measurements at low concentrations, the relatively high RSDs for these constituents were not considered to be of concern and, therefore, no detections were flagged as a result of variability in replicate sample pairs.

Matrix Spike Recoveries

Tables A5A and A5B present a summary of matrix-spike recoveries for the CENSIE study. Addition of 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 ground water, on the analytical technique used to measure the constituent. Spike samples were collected and analyzed for VOCs, gasoline oxygenates, pesticide compounds, compounds of special interest, and pharmaceuticals. More than 75 percent of the 194 spike compounds had recoveries within the acceptable range of 70 to 130 percent (tables A5A and A5B). Spike compounds with acceptable recoveries include 74 of 85 VOCs, 8 of 8 gasoline oxygenates, and 2 of 2 compounds of special interest. None of the VOC compounds with low or high recoveries were detected in ground-water samples; however, low recoveries may indicate that the compounds might not have been detected in some samples if the compound was present at low concentrations. With the exception of deethylatrazine (pesticide degradate), none of the pesticide compounds with low or high recoveries were detected in ground-water samples.

Surrogate Compound Recoveries

Surrogate compounds were added to environmental and quality-control samples in the laboratory prior to analysis to evaluate the recovery of similar constituents. Table A6 lists the surrogate, analytical schedule on which it was applied, the number of analyses for blank and non-blank samples, the number of surrogate recoveries below 70 percent, and the number of surrogate recoveries above 130 percent for the blank and non-blank samples. Blank and non-blank samples were considered separately to assess whether the matrices present in non-blank samples affect surrogate recoveries. No systematic differences between surrogate recoveries in blank and non-blank samples were observed. Greater than 90 percent of the total number of samples had surrogate recoveries between the acceptable limits of between 70 and 130 percent. The median surrogate recoveries for all analytes also were within the acceptable limits of between 70 and 130 percent. Samples with low recoveries of some surrogates may indicate that some analytes may not have been detected in these samples if present at low concentrations. Samples with high recoveries of some surrogates may indicate that the reported concentrations of some analytes may be biased high. No ground-water sample data were censored as a result of the surrogate recovery data.

Table A1. Analytical methods used for the determination of organic, inorganic, and microbial constituents by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and additional contract laboratories.

[**Analytical method:** MI agar, supplemented nutrient agar that causes coliforms (*Escherichia* and total) to produce distinctly different fluorescence under ultraviolet lighting, thus aiding in their detection and enumeration. **Abbreviations:** NWQL, National Water-Quality Laboratory; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; UV, ultraviolet; VIS, visible]

Analyte	Analytical method	Laboratory and analytical schedule or labcode	Method references
	Water-quality indicators		
Field parameters	Various measurement techniques	USGS field measurement	U.S. Geological Survey, variously dated
	Organic constituents		
Volatile organic compounds	Purge and trap capillary gas chromatography/mass spectrometry	NWQL; Schedule 2020	Connor and others, 1998
Gasoline oxygenates	Heated purge and trap/gas chromatography/mass spectrometry	NWQL; Schedule 4024	Rose and Sandstrom, 2003
Pesticides	Solid-phase extraction and chromatography/mass spectrometry	NWQL; Schedule 2033	Zaugg and others, 1995; Lindley and others, 1996; Sandstrom and others, 2001; Madsen and others, 2003
	Constituents of special interest		
N-Nitrosodimethylamine (NDMA)	Chromatography and mass spectrometry; USEPA method 1625, modified	Montgomery Watson Harza Laboratory	U.S. Environmental Protection Agency, 1996; U.S. Environmental Protection Agency, 1999
Percholorate	Chromatography and mass spectrometry; USEPA method 314	Montgomery Watson Harza Laboratory	Hautman and others, 1999
1,2,3-Trichloropropane	Gas chromatography/electron capture detector; USEPA method 524.2, modified	Montgomery Watson Harza Laboratory	U.S. Environmental Protection Agency, 1995
	Inorganic constituents		
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; American Public Health Association, 1998; Garbarino, 1999; Garbarino and Damrau, 2001; Garbarino and others, 2006
Nutrients	Alkaline persulfate digestion, Kjeldahl digestion	NWQL; Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
Dissolved organic carbon	UV-promoted persulfate oxidation and infrared spectrometry	NWQL; Labcode 2613	Brenton and Arnett, 1993
Chromium, arsenic and iron speciation	Various techniques of ultraviolet visible (UV-VIS) spectrophotometery and atomic absorbance spectroscopy	USGS Trace Metal Laboratory, Boulder, Colorado	Stookey, 1970; To and others, 1999; Ball and McCleskey, 2003a and 2003b; McCleskey and others, 2003

Table A1. Analytical methods used for the determination of organic, inorganic, and microbial constituents by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and additional contract laboratories.—Continued

[**Analytical method:** MI agar, supplemented nutrient agar that causes coliforms (*Escherichia* and total) to produce distinctly different fluorescence under ultraviolet lighting, thus aiding in their detection and enumeration. **Abbreviations:** NWQL, National Water-Quality Laboratory; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; UV, ultraviolet; VIS, visible]

Analyte	Analytical method	Laboratory and analytical schedule or labcode	Method references
		Stable isotopes	
Stable isotopes of water	Gaseous hydrogen and carbon dioxide-water equilibration and stable-isotope mass spectrometry	USGS Stable Isotope Laboratory, Reston, Virginia; Schedule 1142	Epstein and Mayeda, 1953; Coplen and others, 1991; Coplen, 1994
Nitrogen and oxygen isotopes of nitrate: δ^{15}N-NO_3 and δ^{18}O-NO_3	Denitrifier method and mass spectrometry	Lawrence Livermore National Laboratory	Singleton and others, 2005
Carbon isotopes	Accelerator mass spectometry	University of Waterloo, Environmental Isotope Laboratory; University of Arizona Accelerator Mass Spectrometry Laboratory; Schedule 2015	Donahue and others, 1990; Jull and others, 2004
		Radioactivity and gases	
Tritium (USGS)	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California; Labcode 1565	Thatcher and others, 1977
Tritium and noble gases	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory	Moran and others, 2002; Eaton and others, 2004
Radon-222	Liquid scintillation counting	NWQL; Labcode 1369	American Society for Testing and Materials, 1998
Radium-226 and -228	Radon emanation method, USEPA method 903.1; USEPA method 904.0, modified	Eberline Analytical Services; Schedule 1262	Krieger and Whittaker, 1980
Gross alpha/beta radioactivity	Alpha and beta activity counting, USEPA method 900.0, modified	Eberline Analytical Services; Schedule 1792	Krieger and Whittaker, 1980
Uranium-234, -235, and -238	Alpha-particle spectrometry	Eberline Analytical Services; Schedule 1130	American Society for Testing and Materials, D 3972
Dissolved gases: nitrogen, argon, and methane	Membrane inlet mass spectrometry	Lawrence Livermore National Laboratory	Singleton and Hudson, 2005; Singleton and others, 2007
		Microbial constituents	
F-specific and somatic coliphage	Single-agar layer (SAL) and two-step enrichment methods	USGS Ohio Water Microbiology Laboratory	U.S. Environmental Protection Agency, 2001a
Escherichia coli and total coliform	Membrane filter technique with "MI agar"	USGS field personel	U.S. Environmental Protection Agency, 2002b

Table A2. Preferred analytical schedules for constituents appearing on multiple schedules for samples collected from wells for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[**Laboratoris:** LLNL, Lawrence Livermore National Laboratory; MWH, Montgomery Watson-Harza Laboratory; SITL, U.S. Geological Survey Stable Isotope and Tritium Laboratory; TML, U.S. Geological Survey Trace Metal Laboratory. **Abbreviations:** VOC, volatile organic compound]

Constituent	Primary constituent classification	Analytical schedules	Preferred analytical schedule
Results from preferred method reported			
Acetone	VOC	2020; 4024	2020
Diisopropyl ether	VOC	2020; 4024	2020
Ethyl *tert*-butyl ether (ETBE)	VOC	2020; 4024	2020
Methyl *tert*-butyl ether (MTBE)[1]	Gasoline oxygenate	2020; 4024	2020
tert-Amyl methyl ether (TAME)	Gasoline oxygenate	2020; 4024	2020
Results from both methods reported			
Arsenic, total[1]	Trace element	1948, TML	1948
Chromium, total	Trace element	1948, TML	1948
Iron, total[1]	Trace element	1948, TML	1948
1,2,3-Trichloropropane (1,2,3-TCP)	VOC	2020, MHW	MWH
Tritium[1]	Radioactive isotope	LLNL, SITL	both
Alkalinity[1]	Water-quality indicator	1948, field	field
pH[1]	Water-quality indicator	1948, field	field
Specific conductance[1]	Water-quality indicator	1948, field	field

[1] Constituents detected in ground-water samples.

Table A3. Quality-control summary for constituents detected in field blanks and ground-water samples collected for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[No detections in field blanks for pesticide compounds, constituents of special interest, or arsenic, chromium, and iron speciation. Censored data are reported but not used in summary statistics. **Abbreviations:** E, estimated value; mg/L, milligram per liter; µg/L, micrograms per liter]

Compounds	Number of field blank detections/analyses	Concentrations detected in field blanks	Number of ground-water samples censored
Volatile organic compounds and gasoline oxygenates (µg/L)			
Ethylbenzene	1 / 4	E0.02	0
Methylene chloride (dichloromethane)	1 / 4	.2	0
Methyl ethyl ketone (2-butanone, MEK)	1 / 4	2.4	1
Styrene	1 / 4	E.03	0
Toluene[1]	3 / 4	E.01,E.02, E.04	2
m- and *p*-Xylene	1 / 4	E.08	0
o-Xylene	1 / 4	E.04	0
Nutrients and major and minor ions (mg/L)			
Orthophosphate	1 / 4	0.014	2
Calcium	1 / 4	E.01	0
Silica	3 / 4	E.02, E.03, E.03	0
Trace elements (µg/L)			
Chromium	1 / 4	E0.03	13
Iron	1 / 4	22	11
Silver	1 / 4	E.2	1
Strontium	1 / 4	E.24	0
Uranium	1 / 4	E.03	0

[1] Toluene also was detected in one associated source-solution blank.

Table A4. Quality-control summary of replicate analyses of organic constituents and constituents of special interest detected in samples collected from wells for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[**Abbreviations:** RSD, relative standard deviation in percent; na, not applicable; µg/L, microgram per liter]

Constituent	Number of RSDs greater than zero/replicate pairs	RSD (percent)		Measured values for pairs with RSD greater than zero (environmental, replicate) (µg/L)
		Maximum	Median	
Volatile organic compounds, gasoline oxygenates and additives (Schedules 2020 and 4204)				
All VOCs from schedule 2020 and 4024	0/5	0	na	na
Pesticides and pesticide degradates (Schedule 2033)				
3,4-Dichloroaniline	1/5	13.00	0	E 0.005, E 0.006
All other pesticides and pesticide degradates from schedule 2033	0/5	0	na	na
Constituents of special interest[1]				
N-Nitrosodimethylamine, Perchlorate, and 1,2,3-Trichloropropane	0/3	9	< 1	na

[1] Analyses performed at Montgomery Watson Harza Laboratories, Monrovia, California.

Table A5a. Quality-control summary of matrix-spike recoveries of volatile organic compounds (VOCs), gasoline oxygenates and degradates, and compounds of special interest in samples collected from wells for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[Acceptable recovery range is between 70 and 130 percent; values in bold fall outside this range]

Constituent	Number of spiked samples	Recovery (percent)		
		Minimum	Maximum	Median
Volatile organic compounds				
Acetone[1]	5	82	104	89
Acrylonitrile	5	106	115	106
tert-Amyl methyl ether (methyl tert-pentyl ether, TAME)[1]	5	119	**132**	**131**
Benzene[2]	5	96	109	100
Bromobenzene	5	88	108	94
Bromochloromethane	5	75	93	88
Bromodichloromethane	5	79	117	96
Bromoform (tribromomethane)	5	80	114	100
Bromomethane (methyl bromide)	5	78	98	90
n-Butylbenzene	5	72	94	83
sec-Butylbenzene	5	85	104	94
tert-Butylbenzene	5	91	109	107
Carbon disulfide[2]	5	83	103	100
Carbon tetrachloride (tetrachloromethane)	5	**134**	**191**	**171**
Chlorobenzene	5	100	106	102
Chloroethane	5	71	88	88
Chloroform (trichloromethane)[2]	5	81	111	98
Chloromethane	5	88	100	88
3-Chloropropene	5	**138**	**153**	**147**
2-Chlorotoluene	5	89	102	98
4-Chlorotoluene	5	75	89	82
Dibromochloromethane	5	95	131	113
1,2-Dibromo-3-chloropropane (DBCP)	5	89	113	100
1,2-Dibromoethane (EDB)	5	92	115	98
Dibromomethane	5	74	111	94
1,2-Dichlorobenzene	5	81	113	98
1,3-Dichlorobenzene	5	85	117	98
1,4-Dichlorobenzene	5	83	109	94
trans-1,4-Dichloro-2-butene	5	85	111	86
Dichlorodifluoromethane (CFC-12)	5	**62**	89	70
1,1-Dichloroethane (1,1-DCA)	5	**135**	**159**	**153**
1,2-Dichloroethane (1,2-DCA)	5	107	**148**	**131**
1,1-Dichloroethene (1,1-DCE)	5	85	102	100
cis-1,2-Dichloroethene (*cis*-1,2-DCE)	5	96	104	100
trans-1,2-Dichloroethene (*trans*-1,2-DCE)	5	96	106	100
1,2-Dichloropropane	5	96	109	96
1,3-Dichloropropane	5	125	143	125
2,2-Dichloropropane	5	**62**	99	96
1,1-Dichloropropene	5	**140**	**182**	**157**
cis-1,3-Dichloropropene	5	88	102	97
trans-1,3-Dichloropropene	5	94	106	96
Diethyl ether	5	113	**131**	125
Diisopropyl ether (DIPE)[1]	5	90	112	109
Ethylbenzene	5	98	102	102
Ethyl *tert*-butyl ether (ETBE)[1]	5	94	113	106
Ethyl methacrylate	5	86	109	98
o-Ethyl toluene	5	74	82	77
Hexachlorobutadiene	5	**61**	99	76
Hexachloroethane	5	84	123	106
2-Hexanone (*n*-butyl-2-methyl ketone)	5	90	110	96
Iodomethane (methyl iodide)	5	92	111	105

Table A5a. Quality-control summary of matrix-spike recoveries of volatile organic compounds (VOCs), gasoline oxygenates and degradates, and compounds of special interest in samples collected from wells for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.—Continued

[Acceptable recovery range is between 70 and 130 percent; values in bold fall outside this range]

Constituent	Number of spiked samples	Recovery (percent)		
		Minimum	Maximum	Median
Volatile organic compounds—Continued				
Isopropylbenzene (Cumene)	5	96	109	104
4-Isopropyl-1-methylbenzene	5	76	90	83
Methyl acrylate	5	102	112	105
Methyl acrylonitrile	5	84	90	86
Methyl tert-butyl ether (MTBE)[1],[2]	5	94	110	105
Methyl isobutyl ketone (4-methyl-2-pentanone, MIBK)	5	90	107	92
Methylene chloride (dichloromethane)	5	**24**	**30**	**24**
Methyl ethyl ketone (2-butanone, MEK)	5	99	117	103
Methyl methacrylate	5	81	105	90
Naphthalene	5	72	111	74
Perchloroethene (PCE)[2]	5	81	106	94
n-Propylbenzene	5	85	100	94
Styrene	5	87	100	96
1,1,1,2-Tetrachloroethane	5	81	110	96
1,1,2,2-Tetrachloroethane	5	113	**152**	127
Tetrahydrofuran	5	107	123	112
1,2,3,4-Tetramethylbenzene	5	**63**	**68**	**63**
1,2,3,5-Tetramethylbenzene	5	58	75	62
Toluene	5	94	106	96
1,2,3-Trichlorobenzene	5	**51**	**63**	**59**
1,2,4-Trichlorobenzene	5	106	**133**	115
1,1,1-Trichloroethane (TCA)	5	85	117	104
1,1,2-Trichloroethane	5	71	93	88
Trichloroethene (TCE)	5	88	106	88
Trichlorofluoromethane (CFC-11)	5	93	**134**	116
1,2,3-Trichloropropane (1,2,3-TCP)[3]	5	79	111	95
1,1,2-Trichlorotrifluoroethane (CFC-113)	5	**68**	96	77
1,2,3-Trimethylbenzene	5	71	88	80
1,2,4-Trimethylbenzene	5	79	96	84
1,3,5-Trimethylbenzene	5	94	109	98
Vinyl bromide (bromoethene)	5	101	122	117
Vinyl chloride (chloroethene)	5	87	106	96
m- and *p*-Xylene	5	166	179	170
o-Xylene	5	74	84	79
Gasoline oxygenates and degradates				
Acetone 1	5	68	110	85
tert-Amyl alcohol	5	94	108	99
tert-Amyl methyl ether (methyl *tert*-pentyl ether, TAME)[1]	5	107	125	115
tert-Butyl alcohol (TBA)	5	87	105	92
Diisopropyl ether (DIPE)[1]	5	104	124	113
Ethyl tert-butyl ether (ETBE)[1]	5	104	129	113
Methyl acetate	5	72	122	107
Methyl *tert*-butyl ether (MTBE)[1,2]	5	99	118	106
Constituents of special interest				
N-Nitrosodimethylamine (NDMA)	5	**62**	111	116
1,2,3-Trichloropropane (1,2,3-TCP)[3]	5	84	87	97

[1] Constituents appear on schedules 2020 and 4024; schedule 2020 is the preferred analytical schedule.

[2] Constituents detected in ground-water samples.

[3] Constituents appear on schedule 2020 and analysis by Montgomery Watson Harza Laboratory; Montgomery Watson Harza Laboratory is the preferred analytical method.

[4] Constituents analyzed by Montgomery Watson Harza Laboratory.

Table A5b. Quality-control summary of matrix-spike recoveries of pesticides and pesticide degradates in samples collected from wells for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[Acceptable recovery range is between 70 and 130 percent; values in bold fall outside this range]

Constituent	Number of spiked samples	Recovery (percent)		
		Minimum	Maximum	Median
Volatile organic compounds				
Acetochlor	5	90	95	105
Alachlor	5	92	98	106
Atrazine[1]	5	92	95	98
Azinphos-methyl	5	72	76	119
Azinphos-methyl-oxon	5	**40**	**49**	88
Benfluralin	5	**59**	**69**	72
Carbaryl	5	79	96	111
Carbofuran	5	92	102	118
2-Chloro-2,6-diethylacetanilide	5	89	102	113
4-Chloro-2-methylphenol	5	**48**	**58**	90
Chlorpyrifos	5	84	88	95
Chlorpyrofos, oxygen analog	5	**10**	**40**	**59**
Cyanazine	5	81	83	97
Cyfluthrin	5	**45**	**61**	82
λ-Cyhalothrin	5	**28**	**36**	**50**
Cypermethrin	5	**43**	**60**	77
DCPA {Dacthal}	5	91	97	98
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino -s-triazine)[1]	5	**44**	**47**	**61**
Desulfinylfipronil	5	**38**	**41**	**43**
Desulfinylfipronil amide	5	**33**	**43**	**64**
Diazinon	5	84	93	97
Diazinon, oxygen analog	5	**59**	88	98
3,4-Dichloroaniline[1]	5	72	82	99
3,5-Dichloroaniline	5	81	85	98
Dichlorvos	5	**20**	**29**	**49**
Dicrotophos	5	**29**	**30**	**30**
Dieldrin	5	92	104	108
2,6-Diethylaniline	5	91	97	108
Dimethoate	5	**28**	**31**	**48**
Disulfoton	5	**59**	88	91
Disulfoton sulfone	5	79	98	107
α-Endosulfan	5	84	90	96
Endosulfan sulfate	5	87	93	105
EPTC	5	85	96	100
Ethion	5	75	95	97
Ethion monoxon	5	**69**	98	127
Ethoprop	5	87	110	127
2-Ethyl-6-methylaniline	5	**85**	96	104
Fenamiphos	5	**59**	98	**156**
Fenamiphos sulfone	5	**55**	**63**	**143**
Fenamiphos sulfoxide	5	**20**	**29**	**49**
Fipronil	5	76	90	105
Fipronil sulfide	5	**37**	**40**	**42**
Fipronil sulfone	5	**32**	**54**	**57**
Fonofos	5	86	89	92
Hexazinone	5	**65**	77	102
Iprodione	5	**22**	**27**	**52**
Isofenphos	5	92	103	106
Malaoxon	5	**48**	91	116
Malathion	5	80	96	106
Metalaxyl	5	85	92	98

Table A5b. Quality-control summary of matrix-spike recoveries of volatile organic compounds (VOCs), gasoline oxygenates and degradates, and compounds of special interest in samples collected from wells for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.—Continued

[Acceptable recovery range is between 70 and 130 percent; values in bold fall outside this range]

Constituent	Number of spiked samples	Recovery (percent)		
		Minimum	Maximum	Median
Volatile organic compounds—Continued				
Methidathion	5	98	113	128
Metolachlor	5	101	104	110
Metribuzin	5	73	79	91
Molinate	5	97	103	111
Myclobutanil	5	79	93	109
1-Naphthol	5	**10**	**29**	**68**
Oxyfluorfen	5	**55**	**62**	**67**
Paraoxon-methyl	5	**30**	**50**	**68**
Parathion-methyl	5	**63**	77	92
Pendimethalin	5	73	90	107
cis-Permethrin	5	**49**	**61**	**68**
Phorate	5	72	93	101
Phorate oxygen analog	5	**69**	108	**147**
Phosmet	4	**8**	**8**	**8**
Phosmet oxon	4	**49**	**49**	**50**
Prometon	5	79	91	98
Prometryn	5	90	96	104
Pronamide	5	85	93	100
Propanil	5	88	93	104
Propargite	5	70	88	98
cis-Propiconazole	5	80	102	**141**
trans-Propiconazole	5	79	92	**130**
Simazine[1]	5	92	101	106
Tebuconazole	5	**38**	**58**	95
Tebuthiuron	5	90	**161**	**186**
Tefluthrin	5	**41**	**45**	**54**
Terbufos	5	90	121	128
Terbufos oxygen analog sulfone	5	**49**	91	117
Terbuthylazine	5	90	98	99
Thiobencarb	5	101	111	118
Tribufos	5	**55**	81	87
Trifluralin	5	**63**	75	75

[1] Constituents detected in ground-water samples.

Table A6. Quality-control summary for surrogate recoveries of volatile organic compounds, gasoline oxygenates and degradates, pesticides and pesticide degradates, and constituents of special interest in samples collected from wells for the Central Sierra Groundwater Ambient Monitoring and Assessment (GAMA) study, California, May 2006.

[Acceptable recovery range is between 70 and 130 percent. **Abbreviations:** MWH, Montgomery Watson-Harza Laboratory; VOC, volatile organic compound]

Surrogate	Analytical schedule	Constituent class	Blank samples				Environmental samples			
			Number of analyses	Median recovery (percent)	Number of surrogate recoveries		Number of analyses	Median recovery (percent)	Number of surrogate recoveries	
					Below 70 percent	Above 130 percent			Below 70 percent	Above 130 percent
1,4-Bromofluorobenzene	2020, 4024	VOC/gasoline oxygenate	14	76	4	0	68	84	5	0
Diazinon-d10	2033	Pesticides and degradates	4	98	0	0	34	95	1	0
1,2-Dichloroethane-d4	2020, 4024	VOC/gasoline oxygenate	14	121	0	4	68	112	0	13
α-HCH-d6	2033	Pesticides and degradates	4	95	0	0	34	89	4	0
Isobutyl alcohol-d6	4024	Pesticides and degradates	4	93	0	0	35	94	0	0
NDMA-d6	MWH	Constituent of special interest	8	95	0	0	35	77	6	0
Toluene-d8	2020, 4024, MWH	Pesticides and degradates	22	93	3	0	103	102	0	0

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