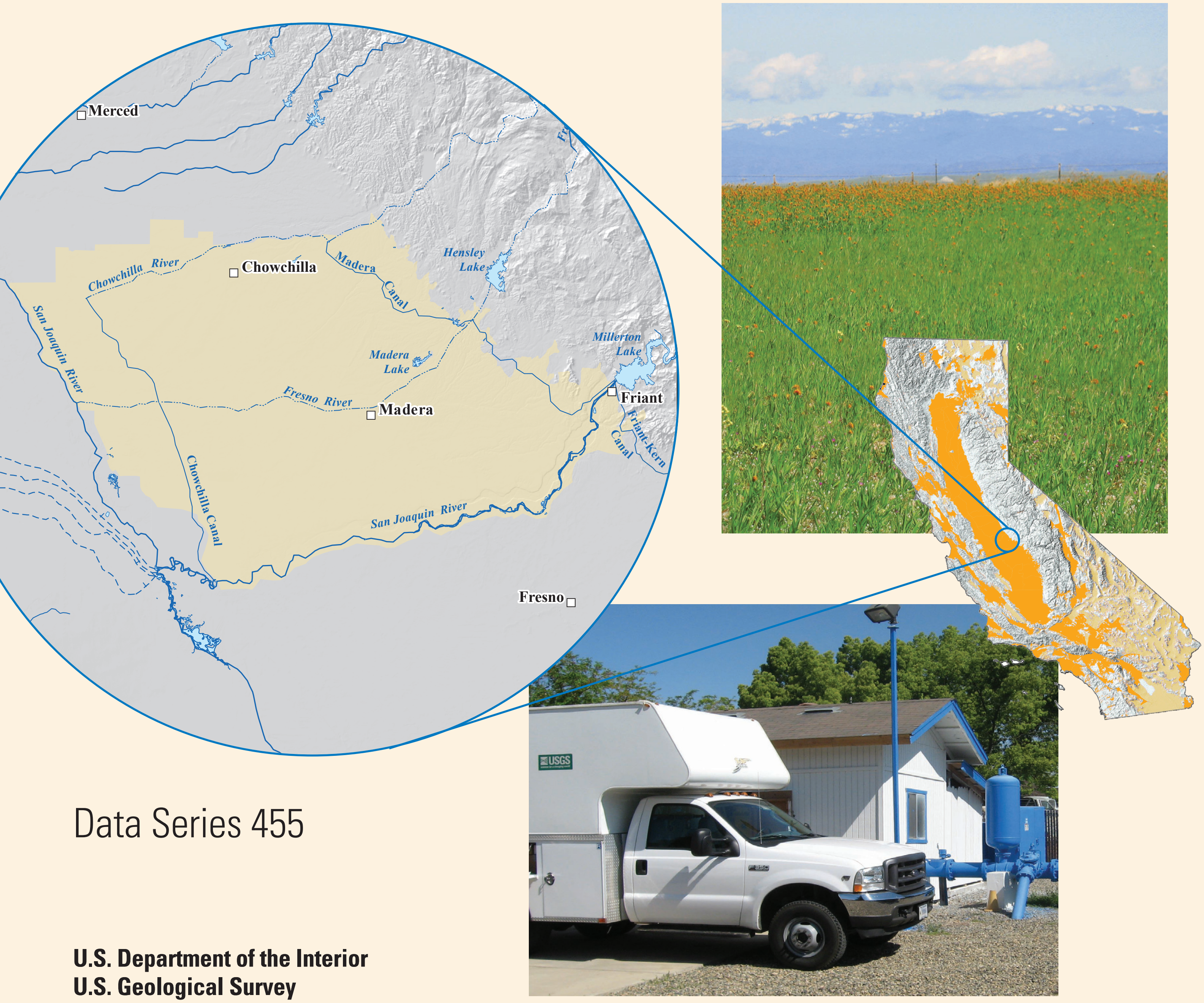
USGS
science for a changing world

In cooperation with the California State Water Resources Control Board

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

Groundwater-Quality Data for the Madera–Chowchilla Study Unit, 2008: Results from the California GAMA Program



Data Series 455

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

Cover Photographs:
Top: View looking east from sampled well located northeast of Chowchilla, California (photograph taken by Jennifer Shelton, U.S. Geological Survey.)
Bottom: Well in Madera County, California (photograph taken by Mike Solt, U.S. Geological Survey.)

Groundwater-Quality Data in the Madera–Chowchilla Study Unit, 2008: Results from the California GAMA Program

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

Prepared in cooperation with the California State Water Resources Control Board

Data Series 455

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

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

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2009

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

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

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

Suggested citation:
Shelton, J.L., Fram, M.S., and Belitz, Kenneth, 2009, Groundwater-quality data for the Madera–Chowchilla study unit, 2008: Results from the California GAMA program: U.S. Geological Survey Data Series 455, 80 p. Available at http://pubs.usgs.gov/ds/455.

Contents

Figures

Tables

Appendix Tables

Abbreviations and Acronyms

AL-US	action level (USEPA)
CAS	Chemical Abstract Service (American Chemical Society)
CSU	combined standard uncertainty
D	detected in groundwater samples
E	estimated or having a higher degree of uncertainty
GAMA	Groundwater Ambient Monitoring and Assessment program
GPS	Global Positioning System
HAL-US	lifetime health advisory level (USEPA)
HPLC	high-performance liquid chromatography
LRL	laboratory reporting level
LSD	land-surface datum
LT-MDL	long-term method detection level
MADCHOW	Madera–Chowchilla study unit
MADCHOWFP	Madera–Chowchilla study unit flow-path well prefix
MCL-US	maximum contaminant level (USEPA)
MCL-CA	maximum contaminant level (CDPH)
MDL	method detection limit
MRL	minimum reporting level
MU	method uncertainty
N	Normal (1-gram-equivalent per liter of solution)
na	not available
nc	sample not collected
np	no preference
nv	no values in category
NL-CA	notification level (CDPH)
NWIS	National Water Information System (USGS)
PCFF-GAMA	portable computer field forms program designed for GAMA sampling
QC	quality control
RPD	relative percent difference
RSD	relative standard deviation
RSD5	risk-specific dose at 10^{-5} (USEPA)
SD	standard deviation
SMCL-CA	secondary maximum contaminant level (CDPH)
SMCL-US	secondary maximum contaminant level (USEPA)
SRL	study reporting level
ssL_C	sample-specific critical level
TDS	total dissolved solids

US	United States
V	constituent detected in blanks and therefore excluded from the dataset of groundwater-quality results
VOC	volatile organic compound
VPDB	Vienna Pee Dee Belemnite
VSMOW	Vienna Standard Mean Ocean Water

Organizations

CDPH	California Department of Public Health
CDWR	California Department of Water Resources
USEPA	U.S. Environmental Protection Agency
LLNL	Lawrence Livermore National Laboratory
NAWQA	National Water Quality Assessment (USGS)
NWQL	National Water Quality Laboratory (USGS)
SWRCB	California State Water Resources Control Board
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WECK	Weck Laboratories, Inc.

Selected chemical names

$CaCO_3$	calcium carbonate
CO_3^{-2}	carbonate
CO_2	carbon dioxide
HCO_3^{-}	bicarbonate
MEK	methyl ethyl ketone (2-butanone)
MTBE	methyl *tert*-butyl ether
NDMA	*N*-nitrosodimethylamine
PCE	perchloroethene (tetrachloroethylene, tetrachloroethene)
TCE	trichloroethene
THM	trihalomethane

Units of measurement

cm^3 STP/g	cubic centimeters of gas at standard temperature and pressure (0 degrees Celsius and 1 atmosphere of pressure) per gram of water
ft	foot (feet)
in	inch
L	liter
mg	milligram
mg/L	milligrams per liter (parts per million)
mi	mile
mL	milliliter
µg/L	micrograms per liter (parts per billion)

µL	microliter
µm	micrometer
pCi/L	picocurie per liter
°C	degrees Celsius
$\delta^{i}E$	delta notation, the ratio of a heavier isotope of an element (${}^{i}E$) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil

Notes

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

$$^{\circ}F=(1.8\times{}^{\circ}C)+32$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

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

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).

This page intentionally left blank.

Groundwater-Quality Data in the Madera–Chowchilla Study Unit, 2008: Results from the California GAMA Program

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

Abstract

Groundwater quality in the approximately 860-square-mile Madera–Chowchilla study unit (MADCHOW) was investigated in April and May 2008 as part of the Priority Basin Project of the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA Priority Basin Project was developed in response to the Groundwater 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).

The study was designed to provide a spatially unbiased assessment of the quality of raw groundwater used for public water supplies within MADCHOW, and to facilitate statistically consistent comparisons of groundwater quality throughout California. Samples were collected from 35 wells in Madera, Merced, and Fresno Counties. Thirty of the wells were selected using a spatially distributed, randomized grid-based method to provide statistical representation of the study area (grid wells), and five more were selected to provide additional sampling density to aid in understanding processes affecting groundwater quality (flow-path wells). Detection summaries in the text and tables are given for grid wells only, to avoid over-representation of the water quality in areas adjacent to flow-path wells.

Groundwater samples were analyzed for a large number of synthetic organic constituents (volatile organic compounds [VOCs], low-level 1,2-dibromo-3-chloropropane [DBCP] and 1,2-dibromoethane [EDB], pesticides and pesticide degradates, polar pesticides and metabolites, and pharmaceutical compounds), constituents of special interest (N-nitrosodimethylamine [NDMA], perchlorate, and low-level 1,2,3-trichloropropane [1,2,3-TCP]), naturally occurring inorganic constituents (nutrients, major and minor ions, and trace elements), and radioactive constituents (uranium isotopes, and gross alpha and gross beta particle activities). Naturally occurring isotopes and geochemical tracers (stable isotopes of hydrogen, oxygen, and carbon, and activities of tritium and carbon-14), and dissolved noble gases also were measured to help identify the sources and ages of the sampled groundwater. In total, approximately 300 constituents and field water-quality indicators were investigated.

Three types of quality-control samples (blanks, replicates, and samples for matrix spikes) each were collected at approximately 11 percent of the wells sampled for each analysis, and the results obtained from these samples were used to evaluate the quality of the data for the groundwater samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that data for the groundwater samples were not compromised by possible contamination during sample collection, handling or analysis. Differences between replicate samples were within acceptable ranges. Matrix spike recoveries were within acceptable ranges for most compounds.

This study did not attempt to evaluate the quality of water delivered to consumers; after withdrawal from the ground, raw groundwater 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 groundwater. However, to provide some context for the results, concentrations of constituents measured in the raw groundwater were compared with regulatory and non-regulatory health-based thresholds established by the U.S. Environmental Protection Agency (USEPA) and the California Department of Public Health (CDPH), and with aesthetic and technical thresholds established by CDPH. Comparisons between data collected for this study and drinking-water thresholds are for illustrative purposes only, and are not indicative of compliance or non-compliance with regulatory thresholds.

The concentrations of most constituents detected in groundwater samples from MADCHOW wells were below drinking-water thresholds. Organic compounds (VOCs and pesticides) were detected in about 40 percent of the samples from grid wells, and most concentrations were less than 1/100 of regulatory or non-regulatory health-based thresholds, although the concentrations of low-level DBCP in 10 percent and low-level EDB in 3 percent of the samples from grid wells were above the corresponding USEPA maximum contaminant levels (MCL-USs). Perchlorate was detected in 70 percent of the samples from grid wells, and most concentrations were less than one-tenth of the CDPH maximum contaminant level (MCL-CA). Low-level 1,2,3-TCP was detected in 33 percent of the samples from grid wells, and all concentrations were less than 1/1,000 of the USEPA lifetime health advisory level (HAL-US). Most concentrations of trace elements and nutrients in samples were below regulatory and non-regulatory health-based thresholds. Concentrations were above the MCL-US for nitrate in 7 percent of the samples from grid wells, for arsenic and uranium in 13 percent each of the samples from grid wells; and the concentration of vanadium was above the CDPH notification level (NL–CA) in 3 percent of the samples from grid wells. Detections of radioactive constituents were below regulatory and non-regulatory health-based thresholds in most samples. Combined activities of uranium isotopes were detected above the MCL-CA in 20 percent of the subset of 25 grid well samples analyzed, and gross alpha particle activity was detected above the MCL-US in 20 percent of the samples from the 30 total grid wells. Most of the samples from MADCHOW grid wells had concentrations of major and minor ions, total dissolved solids, and trace elements below the CDPH secondary maximum contaminant levels (SMCL-CAs), which are nonenforceable thresholds set for aesthetic and technical concerns. Twenty percent of the samples from grid wells contained specific-conductance values, or concentrations of chloride, total dissolved solids, or manganese above the respective SMCL–CAs.

Introduction

Groundwater comprises nearly half of the water used for public supply in California (Hutson and others, 2004). To assess the quality of ambient groundwater in aquifers used for public supply and to establish a baseline groundwater quality monitoring program, the California State Water Resources Control Board (SWRCB), in collaboration with the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL), implemented the Groundwater Ambient Monitoring and Assessment (GAMA) Program (http://www.swrcb.ca.gov/gama). The GAMA Program currently consists of three projects: GAMA Priority Basin Project, conducted by the USGS (*http://ca.water.usgs.gov/gama/*); GAMA Domestic Well Project, conducted by the SWRCB; and GAMA Special Studies, conducted by LLNL.

The SWRCB initiated the GAMA Priority Basin Project in response to legislative mandates (Supplemental Report of the 1999 Budget Act 1999-00 Fiscal Year, and the Groundwater Quality Monitoring Act of 2001 [Sections 10780-10782.3 of the California Water Code, Assembly Bill 599]) to assess and monitor the quality of groundwater used as public supply for municipalities in California. The GAMA Priority Basin Project is a comprehensive assessment of statewide groundwater quality designed to help better understand and identify risks to groundwater resources, and to increase the availability of information about groundwater quality to the public. For the Priority Basin Project, the USGS, in collaboration with the SWRCB, developed the monitoring plan to assess groundwater basins through direct and other statistically reliable sample approaches (Belitz and others, 2003; State Water Resources Control Board, 2003). Key aspects of the project are interagency collaboration and cooperation with local water agencies and well owners. Local participation in the project is entirely voluntary.

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

The range of hydrologic, geologic, and climatic conditions that exist in California must be considered when assessing groundwater 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 active and standby public-supply wells are located in groundwater basins within these hydrologic provinces. These groundwater basins, defined by the California Department of Water Resources (CDWR), generally consist of fairly permeable, unconsolidated deposits of alluvial or volcanic origin (California Department of Water Resources, 2003). Groundwater basins were prioritized for sampling on the basis of the number of public-supply wells in the basin, with secondary consideration given to municipal groundwater use, agricultural pumping, the number of formerly leaking underground fuel tanks, and pesticide applications within the basins (Belitz and others, 2003). In addition, some groundwater 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 as part of the project. The 116 priority basins were grouped into 35 study units. Some areas outside of the defined groundwater basins were included to represent the 20 percent of public-supply wells not located in the groundwater basins.

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 groundwater resource, (2) Trends: detection of changes in groundwater quality, and (3) Understanding: identification of the natural and human factors affecting groundwater quality (Kulongoski and Belitz, 2004). This report is one of a set of reports presenting water-quality data collected in each study unit (Wright and others, 2005; Bennett and others, 2006; Kulongoski and others, 2006; Fram and Belitz, 2007; Kulongoski and Belitz, 2007; Burton and Belitz, 2008; Dawson and others, 2008; Ferrari and others, 2008; Land and Belitz, 2008; Landon and Belitz, 2008; Mathany and others, 2008; Shelton and others, 2008; Schmitt and others, 2008; Ray and others, 2009; Fram and others, 2009). Subsequent reports will address the status, trends, and understanding aspects of the water-quality assessments.

The Madera–Chowchilla GAMA study unit, hereinafter referred to as MADCHOW, is in the southern part of the Central Valley Hydrogeologic Province (*fig. 1*) and is the 24th study unit sampled by the GAMA Priority Basin Project. MADCHOW was considered a high priority for sampling on the basis of the number of public-supply wells, the reliance on groundwater for drinking-water resources, the amount of agricultural pumpage, the number of leaking underground fuel tanks, and the extent of pesticide applications (Belitz and others, 2003).

Purpose and Scope

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

Hydrogeologic Setting

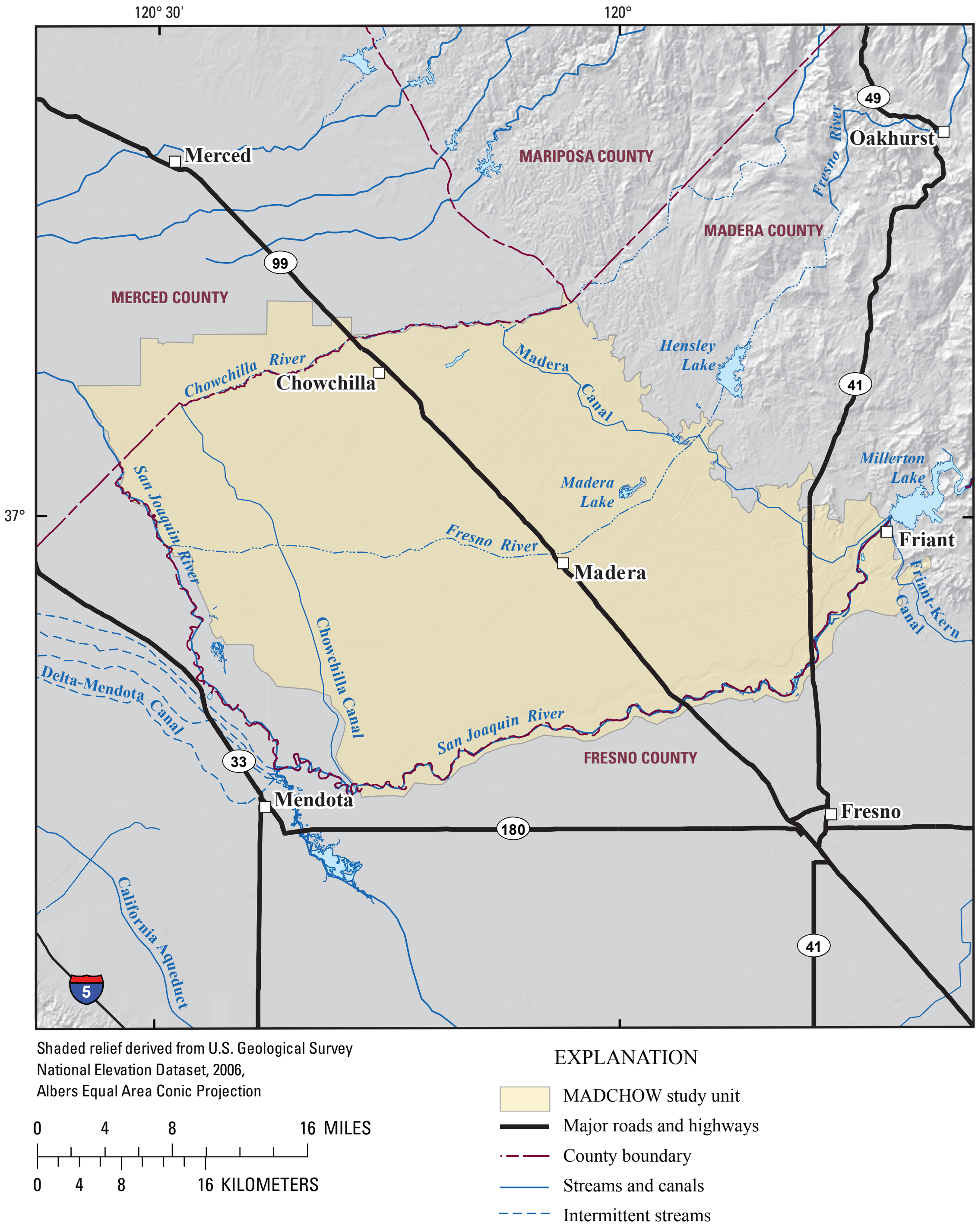
The Madera–Chowchilla study unit (MADCHOW) is in the southern part of the Central Valley hydrogeologic province (*fig. 1*). The study unit is composed of the Madera and the Chowchilla groundwater subbasins of the San Joaquin Valley, as defined by CDWR (California Department of Water Resources, 2003, 2008a, and 2008b). MADCHOW covers an area of approximately 860 square miles (mi^2), primarily in Madera County, with a small portion in Merced County to the north of the Chowchilla River and a small portion in Fresno County to the south of the San Joaquin River (*fig. 2*). The study unit is bounded partially on the north by the Chowchilla River, approximately on the west and south by the San Joaquin River, and on the east by foothills of the Sierra Nevada Mountains.

Similar to most areas in the San Joaquin Valley of California, MADCHOW has a Mediterranean climate, with hot, dry summers, and cool, moist winters. Average annual rainfall is 11 inches (in.) over most of the study unit, increasing to 15 in. per year in the foothills of the Sierra Nevada (Western Regional Climate Center, 2009). The primary surface-water features in MADCHOW are the San Joaquin, Fresno, and Chowchilla Rivers, and the Friant–Kern, Madera, and Chowchilla canals (*fig. 2*).

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

Provinces from Belitz and others, 2003

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



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

Figure 2. The Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing locations of major cities and major hydrologic features.

The primary aquifer system in the San Joaquin Valley consists of Quaternary-age unconsolidated continental deposits. The deposits are composed of alluvial-fan and fluvial gravel, sand, slit, and clay sediments, interbedded with lesser amounts of lacustrine deposits. The sediments were derived from the weathering of the granitic rocks of the Sierra Nevada to the east. The sediments generally are coarsest in the eastern part of the valley along the foothills and become finer westward towards the San Joaquin River, the axial trough of the San Joaquin Valley (Gronberg and others, 1998). The continental deposits bearing freshwater increase in thickness from north to south in the San Joaquin Valley, and are up to 3,000 feet (ft) thick in MADCHOW (Bertoldi and others, 1991). The Corcoran Clay the thickest of the lacustrine deposits, is present in the western half of MADCHOW.

Methods

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

Study Design

The wells selected for sampling in this study reflect the combination of two well-selection strategies. Thirty “grid” wells were selected to provide a statistically unbiased, spatially distributed assessment of the quality of groundwater resources used for public drinking-water supply, and five additional “flow-path” wells were selected to aid in the evaluation of water-quality changes along the regional groundwater flow gradient and between shallow and deeper portions of the aquifer.

The spatially distributed wells were selected using a randomized grid-based method (Scott, 1990). MADCHOW was subdivided into 30 grid cells approximately 30 mi^2 (78 square kilometers [km^2]) in area (*fig. 3*). This grid-cell size met GAMA objectives for the Central Valley hydrogeologic province of a sampling density of at least one well per 38.6 mi^2 (100 km^2) (Bennett and others, 2006). The objective was to select one public-supply well per grid cell. If a grid cell contained more than one public-supply well, each well randomly was assigned a rank. The highest ranking well that met basic sampling criteria (for example, sampling point located prior to treatment, capability to pump for several hours, and available well-construction information), and for which permission to sample could be obtained, then was sampled. If a grid cell contained no accessible public-supply wells, domestic and irrigation wells were considered for sampling. An attempt was made to select domestic and irrigation wells with depths and screened intervals similar to those in public-supply wells in the area. In this fashion, one well was selected in each cell to provide a spatially distributed, randomized monitoring network.

Wells sampled as part of the spatially distributed, randomized grid-cell network are hereafter referred to as “grid wells.” The 30 grid wells sampled in MADCHOW were numbered in the order of sample collection with the prefix “MADCHOW” (*fig. 3*).

Five additional wells were sampled in the northern part of MADCHOW. These additional wells were selected to provide greater sampling density along a generalized flow path parallel to the regional northeast to southwest groundwater flow gradient (*fig. 3*). In addition, these flow-path wells were chosen to be shallower than the nearby grid wells to evaluate differences between shallow and deeper portions of the aquifer system. These five non-randomized wells were not included in the statistical characterization of water quality in MADCHOW because inclusion would have resulted in overrepresentation of certain grid cells. The five flow-path wells were numbered in the order of sample collection with the prefix “MADCHOWFP” (“FP” indicating “flow path”) (*fig. 3*).

Table 1 (all tables at back of report) provides the GAMA alphanumeric identification number for each well, along with the date sampled, sampling schedule, well elevation, well type, and well-construction information. Wells classified as “production wells” have pumps that pump the groundwater from the aquifer to a distribution system. The wells were sampled during April and May 2008. The 30 grid wells included 19 wells classified by CDPH as public-supply wells. Public-supply wells are not identified in *table 1* because of security and confidentiality requirements; the number of public-supply wells in the grid-well network is reported to demonstrate that the network is representative of the parts of the aquifer in the study unit that are used for public supply. The remaining 11 grid wells that were not public-supply wells were selected because no public-supply wells were accessible for sampling in some grid cells, but these eleven wells were screened within similar depth zones as public-supply wells within the study unit and included 8 irrigation and 3 domestic wells. The 5 flow-path wells included 2 domestic wells, 1 irrigation well, and 2 wells classified as public-supply wells by CDPH.

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 then uploaded into the USGS National Water Information System (NWIS). Well owner information is confidential. Well location information and all chemical data currently are inaccessible from NWIS’s public website.

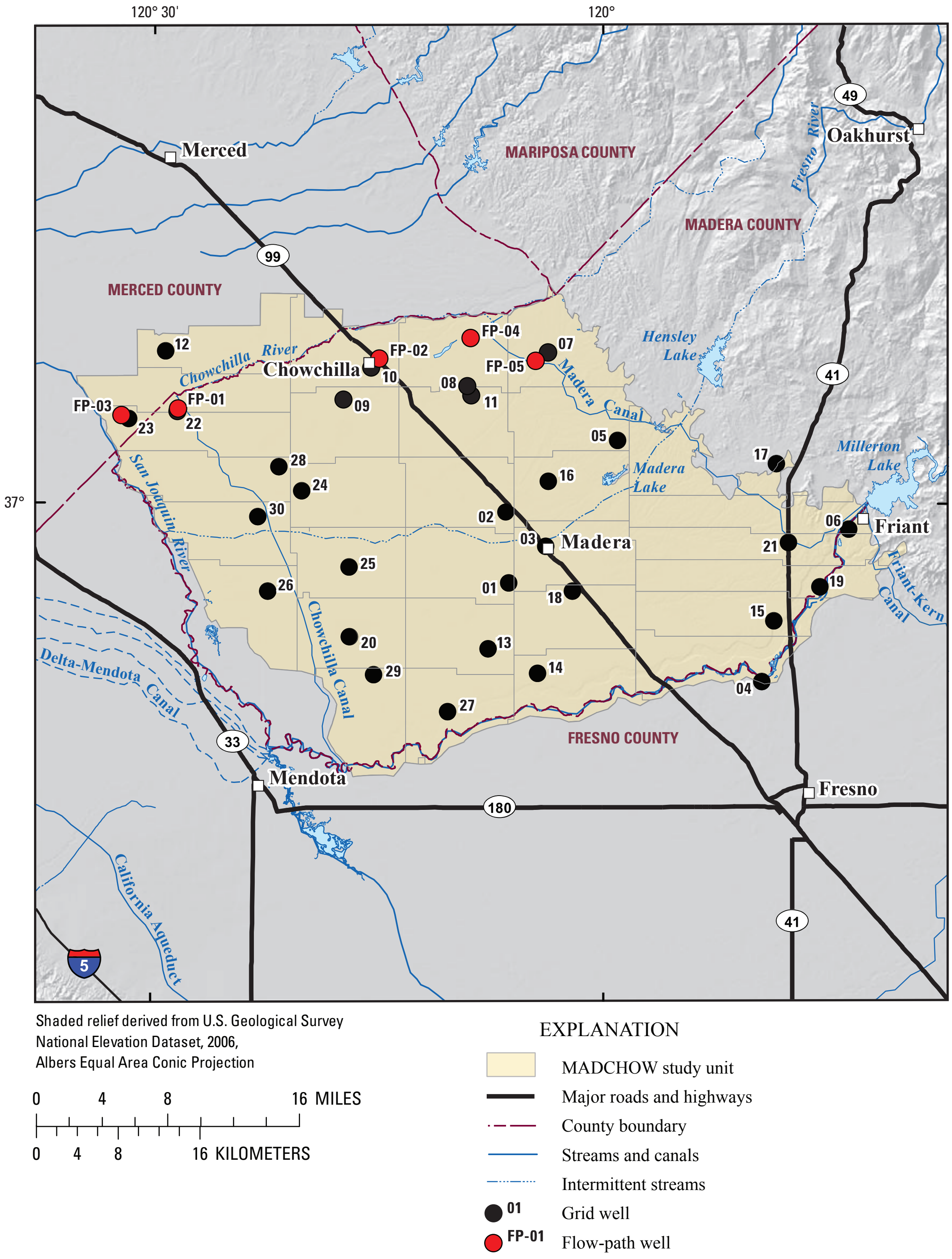


Figure 3. The Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the distribution of study area grid cells and the location of sampled grid wells and flow-path wells. Alphanumeric identification numbers for grid wells have the prefix “MADCHOW”; only the numeric portions are shown on the map. Alphanumeric identification numbers for flow-path wells have the prefix “MADCHOWFP”; only “FP” and the numeric portions are shown on the map.

The wells in MADCHOW were sampled using a tiered analytical approach. All wells were sampled for a standard set of constituents, including field water-quality indicators (alkalinity, dissolved oxygen, pH, specific conductance, and temperature), organic constituents (VOCs, pesticides, and low-level analyses of DBCP and EDB), perchlorate, and low-level analyses of 1,2,3-TCP, inorganic constituents (nutrients, major and minor ions, and trace elements), radioactive constituents (uranium isotopes, and gross alpha and gross beta particle activities), and geochemical and age-dating tracers (stable isotopes of hydrogen and oxygen of water, carbon isotopes, dissolved noble gases, and tritium). The standard set of constituents was termed the intermediate schedule (*table 2*). Wells on the slow schedule were sampled for all the constituents on the intermediate schedule, plus turbidity, pharmaceutical compounds, NDMA, and species of arsenic and iron (*table 2*). Intermediate and slow refer to the time required to sample the well for all the constituents on the schedule. Generally, one slow or two intermediate wells could be sampled in 1 day. Many of the other GAMA study units have had a shorter list of standard constituents and have termed the standard set the fast schedule because three or four fast wells could be sampled in 1 day. In MADCHOW, 25 of the wells were sampled on the intermediate schedule and 10 were sampled on slow schedule.

Sample Collection and Analysis

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

Tables 3A–K list the compounds analyzed in each constituent class. Groundwater samples were analyzed for 85 VOCs (*table 3A*); low-level DBCP and EDB (*table 3B*); 81 pesticides and pesticide degradates (*table 3C*); 58 polar pesticides and metabolites (*table 3D*); 14 pharmaceutical compounds (*table 3E*); 3 constituents of special interest (*table 3F*); 5 nutrients (*table 3G*); 10 major and minor ions and total dissolved solids (*table 3H*); 25 trace elements (*table 3H*); arsenic and iron species (*table 3I*); stable isotopes of hydrogen and oxygen of water, stable isotopes of carbon, and 9 radioactive constituents, including carbon-14 activity, tritium activity, gross alpha and gross beta particle activities (72-hour and 30-day counts), and uranium isotope activities (*table 3J*); helium stable isotope ratios, 5 dissolved noble gases and tritium activity (*table 3K*). The methods used for sample analysis are described in the *Appendix* section of this report “Sample Collection and Analysis.”

Data Reporting

The methods and conventions used for reporting the data are described in the Appendix of this report. Seven 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 (see *Appendix* section “Constituents on Multiple Analytical Schedules” and *table A2*). Concentrations of 1,2,3-TCP, and arsenic and iron, and tritium activities also were measured by more than one laboratory, and both sets of results are reported for these constituents. For field water-quality indicators that also were measured in the laboratory (alkalinity, pH, and specific conductance), the field analyses were preferred, although both sets of results are reported.

Quality-Assurance

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

Water-Quality Results

Quality-Control Results

Results of quality-control analyses (blanks, replicates, matrix spikes, and surrogates) were used to evaluate the quality of the data for the groundwater samples. Of the approximately 300 constituents analyzed, only silica and gross alpha particle activity (72-hour count) were detected in at least one field blank collected in this study unit. On the basis of detections in field blanks collected for this and previous GAMA study units, detections reported by the laboratory for one organic compound (toluene) were considered suspect and, therefore, this constituent was removed from the set of groundwater quality data presented in this report (see *table A3* and additional discussion in the *Appendix*). Results from the replicates confirm that the procedures used to collect and analyze the samples were consistent. Ninety-eight percent of the replicate pairs analyzed for constituents detected in samples had variability between values within acceptable limits;

additional discussion can be found in the Appendix. Median matrix-spike recoveries for 42 of the 224 organic constituents analyzed were lower than the acceptable limits (*tables 3A*, *3C*, and *3D*), which may indicate that these constituents might not have been detected in some samples if their concentrations in these samples had been near the LRLs. The quality-control results are described in the *Appendix* section "Quality-Control Results."

Comparison Thresholds

Concentrations of constituents detected in groundwater samples were compared with CDPH and USEPA regulatory and non-regulatory 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). The chemical data presented in this report are meant to characterize the quality of the untreated groundwater resources within MADCHOW, and are not intended to represent the treated drinking water delivered to consumers by water purveyors. The chemical composition of treated drinking water may differ from untreated groundwater because treated drinking water may be disinfected, filtered, mixed with other waters, and exposed to the atmosphere before being delivered to consumers. Comparisons between concentrations of constituents in raw, untreated groundwater and drinking-water thresholds are for illustrative purposes only, and are not indicative of compliance or non-compliance with drinking-water regulations.

The following thresholds were used for comparisons:

- MCL—Maximum Contaminant Level. Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of contaminants in drinking water. MCLs established by the USEPA are the minimum standards with which states are required to comply, and individual states may choose to set more stringent standards. CDPH has established MCLs for additional constituents not regulated by the USEPA, as well as lowered the threshold concentration for a number of constituents with MCLs established by the USEPA. In this report, a threshold set by the USEPA and adopted by CDPH is labeled "MCL-US", and one set by CDPH that is more stringent than the MCL-US is labeled "MCL-CA". CDPH is notified when constituents are detected at concentrations greater than an MCL-US or MCL-CA thresholds in samples collected for the GAMA Priority Basin Project, but these detections do not constitute violations of CDPH regulations.
- AL—Action Level. Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of copper and lead in drinking water. Detections of copper or lead above the action-level thresholds trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and CDPH currently are the same, thus the thresholds are labeled "AL-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, or technical qualities of drinking water, such as scaling and staining. Both the USEPA and CDPH define SMCLs, but unlike MCLs, SMCLs established by CDPH are not required to be at least as stringent as those established by USEPA. SMCLs established by CDPH are used in this report (SMCL-CA) for all constituents that have SMCL-CA values. The SMCL-US is used for pH because no SMCL-CA has been defined.
- NL—Notification Level. Health-based notification levels established by CDPH for some of the constituents in drinking water that lack MCLs (NL-CA). If a constituent is detected above its NL-CA, California state law requires timely notification of local governing bodies and recommends consumer notification.
- HAL—Lifetime Health Advisory Level. The maximum concentration of a constituent at which its presence in drinking water is not expected to cause any adverse carcinogenic effects for a lifetime of exposure. HALs are established by the USEPA (HAL-US) and are calculated assuming consumption of 2 liters (2.1 quarts) of water per day over a 70-year lifetime by a 70-kilogram (154-pound) adult and that 20 percent of a person's exposure comes from drinking water.
- RSD5—Risk-Specific Dose. The concentration of a constituent in drinking water corresponding to an excess estimated lifetime cancer risk of 1 in 100,000. RSD5 is an acronym for risk-specific dose at 10^{-5}. RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by ten (RSD5-US).

For constituents with MCLs, detections in groundwater 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; concentrations of these constituents in groundwater samples were compared with both levels. The SMCL-US values for these constituents correspond 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-US, detected concentrations were compared with the RSD5-US. Note that if a constituent has more than one type of established threshold, using this hierarchy to select the comparison threshold will not necessarily result in selection of the threshold with the lowest concentration. For example, zinc has an SMCL-CA of 5,000 µg/L and a HAL-US of 2,000 µg/L, and the comparison threshold selected by this hierarchy is the SMCL-CA. The comparison thresholds used in this report are listed in *tables 3A–K* for all constituents and in *tables 4–13* for constituents detected in groundwater samples from MADCHOW. Note that not all constituents analyzed for this study have established thresholds. Detections of constituents at concentrations greater than the selected comparison thresholds are marked with asterisks in *tables 4–13*.

Groundwater-Quality Data

Results from analyses of raw (untreated) groundwater samples from MADCHOW are presented in *tables 4–13*. Groundwater samples collected in MADCHOW were analyzed for up to 229 organic constituents and constituents of special interest, of which 197 were not detected in any of the samples (*tables 3A–D* and *3F*). The samples were analyzed for up to 64 naturally occurring inorganic constituents, isotopic tracers, and radioactivity (*tables 3G–K*). The results tables present only the constituents that were detected and list only samples in which at least one constituent was detected. The tables containing organic constituent classes and constituents of special interest that were analyzed at all of the grid wells include the number of wells at which each constituent was detected, the percentage of grid wells in which each constituent was detected, and the total number of constituents detected at each well (*tables 5–7*). Results from the flow-path wells are presented in the tables, but these results were excluded from the detection frequency calculations to avoid statistically over-representing the areas near the vicinity of the flow-path wells.

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

- Organic constituents
  - VOCs and low-level DBCP and EDB (*table 5*)
  - Pesticides and pesticide degradates and polar pesticides and metabolites (*tables 6A,6B*)
- Constituents of special interest (*table 7*)
- Inorganic constituents
  - Nutrients (*table 8*)
  - Major and minor ions and total dissolved solids (*table 9*)
  - Trace elements (*table 10*)
  - Species of arsenic and iron (*table 11*)
- Isotopic tracers (*table 12*)
- Radioactive constituents (*tables 13A,13B*)

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 Water-Quality Indicators

Field and laboratory measurements of turbidity, dissolved oxygen, water temperature, pH, specific conductance, and alkalinity are presented in *table 4*. Alkalinity and dissolved oxygen are used as indicators of natural processes that control water chemistry. The pH value indicates the acidity or basicity of the water. Low pH in water may contribute to corrosion and high pH in water may contribute to scaling. All pH values were within the SMCL-US range for pH, 6.5 to 8.5 standard units. Specific conductance is a measure of the electrical conductivity of the water and is proportional to the amount of total dissolved solids (TDS) in the water. Samples from two grid wells had field and laboratory specific-conductance values above the upper SMCL-CA, samples from three additional grid wells had field and laboratory specific-conductance values above the recommended SMCL-CA, and specific-conductance values for samples from the remaining 25 grid wells were below the recommended SMCL-CAOrganic Constituents

Volatile organic compounds (VOCs) are 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 groundwater than in surface water because groundwater is isolated from the atmosphere. Of the 85 VOCs and low-level DBCP and EDB analyzed, 12 were detected in groundwater samples; concentrations in all but 3 samples were below health-based thresholds, and most were less than about one one-hundredth of the threshold levels (*table 5*). Chloroform, a byproduct of drinking-water disinfection; 1,2-dibromo-3-chloropropane (DBCP), a fumigant; and perchloroethene (PCE), a solvent used for dry-cleaning, were detected in 10 percent or more of the grid well samples. Chloroform and PCE are among the most commonly detected VOCs in groundwater nationally (Zogorski and others, 2006). One or more VOCs were detected in samples from 9 of the 30 grid wells. The fumigant, DBCP, was detected above the MCL-US in three samples from grid wells and one of these samples also contained the fumigant, EDB, above the MCL-US.

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 139 pesticides and pesticide degradates and polar pesticides and metabolites analyzed, 11 were detected in groundwater samples from grid wells; all concentrations were below health-based thresholds, and all were less than 1/100 of the threshold values (*tables 6A, 6B*). The herbicides atrazine, simazine, and diuron, and two herbicide degradates: deethylatrazine, a degradate of atrazine; and 3,4-dichloroaniline, a degradate of diuron, were detected in 10 percent or more of the grid-well samples (*tables 6A, 6B*). Deethylatrazine, atrazine, and simazine are among the most commonly detected pesticide compounds in groundwater nationally (Gilliom and others, 2006). Pesticide compounds were detected in samples from 8 of the 30 grid wells. The grid wells with detections in *table 6B* are a subset of the grid wells with detections in *table 6A*; therefore the detection frequency of 27 percent applies to both tables. Note the detection frequency in *table 6A* does not include the three fumigants already presented as volatile organic compounds in *table 5*; if these fumigants were included, the detection frequency for any pesticide(s) in the grid wells would be 30 percent.

Constituents of Special Interest

NDMA, perchlorate, and 1,2,3-TCP are constituents of special interest in California because they have been detected recently in water supplies (California Department of Public Health, 2008c). Five grid wells were sampled for NDMA, all 30 grid wells were sampled for perchlorate and low-level 1,2,3-TCP, and all concentrations were below health-based thresholds. NDMA was detected in one grid-well sample at a concentration of one-fourth of the NL-CA (*table 7*). Perchlorate was detected in 70 percent of the grid-well samples, all concentrations were below one-third and most were below one-tenth of the MCL-CA. Thirty-three percent of the grid well samples had detections of low-level 1,2,3-TCP, and all concentrations were below one one-thousandths of the HAL-US.

Inorganic Constituents

Unlike the organic constituents and the constituents of special interest, most of the inorganic constituents naturally are present in groundwater, although their concentrations may be influenced by human activities.

Nutrients (nitrogen and phosphorus) present in groundwater can affect biological activity in aquifers and in surface-water bodies that receive groundwater discharge. Nitrogen may be present in the form of ammonia, nitrite, or nitrate, depending on the oxidation-reduction state of the groundwater. High concentrations of nitrate can adversely affect human health, particularly the health of infants. All concentrations of ammonia and nitrite, and nearly all concentrations of nitrate measured in samples from MADCHOW grid wells were below health-based thresholds (*table 8*). Nitrate concentrations were above the USEPA MCL in 2 of the 30 grid well samples.

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

Chloride concentrations were above the upper SMCL-CA in 1 grid well sample, but below the recommended SMCL-CA in the other 29 grid well samples (*table 9*). TDS concentrations were above the upper SMCL-CA in 2 grid well samples, above the recommended SMCL-CA in 4 grid well samples, and below the recommended SMCL-CA in the remaining 24 grid well samples. Sulfate concentrations were below the recommended SMCL-CA in all MADCHOW grid well samples. Manganese was detected at a concentration above the recommended SMCL-CA in 1 of the 30 grid well samples (*table 10*). Concentrations of iron, silver, and zinc in all MADCHOW grid well samples were below the recommended SMCL-CAs.

One of the major and minor ions (fluoride) and eighteen of the trace elements analyzed in this study have regulatory or non-regulatory health-based thresholds (*table 3H*). Detected concentrations of fluoride were below the MCL-CA in all 30 MADCHOW grid well samples (*table 9*). Of the 18 trace elements with health-based thresholds, 2 were not detected in grid well samples; all detected concentrations of 13 of these trace elements were below health-based thresholds; and some concentrations of 3 of these trace elements (arsenic, vanadium, and uranium) were above health-based thresholds (*table 10*). Arsenic concentrations were above the MCL-US in 4 of the 30 grid well samples, the concentration of vanadium was above the NL-CA in 1 of these samples, and uranium concentrations were above the MCL-US in 4 different grid well samples. Samples from 22 of the 30 grid wells had no trace elements detected at concentrations above health-based thresholds.

Arsenic and iron occur as different species, depending on the oxidation-reduction state of the groundwater. The oxidized and reduced species have different solubilities in groundwater and may have different effects on human health. The relative proportions of the oxidized and reduced species of each element can be used to aid in interpretation of the oxidation–reduction state of the aquifer. Concentrations of total arsenic, total iron, and the concentrations of either the reduced or the oxidized species of each element are reported in *table 11*. The concentration of the other species can be calculated by difference. The concentrations of arsenic and iron reported in *table 11* may be different than those reported in *table 10* because different analytical methods were used (see *Appendix*). The concentrations reported in *table 10* are considered to be more accurate.

Isotopic Tracers and Noble Gases

Isotopic ratios of oxygen and hydrogen in water, tritium and carbon-14 activities, and concentrations of dissolved noble gases may be used as tracers of natural processes affecting groundwater composition and may be used to estimate the age of groundwater. Hydrogen and oxygen stable-isotope ratios in water (*table 12*) aid in interpretation of the sources of groundwater recharge. The stable-isotope ratios of water reflect the altitude, latitude, and temperature of precipitation and also the extent of evaporation of water from surface water bodies or soils prior to infiltration into the aquifer. Concentrations of dissolved noble gases are used to estimate the conditions of groundwater recharge, particularly the temperature of the recharge water. Noble gases dissolve in water that is in contact with the atmosphere, and the solubilities of the different noble gas species vary with temperature. Noble gas analyses were not completed in time to be included in this report; results will be presented in a subsequent publication.

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

Of the isotopic tracer constituents analyzed for this study, tritium is the only one with a health-based threshold. All measured tritium activities in samples from MADCHOW wells were less than 1/1,000 of the MCL-CA (*table 12*).

Radioactive Constituents

Radioactivity is the release of energy or energetic particles during changes in the structure of the nucleus of an atom. Most of the radioactivity in groundwater comes from decay of naturally-occurring isotopes of uranium and thorium that are present in minerals in the sediments or fractured rocks of the aquifer. Both uranium and thorium decay in a series of steps, eventually forming stable isotopes of lead. 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. The alpha and beta particles emitted during radioactive decay are hazardous to human health because these energetic particles may damage cells. Radiation damage to cell DNA may increase the risk of getting cancer.

Activity is often used instead of concentration for reporting the presence of radioactive constituents. Activity of radioactive constituents in groundwater is measured in units of picocuries per liter (pCi/L), and one picocurie is approximately equal to two atoms decaying per minute. The number of atoms decaying is equal to the number of alpha or beta particles emitted.

Samples from 25 of the 30 grid wells were analyzed for uranium isotope activities. Five samples from grid wells had combined uranium isotope activities that were above the MCL-CA (*table 13A*). Four of these same samples also had uranium concentrations above the MCL-US (*table 10*). Gross alpha and beta particle activities were analyzed in all 30 grid well samples. Gross alpha particle activity (72-hour count) was above the MCL-US in six grid well samples and gross alpha particle activity (30-day count) was above the MCL-US in five of these same grid well samples (*table 13B*).

Future Work

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

Summary

Groundwater quality in the approximately 860-square-mile Madera–Chowchilla study unit (MADCHOW) was investigated in April and May 2008 as part of the Priority Basin Project of Groundwater 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. The Priority Basin Project was designed by the USGS and the SWRCB in response to the State of California's Groundwater Quality Monitoring Act of 2001. The project is a comprehensive assessment of statewide groundwater quality designed to identify and characterize risks to groundwater resources, and to increase the availability of information about groundwater quality to the public. MADCHOW was the twenty-fourth study unit sampled as part of the project.

MADCHOW is in the southern part of the Central Valley hydrogeologic province and is comprised of two groundwater subbasins of the San Joaquin Valley defined by the California Department of Water Resources. The MADCHOW study included an assessment of the groundwater quality in samples from 35 wells that are primarily in Madera County, and in Merced and Fresno Counties. Thirty of the wells ("grid wells") were selected using a randomized grid approach to achieve a statistically unbiased representation of groundwater used for public drinking-water supplies. Five more wells ("flow-path wells") were selected to provide additional sampling density to aid in understanding processes affecting groundwater quality.

Groundwater samples were analyzed for VOCs, low-level DBCP and EDB, pesticides and pesticide degradates, polar pesticides and metabolites, constituents of special interest (NDMA perchlorate, low-level 1,2,3-TCP), pharmaceutical compounds, nutrients, major and minor ions, trace elements, species of arsenic and iron, and radioactivity (uranium isotopes, and gross alpha and gross beta particle activities). Naturally occurring isotopes and geochemical tracers (stable isotopes of hydrogen, oxygen, and carbon, and 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 sources and ages of the sampled groundwater. In total, approximately 300 constituents and field water-quality indicators were investigated for this study. This report describes the sampling, analytical, and quality-control methods used in the study, and presents the results of the chemical analyses made of the groundwater samples collected during April and May 2008.

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

The concentrations of most constituents detected in groundwater samples from the 30 MADCHOW grid wells were below regulatory and non-regulatory drinking-water thresholds. One or more organic compounds (VOCs and/or pesticides) were detected in about 40 percent of the grid well samples and generally at less than 1/100 of a regulatory or non-regulatory health-based threshold, although the concentrations of low-level DBCP in 10 percent and low-level EDB in 3 percent of the samples from grid wells were above the corresponding USEPA maximum contaminant levels (MCL-USs). Perchlorate was detected in 70 percent of the samples from grid wells, and most concentrations were less than 1/10 of the CDPH maximum contaminant level (MCL-CA). Low-level 1,2,3-TCP was detected in 33 percent of the samples from grid wells, and all concentrations were less than 1/1,000 of the USEPA lifetime health advisory level. The concentrations of trace elements and nutrients were below regulatory or non-regulatory health-based thresholds with the following exceptions: nitrate was detected above the MCL-US in samples from 7 percent of the grid wells, arsenic and uranium each were detected above the MCL-US in samples from 13 percent each of the grid wells, and vanadium was detected above the CDPH notification level in samples from 3 percent of the grid wells. Combined activities of uranium isotopes were detected above the MCL-CA in 20 percent of the subset of 25 grid well samples analyzed, and gross alpha particle activity was detected above the MCL-US in 20 percent of the samples from the 30 total grid wells. Twenty percent of the samples from grid wells contained specific conductance values, or concentrations of chloride, total dissolved solids, or manganese at concentrations above the non-enforceable CDPH secondary maximum contaminant level thresholds set for aesthetic and technical concerns.

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

Acknowledgments

The authors thank the well owners and water purveyors for their generosity in allowing the U.S. Geological Survey to collect samples from their wells. We also thank the following cooperators for their support: the State Water Resources Control Board, California Department of Public Health, California Department of Water Resources, and Lawrence Livermore National Laboratory. Two reviewers, Jan Stepek (State Water Resources Control Board) and Timothy Mathany (U.S. Geological Survey) provided comments to improve this work. Funding for this work was provided by State bonds authorized by Proposition 50 and administered by the State Water Resources Control Board.

References Cited

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

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

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

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

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

Bertoldi, G.L., Johnston, R.H., and Evenson, K.D., 1991, Ground water in the Central Valley, California—A Summary report: U.S. Geological Survey Professional Paper 1401-A, 44 p.

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

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

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

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

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

California Department of Water Resources, 2008a, California's groundwater: Individual basin descriptions, Chowchilla Subbasin: California Department of Water Resources Bulletin 118, accessed February 5, 2008, at *http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/5-22.05.pdf*

California Department of Water Resources, 2008b, California's groundwater: Individual basin descriptions, Madera Subbasin: California Department of Water Resources Bulletin 118, accessed February 5, 2008, at *http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/5-22.05.pdf*

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

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

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

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

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

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

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

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

Eichelberger, J.W., 1993, Method 504.1, 1,2-dibromoethane (EDB), 1,2-dibromo-3-chloropropane (DBCP), and 1,2,3-trichloropropane (123TCP) in water by microextraction and gas chromatography (rev. 1.0): U.S. Environmental Protection Agency, 20 p.

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

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

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

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

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

Firestone, R.B., Shirley, V.S., Baglin, C.M., Chu, S.Y.F., and Zipkin, J., 1996, Table of Isotopes (8th ed.): New York, John Wiley & Sons, 3,168 p., accessed on April 1, 2007, at *http://ie.lbl.gov/toipdf/toi20.pdf*

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

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

Furlong, E.T., Anderson, B.D., Werner, S.L., Soliven, P.P., Coffey, L.J., and Burkhardt, M.R., 2001, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of pesticides in water by graphitized carbon-based solid-phase extraction and high-performance liquid chromatography/mass spectrometry: U.S. Geological Survey Water-Resources Investigations Report 01–4134, 73 p.

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

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

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

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

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

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

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

Gronberg, J.M., Dubrovsky, N.M., Kratzer, C.R., Domagalski, J.L., Brown, L.R., and Burow, K.R, 1998, Environmental setting and study design for assessing water quality in the San Joaquin–Tulare Basins, California: U.S. Geological Survey Water-Resources Investigations Report 97-4205, 45 p.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Okamoto, H.S., Steeber, W.R., Remoy, R., Hill P., Perera, S.K., eds., 2002, Determination of 1,2,3-trichloropropane in drinking water by purge and trap gas chromatography/mass spectrometry (February 2002): California Department of Health Services, Division of Drinking Water and Environmental Management, Sanitation and Radiation Laboratories Branch, accessed February 5, 2008, at *http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Drinkingwaterlabs/TCPbyPT-GCMS.pdf*

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

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

Plomley, J.B., Koester, C.J., and March, R.E., 1994, Determination of NDMA in complex environmental matrices by quadrupole ion storage tandem mass spectrometry enhanced by unidirectional ion ejection: Analytical Chemistry, v. 66, no. 24, p. 4,437–4,443.

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

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

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

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

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

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

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

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

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

Stumm, W., and Morgan, J.J., 1996, Aquatic Chemistry: Chemical equilibria and rates in natural waters, 3rd ed: New York, John Wiley & Sons, 1,022 p.

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

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

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

U.S. Environmental Protection Agency, 1989, Semivolatile organic compounds by isotope dilution GSMS (July 1989): Washington D.C., U.S. Environmental Protection Agency, 68 p.

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

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

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

U.S. Environmental Protection Agency, 2008b, Drinking water health advisories: 2006 Drinking water standards and health advisory tables (pdf document): U.S. Environmental Protection Agency, accessed February 5, 2008, at URL *http://www.epa.gov/waterscience/criteria/drinking/*

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

U.S. Geological Survey, 2008, June 2008 Quarterly Method Report: U.S. Geological Survey Branch of Quality Systems, Organic Blind Sample Project, Lab Schedule 2033, accessed March 19, 2009, at *http://bqs.usgs.gov/OBSP/Reports/June2008Quarterly.html*

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

Western Regional Climate Center, 2009, Western Regional Climate Center, Summary climate data for central California, average monthly precipitation data for Madera, California, and for Friant Government Camp, California: Western Regional Climate Center, accessed May 22, 2009, at *http://water.usgs.gov/owq/FieldManual*

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

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

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

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

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

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

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

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

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

Tables

Table 1. Identification, sampling, and construction information for wells sampled for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[**GAMA well identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. **Sampling schedule:** Sampling schedules are shown in *table 2*. Land-surface datum (LSD) is a datum plane that is approximately at land surface at each well. The elevation of the LSD is described in feet above the North American Vertical Datum 1988. **Other abbreviations:** ft, foot; LSD, land surface datum; NAVD88, North American Vertical Datum 1988; na, not available; >, greater than]

GAMA identification number	Date (m/dd/yyyy)	Sampling schedule	Elevation of LSD (ft above NAVD88)	Well type	Well depth (ft below LSD)	Top perforation (ft below LSD)	Bottom perforation (ft below LSD)
			Grid wells				
MADCHOW-01	4/14/2008	Intermediate	248	Production	592	210	588
MADCHOW-02	4/15/2008	Intermediate	252	Production	600	240	600
MADCHOW-03	4/15/2008	Intermediate	274	Production	540	240	520
MADCHOW-04	4/16/2008	Intermediate	339	Production	480	180	470
MADCHOW-05	4/16/2008	Intermediate	356	Production	340[1]	na	na
MADCHOW-06	4/17/2008	Intermediate	325	Production	na	na	na
MADCHOW-07	4/21/2008	Slow	346	Production	>300[2]	na	na
MADCHOW-08	4/22/2008	Slow	286	Production	820	420	810
MADCHOW-09	4/22/2008	Intermediate	220	Production	234	na	na
MADCHOW-10	4/24/2008	Slow	236	Production	830[1]	506	830
MADCHOW-11	4/24/2008	Intermediate	284	Production	780	385	770
MADCHOW-12	4/28/2008	Intermediate	143	Production	300	240	300
MADCHOW-13	4/29/2008	Intermediate	223	Production	670	500	660
MADCHOW-14	4/30/2008	Intermediate	238	Production	360	na	na
MADCHOW-15	4/30/2008	Intermediate	363	Production	450	390	450
MADCHOW-16	5/1/2008	Intermediate	291	Production	740	330	740
MADCHOW-17	5/1/2008	Intermediate	487	Production	140[1]	na	na
MADCHOW-18	5/6/2008	Intermediate	268	Production	330	210	280
MADCHOW-19	5/6/2008	Intermediate	295	Production	200	140	na
MADCHOW-20	5/7/2008	Intermediate	177	Production	na	na	na
MADCHOW-21	5/7/2008	Intermediate	428	Production	320	240	320
MADCHOW-22	5/8/2008	Slow	144	Production	na	na	na
MADCHOW-23	5/12/2008	Slow	123	Production	655	400	655
MADCHOW-24	5/13/2008	Intermediate	168	Production	294	244	na
MADCHOW-25	5/13/2008	Intermediate	180	Production	na	na	na
MADCHOW-26	5/14/2008	Intermediate	154	Production	510	210	510
MADCHOW-27	5/14/2008	Intermediate	202	Production	480	240	480
MADCHOW-28	5/19/2008	Intermediate	172	Production	240	204	212
MADCHOW-29	5/20/2008	Intermediate	177	Production	340	160	324
MADCHOW-30	5/21/2008	Intermediate	155	Production	388	358	388
			Flow-path wells				
MADCHOWFP-01	4/23/2008	Slow	145	Production	254	212	na
MADCHOWFP-02	5/5/2008	Slow	249	Production	377	242	na
MADCHOWFP-03	5/15/2008	Slow	122	Production	198	163	na
MADCHOWFP-04	5/21/2008	Slow	296	Production	200	184	196
MADCHOWFP-05	5/22/2008	Slow	340	Production	340	240	340

[1] Well depth estimated from reported hole depth, pump service records, or personal communication from well driller.

[2] Well depth measured to be deeper than the length of the 300-foot calibrated electric sounder.

Table 2. Classes of chemical constituents and field water-quality indicators collected for the slow and intermediate sampling schedules in the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

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

Constituent classes	Slow schedule (10 wells)	Intermediate schedule (25 wells)	Analyte list table	Results table
Field water-quality indicators				
Alkalinity, dissolved oxygen, pH, specific conductance, and temperature	X	X	—	4
Turbidity	X	—	—	4
Organic constituents				
Volatile organic compounds (VOCs)	X	X	3A	5
Low-level 1,2-dibromo-3-chloropropane (DBCP) and 1,2-dibromoethane (EDB)	X	X	3B	5
Pesticides and pesticide degredates	X	X	3C	6A
Polar pesticides and metabolites	X	X	3D	6B
Pharmaceutical compounds	X	—	3E	—(1)
Constituents of special interest				
N-Nitrosodimethylamine (NDMA)	X	—	3F	7
Perchlorate	X	X	3F	7
Low-level 1,2,3-trichloropropane (1,2,3-TCP)	X	X	3F	7
Inorganic constituents				
Nutrients	X	X	3G	8
Major and minor ions and trace elements	X	X	3H	9, 10
Arsenic and iron species	X	—	3I	11
Isotopic tracers				
Stable isotopes of hydrogen and oxygen of water	X	X	3J	12
Stable isotopes of carbon and carbon-14 activity	X	X	3J	12
Radioactivity and noble gases				
Tritium activity	X	X	3J	12
Tritium activity and noble gases	X	X	3K	—(1)
Gross alpha and gross beta particle activities	X	X	3J	13
Uranium isotope activities	X	X	3J	13

[1] Data will be presented in subsequent publications.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; 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}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in ground-water samples (*table 5*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number[1]	LRL (µg/L)	Threshold type[2]	Threshold level (µg/L)	Detection
Acetone	Solvent	81552	67-64-1	4	na	na	—
Acrylonitrile	Organic synthesis	34215	107-13-1	0.4	RSD5-US	0.6	—
tert-Amyl methyl ether (TAME)	Gasoline oxygenate	50005	994-05-8	0.06	na	na	—
Benzene	Gasoline hydrocarbon	34030	71-43-2	0.016	MCL-CA	1	—
Bromobenzene	Solvent	81555	108-86-1	0.02	na	na	—
Bromochloromethane	Fire retardant	77297	74-97-5	0.06	HAL-US	90	—
Bromodichloromethane	Disinfection by-product (THM)	32101	75-27-4	0.04	MCL-US	[3]80	D
Bromoform (Tribromomethane)	Disinfection by-product (THM)	32104	75-25-2	0.08	MCL-US	[3]80	D
Bromomethane (Methyl bromide)	Fumigant	34413	74-83-9	0.4	HAL-US	10	—
n-Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	0.14	NL-CA	260	—
sec-Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	0.04	NL-CA	260	—
tert-Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	0.06	NL-CA	260	—
Carbon disulfide	Organic synthesis	77041	75-15-0	0.06	NL-CA	160	—
Carbon tetrachloride (Tetrachloromethane)	Solvent	32102	56-23-5	0.08	MCL-CA	0.5	—
Chlorobenzene	Solvent	34301	108-90-7	0.02	MCL-CA	70	—
Chloroethane	Solvent	34311	75-00-3	0.1	na	na	—
Chloroform (Trichloromethane)	Disinfection by-product (THM)	32106	67-66-3	0.02	MCL-US	[3]80	D
Chloromethane	Solvent	34418	74-87-3	0.1	HAL-US	30	—
3-Chloropropene	Organic synthesis	78109	107-05-1	0.08	na	na	—
2-Chlorotoluene	Solvent	77275	95-49-8	0.04	NL-CA	140	—
4-Chlorotoluene	Solvent	77277	106-43-4	0.04	NL-CA	140	—
Dibromochloromethane	Disinfection by-product (THM)	32105	124-48-1	0.12	MCL-US	[3]80	D
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	0.5	MCL-US	0.2	D
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.04	MCL-US	0.05	D
Dibromomethane	Solvent	30217	74-95-3	0.04	na	na	—
1,2-Dichlorobenzene	Solvent	34536	95-50-1	0.02	MCL-CA	600	—
1,3-Dichlorobenzene	Solvent	34566	541-73-1	0.04	HAL-US	600	—
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	0.02	MCL-CA	5	—
trans-1,4-Dichloro-2-butene	Organic synthesis	73547	110-57-6	0.6	na	na	—
Dichlorodifluoromethane (CFC-12)	Refrigerant	34668	75-71-8	0.14	NL-CA	1,000	—
1,1-Dichloroethane (1,1-DCA)	Solvent	34496	75-34-3	0.04	MCL-CA	5	D
1,2-Dichloroethane (1,2-DCA)	Solvent	32103	107-06-2	0.06	MCL-CA	0.5	—
1,1-Dichloroethene (1,1-DCE)	Organic synthesis	34501	75-35-4	0.02	MCL-CA	6	—
cis-1,2-Dichloroethene (*cis*-1,2-DCE)	Solvent	77093	156-59-2	0.02	MCL-CA	6	D

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; 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}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in ground-water samples (*table 5*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number[1]	LRL (µg/L)	Threshold type[2]	Threshold level (µg/L)	Detection
trans-1,2-Dichloroethene (*trans*-1,2-DCE)	Solvent	34546	156-60-5	0.018	MCL-CA	10	—
1,2-Dichloropropane	Fumigant	34541	78-87-5	0.02	MCL-US	5	D
1,3-Dichloropropane	Fumigant	77173	142-28-9	0.06	na	na	—
2,2-Dichloropropane	Fumigant	77170	594-20-7	0.06	na	na	—
1,1-Dichloropropene	Organic synthesis	77168	563-58-6	0.04	na	na	—
cis-1,3-Dichloropropene	Fumigant	34704	10061-01-5	0.1	RSD5-US	[4]4	—
trans-1,3-Dichloropropene	Fumigant	34699	10061-02-6	0.1	RSD5-US	[4]4	—
Diethyl ether	Solvent	81576	60-29-7	0.12	na	na	—
Diisopropyl ether (DIPE)	Gasoline oxygenate	81577	108-20-3	0.06	na	na	—
Ethylbenzene	Gasoline hydrocarbon	34371	100-41-4	0.04	MCL-CA	300	—
Ethyl *tert*-butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.04	na	na	—
Ethyl methacrylate	Organic synthesis	73570	97-63-2	0.14	na	na	—
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	Gasoline hydrocarbon	77220	611-14-3	0.04	na	na	—
Hexachlorobutadiene	Organic synthesis	39702	87-68-3	0.06	RSD5-US	9	—
Hexachloroethane	Solvent	34396	67-72-1	0.14	HAL-US	1	—
2-Hexanone (*n*-Butyl methyl ketone)	Solvent	77103	591-78-6	0.6	na	na	—
Iodomethane (Methyl iodide)	Organic synthesis	77424	74-88-4	0.4	na	na	—
Isopropylbenzene	Gasoline hydrocarbon	77223	98-82-8	0.04	NL-CA	770	—
4-Isopropyl-1-methyl benzene	Gasoline hydrocarbon	77356	99-87-6	0.08	na	na	—
Methyl acrylate	Organic synthesis	49991	96-33-3	0.6	na	na	—
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	0.2	na	na	—
Methyl *tert*-butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.1	MCL-CA	13	—
Methyl *iso*-butyl ketone (MIBK)	Solvent	78133	108-10-1	0.4	NL-CA	120	—
Methylene chloride (Dichloromethane)	Solvent	34423	75-09-2	0.04	MCL-US	5	—
Methyl ethyl ketone (2-butanone, MEK)	Solvent	81595	78-93-3	1.6	HAL-US	4,000	—
Methyl methacrylate	Organic synthesis	81597	80-62-6	0.2	na	na	—
Naphthalene	Gasoline hydrocarbon	34696	91-20-3	0.2	NL-CA	17	—
Perchloroethene (Tetrachloroethene, PCE)	Solvent	34475	127-18-4	0.04	MCL-US	5	D
n-Propylbenzene	Solvent	77224	103-65-1	0.04	NL-CA	260	—
Styrene	Gasoline hydrocarbon	77128	100-42-5	0.04	MCL-US	100	—(5)
1,1,1,2-Tetrachloroethane	Solvent	77562	630-20-6	0.04	HAL-US	70	—
1,1,2,2-Tetrachloroethane	Solvent	34516	79-34-5	0.1	MCL-CA	1	—
Tetrahydrofuran	Solvent	81607	109-99-9	1.4	na	na	—
1,2,3,4-Tetramethylbenzene	Gasoline hydrocarbon	49999	488-23-3	0.14	na	na	—
1,2,3,5-Tetramethylbenzene	Gasoline hydrocarbon	50000	527-53-7	0.12	na	na	—

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; 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}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in ground-water samples (*table 5*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number[1]	LRL (µg/L)	Threshold type[2]	Threshold level (µg/L)	Detection
Toluene	Gasoline hydrocarbon	34010	108-88-3	0.018	MCL-CA	150	—(6)
1,2,3-Trichlorobenzene	Organic synthesis	77613	87-61-6	0.08	na	na	—
1,2,4-Trichlorobenzene	Solvent	34551	120-82-1	0.08	MCL-CA	5	—
1,1,1-Trichloroethane (1,1,1-TCA)	Solvent	34506	71-55-6	0.02	MCL-CA	200	—
1,1,2-Trichloroethane (1,1,2-TCA)	Solvent	34511	79-00-5	0.06	MCL-CA	5	—
Trichloroethene (TCE)	Solvent	39180	79-01-6	0.02	MCL-US	5	D
Trichlorofluoromethane (CFC-11)	Refrigerant	34488	75-69-4	0.08	MCL-CA	150	—
1,2,3-Trichloropropane (1,2,3-TCP)	Solvent/organic synthesis	77443	96-18-4	0.12	HAL-US	40	—
Trichlorotrifluoroethane (CFC-113)	Refrigerant	77652	76-13-1	0.04	MCL-CA	1,200	—
1,2,3-Trimethylbenzene	Gasoline hydrocarbon	77221	526-73-8	0.08	na	na	—
1,2,4-Trimethylbenzene	Gasoline hydrocarbon	77222	95-63-6	0.04	NL-CA	330	D
1,3,5-Trimethylbenzene	Organic synthesis	77226	108-67-8	0.04	NL-CA	330	—
Vinyl bromide (Bromoethene)	Fire retardant	50002	593-60-2	0.12	na	na	—
Vinyl chloride (Chloroethene)	Organic synthesis	39175	75-01-4	0.08	MCL-CA	0.5	—
m- and *p*-Xylene	Gasoline hydrocarbon	85795	108-38-3/ 106-42-3	0.08	MCL-CA	[7]1,750	—
o-Xylene	Gasoline hydrocarbon	77135	95-47-6	0.04	MCL-CA	[7]1,750	—

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

[2] 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.

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

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

[5] 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.

[6] All detections of toluene were V-coded based on frequency of detections in field blanks and source solution blanks from the previous 23 GAMA study units and were excluded from the dataset of ground-water quality results.

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

Table 3B. Low-level 1,2-dibromo-3-chloropropane (DBCP) and 1,2-dibromoethane (EDB), primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 1306.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in ground-water samples (*table 5*); µg/L, micrograms per liter]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type[1]	Threshold level (µg/L)	Detection
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	0.030	MCL-US	0.2	D
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.02	MCL-US	0.05	D

[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.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in ground-water samples (*table 6A*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type[1]	Threshold level (µg/L)	Detection
Acetochlor	Herbicide	49260	34256-82-1	0.006	na	na	—
Alachlor	Herbicide	46342	15972-60-8	0.006	MCL-US	2	—
Atrazine	Herbicide	39632	1912-24-9	0.007	MCL-CA	1	D
Azinphos-methyl	Insecticide	82686	86-50-0	0.12	na	na	—(2)
Azinphos-methyl oxon	Insecticide degradate	61635	961-22-8	0.042	na	na	—(2)
Benfluralin	Herbicide	82673	1861-40-1	0.01	na	na	—(2)
Carbaryl	Insecticide	82680	63-25-2	0.06	RSD5-US	400	—
Carbofuran	Insecticide	82674	1563-66-2	0.02	MCL-CA	18	—
2-Chloro-2,6-diethylacetanilide	Herbicide degradate	61618	6967-29-9	0.01	na	na	—
4-Chloro-2-methylphenol	Herbicide degradate	61633	1570-64-5	0.005	na	na	—(2)
Chlorpyrifos	Insecticide	38933	2921-88-2	0.005	HAL-US	2	—(2)
Chlorpyrifos-oxon	Insecticide degradate	61636	5598-15-2	0.0562	na	na	—(2)
Cyanazine	Herbicide	04041	21725-46-2	0.02	HAL-US	1	—
Cyfluthrin	Insecticide	61585	68359-37-5	0.016	na	na	—(2)
λ-Cyhalothrin	Insecticide	61595	91465-08-6	0.004	na	na	—(2)
Cypermethrin	Insecticide	61586	52315-07-8	0.014	na	na	—(2)
DCPA (Dacthal)	Herbicide	82682	1861-32-1	0.003	HAL-US	70	—
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	Herbicide degradate	04040	6190-65-4	0.014	na	na	D[2]
Desulfinylfipronil	Insecticide degradate	62170	na	0.012	na	na	—
Desulfinylfipronil amide	Insecticide degradate	62169	na	0.029	na	na	—
Diazinon	Insecticide	39572	333-41-5	0.005	HAL-US	1	—
3,4-Dichloroaniline	Herbicide degradate	61625	95-76-1	0.006	na	na	D
3,5-Dichloroaniline	Herbicide degradate	61627	626-43-7	0.008	na	na	—
Dichlorvos	Insecticide	38775	62-73-7	0.013	na	na	—(2)
Dicrotophos	Insecticide	38454	141-66-2	0.0843	na	na	—(2)
Dieldrin	Insecticide	39381	60-57-1	0.009	RSD5-US	0.02	—
2,6-Diethylaniline	Herbicide degradate	82660	579-66-8	0.006	na	na	—
Dimethoate	Insecticide	82662	60-51-5	0.006	na	na	—(2)
Disulfoton	Insecticide	82677	298-04-4	0.04	HAL-US	0.7	—(2)
Disulfoton sulfone	Insecticide degradate	61640	2497-06-5	0.014	na	na	—
α-Endosulfan	Insecticide	34362	959-98-8	0.006	na	na	—
Endosulfan sulfate	Insecticide degradate	61590	1031-07-8	0.022	na	na	—
Ethion	Insecticide	82346	563-12-2	0.006	na	na	—(2)
Ethion monoxon	Insecticide degradate	61644	17356-42-2	0.021	na	na	—(2)
Ethoprop	Herbicide	82672	13194-48-4	0.012	na	na	—

Table 3C. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) 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 threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in ground-water samples (*table 6A*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type[1]	Threshold level (µg/L)	Detection
S-Ethyl-dipropylthiocarbamate (EPTC)	Herbicide	82668	759-94-4	0.002	na	na	—
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	0.01	na	na	—
Fenamiphos	Insecticide	61591	22224-92-6	0.029	HAL-US	0.7	—
Fenamiphos sulfone	Insecticide degradate	61645	31972-44-8	0.053	na	na	—
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	0.2	na	na	—(2)
Fipronil	Insecticide	62166	120068-37-3	0.02	na	na	—
Fipronil sulfide	Insecticide degradate	62167	120067-83-6	0.013	na	na	—
Fipronil sulfone	Insecticide degradate	62168	120068-36-2	0.024	na	na	—(2)
Fonofos	Insecticide	04095	944-22-9	0.01	HAL-US	10	—
Hexazinone	Herbicide	04025	51235-04-2	0.008	HAL-US	400	D[2]
Iprodione	Fungicide	61593	36734-19-7	0.01	na	na	—(2)
Isofenphos	Insecticide	61594	25311-71-1	0.006	na	na	—
Malaoxon	Insecticide degradate	61652	1634-78-2	0.02	na	na	—(2)
Malathion	Insecticide	39532	121-75-5	0.016	HAL-US	100	—
Metalaxyl	Fungicide	61596	57837-19-1	0.0069	na	na	—
Methidathion	Insecticide	61598	950-37-8	0.004	na	na	—
Metolachlor	Herbicide	39415	51218-45-2	0.01	HAL-US	700	—
Metribuzin	Herbicide	82630	21087-64-9	0.012	HAL-US	70	—
Molinate	Herbicide	82671	2212-67-1	0.003	MCL-CA	20	—
Myclobutanil	Fungicide	61599	88671-89-0	0.01	na	na	—
1-Naphthol	Insecticide degradate	49295	90-15-3	0.04	na	na	—(2)
Oxyfluorfen	Herbicide	61600	42874-03-3	0.006	na	na	—(2)
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	0.01	na	na	—(2)
Parathion-methyl	Insecticide	82667	298-00-0	0.008	HAL-US	1	—(2)
Pendimethalin	Herbicide	82683	40487-42-1	0.012	na	na	—
cis-Permethrin	Insecticide	82687	54774-45-7	0.01	na	na	—(2)
Phorate	Insecticide	82664	298-02-2	0.04	na	na	—(2)
Phorate oxon	Insecticide degradate	61666	2600-69-3	0.027	na	na	—
Phosmet	Insecticide	61601	732-11-6	0.0079	na	na	—(2)
Phosmet oxon	Insecticide degradate	61668	3735-33-9	0.0511	na	na	—(2)
Prometon	Herbicide	04037	1610-18-0	0.01	HAL-US	100	—
Prometryn	Herbicide	04036	7287-19-6	0.0059	na	na	—
Pronamide	Herbicide	82676	23950-58-5	0.004	RSD5-US	20	—
Propanil	Herbicide	82679	709-98-8	0.006	na	na	—
Propargite	Insecticide	82685	2312-35-8	0.04	na	na	—(2)
cis-Propiconazole	Fungicide	79846	60207-90-1	0.006	na	na	—

Table 3C. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) 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 threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in ground-water samples (*table 6A*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type[1]	Threshold level (µg/L)	Detection
trans-Propiconazole	Fungicide	79847	60207-90-1	0.02	na	na	—
Simazine	Herbicide	04035	122-34-9	0.006	MCL-US	4	D
Tebuthiuron	Herbicide	82670	34014-18-1	0.016	HAL-US	500	D[2]
Tefluthrin	Insecticide	61606	79538-32-2	0.0033	na	na	—
Terbufos	Insecticide	82675	13071-79-9	0.018	HAL-US	0.4	—
Terbufos oxon sulfone	Insecticide degradate	61674	56070-15-6	0.045	na	na	—(2)
Terbuthylazine	Herbicide	04022	5915-41-3	0.0083	na	na	—
Thiobencarb	Herbicide	82681	28249-77-6	0.01	MCL-CA	70	—
Tribufos	Defoliant	61610	78-48-8	0.035	na	na	—(2)
Trifluralin	Herbicide	82661	1582-09-8	0.009	HAL-US	10	—(2)

[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] 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. Polar pesticides and metabolites, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2060.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; IRL, interim reporting level; D, detected in ground-water samples (*table 6B*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type[1]	Threshold level (µg/L)	Detection
Acifluorfen	Herbicide	49315	50594-66-6	0.04	na	na	—(2)
Aldicarb	Insecticide	49312	116-06-3	0.12	MCL-US	3	—
Aldicarb sulfone	Degradate	49313	1646-88-4	0.080	MCL-US	3	—
Aldicarb sulfoxide	Degradate	49314	1646-87-3	0.060	MCL-US	4	—
Atrazine	Herbicide	39632	1912-24-9	0.040	MCL-CA	1	D[3]
Bendiocarb	Insecticide	50299	22781-23-3	0.040	na	na	—
Benomyl	Fungicide	50300	17804-35-2	0.040	na	na	—
Bensulfuron-methyl	Herbicide	61693	83055-99-6	0.060	na	na	—
Bentazon	Herbicide	38711	25057-89-0	0.040	MCL-CA	18	—(2)
Bromacil	Herbicide	04029	314-40-9	0.02	HAL-US	70	D
Bromoxynil	Herbicide	49311	1689-84-5	0.120	na	na	—(2)
Caffeine	Beverages	50305	58-08-2	0.060	na	na	—
Carbaryl	Herbicide	49310	63-25-2	0.040	RSD5-US	400	—
Carbofuran	Herbicide	49309	1563-66-2	0.020	MCL-CA	18	—
Chloramben, methyl ester	Herbicide	61188	7286-84-2	0.100	na	na	—
Chlorimuron-ethyl	Herbicide	50306	90982-32-4	0.080	na	na	—
3-(4-Chlorophenyl)-1-methyl urea	Degradate	61692	5352-88-5	0.120	na	na	—
Clopyralid	Herbicide	49305	1702-17-6	0.060	na	na	—
Cycloate	Herbicide	04031	1134-23-2	0.02	na	na	—(2)
2,4-D plus 2,4-D methyl ester	Herbicides	66496	na	0.02[4]	MCL-US	70	—
2,4-DB (4-(2,4-Dichlorophenoxy)butyric acid)	Herbicide	38746	94-82-6	0.020	na	na	—
DCPA (Dacthal) monoacid	Degradate	49304	887-54-7	0.020	na	na	—
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	Degradate	04040	6190-65-4	0.06	na	na	D[3]
Deisopropyl atrazine (2-Chloro-6-ethylamino-4-amino-*s*-triazine)	Degradate	04038	1007-28-9	0.08	na	na	D
Dicamba	Herbicide	38442	1918-00-9	0.040	HAL-US	4000	—(2)
Dichlorprop	Herbicide	49302	120-36-5	0.020	na	na	—
Dinoseb (Dinitrobutyl phenol)	Herbicide	49301	88-85-7	0.040	MCL-CA	7	D[2]
Diphenamid	Herbicide	04033	957-51-7	0.04	HAL-US	200	—
Diuron	Herbicide	49300	330-54-1	0.040	HAL-US	10	D
Fenuron	Herbicide	49297	101-42-8	0.040	na	na	—
Flumetsulam	Herbicide	61694	98967-40-9	0.060	na	na	—
Fluometuron	Herbicide	38811	2164-17-2	0.040	HAL-US	90	—

Table 3D. Polar pesticides and metabolites, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2060.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; IRL, interim reporting level; D, detected in ground-water samples (*table 6B*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type[1]	Threshold level (µg/L)	Detection
Hydroxyatrazine (2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine)	Degradate	50355	2163-68-0	0.040	na	na	—
3-Hydroxycarbofuran	Degradate	49308	16655-82-6	0.040	na	na	—
Imazaquin	Herbicide	50356	81335-37-7	0.040	na	na	—(5)
Imazethapyr	Herbicide	50407	81335-77-5	0.040	na	na	D[5]
Imidacloprid	Insecticide	61695	138261-41-3	0.060	na	na	—
Linuron	Herbicide	38478	330-55-2	0.020	na	na	—
MCPA (2-Methyl-4-chlorophenoxyacetic acid)	Herbicide	38482	94-74-6	0.060	HAL-US	30	—
MCPB (4-(2-Methyl-4-chlorophenoxy)butyric acid)	Herbicide	38487	94-81-5	0.060	na	na	—(2)
Metalaxyl	Fungicide	50359	57837-19-1	0.020	na	na	—
Methiocarb	Insecticide	38501	2032-65-7	0.040	na	na	—
Methomyl	Insecticide	49296	16752-77-5	0.120	HAL-US	200	—
Metsulfuron methyl[4]	Herbicide	61697	74223-64-6	0.14[4]	na	na	—
Neburon	Herbicide	49294	555-37-3	0.020	na	na	—
Nicosulfuron	Herbicide	50364	111991-09-4	0.10	na	na	—(5)
Norflurazon	Herbicide	49293	27314-13-2	0.020	na	na	D
Oryzalin	Herbicide	49292	19044-88-3	0.040	na	na	—
Oxamyl	Insecticide	38866	23135-22-0	0.120	MCL-CA	50	—
Picloram	Herbicide	49291	1918-02-01	0.120	MCL-US	500	—
Propham	Herbicide	49236	122-42-9	0.040	HAL-US	100	—
Propiconazole	Fungicide	50471	60207-90-1	0.040	na	na	—
Propoxur	Insecticide	38538	114-26-1	0.040	na	na	—
Siduron	Herbicide	38548	1982-49-6	0.020	na	na	—
Sulfometuron-methyl	Herbicide	50337	74222-97-2	0.060	na	na	—
Tebuthiuron	Herbicide	82670	34014-18-1	0.040	HAL-US	500	D[3]
Terbacil	Herbicide	04032	5902-51-2	0.04	HAL-US	90	—
Triclopyr	Herbicide	49235	55335-06-3	0.080	na	na	—

[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] 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.

[3] Compounds analyzed in Schedule 2033 and 2060, but values are reported for the preferred Schedule 2033.

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

[5] The median laboratory matrix-spike recovery was greater than 130 percent. High recoveries may indicate that reported values could be higher than what is in the sample.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Other abbreviations:** CAS, Chemical Abstract Service; MDL, method detection limit; na, not available; SRL, study reporting level; µg/L, micrograms per liter]

Constituent	Primary use or source	USGS parameter code	CAS number	MDL[1] (µg/L)	Threshold type	Threshold level (µg/L)
Acetaminophen	Analgesic	62000	103-90-2	0.60	na	na
Albuterol	Anti-inflammatory; bronchodilator	62020	18559-94-9	0.03	na	na
Caffeine	Stimulant	50305	58-08-2	0.40	na	na
Carbamazapine	Anticonvulsant; analgesic; mood stabilizer	62793	298-46-4	0.02	na	na
Codeine	Opioid narcotic	62003	76-57-3	0.02	na	na
Cotinine	Nicotine metabolite	62005	486-56-6	0.03	na	na
Dehydronifedipine	Antianginal metabolite	62004	67035-22-7	0.03	na	na
Diltiazem	Antianginal; antihypertensive	62008	42399-41-7	0.02	na	na
Diphenhydramine	Antihistamine	62796	58-73-1	0.03	na	na
1,7-Dimethylxanthine	Caffeine metabolite	62030	611-59-6	0.10	na	na
Sulfamethoxazole	Antibacterial, antiprotozoal	62021	723-46-6	0.05	na	na
Thiabendazole	Anthelmintic	62801	148-79-8	0.02	na	na
Trimethoprim	Antibacterial	62023	738-70-5	0.01	na	na
Warfarin	Anticoagulant	62024	81-81-2	0.03	na	na

[1] The California Groundwater Ambient Monitoring and Assessment (GAMA) program uses more conservative reporting limits for the pharmaceutical compounds than those used by the USGS National Water Quality Laboratory (NWQL). The data for samples from this study unit were reported by the NWQL with interim laboratory reporting limits, and results below the interim method detection limits were included in the dataset. The GAMA program examined laboratory quality-control data and decided that the rate of false-positive detections was too high using this set of reporting limits. The reporting limits used by GAMA have significantly higher concentrations than those originally reported with the data, and GAMA does not report results below the selected method detection limits. For albuterol, carbamazepine, codeine, cotinine, dehydronifedipine, diltiazem, 1,7-dimethylxanthine, sulfamethoxazole, thiabendazole, trimethoprim, and warfarin, the MDLs correspond to the long-term method detection limits determined by the USGS Branch of Quality Systems in October 2007 (BQS LT-MDL). For acetaminophen, caffeine, and diphenhydramine, the MDLs correspond to the effective method detection limits determined from assessment of quality-control data associated with GAMA samples collected from May 2004 through September 2007 (GAMA SRL). The GAMA SRLs are higher than the BQS LT-MDLs for those compounds. Detections reported by the USGS National Water Quality Laboratory with concentrations lower than the BQS LT-MDL or GAMA SRL are reported as nondetects by the GAMA program.

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

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** CAS, Chemical Abstract Service; MRL, minimum reporting level; D, detected in ground-water samples (*table 7*); µg/L, micrograms per liter]

Constituent	Primary use or source	USGS parameter code	CAS number	MRL (µg/L)	Threshold type[1]	Threshold level (µg/L)	Detection
N-Nitrosodimethylamine (NDMA)	Rocket fuel, plasticizer, disinfection by-product	34438	62-75-9	0.0020	NL-CA	0.010	D
Perchlorate	Rocket fuel, fireworks, flares, natural, fertilizer	61209	14797-73-0	0.10	MCL-CA	6	D
1,2,3-Trichloropropane (1,2,3-TCP)	Fumigant, solvent	77443	96-18-4	0.0050	HAL-US	40	D

[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.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 8*); na, not available; mg/L, milligrams per liter]

Constituent	USGS parameter code	CAS number	LRL (mg/L)	Threshold type[1]	Threshold level (mg/L)	Detection
Ammonia (as nitrogen)	00608	7664-41-7	0.02	HAL-US	[2]24.7	D
Nitrite (as nitrogen)	00613	14797-65-0	0.002	MCL-US	1	D
Nitrite plus nitrate (as nitrogen)	00631	na	0.04	MCL-US	10	D
Nitrogen, total (ammonia, nitrite, nitrate, organic nitrogen)	62854	17778-88-0	0.06	na	na	D
Orthophosphate, as phosphorus	00671	14265-44-2	0.006	na	na	D

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; IRL, interim reporting level; LRL, laboratory reporting level; D, detected in groundwater samples (*tables 9* and *10*); na, not available; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not detected]

Constituent	USGS parameter code	CAS number	LRL	Threshold type[1]	Threshold level	Detection
Major and minor ions (mg/L)						
Bromide	71870	24959-67-9	[2]0.02	na	na	D
Calcium	00915	7440-70-2	0.04	na	na	D
Chloride	00940	16887-00-6	0.12	SMCL-CA	[3]250 (500)	D
Fluoride	00950	16984-48-8	0.12	MCL-CA	2	D
Iodide	71865	7553-56-2	0.002	na	na	D
Magnesium	00925	7439-95-4	0.02	na	na	D
Potassium	00935	7440-09-7	0.02	na	na	D
Silica	00955	7631-86-9	0.018	na	na	D
Sodium	00930	7440-23-5	0.12	na	na	D
Sulfate	00945	14808-79-8	0.18	SMCL-CA	[3]50 (500)	D
Total dissolved solids (TDS; residue on evaporation, ROE)	70300	na	10	SMCL-CA	[3]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	0.14	MCL-US	6	D
Arsenic	01000	7440-38-2	0.06	MCL-US	10	D
Barium	01005	7440-39-3	0.4	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	0.008	MCL-US	4	D
Boron	01020	7440-42-8	6	NL-CA	1,000	D
Cadmium	01025	7440-43-9	0.04	MCL-US	5	D
Chromium	01030	7440-47-3	0.12	MCL-CA	50	D
Cobalt	01035	7440-48-4	0.02	na	na	D
Copper	01040	7440-50-8	1.0	AL-US	1,300	D
Iron	01046	7439-89-6	8	SMCL-CA	300	D
Lead	01049	7439-92-1	0.08	AL-US	15	D
Lithium	01130	7439-93-2	1.0	na	na	D
Manganese	01056	7439-96-5	0.2	SMCL-CA	50	D
Mercury	71890	7439-97-6	0.01	MCL-US	2	—
Molybdenum	01060	7439-98-7	0.2	HAL-US	40	D
Nickel	01065	7440-02-0	0.2	MCL-CA	100	D
Selenium	01145	7782-49-2	0.04	MCL-US	50	D
Silver	01075	7440-22-4	0.1	SMCL-CA	100	D
Strontium	01080	7440-24-6	0.8	HAL-US	4,000	D
Thallium	01057	7440-28-0	0.04	MCL-US	2	—(4)
Tungsten	01155	7440-33-7	0.06	na	na	D
Uranium	22703	7440-61-1	0.02	MCL-US	30	D
Vanadium	01085	7440-62-2	0.04	NL-CA	50	D
Zinc	01090	7440-66-6	1.8	SMCL-CA[5]	5,000	D

[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] Value is an IRL rather than an LRL.

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

[4] The laboratory raised the LRL to 0.12 mg/L in the MADCHOWFP-03 sample collected on 5/15/08 at 1040 and thallium was not detected.

[5] The secondary maximum contaminant level for zinc is listed as SMCL-CA since SMCLs established by California Department of Public Health are used in this report for all constituents that have SMCL-CAs.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituents or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level; na, not available; mg/L, micrograms per liter. **Other abbreviations:** CAS, Chemical Abstract Service; MDL, method detection limit; D, detected in ground-water samples (*table 11*)]

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

[1] Maximum contaminant level 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.

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

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. 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. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** H, hydrogen; O, oxygen; C, carbon; CAS, Chemical Abstract Service; CSU, 1-sigma combined standard uncertainty; CV, critical value; MRL, minimum reporting level; MU, method uncertainty; na, not available; pCi/L, picocuries per liter; ssL$_C$, sample-specific critical level; D, detected in ground-water samples (*tables 12* and *13*)]

Constituent	USGS parameter code	CAS number	Reporting level type	Reporting level or uncertainty	Threshold type[1]	Threshold level	Detection
Stable isotope ratios (per mil)							
δ^{2}H of water[2]	82082	na	MU	2	na	na	D
δ^{18}O of water[2]	82085	na	MU	0.20	na	na	D
δ^{13}C of dissolved carbonates[3]	82081	na	1 sigma	0.05	na	na	D
Radioactive constituent (percent modern)							
Carbon-14[4]	49933	14762-75-5	1 sigma	0.0015	na	na	D
Radioactive constituents (pCi/L)							
Tritium[5]	07000	10028-17-8	MRL	0.3	MCL-CA	20,000	D
Gross alpha particle activity, 72-hour and 30-day counts[6]	62636, 62639	12587-46-1	ssL$_C$	CSU	MCL-US	15	D
Gross beta particle activity, 72-hour and 30-day counts[6]	62642, 62645	12587-47-2	ssL$_C$	CSU	MCL-CA	50	D
Uranium-234[6]	22610	13966-29-5	ssL$_C$	CSU	MCL-CA[7]	20	D
Uranium-235[6]	22620	15117-96-1	ssL$_C$	CSU	MCL-CA[7]	20	D
Uranium-238[6]	22603	7440-61-1	ssL$_C$	CSU	MCL-CA[7]	20	D

[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] USGS Stable Isotope Laboratory, Reston, Virginia.

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

[5] USGS Stable Isotope and Tritium Laboratory, Menlo Park, California.

[6] Eberline Analytical Services (contract laboratory).

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

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

[The five-digit U.S.Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MU, method uncertainty; na, not available; cm³ STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water; pCi/L, picocuries per liter]

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

[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.

Table 4. Field water-quality indicators in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five digit number below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA Identification number:** MADCHOW, Madera-Chowchilla study unit grid well; MADCHOWFP, Madera-Chowchilla unit flow-path well; Thresholds and threshold levels as of April 14, 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. **Other abbreviations:** ºC, degrees celsius; mg/L, milligrams per liter; nc, sample not collected; na, not available; NTU, nephelometric turbidity unit; RL, reporting limit or range; µS/cm, microsiemens per centimeter; CaCO$_3$, calcium carbonate; <, less than; >, greater than; *, value above threshold level or outside threshold range; **, value above upper threshold level]

GAMA identification number	Turbidity, field (NTU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (ºC) (00010)	pH, lab (standard units) 00403)	pH, field (standard units) (00400)	Specific conduct-ance, lab (µS/cm at 25 ºC) (90095)	Specific conduct-ance, field (µS/cm at 25 ºC) (00095)	Alkalinity, lab (mg/L as CaCO$_3$) (29801)	Alkalinity, field (mg/L as CaCO$_3$) (29802)
Threshold type	**SMCL-CA**	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**na**	**na**
Threshold level	**5**	**na**	**na**	**<6.5 or >8.5**	**<6.5 or >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									
MADCHOW-01	nc	5.1	20.5	7.1	6.8	489	485	185	nc
MADCHOW-02	nc	6.5	22.0	7.5	7.3	203	202	65	nc
MADCHOW-03	nc	3.3	20.5	7.4	7.2	218	218	76	nc
MADCHOW-04	nc	1.4	19.5	7.7	7.3	166	165	77	nc
MADCHOW-05	nc	nc	24.5	7.3	7.0	267	272	97	nc
MADCHOW-06	nc	5.7	22.5	7.9	7.8	397	413	132	nc
MADCHOW-07	0.9	4.5	22.0	7.6	7.3	324	325	105	100
MADCHOW-08	1.0	1.7	23.0	7.7	7.5	317	317	94	92
MADCHOW-09	1.6	7.7	19.5	7.3	7.1	759	760	253	nc
MADCHOW-10	0.8	4.5	22.0	7.8	7.7	211	213	71	67
MADCHOW-11	1.0	7.5	24.0	7.7	7.5	324	330	94	nc
MADCHOW-12	nc	0.3	24.0	8.2	8.0	**1,800	**1,850	82	nc
MADCHOW-13	nc	4.5	22.5	7.9	7.7	206	207	73	nc
MADCHOW-14	nc	6.1	21.0	7.8	7.7	194	194	67	nc
MADCHOW-15	0.1	1.4	23.5	7.5	7.1	168	165	69	nc
MADCHOW-16	nc	4.2	24.5	7.6	7.4	233	237	76	nc
MADCHOW-17	nc	5.7	21.5	7.5	7.2	389	395	152	nc
MADCHOW-18	nc	7.2	20.5	7.2	6.8	452	467	148	nc
MADCHOW-19	nc	4.0	21.5	7.5	7.0	244	245	87	nc
MADCHOW-20	nc	7.1	20.0	7.4	7.1	* 948	*983	338	nc
MADCHOW-21	nc	6.7	23.5	7.3	7.0	253	268	94	nc
MADCHOW-22	0.6	1.2	22.0	8.1	8.0	278	282	93	88
MADCHOW-23	0.4	0.7	22.0	8.4	8.4	275	272	106	102
MADCHOW-24	nc	5.7	21.0	7.2	8.0	302	317	84	nc
MADCHOW-25	nc	5.7	21.0	7.2	7.0	**1,650	**1,650	536	nc
MADCHOW-26	nc	6.0	20.5	7.3	7.0	*1,300	*1,310	264	nc
MADCHOW-27	nc	1.6	20.5	7.8	7.6	422	425	157	nc
MADCHOW-28	nc	7.5	21.0	7.3	6.9	*1,270	*1,290	394	nc
MADCHOW-29	nc	7.2	21.5	7.5	7.2	745	744	279	nc
MADCHOW-30	nc	3.0	22.5	8.4	8.4	272	275	67	nc
Flow-path wells									
MADCHOWFP-01	2.9	8.2	21.0	7.6	7.4	812	820	263	256
MADCHOWFP-02	0.1	6.0	21.5	7.9	7.5	221	225	71	68
MADCHOWFP-03	0.4	7.8	19.0	7.1	6.8	**5,740	**5,870	182	178
MADCHOWFP-04	0.2	3.3	20.0	7.4	7.4	255	255	83	81
MADCHOWFP-05	0.5	1.3	23.0	7.8	7.6	399	402	136	134

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

Table 5. Volatile organic compounds (VOCs) and low-level 1,2-dibromo-3-chloropropane (DBCP) and 1,2-dibromoethane (EDB) detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed, but only samples with detections are listed. Analytes are grouped by primary use or source and listed in order of decreasing detection frequency in the thirty grid wells. All analytes are listed in *tables 3A* and *3B*. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** 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. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; V, constituent detected in blanks and therefore excluded from the dataset of ground-water quality results; µg/L, micrograms per liter; —, not detected; *, value above threshold level]

	Disinfection by-products (THMs)				Fumigants			Solvents			Gasoline hydrocarbons			
GAMA identification number	Chloroform (µg/L) (32106)	Bromo-dichloro methane (µg/L) (32101)	Dibromo-chloro-methane (µg/L) (32105)	Bromo-form (µg/L) (32104)	1,2-Dibromo-3-chloro propane (DBCP) (µg/L) (82625)	1,2-Dichloro-propane (µg/L) (34541)	1,2-Dibromo-ethane (EDB) (µg/L) (77651)	Perchloro-ethene (PCE) (µg/L) (34475)	Trichloro-ethene (TCE) (µg/L) (39180)	1,1-Dichloro-ethane (µg/L) (34496)	cis-1,2-Dichloro-ethene (µg/L) (77093)	1,2,4-Trimethyl-benzene (µg/L) (77222)	Toluene (µg/L) (34010)	VOC detec-tions per well
Threshold type[1]	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-US**	**NL-CA**	**MCL-CA**	
Threshold level	**[2]80**	**[2]80**	**[2]80**	**[2]80**	**0.2**	**5**	**0.02**	**5**	**5**	**5**	**6**	**330**	**150**	
[LRL]	**[0.02]**	**[0.04]**	**[0.12]**	**[0.08]**	**[0.030]**	**[0.02]**	**[0.04]**	**[0.04]**	**[0.02]**	**[0.04]**	**[0.02]**	**[0.04]**	**[0.018]**	
						Grid wells								
MADCHOW-01	E0.08	E0.06	0.2	0.91	*0.35	E0.06	*E0.05	0.21	—	E0.05	—	—	—	9
MADCHOW-03	E0.02	—	—	—	—	—	—	2.27	0.3	—	0.31	—	—	4
MADCHOW-04	E0.06	—	—	—	—	—	—	—	—	—	—	—	—	1
MADCHOW-05	E0.03	—	—	—	—	—	—	—	—	—	—	—	—	1
MADCHOW-09	E0.04	—	—	—	—	—	—	E0.06	E0.03	—	—	—	—	3
MADCHOW-18	—	—	—	—	*0.51	E0.06	—	—	—	—	—	—	—	2
MADCHOW-19	—	—	—	—	*0.82	—	—	—	—	—	—	—	—	1
MADCHOW-23	—	—	—	—	—	—	—	—	—	—	—	—	V0.02	0
MADCHOW-25	—	—	—	—	—	—	—	—	—	—	—	E0.08	—	1
MADCHOW-27	—	—	—	—	—	—	—	—	—	—	—	E0.09	—	1
Number of detections	5	1	1	1	3	2	1	3	2	1	1	2	0	
Detection frequency (percent)	16.7	3.3	3.3	3.3	10	6.7	3.3	10	6.7	3.3	3.3	6.7	0	[3]30
						Flow-path wells								
MADCHOWFP-01	E0.04	—	—	—	—	—	—	—	—	—	—	—	—	1

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

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

Table 6A. Pesticides and pesticide degradates detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the thirty grid wells. All analytes are listed in *table 3C*. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; µg/L, micrograms per liter; —, not detected]

GAMA identification number	Deethyl-atrazine (µg/L) (04040)	Simazine (µg/L) (04035)	3,4-Dichloro-aniline (µg/L) (61625)	Atrazine (µg/L) (39632)	Hexazinone (µg/L) (04025)	Tebuthiuron (µg/L) (82670)	Pesticide detections per well
Threshold type[1]	**na**	**MCL-US**	**MCL-CA**	**MCL-CA**	**HAL-US**	**HAL-US**	
Threshold level	**na**	**4**	**1**	**1**	**400**	**500**	
[LRL]	**[0.014]**	**[0.006]**	**[0.006]**	**[0.007]**	**[0.008]**	**[0.016]**	
Grid wells							
MADCHOW-01	E0.015	E0.006	E0.005	0.009	—	—	4
MADCHOW-03	E0.007	—	—	—	—	—	1
MADCHOW-04	—	0.018	E0.004	—	—	—	2
MADCHOW-06	—	0.011	—	—	—	E0.01	2
MADCHOW-09	E0.007	E0.006	E0.009	—	—	—	3
MADCHOW-18	E0.056	E0.007	E0.005	0.039	—	—	4
MADCHOW-26	E0.018	—	E0.004	E0.005	0.009	—	4
MADCHOW-29	E0.006	0.018	—	—	—	—	2
Number of detections	6	6	5	3	1	1	
Detection frequency (percent)	20	20	17	10	3	3	[2]27
Flow-path wells							
MADCHOWFP-01	E0.038	—	—	0.008	0.011	—	3
MADCHOWFP-03	—	—	E0.004	—	0.010	—	2

---

[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] Frequency of detection of at least one pesticide or pesticide degradate in the grid wells. The grid wells with detections in *table 6B* are a subset of the grid wells with detections in *table 6A*, therefore the detection frequency of 27 percent applies to both tables. Note the detection frequency in *table 6A* does not include the three fumigants already presented as volatile organic compounds in *table 5*; if these fumigants were included, the detection frequency for any pesticide(s) in the grid wells would be 30 percent.

Table 6B. Polar pesticides and metabolites detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells except MADCHOW-17 were analyzed. Only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the twenty-nine grid wells. All analytes are listed in *table 3D*. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera-Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; —, not detected]

GAMA identification number	Diuron (µg/L) (49300)	Bromacil (µg/L) (04029)	Deisopropyl atrazine (µg/L) (04038)	Dinoseb (µg/L) (49301)	Norflurazon (µg/L) (49293)	Imazethapyr (µg/L) (50407)	Pesticide detections per well
Threshold type[1]	**RSD5-US**	**HAL-US**	**na**	**MCL-US**	**na**	**na**	
Threshold level	**20**	**70**	**na**	**7**	**na**	**na**	
[LRL]	**[0.04]**	**[0.02]**	**[0.08]**	**[0.04]**	**[0.02]**	**[0.04]**	
Grid wells							
MADCHOW-01	E0.04	—	—	—	—	—	3
MADCHOW-09	0.15	0.03	—	—	—	—	3
MADCHOW-18	0.08	E0.01	E0.03	E0.04	—	—	6
MADCHOW-29	—	—	—	—	E0.01	—	2
Number of detections	3	2	1	1	1	0	
Detection frequency (percent)	10	7	3	3	3	0	(2)
Flow-path wells							
MADCHOWFP-03	E0.01	—	—	—	—	E0.01	2

[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] The grid wells with detections in *table 6B* are a subset of the grid wells with detections in *table 6A*, therefore the detection frequency of 27 percent reported in *table 6A* applies to both tables. Note the detection frequency reported in *table 6A* does not include the three fumigants already presented as volatile organic compounds in *table 5*; if these fumigants were included, the detection frequency for any pesticide(s) in the grid wells would be 30 percent.

Table 7. Constituents of special interest (*N*-nitrosodimethylamine [NDMA], perchlorate, and low-level 1,2,3-trichloropropane [1,2,3-TCP]) detected in samples collected in the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Information about the analytes given in *table 3F*. Samples from all thirty-five wells were analyzed for 1,2,3-TCP, samples from 34 wells were analyzed for perchlorate, and samples from ten slow wells were analyzed for NDMA. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** MRL, minimum reporting level; µg/L, micrograms per liter; nc, sample not collected; —, not detected]

GAMA identification number	*N*-Nitroso-dimethylamine (NDMA) (µg/L) (34438)	Perchlorate (µg/L) (61209)	1,2,3-Trichloropropane (µg/L) (77443)
Threshold type[1]	**NL-CA**	**MCL-CA**	**HAL-US**
Threshold level	**0.01**	**6**	**40**
[MRL]	**[0.0020]**	**[0.10]**	**[0.0050]**
Grid wells			
MADCHOW-01	nc	0.22	0.0161
MADCHOW-02	nc	0.19	—
MADCHOW-03	nc	—	—
MADCHOW-04	nc	—	—
MADCHOW-05	nc	0.63	—
MADCHOW-06	nc	0.23	0.0237
MADCHOW-07	0.0025	0.84	—
MADCHOW-08	—	—	—
MADCHOW-09	nc	1.80	0.0055
MADCHOW-10	—	—	0.0069
MADCHOW-11	nc	0.15	—
MADCHOW-12	nc	—	—
MADCHOW-13	nc	0.12	—
MADCHOW-14	nc	0.20	—
MADCHOW-15	nc	—	0.0052
MADCHOW-16	nc	0.22	0.0050
MADCHOW-17	nc	0.53	—
MADCHOW-18	nc	0.82	0.0288
MADCHOW-19	nc	0.17	—
MADCHOW-20	nc	0.16	0.0052

Table 7. Constituents of special interest (*N*-nitrosodimethylamine [NDMA], perchlorate, and low-level 1,2,3-trichloropropane [1,2,3-TCP]) detected in samples collected in the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Information about the analytes given in *table 3F*. Samples from all thirty-five wells were analyzed for 1,2,3-TCP, samples from 34 wells were analyzed for perchlorate, and samples from ten slow wells were analyzed for NDMA. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** MRL, minimum reporting level; µg/L, micrograms per liter; nc, sample not collected; —, not detected]

GAMA identification number	*N*-Nitroso-dimethylamine (NDMA) (µg/L) (34438)	Perchlorate (µg/L) (61209)	1,2,3-Trichloropropane (µg/L) (77443)
Threshold type[1]	**NL-CA**	**MCL-CA**	**HAL-US**
Threshold level	**0.01**	**6**	**40**
[MRL]	**[0.0020]**	**[0.10]**	**[0.0050]**
MADCHOW-21	nc	0.88	—
MADCHOW-22	—	—	0.0052
MADCHOW-23	—	—	—
MADCHOW-24	nc	0.30	—
MADCHOW-25	nc	0.16	—
MADCHOW-26	nc	0.13	—
MADCHOW-27	nc	—	0.0198
MADCHOW-28	nc	0.91	—
MADCHOW-29	nc	0.29	—
MADCHOW-30	nc	0.27	—
Number of wells with detections	1	21	10
Detection frequency (percent)[2]	not calculated	70	33
Flow-path wells			
MADCHOWFP-01	—	0.66	—
MADCHOWFP-02	—	nc	0.0051
MADCHOWFP-03	—	0.11	—
MADCHOWFP-04	—	—	—
MADCHOWFP-05	—	—	—

[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] Frequency of detection for constituents of special interest analyzed in the 30 grid wells sampled.

Table 8. Nutrients detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed. Information about the analytes given in *table 3G*. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; mg/L, milligrams per liter; na, not available; —, not detected; *, value above threshold level]

GAMA identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (ammonia + nitrite + nitrate + organic-nitrogen), as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorous (mg/L) (00671)
Threshold type[1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Threshold level	**[2]24.7**	**10**	**1**	**na**	**na**
[LRL]	**[0.02]**	**[0.04]**	**[0.002]**	**[0.06]**	**[0.006]**
		Grid wells			
MADCHOW-01	—	3.88	—	4.03	0.048
MADCHOW-02	—	2.16	—	2.23	0.057
MADCHOW-03	—	0.78	—	0.81	0.058
MADCHOW-04	—	0.42	—	0.45	0.094
MADCHOW-05	—	2.88	—	2.96	0.033
MADCHOW-06	—	4.18	—	4.23	0.018
MADCHOW-07	—	4.07	—	4.20	0.024
MADCHOW-08	—	0.54	—	0.56	0.044
MADCHOW-09	—	*10.3	—	10.9	0.028
MADCHOW-10	—	0.50	—	0.52	0.038
MADCHOW-11	—	1.00	—	1.04	0.041
MADCHOW-12	0.027	—	—	—	0.017
MADCHOW-13	—	0.85	—	0.86	0.048
MADCHOW-14	—	1.24	—	1.21	0.032
MADCHOW-15	—	0.87	—	0.88	0.104
MADCHOW-16	—	1.03	—	1.05	0.040
MADCHOW-17	E0.012	5.49	—	5.60	0.148
MADCHOW-18	E0.014	5.96	—	6.03	0.082
MADCHOW-19	—	1.75	—	1.89	0.047
MADCHOW-20	—	6.00	—	6.29	0.044
MADCHOW-21	—	5.43	—	5.67	0.153
MADCHOW-22	—	1.56	0.01	1.56	0.029
MADCHOW-23	—	0.34	0.01	0.34	0.035
MADCHOW-24	—	2.78	—	2.84	0.024
MADCHOW-25	—	*38.6	—	38.7	0.056
MADCHOW-26	—	3.00	—	2.93	0.051
MADCHOW-27	—	1.16	—	1.25	0.064

Table 8. Nutrients detected in s amples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[The five digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed. Information about the analytes given in *table 3G*. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; mg/L, milligrams per liter; na, not available; —, not detected; *, value above threshold level]

GAMA identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (ammonia + nitrite + nitrate + organic-nitrogen), as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorous (mg/L) (00671)
Threshold type[1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Threshold level	**[2]24.7**	**10**	**1**	**na**	**na**
[LRL]	**[0.02]**	**[0.04]**	**[0.002]**	**[0.06]**	**[0.006]**
MADCHOW-28	—	8.57	—	9.17	0.053
MADCHOW-29	—	6.44	—	6.55	0.041
MADCHOW-30	—	3.10	—	3.17	0.017
Flow-path wells					
MADCHOWFP-01	—	9.95	—	10.5	0.026
MADCHOWFP-02	E0.011	1.33	—	1.46	0.044
MADCHOWFP-03	—	9.97	—	10.6	0.037
MADCHOWFP-04	—	0.22	E0.001	0.23	0.108
MADCHOWFP-05	0.034	—	—	E0.03	0.025

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

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five digit number in parenthesis below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed. Information about analytes given in *table 3H*. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** LRL, laboratory reporting level; mg/L, milligrams per liter; E, estimated value; na, not available; —, not detected; *, value above threshold level; **, value above upper threshold level]

GAMA identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Bicarbonate[1] (mg/L)	Carbonate[1] (mg/L)	Bromide (mg/L) (71870)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica (mg/L) (00955)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)
Threshold type[2]	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**SMCL-CA**	**MCL-CA**	**na**	**na**	**SMCL-CA**	**SMCL-CA**
Threshold level	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**[3]250 (500)**	**2**	**na**	**na**	**[3]250 (500)**	**[3]500 (1,000)**
[LRL]	**[0.04]**	**[0.02]**	**[0.02]**	**[0.2]**	**[1]**	**[1]**	**[0.02]**	**[0.12]**	**[0.12]**	**[0.002]**	**[0.018]**	**[0.18]**	**[10]**
						Grid wells							
MADCHOW-01	48.7	15.5	6.39	27.5	225	—	0.05	25.2	E0.09	E0.002	68.9	14.4	340
MADCHOW-02	15.4	4.53	3.04	19.3	79	—	0.04	16.3	0.17	0.004	72.8	3.13	182
MADCHOW-03	16.6	4.63	2.78	20.8	92	—	0.04	17.4	E0.12	E0.001	60.7	4.05	172
MADCHOW-04	13.6	5.46	2.86	11.7	93	—	E0.02	3.99	E0.11	0.009	43.6	2.73	129
MADCHOW-05	19.9	6.60	1.86	24.2	118	—	0.07	15.0	0.24	E0.002	73.8	7.43	222
MADCHOW-06	32.8	3.29	4.36	42.9	160	1	0.10	21.7	0.13	0.022	29.5	22.5	261
MADCHOW-07	27.8	8.51	2.19	23.6	128	—	0.08	13.3	0.34	0.007	69.9	24.3	264
MADCHOW-08	24.1	6.31	4.52	22.7	114	—	0.08	33.9	0.16	0.025	71.2	7.78	243
MADCHOW-09	78.4	23.5	2.71	34.3	308	—	0.13	58.1	0.15	0.004	54.6	18.3	475
MADCHOW-10	13.6	3.32	6.35	18.9	86	—	0.05	19.5	0.15	0.007	73.2	2.97	193
MADCHOW-11	25.1	6.12	4.12	25.2	114	—	0.09	33.8	0.14	0.023	69.4	11.0	257
MADCHOW-12	64.5	16.1	2.00	258	98	1	1.87	**506	—	0.880	16.3	E0.88	**1,070
MADCHOW-13	7.38	2.61	1.58	33.0	88	—	0.05	16.6	0.13	0.009	59.1	3.31	180
MADCHOW-14	13.1	5.02	1.72	16.4	81	—	0.05	15.5	0.12	—	62.8	2.70	176
MADCHOW-15	8.41	3.58	3.21	19.7	84	—	0.03	9.06	0.21	E0.001	48.2	1.91	144
MADCHOW-16	16.6	4.97	2.87	23.5	92	—	0.06	21.3	0.20	0.007	80.7	3.54	209
MADCHOW-17	41.8	12.6	2.45	18.3	185	—	0.07	13.6	E0.12	0.002	43.6	11.6	273
MADCHOW-18	39.0	13.0	6.28	32.1	180	—	0.09	22.6	0.15	0.002	73.2	26.9	337
MADCHOW-19	17.6	8.12	4.40	17.8	106	—	0.06	15.0	0.15	E0.002	74.7	8.44	202
MADCHOW-20	102	27.0	5.39	63.5	411	—	0.13	61.4	E0.10	0.005	63.9	62.0	*632
MADCHOW-21	18.7	7.09	1.87	21.7	114	—	0.07	10.1	0.20	E0.001	86.3	2.87	246
MADCHOW-22	24.2	3.11	1.80	28.0	112	1	0.06	25.2	0.16	0.013	56.6	4.39	220
MADCHOW-23	7.17	1.47	1.53	55.4	126	1.4	0.07	22.9	0.29	0.028	39.7	4.70	198
MADCHOW-24	23.0	4.50	2.15	26.9	102	—	0.07	29.1	0.12	E0.002	33.4	4.93	199

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[The five digit number in parenthesis below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed. Information about analytes given in *table 3H*. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** LRL, laboratory reporting level; mg/L, milligrams per liter; E, estimated value; na, not available; —, not detected; *, value above threshold level; **, value above upper threshold level]

GAMA identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Bicarbonate[1] (mg/L)	Carbonate[1] (mg/L)	Bromide (mg/L) (71870)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica (mg/L) (00955)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)
Threshold type[2]	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**SMCL-CA**	**MCL-CA**	**na**	**na**	**SMCL-CA**	**SMCL-CA**
Threshold level	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**[3]250 (500)**	**2**	**na**	**na**	**[3]250 (500)**	**[3]500 (1,000)**
[LRL]	**[0.04]**	**[0.02]**	**[0.02]**	**[0.2]**	**[1]**	**[1]**	**[0.02]**	**[0.12]**	**[0.12]**	**[0.002]**	**[0.018]**	**[0.18]**	**[10]**
MADCHOW-25	181	57.4	7.01	85.8	653	—	0.23	120	E0.10	0.038	64.2	35.9	**1,040
MADCHOW-26	135	35.0	6.86	81.6	321	—	0.19	222	0.13	0.018	67.0	60.4	*854
MADCHOW-27	35.4	8.67	2.20	43.5	190	1	0.06	19.4	0.16	0.018	68.6	28.5	280
MADCHOW-28	145	35.7	6.77	60.9	480	—	0.21	152	E0.09	0.007	63.6	26.7	*773
MADCHOW-29	76.3	19.7	3.87	53.6	339	—	0.08	30.6	E0.08	0.004	58.0	45.8	*504
MADCHOW-30	15.6	1.00	1.33	38.9	80	1	0.09	29.9	0.15	E0.002	16.3	5.70	162
Flow-path wells													
MADCHOWFP-01	90.9	15.9	5.14	45.1	320	1	0.15	72.7	E0.07	0.005	64.8	19.7	* 528
MADCHOWFP-02	18.8	4.74	2.36	17.9	86	—	0.06	20.0	E0.09	E0.001	62.4	3.54	195
MADCHOWFP-03	658	112	10.6	298	222	—	2.12	**1,850	—	0.021	59.5	25.0	**4,340
MADCHOWFP-04	19.7	4.71	4.06	20.4	101	—	0.06	23.9	0.14	0.021	63.2	3.49	202
MADCHOWFP-05	40.0	8.39	3.20	32.0	165	—	0.07	15.0	0.25	0.038	71.0	43.5	309

[1] Bicarbonate and carbonate concentrations were calculated from the laboratory alkalinity and pH values (*table 4*) using the advanced speciation method (*http://or.water.usgs.gov/alk/methods.html*) with pK1 = 6.35, pK2 = 10.33, and pKW = 14.

[2] 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.

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

Table 10. Trace elements detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed. Mercury and thallium were analyzed, but not detected. *Table 3H* contains additional information about the analytes. Values less than the study reporting level (SRL) are reported with a less than or equal to sign (≤). **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level, na, not available; µg/L, micrograms per liter; —, not detected; *, value above threshold level; ≤, less than or equal to]

GAMA identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
[LRL] or [SRL][1]	**[1.6][1]**	**[0.14]**	**[0.06]**	**[0.36][1]**	**[0.008]**	**[6]**	**[0.04]**	**[0.42[1]**	**[0.02]**	**[1.7][1]**	**[6][1]**	**[0.65[1]**
Threshold type[2]	**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						
MADCHOW-01	—	—	0.75	182	—	38	—	1.3	0.06	2.0	≤5	≤0.64
MADCHOW-02	—	—	1.7	54	—	23	—	2.8	—	—	12	≤0.12
MADCHOW-03	—	—	1.2	51	—	26	—	0.98	—	—	—	≤0.07
MADCHOW-04	—	—	2.2	12	—	21	—	0.65	—	—	—	≤0.24
MADCHOW-05	—	—	2.6	81	—	21	0.06	1.6	0.02	≤0.8	—	≤0.41
MADCHOW-06	≤1.0	—	2.2	37	—	30	—	0.69	0.04	≤1.0	—	≤0.26
MADCHOW-07	—	—	*10.8	66	—	19	—	1.2	E0.01	—	—	≤0.15
MADCHOW-08	≤1.0	E0.09	*12.6	98	—	24	—	0.98	—	≤0.8	—	≤0.33
MADCHOW-09	—	—	0.79	329	—	17	E0.03	3.0	0.06	≤1.4	18	≤0.65
MADCHOW-10	2.4	E0.08	2.2	118	—	33	—	2.0	—	—	—	≤0.06
MADCHOW-11	≤0.9	—	7.9	99	E0.005	32	—	1.4	—	≤1.3	—	≤0.09
MADCHOW-12	≤1.1	—	*20.3	868	E0.01	51	E0.03	—	0.03	—	86	—
MADCHOW-13	≤0.8	—	3.8	31	—	22	—	2.9	—	—	—	≤0.21
MADCHOW-14	—	—	2.3	52	—	26	—	4.4	—	—	—	≤0.14
MADCHOW-15	—	—	2.1	43	—	19	—	≤0.40	—	≤0.5	—	≤0.20
MADCHOW-16	≤1.0	—	2.6	118	—	31	—	2.2	—	—	—	—
MADCHOW-17	—	—	1.6	96	—	14	—	0.67	0.02	—	—	≤0.07
MADCHOW-18	—	—	0.92	172	—	29	—	1.1	E0.02	≤0.8	—	≤0.33
MADCHOW-19	1.8	—	3.8	97	—	17	—	1.4	—	—	—	—
MADCHOW-20	—	—	2.6	159	—	32	—	3.5	0.03	≤0.8	≤5	0.84
MADCHOW-21	1.7	—	2.0	118	E0.01	11	—	1.1	E0.01	—	—	—
MADCHOW-22	≤0.9	E0.08	7.4	507	—	18	—	—	E0.01	—	—	—
MADCHOW-23	1.7	E0.09	*16.2	164	—	32	—	—	—	—	—	≤0.12

Table 10. Trace elements detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed. Mercury and thallium were analyzed, but not detected. *Table 3H* contains additional information about the analytes. Values less than the study reporting level (SRL) are reported with a less than or equal to sign (≤). **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level, na, not available; µg/L, micrograms per liter; —, not detected; *, value above threshold level; ≤, less than or equal to]

GAMA identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
[LRL] or [SRL][1]	**[1.6][1]**	**[0.14]**	**[0.06]**	**[0.36][1]**	**[0.008]**	**[6]**	**[0.04]**	**[0.42[1]**	**[0.02]**	**[1.7][1]**	**[6][1]**	**[0.65[1]**
Threshold type[2]	**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**
MADCHOW-24	≤1.2	—	1.9	59	—	14	E0.02	8.6	E0.01	—	≤5	1.10
MADCHOW-25	1.9	—	1.6	557	—	43	E0.02	1.4	0.16	2.0	—	≤0.45
MADCHOW-26	1.7	—	2.7	252	—	40	E0.02	3.0	0.07	≤1.4	—	1.10
MADCHOW-27	2.1	E0.09	6.3	236	—	47	—	0.53	E0.02	—	≤5	2.38
MADCHOW-28	1.9	—	2.0	471	—	20	—	3.7	0.06	≤0.9	—	≤0.10
MADCHOW-29	1.7	—	1.8	154	—	32	—	2.2	0.03	≤0.5	—	0.90
MADCHOW-30	3.1	—	2.4	27	—	16	—	14.8	—	—	≤4	≤0.07
Flow-path wells												
MADCHOWFP-01	—	—	3.8	350	—	20	E0.03	2.8	0.05	≤0.9	—	≤0.04
MADCHOWFP-02	—	—	1.9	117	E0.004	15	—	2.3	—	—	—	2.69
MADCHOWFP-03	E2.7	—	3.1	*2,170	—	32	E0.09	1.1	0.32	—	E12	≤0.42
MADCHOWFP-04	1.8	—	1.2	177	—	20	—	≤0.15	E0.01	—	22	≤0.15
MADCHOWFP-05	≤1.6	—	2.7	51	—	32	—	—	0.02	—	75	—

Table 10. Trace elements detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed. Mercury and thallium were analyzed, but not detected. *Table 3H* contains additional information about the analytes. Values less than the study reporting level (SRL) are reported with a less than or equal to sign (≤). **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level, na, not available; µg/L, micrograms per liter; —, not detected;
*, value above threshold level; ≤, less than or equal to]

GAMA identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver, dissolved (µg/L) (01075)	Strontium (µg/L) (01080)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
[LRL] or [SRL][1]	[1]	[0.2][1]	[0.2]	[0.36][1]	[0.04]	[0.1]	[0.8]	[0.11][1]	[0.02]	[0.1][1]	[4.8][1]
Threshold type[2]	na	SMCL-CA	HAL-US	MCL-CA	MCL-US	SMCL-CA	HAL-US	na	MCL-US	NL-CA	SMCL-CA[3]
Threshold level	na	50	40	100	50	100	4,000	na	30	50	5,000
					Grid wells						
MADCHOW-01	2.6	0.6	1.4	0.80	0.06	—	370	—	8.64	14.8	≤4.5
MADCHOW-02	1.1	0.6	2.5	≤0.28	0.12	—	114	—	0.28	25.1	9.8
MADCHOW-03	1.1	—	2.2	≤0.11	0.09	—	135	—	0.18	19.1	4.9
MADCHOW-04	2.0	≤0.2	1.5	—	E0.02	—	108	≤0.08	1.61	7.0	≤0.94
MADCHOW-05	1.9	1.9	3.7	≤0.27	0.77	—	160	≤0.06	0.28	19.6	301
MADCHOW-06	5.4	—	2.9	≤0.19	0.28	—	87.0	0.15	12.8	22.7	21.2
MADCHOW-07	10.6	—	4.0	≤0.22	1.6	—	238	≤0.03	0.25	19.6	16.6
MADCHOW-08	3.3	6.5	2.9	≤0.17	0.93	—	237	≤0.11	2.63	2.6	≤3.3
MADCHOW-09	1.7	4.7	0.4	0.37	0.30	—	715	≤0.06	6.28	13.0	96.5
MADCHOW-10	4.9	3.4	1.7	—	0.12	—	147	0.64	0.17	9.3	—
MADCHOW-11	5.2	29.5	3.0	≤0.17	0.54	—	238	≤0.10	0.55	4.7	≤1.2
MADCHOW-12	7.1	*420	1.9	≤0.23	0.09	—	632	0.38	E0.01	0.33	≤1.4
MADCHOW-13	1.6	≤0.2	2.7	—	0.13	—	67.2	0.13	0.14	44.9	10.8
MADCHOW-14	5.7	0.3	1.9	—	0.16	—	104	0.22	0.23	24.7	8.1
MADCHOW-15	E0.90	—	6.5	—	0.08	—	112	≤0.11	0.18	8.4	27.2
MADCHOW-16	1.6	1.5	3.9	—	0.13	—	145	≤0.07	0.18	21.8	≤2.3
MADCHOW-17	11.6	—	0.8	≤0.14	0.34	—	268	—	1.32	37.1	6.9
MADCHOW-18	3.3	≤0.2	2.1	≤0.28	0.07	—	351	—	1.42	16.2	≤3.0
MADCHOW-19	—	—	2.7	≤0.12	0.34	—	166	≤0.05	0.45	13.1	28.3
MADCHOW-20	20.0	—	1.2	0.45	0.38	—	861	0.17	*52.7	14.3	≤1.1
MADCHOW-21	E0.80	0.4	0.8	≤0.17	0.31	—	163	≤0.04	0.40	29.2	16.0
MADCHOW-22	2.8	24.9	1.8	≤0.10	0.34	—	176	0.19	0.77	27.1	≤4.7
MADCHOW-23	2.2	10.0	3.1	—	0.09	—	68.5	1.2	0.59	*108	≤3.2

Table 10. Trace elements detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all thirty-five wells were analyzed. Mercury and thallium were analyzed, but not detected. *Table 3H* contains additional information about the analytes. Values less than the study reporting level (SRL) are reported with a less than or equal to sign (≤). **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level, na, not available; µg/L, micrograms per liter; —, not detected;
*, value above threshold level; ≤, less than or equal to]

GAMA identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver, dissolved (µg/L) (01075)	Strontium (µg/L) (01080)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
[LRL] or [SRL][1]	**[1]**	**[0.2][1]**	**[0.2]**	**[0.36][1]**	**[0.04]**	**[0.1]**	**[0.8]**	**[0.11][1]**	**[0.02]**	**[0.1][1]**	**[4.8][1]**
Threshold type[2]	**na**	**SMCL-CA**	**HAL-US**	**MCL-CA**	**MCL-US**	**SMCL-CA**	**HAL-US**	**na**	**MCL-US**	**NL-CA**	**SMCL-CA[3]**
Threshold level	**na**	**50**	**40**	**100**	**50**	**100**	**4,000**	**na**	**30**	**50**	**5,000**
MADCHOW-24	1.6	0.8	3.0	≤0.19	0.24	—	189	≤0.09	1.53	23.9	15.4
MADCHOW-25	18.2	≤0.1	0.8	1.9	0.10	—	1,650	≤0.09	*87.0	20.1	≤2.8
MADCHOW-26	24.7	—	1.8	1.2	0.24	—	1,030	0.18	*47.3	13.7	≤2.0
MADCHOW-27	8.7	≤0.1	2.1	≤0.29	0.58	—	302	1.4	12.2	20.3	≤2.1
MADCHOW-28	15.8	≤0.1	0.8	0.65	0.34	—	1,260	≤0.09	29.8	13.0	64.9
MADCHOW-29	12.1	0.3	2.1	0.40	0.30	—	556	0.18	*56.1	12.0	≤1.5
MADCHOW-30	E0.60	≤0.1	2.8	≤0.10	0.41	—	122	0.14	0.46	34.6	—
					Flow-path wells						
MADCHOWFP-01	8.9	3.7	0.9	0.46	0.41	—	803	0.17	15.7	16.9	22.9
MADCHOWFP-02	1.9	—	0.8	—	0.14	—	188	≤0.11	0.19	13.6	—
MADCHOWFP-03	25.6	—	E0.5	4.2	0.36	E0.3	* 6,160	—	24.4	9.80	150
MADCHOWFP-04	2.7	16.1	1.7	≤0.20	0.07	—	166	0.16	0.26	4.40	19.6
MADCHOWFP-05	18.0	32.0	5.8	≤0.25	E0.02	—	313	≤0.09	—	≤0.05	38.0

[1] Result is ≤ reported value, based on QC data (including but not limited to field blanks, source-solution blanks, trip blanks, NWQL set blanks, NWQL blank water certificates, and BQS Blank Program data).

[2] 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.

[3] The secondary maximum contaminant level for zinc is listed as SMCL-CA since SMCLs established by CDPH are used in this report for all constituents that have SMCL-CAs.

Table 11. Species of inorganic arsenic and iron detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[Data in this table analyzed at U.S. Geological Survey Trace Metal Laboratory in Boulder, Colorado using research methods and are not stored in the USGS NWIS database. Information about analytes given in *table 3I*. Samples from the ten slow wells were analyzed. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** MDL, method detection limit; na, not available; µg/L, micrograms per liter; —, not detected]

GAMA identification number	Arsenic (µg/L)	Arsenic (III) (µg/L)	Iron (µg/L)	Iron (II) (µg/L)
Threshold type[1]	**MCL-US**	**na**	**SMCL-CA**	**na**
Threshold level	**10**	**na**	**300**	**na**
[MDL]	**[0.5]**	**[1]**	**[2]**	**[2]**
		Grid wells		
MADCHOW-07	2.3	—	—	—
MADCHOW-08	3.1	—	—	—
MADCHOW-22	1.8	—	—	—
MADCHOW-23	3.4	—	—	—
		Flow-path wells		
MADCHOWFP-01	0.8	—	—	—
MADCHOWFP-03	0.5	—	4	4
MADCHOWFP-04	—	—	16	6
MADCHOWFP-05	1.0	2.2	63	4

[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.

Table 12. Results for analyses of stable isotope ratios and tritium and carbon-14 activities in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Information about analytes given in *table 3J*. Samples from all thirty-five 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. **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** na, not available; pCi/L, picocuries per liter; <, less than]

GAMA identification number	$\delta^{2}H$ (per mil) (82082)	$\delta^{18}O$ (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{13}C$ (per mil) (82081)	Carbon-14 (percent modern) (49933)
Threshold type[1]	**na**	**na**	**MCL-CA**	**na**	**na**
Threshold level	**na**	**na**	**20,000**	**na**	**na**
			Grid wells		
MADCHOW-01	–76.1	–10.53	19.8	–15.78	119
MADCHOW-02	–68.0	–9.43	0.6	-19.08	78
MADCHOW-03	–73.6	–10.16	3.1	–17.93	80
MADCHOW-04	–87.4	–12.01	12.9	–15.75	104
MADCHOW-05	–59.4	–7.88	1.1	–15.44	76
MADCHOW-06	–55.7	–7.30	5.4	–18.47	102
MADCHOW-07	–56.1	–7.22	1.3	–15.18	52
MADCHOW-08	–63.4	–8.89	1.0	–16.02	50
MADCHOW-09	9.7	–10.78	16.7	–11.33	113
MADCHOW-10	–66.8	–9.34	<0.3	–14.01	63
MADCHOW-11	–63.7	–8.84	<0.3	–13.89	44
MADCHOW-12	–72.5	–9.87	0.8	–15.35	7
MADCHOW-13	–69.9	–9.74	1.2	–14.17	61
MADCHOW-14	–68.3	–9.59	1.0	–13.46	82
MADCHOW-15	–81.8	–11.19	0.5	–24.17	38
MADCHOW-16	–68.3	–9.63	0.4	–15.65	58
MADCHOW-17	4.5	–7.09	9.9	–16.27	110
MADCHOW-18	–74.9	–10.39	22.6	–13.87	113
MADCHOW-19	–66.6	–8.94	2.7	–13.81	70
MADCHOW-20	–70.9	–9.54	1.3	–15.94	107
MADCHOW-21	–56.5	–7.15	<0.3	–16.74	68
MADCHOW-22	–67.7	–9.32	0.5	–15.57	16
MADCHOW-23	–78.6	–10.54	<0.3	–19.60	5
MADCHOW-24	–67.7	–9.16	4.7	–14.97	54
MADCHOW-25	–62.3	–8.38	3.5	–10.78	112
MADCHOW-26	–65.7	–9.17	0.8	–16.75	100
MADCHOW-27	–88.1	–12.05	27.2	–16.72	98
MADCHOW-28	–75.6	–10.39	21.6	–12.46	112
MADCHOW-29	–70.5	–9.66	8.7	.24	107
MADCHOW-30	–60.5	–8.06	1.1	–19.05	22
			Flow-path wells		
MADCHOWFP-01	–73.0	–9.69	15.9	–13.80	99
MADCHOWFP-02	–68.6	–9.47	0.8	–16.54	86
MADCHOWFP-03	–72.2	–9.47	8.7	–16.79	104
MADCHOWFP-04	–75.2	–10.55	7.5	–16.58	96
MADCHOWFP-05	–58.4	–7.79	0.5	–14.17	11

[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.

Table 13A. Uranium isotopes detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from twenty-nine wells were analyzed. *Table 3J* contains additional information about the analytes. Measured values less than the sample-specific critical level (ssL_C) are reported as nondetects (—). **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; nc, sample not collected; *, value above threshold level]

GAMA identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)	
Threshold type[1]	MCL-CA		MCL-CA		MCL-CA	
Threshold level	[2]20		[2]20		[2]20	
Reporting level method	result ± CSU	ssL_C	result ± CSU	ssL_C	result ± CSU	ssL_C
			Grid wells			
MADCHOW-01	4.00 ± 0.21	0.024	0.140 ± 0.029	0.015	2.90 ± 0.16	0.015
MADCHOW-02	nc	nc	nc	nc	nc	nc
MADCHOW-03	nc	nc	nc	nc	nc	nc
MADCHOW-04	nc	nc	nc	nc	nc	nc
MADCHOW-05	nc	nc	nc	nc	nc	nc
MADCHOW-06	nc	nc	nc	nc	nc	nc
MADCHOW-07	0.200 ± 0.030	0.013	—	0.012	0.100 ± 0.021	0.0095
MADCHOW-08	1.100 ± 0.086	0.014	0.027 ± 0.011	0.012	0.920 ± 0.079	0.010
MADCHOW-09	3.30 ± 0.18	0.020	0.110 ± 0.024	0.011	2.20 ± 0.13	0.013
MADCHOW-10	0.120 ± 0.022	0.017	—	0.012	0.067 ± 0.015	0.0071
MADCHOW-11	0.280 ± 0.045	0.022	0.020 ± 0.013	0.015	0.180 ± 0.033	0.013
MADCHOW-12	0.039 ± 0.017	0.013	—	0.016	0.022 ± 0.012	0.013
MADCHOW-13	0.058 ± 0.020	0.011	—	0.014	0.063 ± 0.020	0.011
MADCHOW-14	0.140 ± 0.028	0.013	—	0.015	0.086 ± 0.022	0.013
MADCHOW-15	0.120 ± 0.030	0.020	—	0.017	0.140 ± 0.031	0.014
MADCHOW-16	0.180 ± 0.034	0.013	—	0.015	0.066 ± 0.022	0.013
MADCHOW-17	0.490 ± 0.058	0.018	0.020 ± 0.013	0.015	0.510 ± 0.059	0.013
MADCHOW-18	0.680 ± 0.055	0.017	0.050 ± 0.014	0.012	0.440 ± 0.042	0.012
MADCHOW-19	0.370 ± 0.036	0.0069	0.018 ± 0.011	0.0084	0.140 ± 0.022	0.012
MADCHOW-20	*24.0 ± 1.1	0.050	*1.50 ± 0.10	0.013	*15.00 ± 0.66	0.047
MADCHOW-21	0.320 ± 0.035	0.0068	0.011 ± 0.007	0.0083	0.260 ± 0.028	0.0068
MADCHOW-22	0.340 ± 0.035	0.0068	—	0.0082	0.270 ± 0.031	0.0068
MADCHOW-23	0.320 ± 0.036	0.0087	—	0.011	0.260 ± 0.036	0.0087
MADCHOW-24	0.820 ± 0.064	0.0092	0.0140 ± 0.0095	0.011	0.400 ± 0.043	0.0092
MADCHOW-25	*39.0 ± 1.7	0.056	*1.30 ± 0.10	0.013	*26.0 ± 1.1	0.051
MADCHOW-26	*23.0 ± 1.7	0.17	*0.86 ± 0.22	0.10	*14.0 ± 1.1	0.17
MADCHOW-27	5.90 ± 0.28	0.018	0.220 ± 0.028	0.0078	3.70 ± 0.19	0.017
MADCHOW-28	*17.0 ± 1.2	0.11	*0.65 ± 0.14	0.079	*9.00 ± 0.74	0.11
MADCHOW-29	*27.0 ± 1.9	0.13	*0.98 ± 0.20	0.088	*19.0 ± 1.4	0.13
MADCHOW-30	0.270 ± 0.032	0.021	—	0.012	0.160 ± 0.023	0.010
			Flow-path wells			
MADCHOWFP-01	9.20 ± 0.44	0.030	0.290 ± 0.044	0.012	5.00 ± 0.26	0.027
MADCHOWFP-02	0.140 ± 0.028	0.015	—	0.013	0.076 ± 0.018	0.010
MADCHOWFP-03	10.00 ± 0.46	0.021	0.290 ± 0.034	0.011	6.20 ± 0.29	0.018
MADCHOWFP-04	0.220 ± 0.027	0.011	—	0.011	0.082 ± 0.017	0.0093
MADCHOWFP-05	nc	nc	nc	nc	nc	nc

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

Table 13B. Gross alpha and gross beta particle activities detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from the ten slow wells were analyzed. *Table 3J* contains additional information about the analytes. The reference nuclide for measurement of gross alpha is thorium-230 and the reference nuclide for measurement of gross beta is cesium-137. Measured values less than the sample-specific critical level (ssL$_C$) are reported as nondetects (—). Values less than activities measured in field blanks (*table A3A*) are reported with a less than or equal to sign (≤). **GAMA identification number:** MADCHOW, Madera–Chowchilla study unit grid well; MADCHOWFP, Madera–Chowchilla study unit flow-path well. Thresholds and threshold levels as of April 14, 2008. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; *, value above threshold level; ≤, less than or equal to]

GAMA identification number	Gross alpha particle activity, 72-hour count (pCi/L) (62636)		Gross alpha particle activity, 30-day count (pCi/L) (62639)		Gross beta particle activity, 72-hour count (pCi/L) (62642)		Gross beta particle activity, 30-day count (pCi/L) (62645)	
Threshold type[1]	**MCL-US**		**MCL-US**		**MCL-CA**		**MCL-CA**	
Threshold value	**15**		**15**		**50**		**50**	
Reporting level method	**result ± CSU**	**ssL$_C$**	**result ± CSU**	**ssL$_C$**	**result ± CSU**	**ssL$_C$**	**result ± CSU**	**ssL$_C$**
Grid wells								
MADCHOW-01	7.3 ± 1.2	0.63	5.9 ± 1.2	0.38	6.30 ± 0.61	0.70	7.90 ± 0.82	0.82
MADCHOW-02	1.50 ± 0.52	0.48	0.77 ± 0.48	0.57	3.00 ± 0.52	0.7	2.60 ± 0.50	0.68
MADCHOW-03	—	1.0	0.62 ± 0.43	0.51	4.20 ± 0.55	0.68	2.90 ± 0.47	0.61
MADCHOW-04	1.80 ± 0.58	0.51	0.59 ± 0.36	0.43	3.50 ± 0.73	1.0	2.50 ± 0.44	0.61
MADCHOW-05	—	0.78	—	0.64	2.30 ± 0.47	0.68	3.00 ± 0.77	1.2
MADCHOW-06	*18.0 ± 2.3	0.98	*18.0 ± 2.6	0.79	5.30 ± 0.53	0.57	7.10 ± 0.89	1.2
MADCHOW-07	1.00 ± 0.56[2]	0.60	—	0.60	2.00 ± 0.71[2]	1.1	≤1.70 ± 0.50	0.74
MADCHOW-08	2.10 ± 0.73	0.90	2.30 ± 0.83	0.83	4.20 ± 0.60	0.83	5.20 ± 0.66	0.82
MADCHOW-09	7.3 ± 1.4	0.98	1.80 ± 0.54	0.56	2.70 ± 0.57[2]	0.79	4.90 ± 0.46	0.49
MADCHOW-10	1.40 ± 0.38	0.35	0.68 ± 0.49	0.64	5.00 ± 0.57	0.72	6.00 ± 0.77	1.0
MADCHOW-11	0.84 ± 0.43	0.54	1.40 ± 0.62	0.67	4.20 ± 0.44	0.51	4.30 ± 0.69	1.0
MADCHOW-12	4.1 ± 1.7	2.1	—	2.3	2.30 ± 0.56	0.83	3.00 ± 0.52	0.72
MADCHOW-13	≤0.65 ± 0.31	0.37	—	0.89	1.40 ± 0.34	0.51	≤1.00 ± 0.55	0.87
MADCHOW-14	≤0.55 ± 0.33	0.43	—	0.57	1.60 ± 0.34	0.49	≤1.50 ± 0.41	0.60
MADCHOW-15	≤0.65 ± 0.34	0.43	—	0.57	3.30 ± 0.51	0.72	3.40 ± 0.50	0.63
MADCHOW-16	1.60 ± 0.44	0.43	—	0.40	2.90 ± 0.47	0.70	2.30 ± 0.56	0.85
MADCHOW-17	—(3)	0.48	1.20 ± 0.52	0.60	1.90 ± 0.44[3]	0.62	2.50 ± 0.40	0.54
MADCHOW-18	4.00 ± 0.77	0.40	1.40 ± 0.68	0.68	6.50 ± 0.56	0.53	6.80 ± 0.75	0.86
MADCHOW-19	2.60 ± 0.66	0.40	1.40 ± 0.62	0.68	4.80 ± 0.55	0.61	4.10 ± 0.55	0.70
MADCHOW-20	*52.0 ± 6.2	1.6	*30.0 ± 4.1	1.5	7.60 ± 0.86	1.1	18.0 ± 1.3	0.92
MADCHOW-21	—	1.0	1.70 ± 0.67	0.74	—	0.71	2.20 ± 0.66	1.0
MADCHOW-22	2.30 ± 0.55	0.49	1.50 ± 0.62	0.70	1.70 ± 0.35	0.50	2.80 ± 0.48	0.66
MADCHOW-23	1.30 ± 0.81	0.93	2.00 ± 0.68	0.60	1.10 ± 0.65	0.98	1.90 ± 0.49	0.70
MADCHOW-24	2.50 ± 0.70	0.62	1.50 ± 0.57	0.56	2.50 ± 0.50	0.69	2.60 ± 0.51	0.70
MADCHOW-25	*72.0 ± 8.8	2.1	*41.0 ± 5.7	2.0	11.0 ± 1.2	1.4	31.0 ± 2.0	1.1
MADCHOW-26	*29.0 ± 4.1	1.6	*28.0 ± 3.9	1.8	8.1 ± 1.1	1.5	18.0 ± 1.3	0.89
MADCHOW-27	10.0 ± 1.8	1.0	7.4 ± 1.4	0.61	3.80 ± 0.59	0.80	5.40 ± 0.67	0.79
MADCHOW-28	*31.0 ± 4.3	1.6	14.0 ± 2.7	2.2	9.20 ± 0.75	0.70	14.0 ± 1.1	1.0
MADCHOW-29	*39.0 ± 4.6	0.99	*20.0 ± 2.6	0.78	5.20 ± 0.58	0.77	18.0 ± 1.1	0.49
MADCHOW-30	—	0.69	—	0.60	1.40 ± 0.42	0.62	≤1.30 ± 0.43	0.63
Flow-path wells								
MADCHOWFP-01	*24.0 ± 3.1	0.95	12.0 ± 1.9	0.89	6.80 ± 0.75	0.84	9.30 ± 0.91	0.99
MADCHOWFP-02	—	0.55	0.73 ± 0.40	0.43	2.90 ± 0.72	1.0	2.20 ± 0.66	1.0
MADCHOWFP-03	*31.0 ± 8.2	7.8	*16.0 ± 5.8	6.1	17.0 ± 3.9	6.0	17.0 ± 2.3	2.9
MADCHOWFP-04	—	1.0	—	0.89	4.90 ± 0.66	0.88	3.70 ± 0.63	0.87
MADCHOWFP-05	2.40 ± 0.60	0.48	—	0.55	3.70 ± 0.63	0.88	3.40 ± 0.42	0.51

[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] 72-hour holding time exceeded by 1 day.

[3] 72-hour holding time exceeded by 2 days.

Appendix

This appendix includes discussions of the methods used to collect and analyze groundwater samples, the conventions used in reporting the resulting water-quality data, the methods used for quality assurance, and the results of quality-control assessments.

Sample Collection and Analysis

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

Prior to sampling, each well was pumped continuously in order to purge at least three casing-volumes of water from the well (Wilde and others, 1999). All wells sampled were production wells so the existing pump on the well was used for sampling. Groundwater samples were collected through Teflon tubing attached to a sampling point on the well discharge pipe with brass and stainless-steel fittings. The sampling point was located as close as possible to the well-head and upstream of any water-storage tanks. The sampling point was always located upstream of any well-head treatment system (if any). If a chlorinating system was attached to the well, the chlorinator was shut off prior to purging and sampling the well in order to clear all chlorine out of the system and the absence of free chlorine was verified using Hach field kits. Samples were collected inside an enclosed chamber located inside a mobile laboratory and connected to the sampling point by a 10- to 50- foot length of Teflon tubing (Lane and others, 2003). All fittings and lengths of tubing were cleaned after each sample was collected (Wilde, 2004).

For the field water-quality indicator measurements, groundwater was pumped through a flow-through chamber fitted with a multi-probe meter that simultaneously measures the field water-quality indicators—dissolved oxygen, pH, specific conductance, and temperature. Field measurements were made in accordance with protocols in the USGS National Field Manual (Radtke and others, 2005; Wilde and Radtke, 2005; Lewis, 2006; Wilde, 2006; Wilde and others, 2006). All sensors on the multi-probe meter were calibrated daily. Measured dissolved oxygen, pH, specific conductance, and temperature values were recorded at 5-minute intervals for at least 30 minutes, and after these values remained stable for 20 minutes, samples to be analyzed in laboratories were collected. At wells sampled on the slow schedule, turbidity also was measured. Turbidity was measured in the mobile laboratory with a calibrated turbidity meter (Wilde and Gibbs, 1998). 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 also were managed by PCFF-GAMA. Information from PCFF-GAMA was uploaded directly into NWIS after samples were collected each week.

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

Samples collected to be analyzed for VOCs, low-level DBCP and EDB, pesticides, pharmaceuticals, nutrients, major ions, and trace elements were stored on ice, and shipped overnight in coolers with ice to the NWQL within three days of sample collection (samples were shipped daily whenever possible). Samples to be analyzed for gross alpha and gross beta particle activities were shipped overnight within two days of sample collection (samples were shipped daily whenever possible). Samples to be analyzed for NDMA, perchlorate, and low-level 1,2,3-TCP were stored on ice and shipped in coolers with ice overnight at the end of each week. Samples to be analyzed for stable isotopes of hydrogen and oxygen of water, uranium and carbon isotopes, tritium, and noble gases were shipped in batches after the last sample was collected in the study unit.

Detailed sampling protocols for individual analyses and groups of constituents are described by Koterba and others (2005) and the USGS National Field Manual (Wilde and others, 1999; Wilde and others, 2004) and in the references for analytical methods listed in *table A1*. The brief descriptions given here are organized in the order that samples were collected at each well. VOCs, low-level DBCP and EDB, and low-level 1,2,3-TCP samples were collected in 40-mL sample vials that were purged with three vial volumes of sample water before bottom filling to eliminate entrainment of ambient air. Six normal (6 N) hydrochloric acid was added as a preservative to the VOC samples, but not to the low-level DBCP and EDB samples, or the low-level 1,2,3-TCP samples. Samples to be analyzed for perchlorate were collected in a plastic bottle and then filtered in two or three 20-mL aliquots through a syringe-tip filter into a sterilized 125-mL bottle. Tritium samples were collected by bottom filling two 1-L polyethylene bottles with unfiltered groundwater, after first overfilling the each bottle with three volumes of water. Samples for analysis of stable isotopes of hydrogen and oxygen of water were collected in 60-mL clear glass bottles filled with unfiltered water, sealed with conical caps, and secured with electrical tape to prevent leakage and evaporation.

Samples to be analyzed for pesticides and pesticide degradation products, polar pesticides and metabolites, pharmaceutical compounds, and NDMA were collected in 1-L baked amber bottles. Pesticides, polar pesticides, and pharmaceutical samples were filtered through a baked, 0.3-µm nominal pore-size glass fiber during collection, whereas the NDMA samples were filtered at Weck Laboratories, Inc. prior to analysis.

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

Samples to be analyzed for noble gases were collected from the sampling point on the well discharge pipe. Noble gases were collected in 3/8-in copper tubes using reinforced nylon tubing connected to the hose bib at the wellhead. 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 groundwater for analyses of noble gases (Weiss, 1968).

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

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

Data Reporting

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

Reporting Limits

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

Concentrations between the LRL and the LT-MDL are reported as "estimated" concentrations (designated with an "E" before the values in the tables and text). In rare cases, concentrations above the LRL may be reported as E-coded values. These cases may occur if the concentration was outside the range of the calibration standards, if the sample was diluted before analysis, or if the result did not meet all laboratory quality-control criteria (Childress and others, 1999).

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

Results for most constituents are presented using the LRL or MRL values provided by the analyzing laboratories. A couple of constituents are reported using the IRL provided by the laboratory. The IRL is an interim reporting level. Results for some constituents are presented using study reporting levels (SRLs) derived from assessing data from quality-control samples associated with groundwater samples collected as part of the GAMA project. The SRLs for trace elements were determined by statistical assessment of results from the field blanks collected in the first 20 GAMA study units (May 2004 through January 2008) (L.D. Olsen and M.S. Fram, U.S. Geological Survey, written commun., 2008). The assessment used order statistics and binomial probabilities to construct an upper confidence limit (Hahn and Meeker, 1991) for the maximum concentration of constituents potentially introduced while groundwater samples were collected, handled, transported, and analyzed. The resulting SRLs for trace elements were set at concentrations representing a confidence limit of 90 percent for the 90th percentile of the 86 field blanks used in the assessment. The SRLs for major and minor ions, nutrients, species of arsenic and iron, and radioactive constituents were determined by assessment of results from field blanks collected in MADCHOW. The maximum concentration of a constituent potentially introduced while groundwater samples were collected, handled, transported, and analyzed was defined as the maximum concentration of the constituent measured in blanks collected in MADCHOW.

For most constituents, this maximum concentration was below the LRL or MRL for the constituent. Data for such constituents are reported as “<” (less than) the LRL or MRL. For some constituents, this maximum concentration was greater than the LRL or MRL, and therefore was defined as the SRL. Detections of those constituents reported by the laboratory with concentrations greater than the LRL or MDL but less than the SRL are given in *tables 10* and *13B* with a less-than-or-equal-to ($\leq$) sign preceding the reported value.

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

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

Notation

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

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

where

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

E is the element (O for oxygen-18, C for carbon, or H for hydrogen),

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

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

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

Constituents on Multiple Analytical Schedules

Fourteen constituents targeted in this study were measured by more than one analytical schedule or more than one laboratory (*table A2*). The preferred methods for these constituents were selected on the basis of the procedure recommended by the NWQL (*http://wwwnwql.cr.usgs.gov/USGS/Preferred_method_selection_procedure.html*). Methods with full approval are preferred over those with provisional approval and approved methods are favored over research methods. The method having greater accuracy and precision and lower LRLs for the overlapping constituents is usually preferred. However, the method having higher LRLs may be selected as the preferred method to provide consistency with the historical data analyzed by the same method.

For the two constituents on NWQL Schedules 2020 (VOCs; *table 3A*) and 1306 (low-level DBCP and EDB; *table 3B*), the preferred method was Schedule 1306 because it has lower LRLs. For the constituents on NWQL Schedules 2033 (pesticides and pesticide degradates; *table 3C*) and 2060 (polar pesticides and metabolites; *table 3D*), the preferred method was Schedule 2033 for three constituents to provide consistency with historical data, and Schedule 2060 for two constituents due to better method performance for these constituents (*table A2*). Only the results from the preferred method are reported.

The constituent 1,2,3-TCP is measured at the USGS NWQL laboratory (Schedule 2020; *table 3A*) and is measured using a lower method reporting level at Weck Laboratories, Inc. (*table 3F*) and both results are reported. Tritium also is measured at two laboratories: Lawrence Livermore National Laboratory (LLNL) (*table 3K*) and U.S. Geological Survey Stable Isotope and Tritium Laboratory (SITL) (*table 3J*), but only the data from SITL was available for reporting at the time of this publication.

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

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

where

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

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

Quality Assurance

The purpose of quality-assurance is to identify which data best represent environmental conditions and which may have been affected by contamination or bias during sample collection, processing, storage, transportation, and (or) laboratory analysis. Four types of quality-control (QC) tests were used in this study: blanks were collected to assess contamination during sample collection, handling or analysis; 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, the detection of an organic constituent (toluene) in a groundwater sample that may have resulted from contamination during sample collection, handling, or analysis was flagged with a “V” remark code in the results table (*table 5*), and was not considered a detection for calculations of detection frequencies in water-quality assessments. Detections of inorganic constituents in groundwater samples that may have resulted from contamination during sample collection, handling, or analysis were flagged with a “≤” symbol to indicate that the amount of potential contamination may have been sufficient to give a false positive relative to the stated reporting level. Because of the possible contamination, the actual concentration in the groundwater sample may be less than or equal to “≤” the measured concentration. The evaluation of QC data presented in this report was based on results for QC samples collected for MADCHOW and on results for QC samples collected for the 20 GAMA study units sampled from May 2004 through January 2008.

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

Blanks

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

Blank Collection and Analysis

Blanks were collected using blank water certified by the NWQL to contain less than the LRL or MRL of the constituents investigated in the study (*http://wwwnwql.cr.usgs.gov/USGS/OBW/obw.html*). Nitrogen-purged, organic-free blank water was used for field blanks of organic constituents, and inorganic-free blank water was used for field blanks of other constituents. Two types of blanks were collected: source-solution and field blanks. Source-solution blanks were collected to assess potential contamination of samples during transport and analysis, and potential contamination of the certified blank water obtained from the USGS NWQL. Field blanks were collected to assess potential contamination of samples during collection, processing, transport, and analysis.

For MADCHOW, blanks were collected at approximately 11 percent of the 35 wells sampled. Field blanks were analyzed for VOCs; low-level DBCP and EDB; pesticides and pesticide degradates; polar pesticides and metabolites; pharmaceuticals; NDMA; perchlorate; low-level 1,2,3-TCP; nutrients; major and minor ions; trace elements; arsenic and iron speciation; and gross alpha and gross beta particle activities (*table A3*). Blank water certified to be free of tritium and noble gasses was not available, thus field blanks were not collected and analyzed for these constituents. The concept of blank samples does not apply to analyses of stable isotope ratios because the constituents (oxygen and hydrogen in water, and carbon in dissolved inorganic carbon) are in all samples.

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 groundwater samples. For field blanks, blank water was either pumped or poured through the sampling equipment (fittings and tubing) used to collect groundwater, then processed, transported, and analyzed using the same protocols used for the groundwater samples. Eight to 12 L of blank water were pumped or poured through the sampling equipment before each field blank was collected.

Assessment of Blanks

Contamination in blanks may originate from several different types of sources that require different strategies to assess the potential for contamination of groundwater samples during sample collection, handling, or analysis. Four primary modes of contamination are assessed in the event of detections in field-blanks or unusual results in groundwater samples: (1) impurities in the water used to collect the blanks, (2) contamination during sample collection and handling from a known source or condition present at the field site, (3) carry-over of material from one sample to the next sample collected with the same sampling equipment, and (4) systematic and random contamination from field and laboratory equipment and processes. The fourth source of contamination (systematic and random) was addressed using a larger set of field blank results from multiple studies, in addition to the results from field blanks collected during the MADCHOW study. The development of this approach and its methods are described by L.D. Olsen and M.S. Fram (U.S. Geological Survey, written commun., 2008).

The first potential mode of contamination evaluated was the presence of impurities in the blank water. Because the blanks were collected using blank water certified by the NWQL to contain less than the LRL or MRL of the constituents investigated in the study, the blank water itself is very rarely the source of constituents detected in field blanks. However, the certification process is sometimes completed after the blank water has been shipped and used, thus, the certificates of analysis must always be checked for any detectable concentrations.

The second potential mode evaluated was contamination from identifiable, known sources at a specific field site. Contamination from specific sources may produce distinctive patterns of detections (particularly of VOC constituents) in field blanks and groundwater samples. Substances that may be encountered at the field site, such as lubricants (for example, WD-40), cements used on PVC-piping, exhaust fumes from pump engines, and the methanol used to clean sample lines, contain recognizable associations of VOC constituents. For example, cements used on PVC-piping are composed of primarily of tetrahydrofuran, acetone, methyl ethyl ketone (MEK), and cyclohexanone (not analyzed in this study). However, detecting these recognizable associations of VOC constituents in groundwater samples does not necessarily indicate contamination during sample collection because these VOC constituents also may occur together in groundwater.

If a recognizable association of VOC constituents was detected in a field blank or in a groundwater sample, the field notes and photographs from the site at which the sample was collected were examined for conditions that may have caused the field blank or the groundwater sample to be contaminated. If the constituents were present in the field blank and the groundwater sample from the same site at similar concentrations and the field notes or photographs indicated that the probable contaminant source was present, the detections of those constituents in the groundwater sample were V-coded, and all other groundwater samples collected at sites where the same condition may have occurred were considered for V-coding. If the constituents were detected in a groundwater sample and not in the associated field blank, or in a groundwater sample from a site where no blanks were collected, and the field notes or photographs indicated conditions that may have resulted in contamination of the groundwater sample during sample collection, the data were considered for V-coding. If no conditions that may have resulted in contamination of the groundwater sample during sample collection were identified in the field notes or photographs, V-codes were not applied on this basis.

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

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

Different notation was used for flagging results for organic and inorganic constituents that may have been affected by contamination during sample collection, handling, or analysis. Inorganic constituents are naturally present in groundwater, and the concerns about inorganic constituents usually are related to concentration, rather than detection (presence or absence). In contrast, concerns about organic constituents usually are related to both detection and concentration. Therefore, different schemas are used for assessing and flagging data for organic and inorganic constituents.

Results for organic constituents that may have been affected by contamination during sample collection, handling, or analysis were flagged with V-codes. The purpose of V-coding was to flag detections that have a greater than acceptable probability of being false-positive detections. A false-positive detection of a constituent is an apparent detection that is caused by contamination during the sample collection, handling, or analysis of a groundwater sample that would otherwise not have a detection of that constituent. Results labeled with V-codes were not considered to be detections of the constituent for this study and were not included in calculations of detection frequencies for organic constituents.

The V-coding level was defined as the highest concentration of the constituent detected in a field blank plus the LT-MDL (equal to one-half the LRL) for that constituent. The following example illustrates why the V-coding level is defined in this way. In this example, the LT-MDL for the constituent is 0.10 μg/L, the true concentration in the groundwater sample is 0.05 μg/L, and the highest concentration measured in a field blank is 0.20 μg/L. It is assumed that the highest concentration measured in a field blank represents the maximum amount of contamination that groundwater samples may receive during collection, handling, transport, or analysis. If the groundwater sample is not affected by contamination during collection, handling, transport, or analysis, the measured concentration will be reported as a nondetect (0.05 μg/L is less than the LT-MDL of 0.10 μg/L). If the maximum amount of contamination (0.20 μg/L) occurs, then the measured concentration will be 0.25 μg/L, which is reported as a detection of the constituent. Therefore, by setting the V-coding level at 0.30 μg/L (the LT-MDL of 0.10 μg/L plus the potential maximum amount of contamination of 0.20 μg/L), detections that might be false-positive detections are removed from of the dataset.

Results for inorganic constituents that may have been affected by contamination during sample collection, handling, transport, or analysis were flagged with a less than or equal to symbol (≤). The ≤ symbol means that the true concentration of the constituent in the groundwater sample is less than or equal to the measured concentration (including the possibility that it may be less than the LT-MDL and therefore a nondetect). For trace elements, the concentration cutoff, hereinafter referred to as the study reporting level (SRL), for assigning the ≤ symbol was determined from a statistical assessment of results for 86 field blanks collected between May 2004 and January 2008 (L.D. Olsen and M.S. Fram, U.S. Geological Survey, written commun., 2008). For all other inorganic constituents, the SRL for assigning the ≤ symbol was determined from assessing the field blanks collected at MADCHOW sites only. The SRL was defined as equaling the highest concentration measured in the 4 field blanks collected at MADCHOW sites (field blanks were collected at approximately 11 percent of the wells sampled).

Replicates

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

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

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

- For concentrations less than 5 times the LRL (<5 LRL), an SD of less than ½ LRL is acceptable
- For concentrations greater than (or equal to) 5 times the LRL (≥5 LRL), an RSD of less than 10 percent is acceptable. For comparison, an RSD of 10 percent is equivalent to a relative percent difference (RPD) of 14 percent.
- For activities of radiochemical constituents (excluding tritium and carbon isotopes because CSU data are not available), the presence of overlap between the results (value ± 1-sigma CSU) is acceptable

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

For organic and inorganic constituents (except for radiochemical constituents, but including tritium and carbon isotopes), if both values for a replicate sample pair were reported as detections, then the SD was calculated if the mean concentration was <5 LRL for the constituent, or the RSD was calculated if the mean concentration was ≥5 LRL for the constituent. If both values were reported as nondetects, the variability was set to zero by definition. Cases other than two detections or two nondetects were treated as follows:

- For organic constituents, if one or both values were assigned a V-code, neither SD nor RSD was calculated. A V-code indicates that the constituent was detected in blanks and was excluded from the dataset of groundwater quality results. The data might not represent the concentration of the constituent in the groundwater sample.
- For organic and inorganic constituents, if one value was reported as a nondetect, and the other value was reported as a detection below the LRL, a value of zero was substituted for the nondetect and the SD calculated. Substituting zero for the nondetect yields the maximum estimate of variability for the replicate pair. For inorganic constituents, if one value for a sample pair was reported as a nondetect and the other value was reported as a ≤-coded value less than the SRL, or if both values were reported as ≤-coded values less than the SRL, neither SD nor RSD was calculated, because the values may be analytically identical. The ≤-code indicates that the value is a maximum potential concentration, and that concentration may be low enough to be reported as a nondetect.
- For organic and inorganic constituents (including tritium and carbon isotopes), if one value was reported as a nondetect and the other value was reported as a detection greater than the LRL, the variability for the pair was considered unacceptable.

Matrix Spikes

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

The GAMA program defined the data quality objective for acceptable matrix-spike recoveries as 70 to 130 percent. Constituents with matrix-spike recoveries outside of this range were flagged as having unacceptable recoveries in *tables 3A,C,D* (none of the constituents listed in *table 3F* had unacceptable matrix-spike recoveries). For many constituents, an acceptable range of 70 to 130 percent for matrix spike recovery was more restrictive than the acceptable control limits for laboratory “set” spike recoveries. Laboratory set spikes are aliquots of laboratory blank water to which the same spike solution used for the matrix spikes has been added. One set spike is analyzed with each set of samples. Acceptable control limits for set spikes are defined relative to the long-term variability in recovery. For example, for many NWQL schedules acceptable set spike recovery is within plus or minus three F-pseudosigma of the median recovery for at least 30 set spikes (Conner and others, 1998; Rose and Sandstrom, 2003). For NWQL schedule 2080 (pharmaceuticals), acceptable set spike recovery is within plus or minus two standard deviations of the long-term mean recovery (Furlong and others, 2008). Results for pharmaceuticals are not presented in this report; they will be included in subsequent publications.

Matrix-spike recovery tests were done for VOCs, pesticides, polar pesticides, pharmaceuticals, NDMA, and low-level 1,2,3-TCP because the analytical methods for these constituents are chromatographic methods that may be susceptible to matrix interferences. Replicate samples for matrix-spike recovery tests were collected at 11 to 14 percent of the wells sampled for the various analytical schedules.

Surrogates

Surrogate compounds are added to environmental samples in the laboratory before analysis in order to evaluate the recovery of similar constituents. Surrogate compounds were added in the laboratory to all groundwater and quality-control samples that were analyzed for VOCs, pesticides and pesticide degradates, polar pesticides and metabolites, and pharmaceuticals by the NWQL (*table A6*); note pharmaceutical data will be presented in a subsequent report. Most of the surrogate compounds are deuterated analogs of compounds being analyzed. For example, the surrogate toluene-*d*8 used for the VOC analytical method has the same chemical structure as toluene, except that the eight hydrogen-1 atoms on the molecule have been replaced by deuterium (hydrogen-2). Toluene-*d*8 and toluene behave very similarly in the analytical procedure, but the small mass difference between the two results in slightly different chromatographic retention times thus the use of a toluene-*d*8 surrogate does not interfere with the analysis of toluene (Grob, 1995). Only 0.015 percent of hydrogen atoms are deuterium (Firestone and others, 1996), thus deuterated compounds like toluene-*d*8 do not occur naturally and are not found in environmental samples. Surrogates are used to identify general problems that may arise during sample analysis that could affect the analysis results for all compounds in that sample. Potential problems include matrix interferences (such as high levels of dissolved organic carbon) that produce a positive bias, or incomplete laboratory recovery (possibly due to improper maintenance and calibration of analytical equipment) that produces a negative bias. A 70 to 130 percent recovery of surrogates is generally considered acceptable; values outside this range indicate possible problems with the processing and analysis of samples (Connor and others, 1998; Sandstrom and others, 2001).

Quality-Control Results

Detections in Field and Source-Solution Blanks

Table A3 presents a summary of detections in field blanks. Four field blanks and source-solution blanks were collected during sampling in MADCHOW for analysis of VOCs, and there were no detections. Concentrations of toluene between E0.01 µg/L and E0.08 µg/L were detected in approximately 40 percent of the field and source-solution blanks in other study units (Wright and others, 2005; Bennett and others, 2006; Kulongoski and others, 2006; Fram and Belitz, 2007; Kulongoski and Belitz, 2007; Dawson and others, 2008; Ferrari and others, 2008; and Landon and Belitz, 2008). Because the certificates of analysis stated that no toluene was detected in the lots of nitrogen-purged, organic-free blank water used when the MADCHOW samples were collected, the source blank water was not considered to be the source of the contamination. The source of the toluene is not known. Because toluene is detected frequently in both source-solution and field blanks, all toluene detections in groundwater samples collected in GAMA study units are subject to V-coding at a level based on the concentrations detected in the blanks. The concentration of toluene detected in one MADCHOW groundwater sample was E0.02 µg/L; this detection was V-coded and excluded from the dataset of groundwater quality results (*tables 5*, *A3*).

Four field blanks were analyzed for low-level DBCP and EDB and there were no detections.

Five field blanks were analyzed for pesticides and pesticide degradates, three field blanks were analyzed for polar pesticides and metabolites, and there were no detections.

Two field blanks were analyzed for NDMA and four field blanks were analyzed for low-level 1,2,3-TCP, and there were no detections. Three field blanks and source-solution blanks were collected for analysis of perchlorate, perchlorate was detected in a source-solution blank at a concentration of 0.27 mg/L, but not detected in any of the field blanks including the field blank collected at the same time as the source-solution blank. The source of this detection is unknown. No groundwater samples were V-coded based on this detection.

Four field blanks were analyzed for nutrients, and there were no detections.

Four field blanks were analyzed for major and minor ions, and silica was detected in two field blanks at concentrations of 0.020 and 0.034 mg/L (*table A3*). The field blank with a silica concentration of 0.020 mg/L was accompanied by a source-solution blank with no detection and the source-solution for the other field blank was not analyzed. The lowest concentration of silica detected in groundwater samples was 16.3 mg/L (*table 9*) which is greater than 0.043 mg/L (0.034 mg/L, the highest concentration in the field blank, plus 0.009 mg/L, one-half the LRL), thus no groundwater data were flagged.

The GAMA study reporting levels (SRLs), instead of the results from the four field blanks collected at MADCHOW sites, were used to determine which trace element data should be flagged; SRLs are based on the results for 86 field blanks collected between May 2004 and January 2008 (L.D. Olsen and M.S. Fram, U.S. Geological Survey, written commun., 2008). Aluminum, barium, chromium, copper, iron, lead, manganese, nickel, tungsten, vanadium, and zinc have SRLs which are tabled instead of LRLs in *table 10*. Measured values that are less than the SRL are flagged with a ≤ symbol in *table 10*. No trace elements were detected in field blanks collected at MADCHOW sites, but at least one groundwater sample for each of the trace elements listed above with SRLs, except for barium, was flagged with a ≤ symbol in *table 10* because the measured values in groundwater samples were less than the respective SRLs (*table A3*).

Two field blanks were collected for the analysis of arsenic and iron by the USGS Trace Metals laboratory in Boulder, Colorado, and there were no detections.

Four field blanks were analyzed for gross alpha and gross beta particle activities. Gross alpha particle activity (72-hour count) was detected in two field blanks, activities were 0.23 ± 0.17 and 0.24 ± 0.17 pCi/L (*table A3*). Three groundwater samples contained activities of 0.65 ± 0.31 , 0.55 ± 0.33, and 0.65 ± 0.34 pCi/L (*table 13B*). The lower confidence limit of the activities measured in these three groundwater samples are less than 0.41 pCi/L, the upper confidence limit of the maximum activity measured in a blank; thus the activities in the groundwater samples were flagged with a ≤ symbol (*table 13B*). Gross beta particle activity (30-day count) was detected in one field blank at an activity of 0.78 ± 0.45 pCi/L (*table A3*). Four groundwater samples contained gross beta particle activities (30-day count) less than 1.23 pCi/L, the upper confidence limit measured in a blank, and thus, were flagged with a ≤ symbol (*table 13B*).

Variability in Replicate Samples

Tables A4A–C summarize the results of replicate analyses for constituents detected in groundwater samples collected in the MADCHOW study. Replicate analyses were made on about 14 percent of the samples collected. Of the 1,402 replicate pairs of constituents analyzed (counted by constituent), 417 were analyzed for constituents detected in at least one groundwater sample. Of these 417 pairs, 10 had results outside the limits for acceptable precision. Results for replicate analyses for constituents that were not detected are not reported in *tables A4A–C*.

Five replicate pairs of samples were analyzed for organic constituents and nearly all pairs were comprised of two values reported as nondetects (*table A4A*). V-coded data for toluene was not calculated because the data are not considered representative of the groundwater. All of the pairs had two concentrations with an RSD value of less than 10 percent (for concentrations five times greater than the LRL), or two concentrations with an SD value of less than one-half of the LRL (for concentrations less than five times the LRL), or two nondetects (*table A4A*). These results indicated data for groundwater samples from the MADCHOW study unit had variability within acceptable ranges.

Replicate pairs of samples were analyzed for constituents of special interest at Weck Laboratories, Inc.. Five replicate pairs of samples were analyzed for constituents of special interest collected at all 35 MADCHOW sites (perchlorate and low-level 1,2,3-TCP) and two replicate pairs of samples were analyzed for NDMA collected at only the 10 slow sites (*table A4A*). Both replicate pairs analyzed for NDMA were comprised of two values reported as nondetects and two of the five replicate pairs each analyzed for perchlorate and low-level 1,2,3-TCP were comprised of detections with concentrations less than five times the corresponding MRLs and SDs were less than one-half of the MRL (*tables 3F* and *A4A*). These results indicated data for groundwater samples from the MADCHOW study unit had variability within acceptable ranges.

Five replicate pairs of samples were analyzed for nutrients, major and minor ions, trace elements, and isotope tracers and two replicate pairs of samples were analyzed for trace element species. Over 97 percent of the pairs yielded two concentrations with a SD value less than one-half of the LRL, MDL, or MRL (for concentrations less than five times the LRL, MDL, or MRL), an RSD value of less than 10 percent (for concentrations five times greater than or equal to the LRL, MDL, or MRL), or two nondetects (*table A4B*). These results indicated data for groundwater samples from the MADCHOW study unit had variability within acceptable ranges.

One replicate pair each for lithium and manganese had an RSD value greater than 10 percent. There is no drinking-water threshold for lithium to compare measured concentrations in groundwater samples to but the elevated RSD will be taken into account in assessments of groundwater quality. However, the concentrations detected in the replicate pair for manganese were 3.7 and 2.5 µg/L, which were less than one-tenth of the SMCL-CA for manganese (*table 3H*). The less than acceptable precision at this low concentration will not affect the assessments of groundwater quality being made by the GAMA Priority Basin Project.

Two replicate pairs of samples were analyzed for species of arsenic and iron by the USGS Trace Metals Laboratory in Boulder, Colorado. Both replicate pairs analyzed for species of arsenic yielded detections with concentrations less than five times the corresponding MDL and SDs were less than one-half of the MDL (*tables 3I* and *A4B*). These results indicated data for groundwater samples from the MADCHOW study unit had variability within acceptable ranges.

Results in four out of the five replicate pairs of samples analyzed for tritium and carbon isotopes (δ^{13}C of dissolved carbonates and carbon-14) indicated data for groundwater samples from the MADCHOW study unit had variability within acceptable ranges for these constituents (*table A4B*). The SD was not calculated for 1 replicate pair for tritium analyses because the environmental value was reported as a detect just above the MRL and the replicate value was reported as a nondetect and less than the MRL (0.4, <0.3). The RSD was greater than 10 percent in 1 of the replicate pair analyses of each of the carbon isotopes.

Five replicate pairs of samples were analyzed for gross alpha and gross beta particle activities, and two replicate pairs of samples were analyzed for uranium isotopes (*table A4C*). Acceptable precision for radiochemical constituents is defined as the presence of overlap between the results (value + 1-sigma CSU) for the two analyses, where the range between the lower confidence limit of the activity measured in the groundwater sample and the upper confidence limit of the activity measured in the groundwater sample overlaps the range between the lower confidence limit of the activity measured in the replicate groundwater sample and the upper confidence limit of the activity measured in the replicate groundwater sample. Eighty-six percent of the replicate pairs were comprised of overlapping values and, therefore, were considered acceptable. One replicate pair each for gross alpha particle activity (72-hour count), gross alpha particle activity (30-day count), gross beta particle activity (30-day count), uranium-234, and uranium-235 were comprised of non-overlapping values. However, the activities were less than one-third of the corresponding MCL-US and MCL-CA thresholds (*table 3J*). The less-than-acceptable precision for these constituents at these low activities will not affect the assessments of groundwater quality being made by the GAMA Priority Basin Project.

Matrix-Spike Recoveries

Tables A5A–A5D presents a summary of matrix-spike recoveries for the MADCHOW 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 groundwater, on the analytical technique used to measure the constituent. Acceptable results for matrix-spike recovery tests were defined as median recoveries between 70 and 130 percent.

Five environmental samples were spiked with VOCs to calculate matrix-spike recoveries (*table A5A*). The median recoveries for all 83 VOC compounds for which there is a spike available for the preferred method of analyses were within 70 to 130 percent. There is no NWQL Schedule 1306 spike available for the two fumigants (DBCP and EDB) analyzed in NWQL Schedules 2020 and 1306. Only results from Schedule 1306, the preferred method, are reported for these constituents. Two VOC spike compounds had at least one matrix-spike recovery greater than 130 percent; however, none were detected in groundwater samples. Six VOC spike compounds had at least one matrix-spike recovery less than 70 percent, but these compounds were not detected in groundwater samples. Low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations.

Five groundwater samples were spiked with pesticide and pesticide degradate compounds in order to calculate matrix-spike recoveries (*table A5B*). The median recoveries for 48 of the 81 compounds were within 70 to 130 percent. Almost two-thirds of the compounds (52 out of 81) had at least 1 matrix-spike recovery less than 70 percent, and 35 compounds had median recoveries less than 70 percent. For 23 compounds all 5 matrix-spike recovery tests yielded recoveries less than 70 percent. Three of these compounds, deethylatrazine, hexazinone, and tebuthiuron, were detected in groundwater samples (*table 6A*). [NOTE – low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations]. A similar pattern of unusually low matrix-spike recoveries that started in March 2008 was noted in an assessment of Schedule 2033 method performance by Organic Blind Sample Program of the Branch of Quality Systems (U.S. Geological Survey, 2008). The Organic Blind Sample Project (OBSP) of the Branch of Quality Systems (BQS) assesses the operational performance of organic analytical methods used for determining water-quality parameters for the USGS National Water Quality Laboratory (NWQL) by means of blind submissions of Quality Assurance (QA) samples.

Four groundwater samples were spiked with polar pesticide and metabolite compounds in order to calculate matrix-spike recoveries (*table A5C*). The median recoveries for 46 of the 55 compounds were within 70 to 130 percent. Out of 55 total compounds, 11 compounds had at least 1 matrix-spike recovery less than 70 percent and 7 compounds had median recoveries less than 70 percent. One of these compounds, dinoseb, was detected in groundwater samples (*table 6B*). (NOTE – low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations.) For one compound all four matrix-spike recovery tests yielded recoveries less than 70 percent. Seven compounds had at least one matrix-spike recovery greater than 130 percent and three compounds had median recoveries greater than 130 percent. One of these compounds, imazethapyr, was detected in groundwater samples (*table 6B*). The one detection of imazethapyr in a groundwater sample was reported by the laboratory with an E-code to indicate greater uncertainty in the magnitude of the reported concentration (*table 6B*).

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

One groundwater sample was spiked with NDMA and five groundwater samples were spiked with 1,2,3-TCP in order to calculate matrix-spike recovery (*table A5D*). Results for matrix-spike recovery tests were within 70 and 130 percent. Tests yielded spike recoveries for 1,2,3-TCP ranging from 86 to 112 percent, with a median recovery of 105 percent.

Surrogate Compound Recoveries

Surrogate compounds were added to environmental samples in the laboratory and analyzed to evaluate the recovery of similar constituents. *Table A6* lists each surrogate, the analytical schedule on which it was applied, the number of analyses for blank and of groundwater samples (environmental samples, replicates, and matrix-spike samples), the number of surrogate recoveries below 70 percent, and the number of surrogate recoveries above 130 percent for the blanks and the groundwater samples. Blank and groundwater samples were considered separately to assess whether the matrices present in groundwater samples affect surrogate recoveries. The presence of sample matrices may decrease the recovery of caffeine-^{13}C (*table A6*). However, because the median matrix-spike recoveries of 84 percent of the polar pesticides and metabolites were within acceptable ranges, this change in surrogate recovery did not have a noticeable effect on the data. More than 95 percent of the surrogate recoveries for VOCs and 90 percent of the surrogate recoveries for pesticide compounds were in the acceptable ranges.

Table A1. Analytical methods used by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and additional contract laboratories.

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

Constituent classes	Analytical Method	Laboratory and analytical schedule	Citation(s)
		Field water-quality indicators	
Field parameters	Calibrated field meters and test kits	USGS field measurement	U.S. Geological Survey, variously dated
		Organic constituents	
Volatile organic compounds (VOCs)	Purge and trap capillary gas chromatography/mass spectrometry	NWQL, Schedule 2020	Connor and others, 1998
Low-level 1,2-dibromo-3-chloropropane (DBCP) and 1,2-dibromoethane (EDB)	Micro-extraction and gas chromatography/electron-capture detection	NWQL, Schedule 1306	Eichelberger, 1993 (USEPA method 504.1)
Pesticides and degradates	Solid-phase extraction and gas chromatography/mass spectrometry	NWQL, Schedule 2033	Zaugg and others, 1995; Lindley and others, 1996; Madsen and others, 2003; Sandstrom and others, 2001
Polar pesticides and metabolites	Solid-phase extraction and high-performance liquid chromatography (HPLC)/mass spectrometry with selective-ion monitoring	NWQL, Schedule 2060	Furlong and others, 2001
Pharmaceuticals	Solid-phase extraction and HPLC/ mass spectrometry	NWQL, Schedule 2080	Kolpin and others, 2002; Furlong and others, 2008
		Constituents of special interest	
N-Nitrosodimethylamine (NDMA)	Isotopic dilution chromatography/ chemical ionization mass spectrometry	Weck Laboratories, Inc., standard operating procedure ORG065.R10	U.S. Environmental Protection Agency, 1989; Plomley and others, 1994
Perchlorate	Chromatography/mass spectrometry	Weck Laboratories, Inc., standard operating procedure ORG099.R01	U.S. Environmental Protection Agency, 2005
Low level 1,2,3-trichloropropane (1,2,3-TCP)	Isotopic dilution purge and trap/gas chromatography/mass spectrometry	Weck Laboratories, Inc., standard operating procedure ORG083	Okamoto and others, 2002
		Inorganic constituents	
Nutrients	Alkaline persulfate digestion, Kjedahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
Major and minor ions and trace elements	Atomic absorption spectrometry, colorimetry, ion-exchange chromatography, inductively-coupled plasma atomic emission spectrometry and mass spectrometry	NWQL, Schedule 1948	Fishman and Friedman, 1989; Fishman, 1993; Faires, 1993; McLain, 1993; Garbarino, 1999; Garbarino and Damrau, 2001; American Public Health Association, 1998; Garbarino and others, 2006
Arsenic and iron speciation	Various techniques of ultraviolet visible (UV-VIS) spectrophotometry and atomic absorbance spectroscopy	USGS Trace Metal Laboratory, Boulder, Colorado (USGSTMCO)	Stookey, 1970; To and others, 1998; McCleskey and others, 2003

Table A1. Analytical methods used by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and additional contract laboratories.—Continued

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

Constituent classes	Analytical Method	Laboratory and analytical schedule	Citation(s)
		Isotopic tracers	
Stable isotopes of hydrogen and oxygen in water	Gaseous hydrogen and carbon dioxide-water equilibration and stable-isotope mass spectrometry	USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA), NWQL Schedule 1142	Epstein and Mayeda, 1953; Coplen and others, 1991; Coplen, 1994
Stable isotopes of carbon and carbon-14 activity	Accelerator mass spectrometry	University of Waterloo, Environmental Isotope Lab (CAN-UWIL), NWQL Schedule 2015; University of Arizona Accelerator Mass Spectrometry Lab (AZ-UAMSL), NWQL Schedule 2015	Donahue and others, 1990; Jull and others, 2004
		Radioactivity and gases	
Tritium activity	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA)	Thatcher and others, 1977
Tritium activity and noble gases	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory (CA-LLNL)	Moran and others, 2002; Eaton and others, 2004
Uranium isotope activities	Chemical separations and alpha-particle spectrometry	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1130	American Society for Testing and Materials, 2002
Gross alpha and gross beta particle activities	Alpha and beta activity counting	Eberline Analytical Services, NWQL Schedule 1792	Krieger and Whittaker, 1980 (USEPA method 900.0)

Table A2. Preferred analytical schedules for constituents appearing on multiple schedules for samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[Preferred analytical schedules are generally the methods of analysis with the greatest accuracy and precision out of the ones used for the compound in question except in cases where consistency with historic data analyzed using the same method is preferred. LLNL, Lawrence Livermore National Laboratory; Weck, Weck Laboratories, Inc.; SITL, U.S. Geological Survey Stable Isotope and Tritium Laboratory; TML, U.S. Geological Survey Trace Metal Laboratory, Boulder, Colorado; VOC, volatile organic compound; np, no preference]

Constituent	Primary constituent classification	Analytical schedules	Preferred analytical schedule
Results from preferred method reported			
Atrazine	Pesticide	2033, 2060	2033
Carbofuran	Herbicide	2033, 2060	2060
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	Pesticide degradate	2033, 2060	2033
DBCP (1,2-Dibromo-3-chloropropane)	VOC, fumigant	1306, 2020	1306
EDB (1,2-Dibromoethane)	VOC, fumigant	1306, 2020	1306
Metalaxyl	Fungicide	2033, 2060	2060
Tebuthiuron	Pesticide	2033, 2060	2033
Results from both methods reported			
Alkalinity	Field water-quality indicator	field, 1948	field
Arsenic, total	Trace element	1948, TML	1948
Iron, total	Trace element	1948, TML	1948
pH	Field water-quality indicator	field, 1948	field
Specific conductance	Field water-quality indicator	field, 1948	field
1,2,3-Trichloropropane (1,2,3-TCP)	VOC	Weck, 2020	np
Tritium	Inorganic tracer	LLNL, SITL	np

Table A3. Constituents detected in field blanks collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[V-coded data for ground-water samples are excluded from the dataset of ground-water quality results because the constituents were detected in blanks at similar concentrations or were determined to be a result of contamination during sample collection. **Abbreviations:** SRL, study reporting level; µg/L, micrograms per liter; mg/L, milligrams per liter; — not detected; pCi/L, picocuries per liter; ≤, less than or equal to]

Constituent	Number of field blank detections/ number of field blanks	Concentration detected in field blanks	Number of ground-water samples V-coded or ≤-coded
Organic constituents (mg/L)			
Toluene	0/4	—	[1]1
Constituents of special interest (mg/L)			
Perchlorate	[2]0/3	—	0
Major and minor ions (mg/L)			
Silica	2/4	0.020, 0.034	0
Trace elements (µg/L)			
Aluminum[3]	0/4	—	9
Chromium[3]	0/4	—	2
Copper[3]	0/4	—	12
Iron[3]	0/4	—	5
Lead[3]	0/4	—	23
Manganese[3]	0/4	—	7
Nickel[3]	0/4	—	18
Tungsten[3]	0/4	—	15
Vanadium[3]	0/4	—	1
Zinc[3]	0/4	—	14
Radioactivity (pCi/L)			
Gross alpha particle activity, 72-hour count	[4]2/4	0.23 ± 0.17, 0.24 ± 0.17	3
Gross beta particle activity, 72-hour count	[4]0/4	—	0
Gross beta particle activity, 30-day count	1/4	0.78 ± 0.45	4

[1] Toluene V-coded based on frequency of detections in field blanks and source solution blanks from the previous 23 GAMA study units.

[2] Perchlorate was detected in a source solution blank at a concentration of 0.27 mg/L, but not in the associated field blank.

[3] Constituents have a study reporting level (SRL) defined based on examination of GAMA quality-control samples collected from May 2004 through January 2008 (L.D. Olsen and M.S. Fram, U.S. Geological Survey, written commun., 2008).

[4] 72-hour holding time exceeded by 1 day for one 'SLOW' field blank sample reported as a nondetect.

Table A4A. Quality-control summary for replicate analyses of organic constituents and constituents of special interest detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[SD, standard deviation; RSD, percent relative standard deviation; LRL, laboratory reporting limit; nv, no values in category]

Constituent	Number replicates with nondetects/total number of replicates	Number of SDs greater than ½ the LRL /number of replicates with concentrations less than 5 times the LRL	Number of RSDs greater than 10 percent/number of replicates with concentrations greater than 5 times the LRL
Volatile organic compounds			
Bromodichloromethane	4/5	0/1	nv
Bromoform (Tribromomethane)	4/5	nv	0/1
Chloroform (Trichloromethane)	3/5	0/2	nv
Dibromochloromethane	4/5	0/1	nv
1,1-Dichloroethane (1,1-DCA)	4/5	0/1	nv
cis-1,2-Dichloroethene (*cis*-1,2-DCE)	5/5	nv	nv
1,2-Dichloropropane	3/5	0/2	nv
Perchloroethene (Tetrachloroethene, PCE)	4/5	nv	0/1
Trichloroethene (TCE)	5/5	nv	nv
1,2,4-Trimethylbenzene	5/5	nv	nv
Low-level 1,2-dibromo-3-chloropropane (DBCP) and 1,2-dibromoethane (EDB)			
1,2-Dibromo-3-chloropropane (DBCP)	3/5	0/2	nv
1,2-Dibromoethane (EDB)	4/5	0/1	nv
Pesticides and pesticide degradates			
Atrazine	2/5	0/2	0/1
Azinphos-methyl oxon	[1]5/5	nv	nv
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	2/5	0/3	nv
3,4-Dichloroaniline	3/5	0/2	nv
Hexazinone	4/5	0/1	nv
Phosmet oxon	[2]4/4	nv	nv
Simazine	3/5	0/2	nv
Tebuthiuron	5/5	nv	nv
Polar pesticides and metabolites			
Bromacil	4/5	0/1	nv
Deisopropyl atrazine (2-Chloro-6-ethylamino-4-amino-*s*-triazine)	4/5	0/1	nv
Dinoseb (Dinitrobutyl phenol)	4/5	0/1	nv
Diuron	2/5	0/3	nv
Imazethapyr	5/5	nv	nv
Norflurazon	5/5	nv	nv
Constituents of special interest			
N-Nitrosodimethylamine (NDMA)	2/2	nv	nv
Perchlorate	2/5	0/3	nv
Low-level 1,2,3-trichloropropane (1,2,3-TCP)	2/5	0/3	nv

[1] Laboratory reporting level raised from 0.042 to 0.6 for ground-water sample from MADCHOW-18 and associated replicate.

[2] Laboratory unable to determine selected constituents in replicate sample associated with ground-water sample collected from MADCHOW-15 due to matrix interference.

Table A4B. Quality-control summary for replicate analyses of nutrients, major and minor ions, trace elements, and isotope tracers detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 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. SD, standard deviation; RSD, percent relative standard deviation; LRL, laboratory reporting limit; mg/L, micrograms per liter; mg/L, milligrams per liter; pCi/L, picocuries per liter, nv, no values in category; ≤, less than or equal to]

Constituent	Number of nondetect or ≤-coded replicates/total number of replicates	Number of SDs greater than ½ the LRL, MDL, or MRL/number of replicates with concentrations or activities less than 5 times the LRL, MDL, or MRL	Concentrations or activities of replicates with SDs greater than ½ LRL, MDL, or MRL (environmental, replicate)	Number of RSDs greater than 10 percent/number of replicates with concentrations or activities greater than 5 times the LRL, MDL, or MRL	Concentrations or activities of replicates with RSDs greater than 10 percent (environmental, replicate)
Nutrients, concentrations in mg/L					
Ammonia, as nitrogen	4/5	0/1	nv	nv	nv
Nitrite, as nitrogen	4/5	nv	nv	0/1	nv
Nitrate plus nitrite, as nitrogen	0/5	nv	nv	0/5	nv
Nitrogen, total, as nitrogen	0/5	nv	nv	0/5	nv
Orthophosphate, as phosphorus	0/5	0/1	nv	0/4	nv
Major and minor ions, concentrations in mg/L					
Bromide	0/5	0/4	nv	0/1	nv
Calcium	0/5	nv	nv	0/5	nv
Chloride	0/5	nv	nv	0/5	nv
Fluoride	0/5	0/5	nv	nv	nv
Iodide	0/5	0/4	nv	0/1	nv
Magnesium	0/5	nv	nv	0/5	nv
Potassium	0/5	nv	nv	0/5	nv
Silica	0/5	nv	nv	0/5	nv
Sodium	0/5	nv	nv	0/5	nv
Sulfate	0/5	nv	nv	0/5	nv
Total dissolved solids (TDS; residue on evaporation, ROE)	0/5	nv	nv	0/5	nv
Trace elements, concentrations in µg/L					
Aluminum	4/5	0/1	nv	nv	nv
Antimony	4/5	0/1	nv	nv	nv
Arsenic	0/5	nv	nv	0/5	nv
Barium	0/5	nv	nv	0/5	nv
Beryllium	0/5	nv	nv	nv	nv
Boron	0/5	0/2	nv	0/3	nv
Cadmium	4/5	0/1	nv	nv	nv
Chromium	0/5	0/2	nv	0/3	nv
Cobalt	1/5	0/4	nv	nv	nv
Copper	1/5	0/4	nv	nv	nv
Iron	4/5	0/1	nv	nv	nv
Lead	0/5	0/4	nv	0/1	nv
Lithium	0/5	0/4	nv	1/1	(8.9, 10)
Manganese	1/5	0/2	nv	1/2	(3.7, 2.5)
Molybdenum	0/5	0/1	nv	0/4	nv

Table A4B. Quality-control summary for replicate analyses of nutrients, major and minor ions, trace elements, and isotope tracers detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[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. **Other abbreviations:** SD, standard deviation; RSD, percent relative standard deviation; LRL, laboratory reporting limit; mg/L, micrograms per liter; mg/L, milligrams per liter; pCi/L, picocuries per liter, nv, no values in category; ≤, less than or equal to]

Constituent	Number of nondetect or ≤-coded replicates/total number of replicates	Number of SDs greater than ½ the LRL, MDL, or MRL/number of replicates with concentrations or activities less than 5 times the LRL, MDL, or MRL	Concentrations or activities of replicates with SDs greater than ½ LRL, MDL, or MRL (environmental, replicate)	Number of RSDs greater than 10 percent/number of replicates with concentrations or activities greater than 5 times the LRL, MDL, or MRL	Concentrations or activities of replicates with RSDs greater than 10 percent (environmental, replicate)
Nickel	2/5	0/3	nv	nv	nv
Selenium	0/5	0/4	nv	0/1	nv
Silver	5/5	nv	nv	nv	nv
Strontium	0/5	nv	nv	0/5	nv
Tungsten	2/5	0/2	nv	0/1	nv
Uranium	0/5	nv	nv	0/5	nv
Vanadium	0/5	nv	nv	0/5	nv
Zinc	0/5	0/3	nv	0/2	nv
Arsenic and iron species, concentrations in µg/L					
Arsenic, total	0/2	0/2	nv	nv	nv
Arsenic (III)	2/2	nv	nv	nv	nv
Iron, total	2/2	nv	nv	nv	nv
Iron (II)	2/2	nv	nv	nv	nv
Isotopic tracers, in units as noted					
δ^{2}H (per mil)	0/5	nv	nv	0/5	nv
δ^{18}O (per mil)	0/5	nv	nv	0/5	nv
Tritium (pCi/L)	1/5	[1]nv	[1]nv	0/3	nv
δ^{13}C of dissolved carbonates (per mil)	0/5	nv	nv	1/5	(–13.87, –16.63)
Carbon-14 (percent modern)	0/5	nv	nv	1/5	(5, 4)

[1] The SD was not calculated because the variability for 1 replicate pair was considered outside the limits for acceptable precision since the environmental value was reported as a detect just above the MRL and the replicate value was reported as a nondetect and less than the MRL (0.4, <0.3).

Table A4C. Quality-control summary for replicate analyses of radiochemical constituents detected in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[Non-overlapping, results are reported as "+" for the upper confidence interval and "–" for the lower confidence interval of the activity measured in the groundwater sample, which provides a range of activity possible for overlap. pCi/L, picocuries per liter; —, not detected (sample result is less than critical value); nv, no values in category]

Constituent	Number of non-overlapping values/total number of replicates	Activites for replicates with non-overlapping values (environmental, replicate) (pCi/L)
Gross alpha particle activity, 72 hour count	1/5	(1.3 ± 0.81, —)
Gross alpha particle activity, 30 day count	1/5	(2.0 ± 0.68, 0.62 ± 0.46)
Gross beta particle activity, 72 hour count	0/5	nv
Gross beta particle activity, 30 day count	1/5	(6.8 ± 0.75, 3.9 ± 0.92)
Uranium-234	1/4	(0.12 ± 0.030, 0.059 ± 0.024)
Uranium-235	1/4	(0.29 ± 0.044, 0.20 ± 0.034)
Uranium-238	0/4	nv

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[Acceptable recovery range is between 70 and 130 percent; na, not available]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetone	5	75	122	103
Acrylonitrile	5	104	127	115
tert-Amyl methyl ether (TAME)	5	91	110	100
Benzene	5	105	111	107
Bromobenzene	5	102	113	104
Bromochloromethane	5	109	118	111
Bromodichloromethane[1]	5	103	118	106
Bromoform (Tribromomethane)[1]	5	87	120	105
Bromomethane (Methyl bromide)	5	62	117	99
n-Butylbenzene	5	89	100	91
sec-Butylbenzene	5	96	108	100
tert-Butylbenzene	5	99	114	102
Carbon disulfide	5	71	93	87
Carbon tetrachloride (Tetrachloromethane)	5	104	111	109
Chlorobenzene	5	102	109	107
Chloroethane	5	91	117	114
Chloroform (Trichloromethane)[1]	5	109	120	110
Chloromethane	5	81	105	103
3-Chloropropene	5	67	125	118
2-Chlorotoluene	5	103	110	106
4-Chlorotoluene	5	99	103	102
Dibromochloromethane[1]	5	98	114	105
1,2-Dibromo-3-chloropropane (DBCP)[1,2]	na	na	na	na
1,2-Dibromoethane (EDB)[1,2]	na	na	na	na
Dibromomethane	5	104	117	106
1,2-Dichlorobenzene	5	107	118	112
1,3-Dichlorobenzene	5	103	117	106
1,4-Dichlorobenzene	5	102	112	104
trans-1,4-Dichloro-2-butene	5	96	109	104
Dichlorodifluoromethane (CFC-12)	5	62	82	77
1,1-Dichloroethane (1,1-DCA)[1]	5	109	114	111
1,2-Dichloroethane (1,2-DCA)	5	103	109	105
1,1-Dichloroethene (1,1-DCE)	5	93	104	100
cis-1,2-Dichloroethene (*cis*-1,2-DCE)[1]	5	104	113	108
trans-1,2-Dichloroethene (*trans*-1,2-DCE)	5	109	120	114
1,2-Dichloropropane	5	105	114	108
1,3-Dichloropropane	5	108	119	110
2,2-Dichloropropane	5	78	103	88
1,1-Dichloropropene	5	94	104	99
cis-1,3-Dichloropropene	5	86	105	95
trans-1,3-Dichloropropene	5	88	109	96
Diethyl ether	5	106	122	119
Diisopropyl ether (DIPE)	5	95	118	110
Ethylbenzene	5	95	108	100
Ethyl *tert*-butyl ether (ETBE)	5	92	111	102
Ethyl methacrylate	5	92	105	103
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	5	92	103	96

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent; na, not available]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Hexachlorobutadiene	5	79	88	82
Hexachloroethane	5	93	110	100
2-Hexanone (*n*-Butyl methyl ketone)	5	94	118	108
Iodomethane (Methyl iodide)	5	76	139	124
Isopropylbenzene	5	88	108	94
4-Isopropyl-1-methyl benzene	5	88	102	95
Methyl acrylate	5	108	118	109
Methyl acrylonitrile	5	110	126	118
Methyl tert-butyl ether (MTBE)	5	88	110	102
Methyl iso-butyl ketone (MIBK)	5	97	112	108
Methylene chloride (Dichloromethane)	5	98	115	108
Methyl ethyl ketone (2-butanone, MEK)	5	97	110	105
Methyl methacrylate	5	88	108	103
Naphthalene	5	89	137	112
Perchloroethene (PCE, Tetrachloroethene)[1]	5	104	116	107
n-Propylbenzene	5	91	100	95
Styrene	5	6	106	7
1,1,1,2-Tetrachloroethane	5	108	130	111
1,1,2,2-Tetrachloroethane	5	106	127	111
Tetrahydrofuran	5	101	120	109
1,2,3,4-Tetramethylbenzene	5	85	130	89
1,2,3,5-Tetramethylbenzene	5	53	131	97
Toluene[1]	5	104	106	104
1,2,3-Trichlorobenzene	5	104	124	107
1,2,4-Trichlorobenzene	5	92	113	96
1,1,1-Trichloroethane (1,1,1-TCA)	5	102	110	108
1,1,2-Trichloroethane (1,1,2-TCA)	5	103	127	106
Trichloroethene (TCE)[1]	5	101	105	103
Trichlorofluoromethane (CFC-11)	5	95	108	99
1,2,3-Trichloropropane (1,2,3-TCP)	5	98	116	106
Trichlorotrifluoroethane (CFC-113)	5	85	99	88
1,2,3-Trimethylbenzene	5	98	116	102
1,2,4-Trimethylbenzene[1]	5	92	110	104
1,3,5-Trimethylbenzene	5	49	104	97
Vinyl bromide (Bromoethene)	5	84	109	103
Vinyl chloride (Chloroethene)	5	99	113	103
m- and *p*-Xylene	5	96	107	104
o-Xylene	5	89	106	99

[1] Constituents detected in ground-water samples.

[2] Constituents on Schedules 2020 and 1306; only values from the preferred method (Schedule 1306) are reported; there is no spike solution available for Schedule 1306.

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[Acceptable recovery range is between 70 and 130 percent; na, not available]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetochlor	5	83	91	86
Alachlor	5	83	91	89
Atrazine[1,2]	5	81	94	87
Azinphos-methyl	5	54	96	68
Azinphos-methyl oxon	5	22	64	38
Benfluralin	5	54	60	57
Carbaryl	5	90	107	98
Carbofuran[3]	na	na	na	na
2-Chloro-2,6-diethylacetanilide	5	79	94	88
4-Chloro-2-methylphenol	5	42	78	60
Chlorpyrifos	5	42	82	67
Chlorpyrifos-oxon	5	14	69	19
Cyanazine	5	48	94	82
Cyfluthrin	5	37	52	46
λ-Cyhalothrin	5	29	36	34
Cypermethrin	5	38	55	45
DCPA (Dacthal)	5	90	95	92
Deethylatrazine (2-Chloro-4-isopropyl-amino-6-amino-*s*-triazine)[1,2]	[4]4	[4]50	61	56
Desulfinylfipronil	5	89	101	90
Desulfinylfipronil amide	5	29	103	81
Diazinon	5	70	85	82
3,4-Dichloroaniline[1]	5	64	73	70
3,5-Dichloroaniline	5	75	81	80
Dichlorvos	5	4	58	16
Dicrotophos	5	18	84	37
Dieldrin	5	74	102	83
2,6-Diethylaniline	5	73	84	80
Dimethoate	5	12	49	37
Disulfoton	5	42	69	63
Disulfoton sulfone	5	63	88	74
α-Endosulfan	5	64	84	73
Endosulfan sulfate	5	66	77	74
Ethion	5	50	64	57
Ethion monoxon	5	62	73	66
Ethoprop	5	78	100	88
S-Ethyl-dipropylthiocarbamate (EPTC)	5	82	86	84
2-Ethyl-6-methylaniline	5	70	84	80
Fenamiphos	5	70	87	72
Fenamiphos sulfone	5	49	81	76
Fenamiphos sulfoxide	5	4	38	24
Fipronil	5	64	88	74
Fipronil sulfide	5	66	96	78
Fipronil sulfone	5	55	76	62
Fonofos	5	72	80	77
Hexazinone[1]	5	22	58	45
Iprodione	5	45	58	45

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent; na, not available]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Isofenphos	5	65	90	81
Malaoxon	5	52	74	67
Malathion	5	70	86	82
Metalaxyl[3]	na	na	na	na
Methidathion	5	71	85	77
Metolachlor	5	79	93	92
Metribuzin	5	50	80	75
Molinate	5	82	88	85
Myclobutanil	5	67	90	77
1-Naphthol	5	12	50	16
Oxyfluorfen	5	52	79	56
Paraoxon-methyl	5	35	55	46
Parathion-methyl	5	61	94	68
Pendimethalin	5	75	86	77
cis-Permethrin	5	39	55	41
Phorate	5	41	70	62
Phorate oxon	5	78	96	94
Phosmet	5	6	23	13
Phosmet oxon	5	6	52	21
Prometon	5	72	85	74
Prometryn	5	80	92	86
Pronamide	5	71	84	79
Propanil	5	80	100	87
Propargite	5	42	58	55
cis-Propiconazole	5	74	101	82
trans-Propiconazole	5	69	89	78
Simazine[1]	5	58	90	82
Tebuthiuron[1,2]	5	37	40	37
Tefluthrin	5	57	73	71
Terbufos	5	57	73	71
Terbufos oxon sulfone	5	60	74	61
Terbuthylazine	5	87	94	91
Thiobencarb	5	78	99	94
Tribufos	5	33	49	47
Trifluralin	5	64	70	66

[1] Constituents detected in ground-water samples.

[2] Constituents on Schedule 2033 and 2060; only values from Schedule 2033 are reported because it is the preferred analytical schedule.

[3] Constituents on Schedules 2033 and 2060; only values from Schedule 2060 are reported because it is the preferred analytical schedule.

[4] The spike concentration was too small relative to the environmental concentration so the negative spike recovery for one result is not valid and not reported.

Table A5C. Quality-control summary for matrix-spike recoveries of polar pesticides and metabolites in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[Acceptable recovery range is between 70 and 130 percent; na, not available]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acifluorfen	4	50	71	64
Aldicarb	4	57	84	74
Aldicarb sulfone	4	68	104	96
Aldicarb sulfoxide	4	97	112	102
Atrazine[1,2]	na	na	na	na
Bendiocarb	4	84	91	87
Benomyl	4	72	139	96
Bensulfuron-methyl	4	98	132	119
Bentazon	4	42	100	58
Bromacil[1]	4	86	94	87
Bromoxynil	4	44	96	54
Caffeine	4	70	112	94
Carbaryl	4	87	91	89
Carbofuran[3]	4	97	106	103
Chloramben, methyl ester	4	71	100	77
Chlorimuron-ethyl	4	94	142	129
3-(4-Chlorophenyl)-1-methyl urea	4	70	104	84
Clopyralid	4	73	88	74
Cycloate	4	62	90	68
2,4-D plus 2,4-D methyl ester	4	78	83	80
2,4-DB (4-(2,4-Dichlorophenoxy)butyric acid)	4	71	75	73
DCPA (Dacthal) monoacid	4	71	86	75
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine)[1,2]	na	na	na	na
Deisopropyl atrazine (2-Chloro-6-ethylamino-4-amino-*s*-triazine)[1]	4	87	92	88
Dicamba	4	62	80	68
Dichlorprop	4	88	99	93
Dinoseb (Dinitrobutyl phenol)[1]	4	38	85	63
Diphenamid	4	99	108	104
Diuron[1]	4	97	108	101
Fenuron	4	102	114	109
Flumetsulam	4	92	123	110
Fluometuron	4	98	101	99
Hydroxyatrazine (2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine)	4	85	97	97
3-Hydroxycarbofuran	4	90	120	105
Imazaquin	4	111	253	171
Imazethapyr[1]	4	111	195	151
Imidacloprid	4	94	110	104
Linuron	4	89	99	92
MCPA (2-Methyl-4-chlorophenoxyacetic acid)	4	84	98	88
MCPB (4-(2-Methyl-4-chlorophenoxy)butyric acid)	4	64	67	66
Metalaxyl[3]	4	93	102	95
Methiocarb	4	86	101	90
Methomyl	4	94	106	101
Metsulfuron methyl	4	71	134	107

Table A5C. Quality-control summary for matrix-spike recoveries of polar pesticides and metabolites in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent; na, not available]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Neburon	4	83	94	89
Nicosulfuron	4	190	379	262
Norflurazon[1]	4	92	116	104
Oryzalin	4	69	83	76
Oxamyl	4	92	100	96
Picloram	4	70	93	74
Propham	4	67	90	78
Propiconazole	4	77	94	85
Propoxur	4	95	107	103
Siduron	4	94	125	112
Sulfometuron-methyl	4	108	130	121
Tebuthiuron[1,2]	na	na	na	na
Terbacil	4	82	94	91
Triclopyr	4	74	90	82

[1] Constituents detected in ground-water samples.

[2] Constituents on Schedule 2033 and 2060; only values from Schedule 2033 are reported because it is the preferred analytical schedule.

[3] Constituents on Schedules 2033 and 2060; only values from Schedule 2060 are reported because it is the preferred analytical schedule.

Table A5D. Quality-control summary for matrix-spike recoveries of *N*-nitrosodimethylamine (NDMA) and low-level 1,2,3-trichloropropane (1,2,3-TCP) in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
N-Nitrosdimethylamine (NDMA)[1]	1	80	80	80
Low-level 1,2,3-trichloropropane (1,2,3-TCP)[1]	5	86	112	105

[1] Constituents detected in ground-water samples.

Table A6. Quality-control summary for surrogate recoveries of volatile organic compounds, pesticides and pesticide degradates, and polar pesticides and metabolites in samples collected for the Madera–Chowchilla Groundwater Ambient Monitoring and Assessment (GAMA) study, California, April and May 2008.

[VOC, volatile organic compound]

Surrogate	Analytical schedule	Constitutent or constituent class analyzed	Number of analyses	Median recovery (percent)	Number of surrogate recoveries below 70 percent	Number of surrogate recoveries above 130 percent
Blanks						
1-Bromo-4-fluorobenzene	2020	VOC	4	82	0	0
1,2-Dichloroethane-*d*4	2020	VOC	4	115	0	1
Toluene-*d*8	2020	VOC	4	93	0	0
Diazinon-*d*10	2033	Pesticide	4	92	1	0
α-HCH-*d*6	2033	Pesticide	4	88	0	0
Barban	2060	Polar pesticide	3	87	0	0
Caffeine-^{13}C	2060	Polar pesticide	3	93	0	0
2,4,5-T	2060	Polar pesticide	3	80	0	0
Ground-water, replicate, and matrix-spike test samples						
1-Bromo-4-fluorobenzene	2020	VOC	35	80	1	0
1,2-Dichloroethane-*d*4	2020	VOC	35	120	0	4
Toluene-*d*8	2020	VOC	35	94	0	0
Diazinon-*d*10	2033	Pesticide	35	84	7	0
α-HCH-*d*6	2033	Pesticide	35	90	0	0
Barban	2060	Polar pesticide	34	84	1	0
Caffeine-^{13}C	2060	Polar pesticide	34	83	7	0
2,4,5-T	2060	Polar pesticide	34	84	0	0

Manuscript approved for publication, June 25, 2009
Prepared by the USGS Publishing Network,
Publishing Service Center, Sacramento, California

For more information concerning the research in this report, contact the
California Water Science Center Director,
U.S. Geological Survey, 6000 J Street
Sacramento, California 95819
http://ca.water.usgs.gov

Shelton and others—**Groundwater-Quality Data for the Madera–Chowchilla Study Unit, 2008: Results from the California GAMA Program**—Data Series 455

Printed on recycled paper