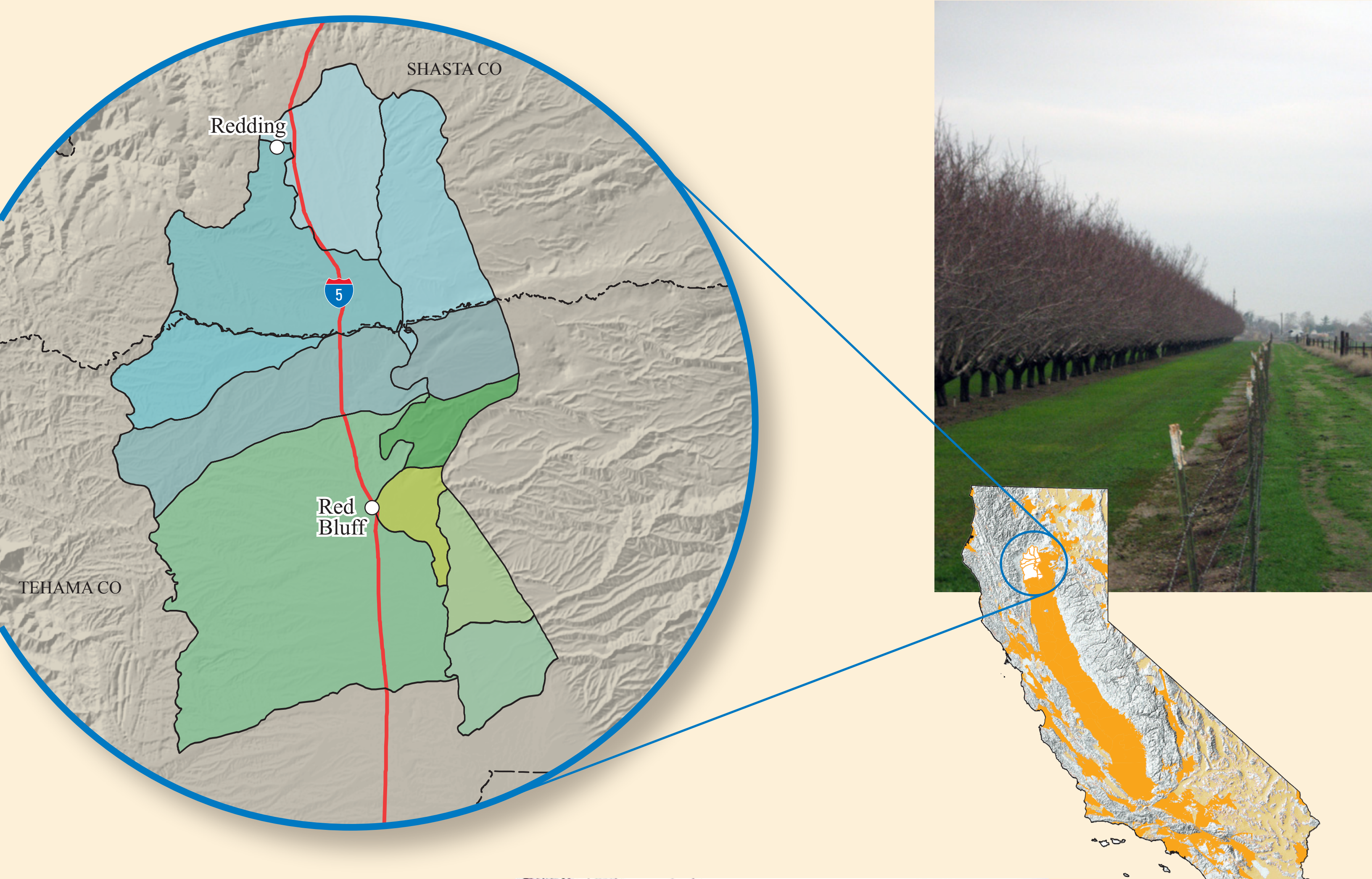
Prepared in cooperation with the California State Water Resources Control Board
A product of the California Groundwater Ambient Monitoring and Assessment (GAMA) Program

Groundwater Quality Data for the Northern Sacramento Valley, 2007: Results from the California GAMA Program



Data Series 452

U.S. Department of the Interior
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Cover Photographs:
Top: View looking down the fence line, 2008. (Photograph taken by Michael Wright, U.S. Geological Survey.)
Bottom: A well/pump in a field, 2008. (Photograph taken by George Bennett, U.S. Geological Survey.)

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

U.S. Geological Survey
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Abbreviations and Acronyms

AB	Assembly Bill (through the California State Assembly)
CAS	Chemical Abstract Service (American Chemical Society)
CSU	combined standard uncertainty
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
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
NL-CA	notification level (CDPH)
NSAC	Northern Sacramento Valley Study Area grid well
NSAC-MW	Northern Sacramento Valley Study Area monitoring well
NSAC-U	Northern Sacramento Valley Study Area understanding well
NWIS	National Water Information System (USGS)
PCFF-GAMA	personal 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)
RED	Redding Study Area grid well
RED-MW	Redding Study Area monitoring well

RED-U	Redding Study Area understanding well
REDSAC	Northern Sacramento Valley study unit
SMCL-CA	secondary maximum contaminant level (CDPH)
SRL	study reporting level
ssL_C	sample-specific critical level
TT-US	treatment technique (USEPA)
US	United States
V	analyte detected in sample and its associated blanks; thus the result is not considered a detection for groundwater quality assessment
VPDB	Vienna Pee Dee Belemnite
VSMOW	Vienna Standard Mean Ocean Water

Organizations	
CDPH	California Department of Public Health
DWR	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	State Water Resources Control Board
USGS	U.S. Geological Survey
WECK	Weck Laboratories, Inc.

Selected chemical names	
C	carbon
$CaCO_3$	calcium carbonate
CFC	chlorofluorocarbon
CO_3^{-2}	carbonate
DOC	dissolved organic carbon
H	hydrogen
HCl	hydrochloric acid
HCO_3^-	bicarbonate
MTBE	methyl *tert*-butyl ether
N	nitrogen
NDMA	*N*-Nitrosodimethylamine
O	oxygen
PCE	perchloroethene (tetrachloroethene)

TCP	trichloropropane
TDS	total dissolved solids
THM	trihalomethane
VOC	volatile organic compound

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
km	kilometer
L	liter
mg	milligram
mg/L	milligram per liter (parts per million)
mi	mile
mL	milliliter
µg/L	microgram per liter (parts per billion)
pCi/L	picocurie per liter
$\delta^{i}E$	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:

$$°F=(1.8\times°C)+32$$

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

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

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

Groundwater Quality Data for the Northern Sacramento Valley, 2007: Results from the California GAMA Program

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Abstract

Groundwater quality in the approximately 1,180-square-mile Northern Sacramento Valley study unit (REDSAC) was investigated in October 2007 through January 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 REDSAC and to facilitate statistically consistent comparisons of groundwater quality throughout California. Samples were collected from 66 wells in Shasta and Tehama Counties. Forty-three of the wells were selected using a spatially distributed, randomized grid-based method to provide statistical representation of the study area (grid wells), and 23 were selected to aid in evaluation of specific water-quality issues (understanding wells).

The groundwater samples were analyzed for a large number of synthetic organic constituents (volatile organic compounds [VOC], pesticides and pesticide degradates, and pharmaceutical compounds), constituents of special interest (perchlorate and *N*-nitrosodimethylamine [NDMA]), naturally occurring inorganic constituents (nutrients, major and minor ions, and trace elements), radioactive constituents, and microbial constituents. Naturally occurring isotopes (tritium, and carbon-14, and stable isotopes of nitrogen and oxygen in nitrate, stable isotopes of hydrogen and oxygen of water), and dissolved noble gases also were measured to help identify the sources and ages of the sampled ground water. In total, over 275 constituents and field water-quality indicators were investigated.

Three types of quality-control samples (blanks, replicates, and sampmatrix spikes) were collected at approximately 8 to 11 percent of the wells, and the results for these samples were used to evaluate the quality of the data obtained from the groundwater samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that contamination was not a noticeable source of bias in the data for the groundwater samples. Differences between replicate samples were within acceptable ranges for nearly all compounds, indicating acceptably low variability. 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 ground water. 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 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 do not indicate compliance or noncompliance with those thresholds.

The concentrations of most constituents detected in groundwater samples from REDSAC were below drinking-water thresholds. Volatile organic compounds (VOC) and pesticides were detected in less than one-quarter of the samples and were generally less than a hundredth of any health-based thresholds. NDMA was detected in one grid well above the NL-CA. Concentrations of all nutrients and trace elements in samples from REDSAC wells were below the health-based thresholds except those of arsenic in three samples, which were above the USEPA maximum contaminant level (MCL-US). However, none of these wells were public-supply wells. Concentrations of all radioactive constituents were below health-based thresholds except radon-222, which was detected above the proposed MCL-US of 300 pCi/L in samples from 11 grid wells. Most of the samples from REDSAC wells had concentrations of major elements, total dissolved solids, and trace elements below the non-enforceable thresholds set for aesthetic or technical concerns. A few samples contained iron, manganese, or pH at levels above the SMCL-CA or SMCL-US thresholds.

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 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.waterboards.ca.gov/gama*). The GAMA program currently consists of three projects: GAMA Priority Basins 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 the data collected during the study include analyses for an extensive number of chemical constituents at very low concentrations, analyses that are not normally available. A broader understanding of groundwater composition will be especially useful for providing an early indication of changes in water quality and for identifying the natural and human factors affecting water quality. Additionally, the GAMA Priority Basin Project will analyze a broader suite of constituents than that required by the California Department of Public Health (CDPH; formerly California Department of Health Services, renamed on July 1, 2007). An understanding of the occurrence and distribution of these constituents 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 in an assessment of groundwater quality. Belitz and others (2003) partitioned the State into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics (*fig. 1*), and representative regions in all 10 provinces were included in the project design. Eighty percent of California's approximately 16,000 public-supply wells are located in groundwater basins within these hydrologic provinces. These groundwater basins, defined by the California Department of Water Resources, generally consist of relatively permeable, unconsolidated deposits of alluvial or volcanic origin (California Department of Water Resources, 2003). Groundwater basins, as well as their subbasins, 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. The 116 priority basins were grouped into 35 study units. Some areas outside of the defined groundwater basins were added to their nearest respective study units to represent the 20 percent of public-supply wells not located in the groundwater basins.

Three types of water-quality assessments are being conducted using 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 series 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; Milby Dawson and others, 2008; Ferrari and others, 2008: Land and Belitz, 2008; Shelton and others, 2008). Subsequent reports will address the status, trends, and understanding aspects of the water-quality assessments.

The Northern Sacramento Valley GAMA study unit, hereinafter referred to as REDSAC (after "Redding" and "Sacramento"), consists of 11 groundwater sub-basins within the Redding Area and the Sacramento Valley Basins. REDSAC was considered high priority for sampling to provide adequate representation of the Central Valley hydrogeologic province (Belitz and others, 2003).

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 Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study unit.

Purpose and Scope

The purposes of this report are (1) to describe the study design, including the hydrogeologic setting of REDSAC 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 REDSAC. Groundwater samples were analyzed for organic, inorganic, radioactive, and microbial constituents, field parameters, naturally occurring isotopes, and dissolved noble gases. The chemical and microbial data presented in this report were evaluated by comparing these data to State and Federal drinking-water regulatory and nonregulatory health-based standards that are applied to treated drinking water. Regulatory and nonregulatory thresholds considered for this report are those established by the United States Environmental Protection Agency (USEPA) and the California Department of Public Health (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

Knowledge of the hydrologeologic setting is important in the design of a groundwater-quality investigation. The Northern Sacramento Valley study unit (REDSAC) covers approximately 1,180 square miles in Shasta and Tehama Counties, California, at the northern end of the Central Valley hydrogeologic province (as described by Belitz and others, 2003) (*fig. 1*). The long axis of the study unit trends north-south for a distance of approximately 50 miles along the Sacramento River; the short axis is approximately 30 miles long, and corresponds to the width of the Central Valley between the northern Coast Ranges to the west (*fig. 2*) and the Sierra Nevada to the east (*fig. 1*). REDSAC contains 11 groundwater subbasins, including 6 subbasins of the Redding Area groundwater basin and 5 subbasins of the Sacramento Valley groundwater basin (California Department of Water Resources, 2003) (*fig. 2*). For the purposes of this study, the Redding Area groundwater basin as defined by CADWR was designated as the “Redding study area”, and the Sacramento Valley basin as defined by CADWR was designated the “Northern Sacramento Valley study area.” The Redding study area consists of the subbasins Enterprise, Millville, Anderson, South Battle Creek, Rosewood, and Bowman. The Northern Sacramento Valley study area includes the Bend, Red Bluff, Antelope, Dye Creek, and Los Molinos subbasins.

The main water-bearing deposits in REDSAC are primarily continental deposits of late Tertiary (Pliocene) to Quaternary (Holocene) age (California Department of Water Resources, 2003). These deposits have a cumulative thickness of several hundred feet near the foothills of the Coast Ranges, the Klamath Mountains, and the Cascade Range, and increase to approximately 4,000 feet near the valley center (California Department of Water Resources, 2003). Sources of groundwater recharge are direct infiltration of precipitation, river and stream flow, and agricultural irrigation return flow. The primary surface-water features of REDSAC include the Sacramento River, several canals, and minor rivers and their principal tributaries.

Redding Study Area

The Redding study area is bounded to the north by bedrock of the Klamath Mountains, to the east by the Cascade Range, to the south by the Sacramento Valley groundwater basin, and to the west by the northern Coast Ranges (*fig. 3*). It covers an area of approximately 600 square miles and is within Shasta County (California Department of Water Resources 2003). Average annual precipitation ranges from 26 to 33 inches, increasing to the north and the west. The main water-bearing aquifer within this study area on the western side of the Sacramento River is the Tehama (Pliocene) Formation; on the eastern side of the Sacramento River, it is the Tuscan (Pliocene) Formation. The Tehama Formation consists of unconsolidated to moderately consolidated coarse and fine-grained sediments derived from the northern Coast Ranges to the west. The Tehama Formation is up to 4,000 feet thick and varies in depth from a few feet to several hundred feet below the land surface, with depth generally increasing towards the east (California Department of Water Resources, 2003). The Tuscan formation is derived from the Cascade Range to the east and is primarily composed of volcaniclastic sediments (California Department of Water Resources 2003). The Tuscan formation is up to 1,500 feet thick and varies in depth from a few feet to several hundred feet below the land surface, with depth generally increasing towards the east (California Department of Water Resources 2003).

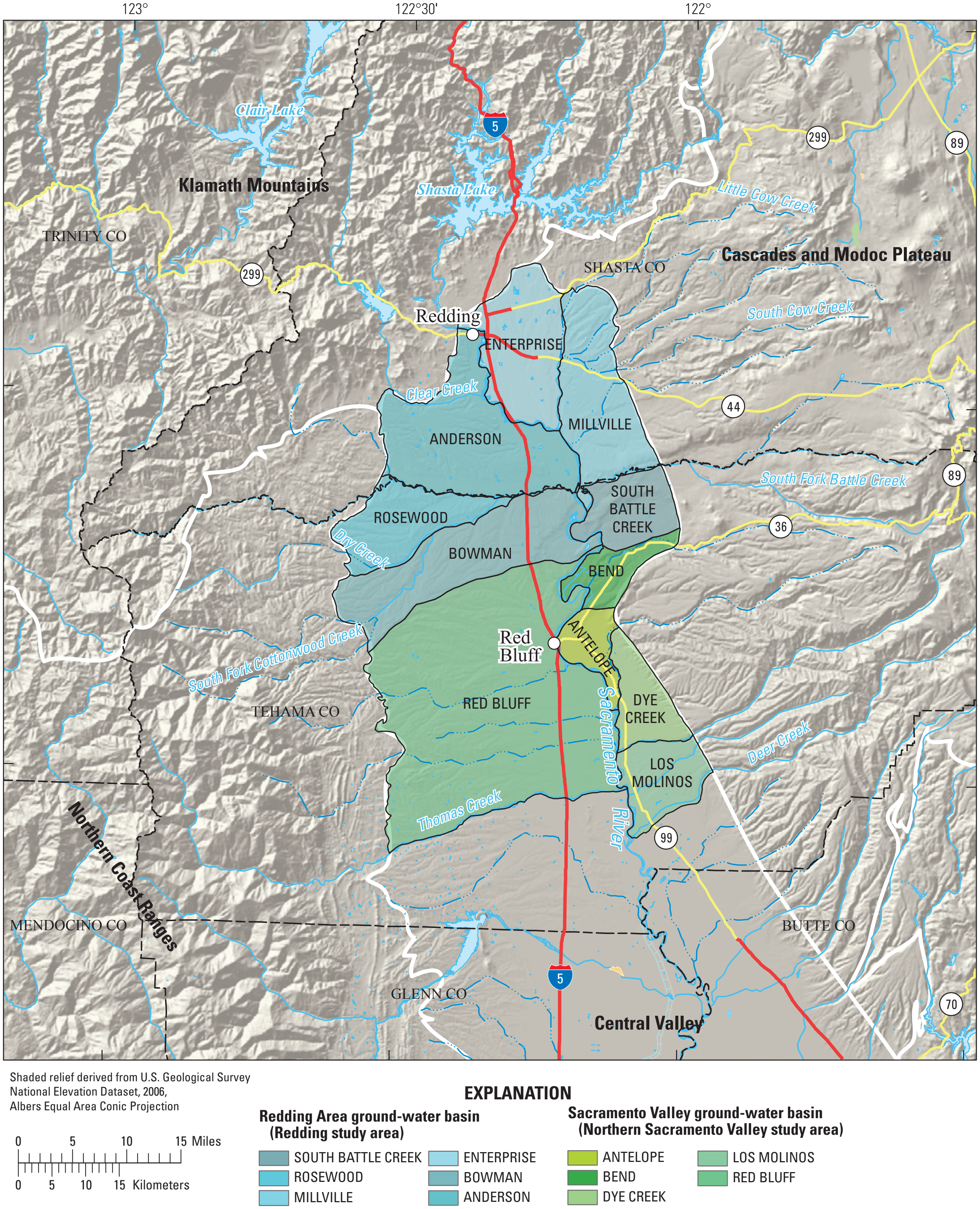

Figure 2. The Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the California Department of Water Resources groundwater basins within the study unit and major hydrologic features.

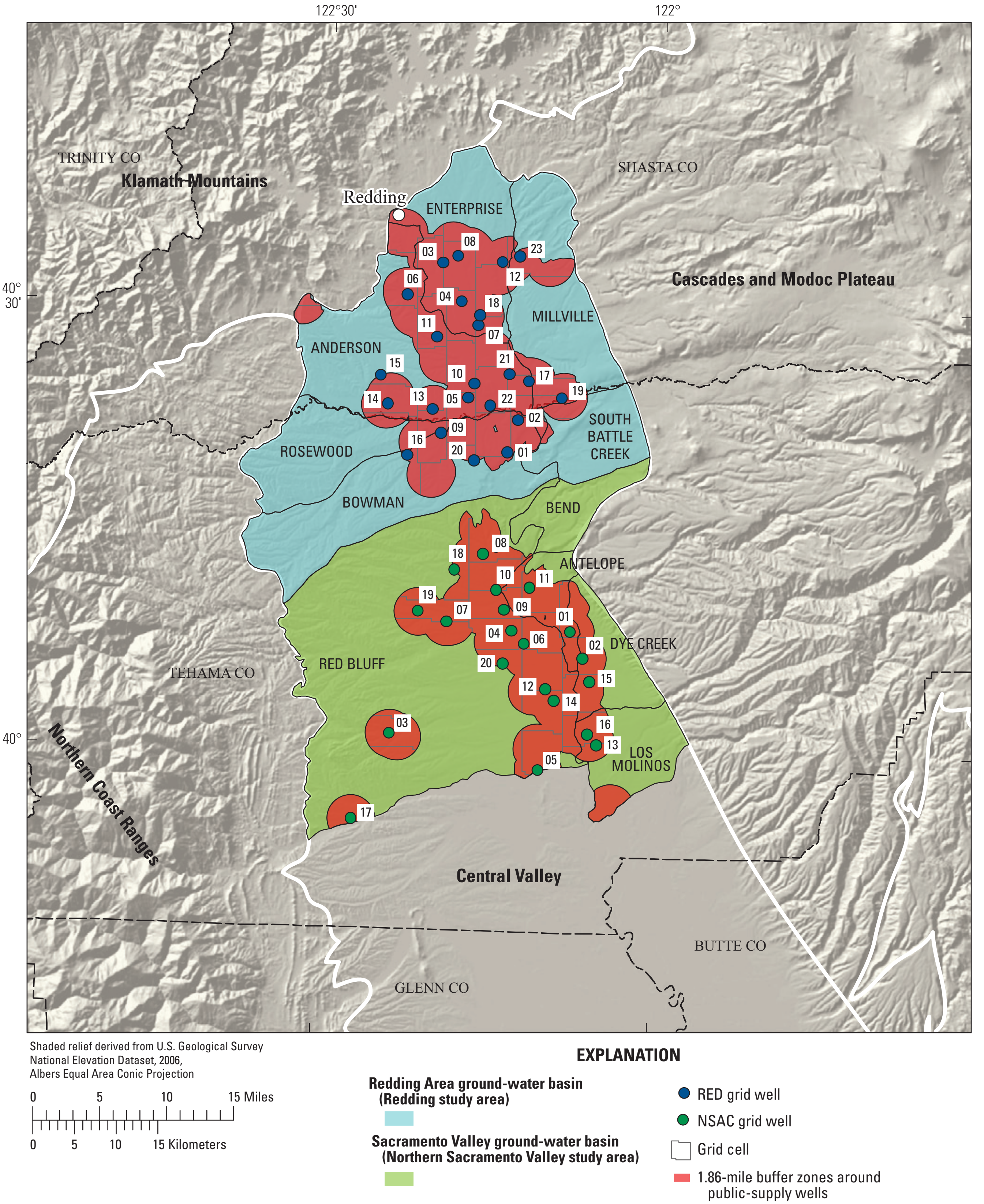

Figure 3. The Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the 1.86-mile buffer zones around the public-supply wells, the distribution of study area grid cells, and the locations of sampled grid wells.

Northern Sacramento Valley Study Area

The Northern Sacramento Valley study area is bounded to the north by the hydrologic division between the Redding area and the Sacramento Valley groundwater basins, to the east by the Cascade Ranges and the Chico Monocline, to the south by Deer and Thomas Creeks, and to the west by the Coast Ranges. It covers an area of approximately 580 square miles and lies within Tehama County (California Department of Water Resources 2003). Average precipitation ranges from 21 to 26 inches, increasing to the north and northeast. The main water-bearing aquifer within this study area on the western side of the Sacramento River is the Tehama (Pliocene) Formation; on the eastern side of the Sacramento River, it is the Tuscan (Pliocene) Formation. The Tehama Formation consists of unconsolidated to moderately consolidated coarse and fine-grained sediments derived from the Coast Ranges to the west. The Tehama Formation is up to 4,000 feet thick and varies in depth from a few feet to several hundred feet below the land surface, with depth generally increasing to the east towards the Sacramento River (California Department of Water Resources, 2003). The Tuscan formation is derived from the Cascade Range to the east and is primarily composed of volcaniclastic sediments (California Department of Water Resources 2003). The Tuscan formation is up to 2,400 feet thick and varies in depth from a few feet to several hundred feet below the land surface, with thickness generally increasing to the west towards the Sacramento River (California Department of Water Resources 2003).

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, (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 plan, 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. Forty-three "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 twenty-three additional "understanding" wells were selected to provide greater sampling density in several areas to aid in understanding of specific groundwater-quality issues in the study unit.

The spatially distributed wells were selected using a randomized grid-based method (Scott, 1990). Locations of public-supply wells listed in the statewide database maintained by the CDPH were plotted, and 1.86-mi (3-kilometer) radius circles were drawn around each well within the Redding and the Northern Sacramento Valley study areas. The area encompassed by the circles was then divided into 44 grid cells approximating 7 mi^2 (18 km^2) (*fig. 3*). This grid-cell size met the GAMA objectives for the Central Valley hydrogeologic province of a sampling density of at least one well per 10 mi^2 (25 km^2) while having at least 10 grid cells per study area (Bennett and others, 2006). For this assessment, the Redding study area was divided into 24 grid cells covering a total of approximately 170 mi^2, and the Northern Sacramento Valley study area was divided into 20 grid cells covering approximately 140 mi^2.

The objective was to sample one randomly selected public-supply well per grid cell. Forty-three of the 44 grid cells were sampled in REDSAC; one grid cell did not contain active or accessible wells. If a grid cell contained more than one public-supply well, each well was randomly assigned a rank. The lowest numbered well that met basic sampling criteria (for example, sampling point before treatment, capability to pump for several hours, and availability of well-construction information) and for which permission to sample could be obtained was then sampled. If a grid cell did not contain accessible public-supply wells, commercial, irrigation, or domestic wells were considered for sampling. In this fashion, one well was selected in each cell to provide a spatially distributed, randomized monitoring network for each study area. Wells sampled as part of the randomized grid-cell network are hereinafter referred to as "grid wells." The 43 grid wells in REDSAC were numbered in the order of sample collection, with the prefix varying by study area: RED for the Redding study area, and NSAC for the northern Sacramento Valley study area.

Additional wells were sampled to evaluate changes in water chemistry along selected groundwater flow paths or between shallow and deep parts of the aquifers. Wells sampled as part of these studies were not included in the statistical characterization of water quality in REDSAC because inclusion of these wells would have caused overrepresentation of some cells. These 23 additional, non-randomized wells are numbered in the order of sample collection with the prefixes "NSAC-U", "RED-U" ("U" indicating "understanding well"), and "NSAC-MW" "RED-MW" ("MW" indicating "monitoring well ") (*fig. 4*).

Table 1 (all tables shown in back of book) provides the GAMA alphanumeric identification number for each well, along with the date sampled, sampling schedule, well elevation, and well-construction information. Groundwater samples were collected from 30 public supply wells, 14 domestic wells, 13 monitoring wells, 4 irrigation wells, 4 institutional wells, 1 industrial well, and 1 aquaculture well during October 2007 through January 2008.

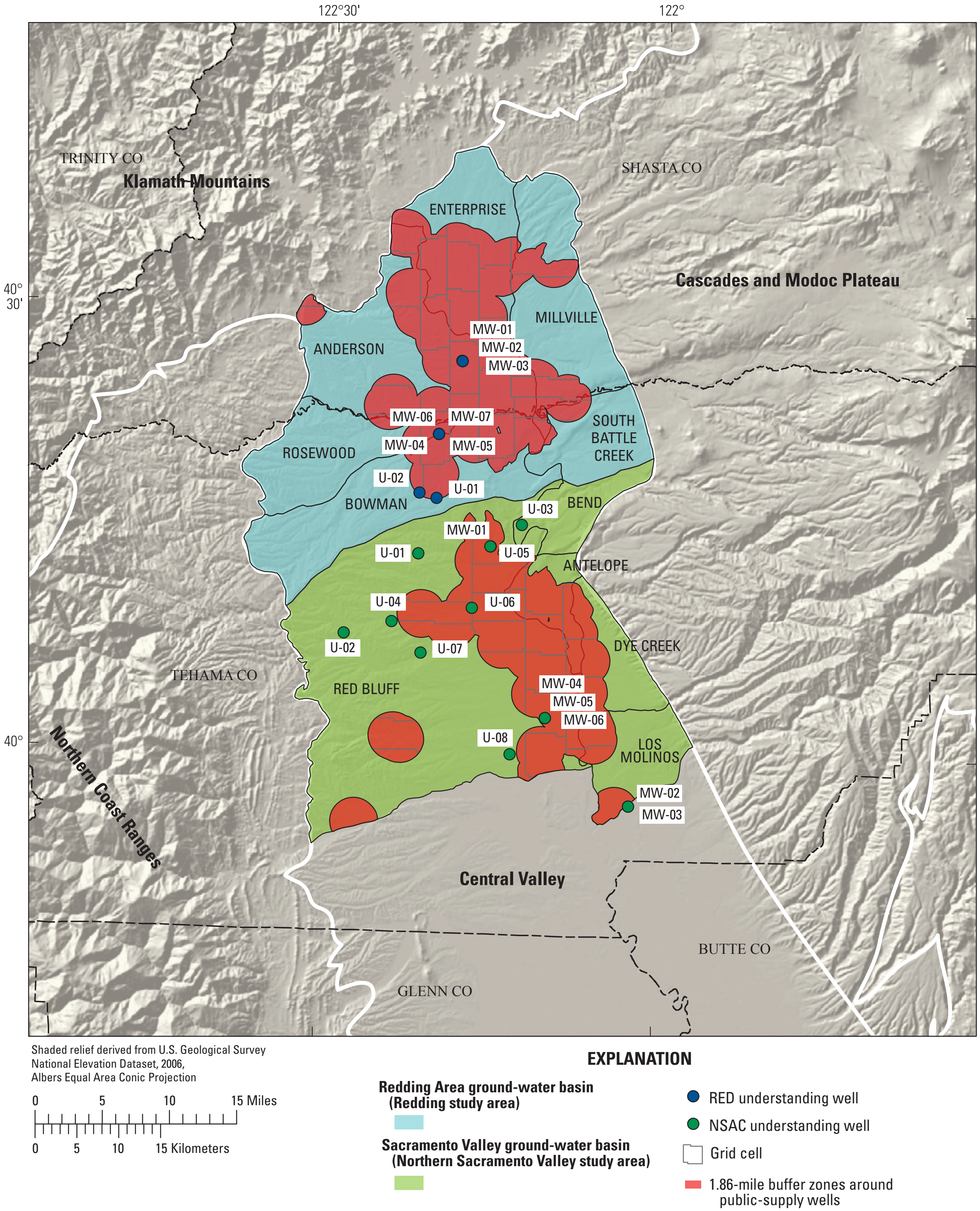

Figure 4. The Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the 1.86-mile buffer zones around all public-supply wells, the distribution of study area grid cells, and the locations of sampled understanding wells and monitoring wells.

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

The wells in REDSAC were sampled using a tiered analytical approach. All wells were sampled for a standard set of constituents, including VOCs, pesticides and pesticide degradates, perchlorate, nutrients and dissolved organic carbon, major and minor ions and trace elements, chromium species, arsenic and iron species, stable isotopes of nitrogen and oxygen in nitrate, stable isotopes of hydrogen and oxygen in water, carbon isotopes, dissolved noble gases, tritium, helium and uranium isotopes (Redding study area only). This 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 pharmaceuticals, radioactive constituents, NDMA, and microbial constituents (*table 2*). Intermediate and slow refer to the time required to sample the well for all the analytes on the schedule. Generally, one slow or two intermediate wells can be sampled in one day. In REDSAC, 54 of the wells were sampled on the intermediate schedule, and 12 on the slow schedule.

Sample Collection and Analysis

Samples were collected in accordance with the protocols established by the USGS National Water Quality Assessment (NAWQA) program (Koterba and others, 1995) and the USGS National Field Manual (U.S. Geological Survey, variously dated). These sampling protocols ensure that a representative sample of groundwater is collected at each site and that the samples are collected and handled in a way that minimizes the potential for contamination. The methods used to collect samples 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*); 122 pesticides and pesticide degradates (*tables 3B,C*); 14 pharmaceutical compounds (*table 3D*); 2 constituents of special interest (*table 3E*); 5 nutrients and dissolved organic carbon (*table 3F*); 10 major and minor ions and total dissolved solids (*table 3G*); 25 trace elements (*table 3G*), arsenic, iron, and chromium species (*table 3H*); stable isotopes of hydrogen and oxygen in water, and 8 radioactive constituents, including tritium and carbon-14 (*tables 3I,J*); 5 dissolved noble gases, and helium stable isotope ratios (*table 3J*); and 2 microbial constituents (*table 3K*). The methods used to collect and analyze samples are described in the *Appendix* section "Sample Collection and Analysis."

Data Reporting

The methods and conventions used for reporting the data are described in the Appendix. Fourteen 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 (*table A2*) are reported. Five other constituents—arsenic, iron, and chromium concentrations and tritium activities—were measured by more than one laboratory, and all sets of results are reported for these constituents.

Quality Assurance

The quality-assurance and quality-control procedures used for this study followed the protocols used by the USGS NAWQA program (Koterba and others, 1995) and described in the USGS National Field Manual (U.S. Geological Survey, variously dated). The quality-assurance plan followed by the NWQL, the primary laboratory used to analyze samples for this study, is described by Maloney (2005) and Pirkey and Glodt (1998). Quality-control (QC) samples collected in REDSAC during the study include source-solution blanks, field blanks, replicates, and matrix spikes 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. A summary of quality-control-sample results are presented in the next section, and quality-control procedures 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 nearly 300 constituents analyzed 20 were detected in at least one field blank. All detected concentrations of four constituents in field blanks were below the project-defined reporting limits; thus, no data for these four constituents were affected. The remaining 16 detections in blanks exceeded the project-defined reporting limits for ammonia as nitrogen, nitrite as nitrogen, aluminum, boron, chromium, cobalt, iron, lead, manganese, mercury, nickel, silica, TDS, iron (II), total iron, and radium-226, resulting in some environmental detections being flagged with a "≤" symbol. This process is explained in the *Appendix*.

Data from replicates indicated that variability between measurements was generally low; relative standard deviations (RSD) were below 5 percent for most replicate pairs for most constituents (*tables A4A–D*). Of the 15 pairs that had RSDs above the acceptable limit of 20 percent, most had concentrations near the LRLs for those constituents, and at these low concentrations, small differences in the measured values in the replicate pairs account for the large RSDs. These replicate results confirm that the procedures used to collect and analyze the samples were consistent.

Median matrix-spike recoveries for 26 of the 207 organic constituents analyzed were lower than the acceptable limits, which may indicate that these constituents might not have been detected in some samples if they were present at very low concentrations. Median matrix-spike recoveries for 2 of the 207 organic constituents analyzed were higher than the acceptable limits. High recoveries may indicate that reported values could be higher than the true concentrations in the sample. The surrogates for approximately 85 percent of the samples analyzed using surrogates had recoveries within acceptable limits.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 drinking-water health-based thresholds and thresholds established for aesthetic purposes (California Department of Public Health, 2008a,b; U.S. Environmental Protection Agency, 2008a–c). The CDPH was formed as a result of a reorganization of the California Department of Health Services (CDHS) on July 1, 2007. The chemical and microbial data presented in this report are meant to characterize the quality of the untreated groundwater resources within REDSAC and do not represent the treated drinking water delivered to consumers by water purveyors. The chemical and microbial composition of treated drinking water may differ from that of 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 do not imply 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 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 an MCL-CA threshold in samples collected for the GAMA Priority Basin Project, but these detections do not violate 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 at concentrations 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 are the same; thus the thresholds are labeled "AL-US" in this report.

- **TT—Treatment Technique.** Legally enforceable standards that apply to public-water systems and are designed to protect public health by limiting the levels of microbial constituents in drinking water. Detections of microbial constituents at abundances above the treatment-technique thresholds trigger requirements for mandatory additional disinfection during water treatment. The action levels established by the USEPA and CDPH currently are the same; thus the thresholds are labeled "TT-US" in this report.

- **SMCL—Secondary Maximum Contaminant Level.** Non-enforceable standards applied to constituents that affect the aesthetic qualities of drinking water, such as taste, odor, and color, 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 (SMCL-CA) are used in this report 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 that have MCLs, the concentrations in groundwater samples were compared to the MCL-US or MCL-CA. Constituents having SMCLs were compared to 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 selecting 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 4–16* for constituents detected in groundwater samples from REDSAC. Not all constituents analyzed for this study have established thresholds available.

Detections of constituents at concentrations greater than the selected comparison thresholds are marked with asterisks in *tables 4–13* In this study, only two constituents (arsenic, and radon-222) were detected at concentrations above health-based thresholds. These constituents were detected in 11 grid wells and 3 understanding wells. Three additional constituents (iron, manganese, and pH) were detected at concentrations above thresholds set for aesthetic or technical qualities. These constituents were detected in five understanding wells, and three grid wells.

Groundwater-Quality Data

Results from analyses of raw (untreated) groundwater samples from REDSAC are presented in tables 4 through 13. Groundwater samples collected in REDSAC were analyzed for nearly 300 constituents, and 228 of these constituents were not detected in any of the samples (*tables 3A–K*). The results tables present only the constituents that were detected and lists only those samples in which at least one constituent was detected. The tables containing organic constituent classes that were analyzed at all of the grid wells include the number of wells at which each analyte was detected, the frequency at which it was detected (in relation to the number of grid wells), and the total number of constituents detected at each well. Results from the understanding 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 understanding wells.

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

- Organic constituents
  - VOCs (*table 5*)
  - Pesticides and pesticide degradates (*table 6*)
- Constituents of special interest (*table 7*)
- Inorganic constituents
  - Nutrients (*table 8*)
  - Major and minor ions and dissolved solids (*table 9*)
  - Trace elements (*table 10*)
  - Arsenic, iron, and chromium speciation (*table 11*)
- Isotopic tracers (*table 12*)
- Radioactive constituents (*table 13*)
- Noble gases (*table 14*)

Results for pharmaceutical compounds, 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 dissolved oxygen, pH, specific conductance, alkalinity, and associated parameters (turbidity and water temperature) are given in *table 4*. Alkalinity and dissolved oxygen are used as indicators of natural processes that control water chemistry. Specific conductance is a measure of electrical conductivity of the water, and is proportional to amount of total dissolved solids (TDS) in the water. The pH value indicates the acidity or basicity of the water. Three understanding wells had laboratory pH values outside of the SMCL-US range for pH; none of these wells are public-supply wells. Laboratory pH values may be higher than field pH values because the pH of groundwater may increase upon exposure to the atmosphere (see *Appendix*).

Organic Constituents

Volatile organic compounds (VOC) can be present in paints, solvents, fuels, fuel additives, refrigerants, fumigants, and disinfected water, and are characterized by their tendency to evaporate. VOCs generally persist longer in groundwater than in surface water because groundwater is isolated from the atmosphere. Of the 85 VOCs analyzed, 15 were detected in groundwater samples; all concentrations were below health-based thresholds, and most were less than a hundredth of the threshold values (*table 5*). Of the 15 VOCs detected, only 7 were detected in the wells sampled on the spatially-distributed grid; these included 2 disinfection by-products, 1 solvent, 1 gasoline oxygenate, and 3 gasoline hydrocarbons. Chloroform, a byproduct of drinking-water disinfection, was the only VOC detected in more than 20 percent of the grid well samples. This compound is among the most commonly detected VOCs in groundwater nationally (Zogorski and others, 2006). One or more VOCs were detected in 10 of the 43 grid wells sampled.

Pesticides include herbicides, insecticides, and fungicides, and are used to control weeds, insects, fungi, and other pests in agricultural, urban, and suburban settings. One or more pesticide compounds were detected in 14 of the 43 grid wells. Of the 122 pesticides and pesticide degradates analyzed for groundwater samples, only 4 were detected. All concentrations were less than a hundredth of the threshold values (*table 6*). The herbicides atrazine, prometon, simazine, and deethylatrazine, a degradate of atrazine, were detected in more than 33 percent of the grid well samples. These four compounds are among the most commonly detected pesticide compounds in groundwater nationally (Gilliom and others, 2006). Some of the pesticide samples were partially ruined during extraction or analysis (*tables 3B,C*).

Constituents of Special Interest

Perchlorate and NDMA are constituents of special interest in California because they may adversely affect water quality and recently have been found in water supplies (California Department of Public Health, 2008b). Perchlorate was detected in approximately 70 percent of the 43 grid well samples, and all concentrations in REDSAC samples were less than one-sixth of the MCL-CA (*table 7*). NDMA was analyzed for in samples only from the 12 slow-schedule wells in REDSAC and was detected in 5 grid wells. NDMA was detected in one grid well at a level above the NL-CA threshold of 0.010 μg/L.

Inorganic Constituents

Unlike the organic constituents and the constituents of special interest, most of the inorganic constituents are naturally present in ground water, although their concentrations may be influenced by human activities. Nutrients (nitrogen and phosphorus) and dissolved organic carbon 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 ground water. High concentrations of nitrate can adversely affect human health, particularly the health of infants. All concentrations of nitrate, nitrite, and ammonia measured in samples from REDSAC wells were below health-based thresholds (*table 8*).

The major-ion composition, total dissolved solids (TDS) content, and levels of certain trace elements in groundwater affect the aesthetic properties of water, such as taste, color, and odor, and the technical properties, such as scaling and staining. Although there are no adverse health effects directly associated with these properties, they may reduce consumer satisfaction with the water or may have economic effects. CDPH has established non-enforceable thresholds (SMCL-CA) that are based on aesthetic or technical properties rather than health-based concerns for the major ions chloride and sulfate, TDS, and several trace elements. The concentrations of chloride, fluoride, sulfate, and TDS measured in samples from REDSAC wells were all below the recommended SMCL-CAs (*table 9*).

Of the 25 trace elements analyzed, 3 were not detected in any samples (silver, beryllium, and thallium). The concentrations of iron and manganese are affected by the oxidation-reduction state of the ground water. Precipitation of minerals containing iron or manganese may stain surfaces orange, brown, or black. Iron was detected in 30 percent of the samples (13 from grid wells, and 10 from understanding wells; *table 10*). One understanding well had iron concentrations above the SMCL-CA, but it was not a public supply well. Manganese was detected in 25 grid wells, and 21 understanding wells. Three wells (2 grid and 1 understanding) had concentrations of manganese above the SMCL-CA.

Twenty-two of the 25 trace elements analyzed in this study have health-based thresholds (*table 3G*). Of the 22 trace elements with health-based thresholds, 19 were detected and all concentrations were below health-based thresholds. Arsenic was detected in all wells sampled, but only samples from three understanding wells had arsenic concentrations above the MCL-US. However, none of these wells were public-supply wells.

Arsenic, iron, and chromium occur as different species, depending on the oxidation-reduction state of the ground water. The oxidized and reduced species have different solubilities in groundwater and may have different effects on human health. The relative proportions of the oxidized and reduced species of each element can be used to help interpret the oxidation–reduction state of the aquifer. Concentrations of total arsenic, total iron, total chromium, and the concentrations of either the reduced or the oxidized species of each element are given in *table 11*. The concentration of the other species can be calculated by the difference. The concentrations of arsenic, iron, and chromium reported in *table 11* may be slightly 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 hydrologic processes. Isotopic ratios of hydrogen and oxygen of water (*table 12*) aid in interpretation of the sources of groundwater recharge. These stable-isotope ratios reflect the altitude, latitude, and temperature of precipitation and also the extent of evaporation of the water in surface water bodies or soils before being infiltrated 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 in the air dissolved in water that is in contact with the atmosphere, and the solubilities of the different noble gas species vary with temperature. Additional stable-isotope ratios of nitrogen and oxygen derived from dissolved nitrate (*table 12*) can be used to help interpret sources and processes affecting these solutes in aquifers.

Tritium activities (*table 12*), carbon-14 activities (*table 12*), and helium isotopic ratios (*table 14*) also provide information about the age (time since recharge) of the ground water. Tritium is a short-lived radioactive isotope of hydrogen that is incorporated into the water molecule. Low levels of tritium are continuously produced by interaction of cosmic radiation with the Earth's atmosphere, and a large amount of tritium was produced as a result atmospheric testing of nuclear weapons between 1952 and 1963. Thus, concentrations of tritium above background levels 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 ground water.

Carbon-14 (*table 12*) is a radioactive isotope of carbon. Low levels of carbon-14 are continuously produced by interaction of cosmic radiation with the Earth's atmosphere, and incorporated into atmospheric carbon dioxide. The carbon dioxide dissolves in precipitation, surface water, and 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 that has a health-based threshold. Tritium was not detected above the health-based threshold in any of the REDSAC groundwater samples.

Radioactive Constituents

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

Activity is often used instead of concentration for reporting the presence of radioactive constituents. Activity of radioactive constituents in groundwater is measured in units of picocuries per liter (pCi/L), and one picocurie 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.

The REDSAC samples analyzed for radioactive constituents had activities of radium and of gross alpha and beta emitters less than established health-based standards (*table 13A,B*). Activities of radon-222 in samples from 11 grid wells (*table 13C*) were above the proposed MCL-US of 300 pCi/L; however, none were greater than the alternative proposed MCL-US of 4,000 pCi/L.

Microbial Indicators

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

Samples from 10 REDSAC wells were analyzed for microbial indicators (NSAC-01, NSAC-02, NSAC-08, NSAC-09, NSAC-16, RED-03, RED-06, RED-07, and RED-12, RED-14). None of the samples from the 10 wells contained the viral indicators F-specific and somatic coliphage.

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 reports.

Summary

Groundwater quality in the approximately 1,180-square-mile Northern Sacramento Valley study unit (REDSAC) was investigated in October 2007 through January 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 SWRCB and the USGS in response to the 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. REDSAC was the twentieth study unit to be sampled as part of the project.

REDSAC is in the northern part of the Central Valley Province and includes within it 11 groundwater subbasins; together these subbasins comprise parts of two larger groundwater basins defined by the California Department of Water Resources (California Department of Water Resources, 2003). The REDSAC study included assessment of the groundwater quality in samples from 66 wells in Shasta and Tehama Counties. Forty-three of the wells were selected using a randomized grid approach to achieve a statistically unbiased representation of groundwater used for public drinking-water supplies. Twenty-three of the wells were selected to provide additional sampling density to aid in understanding processes affecting groundwater quality.

Groundwater samples were analyzed for volatile organic compounds pesticides and pesticide degradates, pharmaceutical compounds, constituents of special interest (perchlorate and *N*-nitrosodimethylamine [NDMA]), nutrients, major and minor ions, trace elements, radioactivity, and microbial constituents. Naturally occurring isotopes (stable isotopes of hydrogen, oxygen, nitrogen and carbon), activities of tritium and carbon-14, and dissolved noble gases also were measured to provide a data set that will be used to help interpret the sources and ages of the sampled ground water. In total, nearly 300 constituents and field water-quality indicators were investigated for this study. This report describes the sampling, analytical, and quality-assurance methods used in the study and presents the results of the chemical and microbial analyses of the groundwater samples collected during October 2007 through January 2008.

Three types of quality-control samples (blanks, replicates, and samples for matrix spikes) were collected at approximately 8 to 11 percent of the wells, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that contamination was not a noticeable source of bias in the data for the groundwater samples. Differences between replicate samples were within acceptable ranges, indicating acceptably low variability. 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, water 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 ground water. 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).

All concentrations of VOCs and pesticides were below health-based thresholds, and most were less than a hundredth of the threshold values. All concentrations of perchlorate, nitrate, and radioactive constituents were below established thresholds. Arsenic was detected above the maximum contaminant level (MCL-US) in one understanding well, and radon-222 was detected above the proposed MCL-US in 11 wells, but no wells had concentrations above the proposed alternative MCL-US. Iron, and manganese, were detected at concentrations above secondary maximum contaminant levels (SMCL-CA), and pH was detected at concentrations above secondary maximum contaminant levels (SMCL-US), nonenforceable thresholds set for aesthetic concerns, in samples from several of the wells. Subsequent reports will present analyses 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.

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Tables

Table 1. Well Identification, sampling and construction information for wells sampled for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding study area understanding well; RED-MW, Redding study area monitoring well; ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

GAMA well identification number	Sampling information			Construction information		
	Date	Sampling schedule [1]	Elevation of LSD (ft above NAVD 88) [2]	Well depth (ft below LSD)	Top perforation (ft below LSD)	Bottom perforation (ft below LSD)
			Grid wells			
NSAC-01	10/04/2007	Slow	252	185	30	175
NSAC-02	10/24/2007	Slow	238	85	na	na
NSAC-03	10/29/2007	Slow	515	na	na	na
NSAC-04	10/30/2007	Slow	294	212	100	211
NSAC-05	10/31/2007	Intermediate	256	na	na	na
NSAC-06	10/31/2007	Intermediate	284	158	118	158
NSAC-07	11/01/2007	Intermediate	482	450	na	na
NSAC-08	11/05/2007	Slow	420	290	280	290
NSAC-09	11/06/2007	Slow	316	510	230	500
NSAC-10	11/06/2007	Intermediate	287	300	na	na
NSAC-11	11/26/2007	Intermediate	267	80	na	na
NSAC-12	11/27/2007	Intermediate	251	240	na	na
NSAC-13	11/27/2007	Intermediate	207	220	100	220
NSAC-14	11/28/2007	Intermediate	226	430	140	420
NSAC-15	11/28/2007	Intermediate	237	260	130	200
NSAC-16	12/06/2007	Slow	222	307	90	307
NSAC-17	12/13/2007	Intermediate	594	na	na	na
NSAC-18	12/18/2007	Intermediate	488	240	na	na
NSAC-19	01/08/2008	Intermediate	433	339	117	156
NSAC-20	01/15/2008	Intermediate	310	202	na	na
RED-01	10/01/2007	Intermediate	707	418	308	398
RED-02	10/01/2007	Intermediate	544	475	245	405
RED-03	10/02/2007	Slow	529	510	244	460
RED-04	10/03/2007	Intermediate	492	395	150	390
RED-05	10/03/2007	Intermediate	479	492	192	448
RED-06	10/22/2007	Slow	459	30	na	na
RED-07	10/23/2007	Slow	476	201	95	195
RED-08	10/23/2007	Intermediate	572	232	194	232
RED-09	10/25/2007	Intermediate	504	199	124	196
RED-10	10/25/2007	Intermediate	631	530	na	na
RED-11	11/07/2007	Intermediate	478	355	144	349
RED-12	11/08/2007	Slow	457	360	160	360
RED-13	11/20/2007	Intermediate	476	431	80	410
RED-14	11/29/2007	Slow	521	450	216	444
RED-15	12/03/2007	Intermediate	756	367	307	367
RED-16	12/03/2007	Intermediate	519	104	na	na
RED-17	12/05/2007	Intermediate	378	160	140	160
RED-18	12/05/2007	Intermediate	465	na	na	na
RED-19	12/11/2007	Intermediate	421	300	100	300
RED-20	12/12/2007	Intermediate	577	353	na	na
RED-21	12/12/2007	Intermediate	424	na	na	na
RED-22	01/15/2008	Intermediate	410	120	118	120
RED-23	01/16/2008	Intermediate	466	135	100	135

Table 1. Well Identification, sampling and construction information for wells sampled for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding study area understanding well; RED-MW, Redding study area monitoring well; ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

GAMA well identification number	Sampling information			Construction information		
	Date	Sampling schedule [1]	Elevation of LSD (ft above NAVD 88) [2]	Well depth (ft below LSD)	Top perforation (ft below LSD)	Bottom perforation (ft below LSD)
			Understanding Wells			
NSAC-MW-01	01/07/2008	Intermediate	357	415	160	395
NSAC-MW-02	01/08/2008	Intermediate	232	369	164	359
NSAC-MW-03	01/08/2008	Intermediate	227	871	760	850
NSAC-MW-04	01/09/2008	Intermediate	248	200	150	180
NSAC-MW-05	01/09/2008	Intermediate	248	780	680	750
NSAC-MW-06	01/10/2008	Intermediate	248	980	940	960
NSAC-U-01	12/04/2007	Intermediate	559	227	224	227
NSAC-U-02	12/04/2007	Intermediate	606	124	119	124
NSAC-U-03	12/13/2007	Intermediate	349	na	na	na
NSAC-U-04	12/18/2007	Intermediate	510	198	na	na
NSAC-U-05	01/07/2008	Intermediate	357	140	100	140
NSAC-U-06	01/07/2008	Intermediate	306	136	na	na
NSAC-U-07	01/09/2008	Intermediate	447	214	na	na
NSAC-U-08	01/14/2008	Intermediate	304	na	na	na
RED-MW-01	01/15/2008	Intermediate	442	540	480	520
RED-MW-02	01/15/2008	Intermediate	442	110	70	110
RED-MW-03	01/15/2008	Intermediate	442	200	170	200
RED-MW-04	01/16/2008	Intermediate	454	865	755	855
RED-MW-05	01/16/2008	Intermediate	454	194	154	189
RED-MW-06	01/17/2008	Intermediate	454	440	360	430
RED-MW-07	01/17/2008	Intermediate	454	65	50	60
RED-U-01	01/08/2008	Intermediate	640	339	335	339
RED-U-02	01/14/2008	Intermediate	682	263	261	263

[1] Sampling schedules are described in *table 2*.

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

Table 2. Classes of chemical and water-quality indicators and microbial constituents collected for the slow, and intermediate well sampling schedules in the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

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

Analyte classes	Slow schedule	Intermediate schedule	Analyte list table	Results table
Water-quality indicators				
Dissolved oxygen, temperature, specific conductance	X	X	—	*4*
pH, alkalinity	X	X	—	*4*
Turbidity	X	—	—	*4*
Organic constituents				
Volatile organic compounds	X	X	*3A*	*5*
Pesticides and pesticide degradates	X	X	*3B*	*6*
Pharmaceutical compounds	X	—	*3D*	None
Constituents of special interest				
Perchlorate	X	X	*3E*	*7*
N-Nitrosodimethylamine (NDMA)	X	—	*3E*	*7*
Inorganic constituents				
Nutrients and dissolved organic carbon	X	X	*3F*	*8*
Major and minor ions and trace elements	X	X	*3G*	*9*, *10*
Chromium abundance and species	X	X	*3H*	*11*
Arsenic and iron abundances and species	X	X	*3H*	*11*
Stable isotopes				
Stable isotopes of nitrogen and oxygen in nitrate	X	X	*3I*	*12*
Stable isotopes of hydrogen and oxygen in water	X	X	*3I*	*12*
Stable isotopes of carbon and carbon-14 abundance	X	X	*3I*	*12*
Radioactivity and noble gases				
Tritium	X	X	*3J*	*12*
Tritium and noble gases	X	X	*3J*	*14*
Radium isotopes	X	—	*3I*	*13A*
Radon-222	X	—	*3I*	*13C*
Gross alpha and beta radioactivity	X	—	*3I*	*13B*
Uranium isotopes [1]	X	X	*3I*	*13C*
Microbial constituents				
Microbial indicators	X	—	*3K*	None

[1] Only in the Redding study area.

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 values as of September 12, 2008. **Threshold type**: HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations**: CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples (*table 5*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number [1]	LRL (µg/L)	Threshold type [2]	Threshold value (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	D
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	D
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	—
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.04	MCL-US	0.05	—
Dibromomethane	Solvent	30217	74-95-3	0.04	na	na	—
1,2-Dichlorobenzene	Solvent	34536	95-50-1	0.02	MCL-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	—
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	—
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	—
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	—

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 values as of September 12, 2008. **Threshold type**: HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations**: CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples (*table 5*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number [1]	LRL (µg/L)	Threshold type [2]	Threshold value (µg/L)	Detection
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	D
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	D
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	D
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	—
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	D
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	—
Toluene	Gasoline hydrocarbon	34010	108-88-3	0.018	MCL-CA	150	D
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	—
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 [5]	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

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 values as of September 12, 2008. **Threshold type**: HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations**: CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples (*table 5*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number [1]	LRL (µg/L)	Threshold type [2]	Threshold value (µg/L)	Detection
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	[6] 1,750	D
o-Xylene	Gasoline hydrocarbon	77135	95-47-6	0.04	MCL-CA	[6] 1,750	D

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

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

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

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2032.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of September 12, 2008.**Threshold type**: HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations**: CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 6*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type [1]	Threshold value (µg/L)	Detection
Acetochlor	Herbicide	49260	34256-82-1	0.006	na	na	—
Alachlor	Herbicide	46342	15972-60-8	0.005	MCL-US	2	—
Atrazine	Herbicide	39632	1912-24-9	0.007	MCL-CA	1	D
Azinphos-methyl	Insecticide	82686	86-50-0	0.05	na	na	—
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	0.041	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	0.0065	na	na	—
4-Chloro-2-methylphenol	Herbicide degradate	61633	1570-64-5	0.0050	na	na	—[2]
Chlorpyrifos	Insecticide	38933	2921-88-2	0.005	HAL-US	2	—
Chlorpyrifos oxon	Insecticide degradate	61636	5598-15-2	0.0562	na	na	—[2]
Cyfluthrin	Insecticide	61585	68359-37-5	0.053	na	na	—[2]
λ-Cyhalothrin	Insecticide	61595	91465-08-6	0.0089	na	na	—[2]
Cypermethrin	Insecticide	61586	52315-07-8	0.046	na	na	—[2]
Dacthal (DCPA)	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	0.0045	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	0.0061	na	na	—[2]
Ethion	Insecticide	82346	563-12-2	0.016	na	na	—
Ethion monoxon	Insecticide degradate	61644	17356-42-2	0.021	na	na	—
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	0.010	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	—[2]
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	0.040	na	na	—[2]
Fipronil	Insecticide	62166	120068-37-3	0.016	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	0.0053	HAL-US	10	—
Hexazinone	Herbicide	04025	51235-04-2	0.026	HAL-US	400	—
Iprodione	Fungicide	61593	36734-19-7	0.026	na	na	—[2]
Isofenphos	Insecticide	61594	25311-71-1	0.011	na	na	—

Table 3B. 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 2032.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of September 12, 2008.**Threshold type**: HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations**: CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 6*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type [1]	Threshold value (µg/L)	Detection
Malaoxon	Insecticide degradate	61652	1634-78-2	0.039	na	na	—
Malathion	Insecticide	39532	121-75-5	0.027	HAL-US	100	—
Metalaxyl	Fungicide	61596	57837-19-1	0.0069	na	na	—
Methidathion	Insecticide	61598	950-37-8	0.0087	na	na	—
Metolachlor	Herbicide	39415	51218-45-2	0.006	HAL-US	700	—
Metribuzin	Herbicide	82630	21087-64-9	0.028	HAL-US	70	—
Molinate	Herbicide	82671	2212-67-1	0.0016	MCL-CA	20	—
Myclobutanil	Fungicide	61599	88671-89-0	0.033	na	na	—
1-Naphthol	Insecticide degradate	49295	90-15-3	0.0882	na	na	— [2]
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	0.019	na	na	— [2]
Parathion-methyl	Insecticide	82667	298-00-0	0.015	HAL-US	1	—
Pendimethalin	Herbicide	82683	40487-42-1	0.022	na	na	—
cis-Permethrin	Insecticide	82687	54774-45-7	0.006	na	na	—
Phorate	Insecticide	82664	298-02-2	0.055	na	na	—
Phorate oxon	Insecticide degradate	61666	2600-69-3	0.027	na	na	—
Phosmet [4]	Insecticide	61601	732-11-6	0.0079	na	na	— [2]
Phosmet oxon [4]	Insecticide degradate	61668	3735-33-9	0.0511	na	na	— [2]
Prometon	Herbicide	04037	1610-18-0	0.01	HAL-US	100	D
Prometryn	Herbicide	04036	7287-19-6	0.0059	na	na	—
Pronamide (Propyzamide)	Herbicide	82676	23950-58-5	0.004	RSD5-US	20	—
Propanil	Herbicide	82679	709-98-8	0.011	na	na	—
cis-Propiconazole	Fungicide	79846	60207-90-1	0.008	na	na	—
trans-Propiconazole	Fungicide	79847	60207-90-1	0.0133	na	na	—
Simazine	Herbicide	04035	122-34-9	0.005	MCL-US	4	D
Tebuthiuron	Herbicide	82670	34014-18-1	0.016	HAL-US	500	—
Terbufos	Insecticide	82675	13071-79-9	0.017	HAL-US	0.4	— [3]
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	Herbicide	61610	78-48-8	0.0044	na	na	—
Trifluralin	Herbicide	82661	1582-09-8	0.009	HAL-US	10	—

[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] The median laboratory matrix-spike recovery was greater than 130 percent. High recoveries may indicate that the compound may have been detected in some samples at a higher value than was actually present in the sample.

[4] Some of the samples partially ruined during extraction or analysis.

Table 3C. Polar pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the 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 values as of September 12, 2008. **Threshold type**: HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}; **Other abbreviations**: CAS, Chemical Abstract Service; LRL, laboratory reporting level; MRL, method reporting level; D, detected in groundwater samples (*table 6*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Number of sample results [1]	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type [2]	Threshold value (µg/L)	Detection
Acifluorfen	52	Herbicide	49315	50594-66-6	0.028	na	na	—
Aldicarb [3]	66	Insecticide	49312	116-06-3	[3] 0.04	MCL-US	3	—[4]
Aldicarb sulfone	48	Degradate	49313	1646-88-4	0.018	MCL-US	3	—
Aldicarb sulfoxide	48	Degradate	49314	1646-87-3	0.022	MCL-US	4	—
Atrazine	66	Herbicide	39632	1912-24-9	0.008	MCL-CA	1	D
Bendiocarb	48	Insecticide	50299	22781-23-3	0.020	na	na	—[4]
Benomyl	66	Fungicide	50300	17804-35-2	0.022	na	na	—[4]
Bensulfuron-methyl	66	Herbicide	61693	83055-99-6	0.018	na	na	—
Bentazon	66	Herbicide	38711	25057-89-0	0.012	MCL-CA	18	—
Bromacil	66	Herbicide	04029	314-40-9	0.018	HAL-US	70	—
Bromoxynil	52	Herbicide	49311	1689-84-5	0.028	na	na	—
Caffeine	66	Beverages	50305	58-08-2	0.018	na	na	—
Carbaryl	48	Herbicide	49310	63-25-2	0.018	RSD5-US	400	—
Carbofuran	48	Herbicide	49309	1563-66-2	0.016	MCL-CA	18	—
Chloramben, methyl ester	60	Herbicide	61188	7286-84-2	0.024	na	na	—
Chlorimuron-ethyl	52	Herbicide	50306	90982-32-4	0.032	na	na	—
3-(4-Chlorophenyl)-1-methyl urea	66	Degradate	61692	5352-88-5	0.036	na	na	—[4]
Clopyralid	66	Herbicide	49305	1702-17-6	0.024	na	na	—[4]
Cycloate	66	Herbicide	04031	1134-23-2	0.014	na	na	—
2,4-D plus 2,4-D methyl ester (summed on a molar basis)	52	Herbicides	66496	na	0.020	MCL-US	[5] 70	—
2,4-DB (4-(2,4-Dichlorophenoxy) butyric acid)	66	Herbicide	38746	94-82-6	0.020	na	na	—
DCPA (Dacthal) monoacid	66	Degradate	49304	887-54-7	0.028	na	na	—
Deethylatrazine (2-Chloro-4-isopropyl-amino-6-amino-*s*-triazine)	66	Degradate	04040	6190-65-4	0.028	na	na	D[4]
Deisopropyl atrazine (2-Chloro-6-ethylamino-4-amino-*s*-triazine)	66	Degradate	04038	1007-28-9	0.08	na	na	—[4]
Dicamba	66	Herbicide	38442	1918-00-9	0.036	HAL-US	4,000	—
Dichlorprop	66	Herbicide	49302	120-36-5	0.028	na	na	—
Dinoseb (Dinitrobutyl phenol)	66	Herbicide	49301	88-85-7	0.038	MCL-CA	7	—
Diphenamid	52	Herbicide	04033	957-51-7	0.010	HAL-US	200	—
Diuron	66	Herbicide	49300	330-54-1	0.015	HAL-US	10	—
Fenuron	66	Herbicide	49297	101-42-8	0.019	na	na	—
Flumetsulam	61	Herbicide	61694	98967-40-9	0.040	na	na	—
Fluometuron	66	Herbicide	38811	2164-17-2	0.016	HAL-US	90	—
Hydroxyatrazine (2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine)	66	Degradate	50355	2163-68-0	0.032	na	na	—
3-Hydroxycarbofuran	48	Degradate	49308	16655-82-6	0.008	na	na	—

Table 3C. Polar pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the 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 values as of September 12, 2008. **Threshold type**: HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}; **Other abbreviations**: CAS, Chemical Abstract Service; LRL, laboratory reporting level; MRL, method reporting level; D, detected in groundwater samples (*table 6*); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent	Number of sample results [1]	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type [2]	Threshold value (µg/L)	Detection
Imazaquin	52	Herbicide	50356	81335-37-7	0.036	na	na	—
Imazethapyr	66	Herbicide	50407	81335-77-5	0.038	na	na	—
Imidacloprid	66	Insecticide	61695	138261-41-3	0.020	na	na	—
Linuron	66	Herbicide	38478	330-55-2	0.014	na	na	—
MCPA (2-Methyl-4-chlorophenoxyacetic acid)	66	Herbicide	38482	94-74-6	0.030	HAL-US	30	—
MCPB (4-(2-Methyl-4-chlorophenoxy) butyric acid)	66	Herbicide	38487	94-81-5	0.010	na	na	—
Metalaxyl	66	Fungicide	50359	57837-19-1	0.012	na	na	—
Methiocarb	48	Insecticide	38501	2032-65-7	0.010	na	na	—
Methomyl	56	Insecticide	49296	16752-77-5	0.020	HAL-US	200	—
Metsulfuron methyl [3]	47	Herbicide	61697	74223-64-6	[3] 0.025	na	na	—
Neburon	66	Herbicide	49294	555-37-3	0.012	na	na	—
Nicosulfuron	62	Herbicide	50364	111991-09-4	0.04	na	na	— [6]
Norflurazon	66	Herbicide	49293	27314-13-2	0.020	na	na	—
Oryzalin	66	Herbicide	49292	19044-88-3	0.012	na	na	—
Oxamyl	48	Insecticide	38866	23135-22-0	0.030	MCL-CA	50	—
Picloram	52	Herbicide	49291	1918-02-01	0.032	MCL-US	500	—
Propham	66	Herbicide	49236	122-42-9	0.030	HAL-US	100	—
Propiconazole	66	Fungicide	50471	60207-90-1	0.010	na	na	—
Propoxur	48	Insecticide	38538	114-26-1	0.008	na	na	—
Siduron	66	Herbicide	38548	1982-49-6	0.020	na	na	—
Sulfometuron-methyl	52	Herbicide	50337	74222-97-2	0.038	na	na	—
Tebuthiuron	66	Herbicide	82670	34014-18-1	0.026	HAL-US	500	—
Terbacil	66	Herbicide	04032	5902-51-2	0.016	HAL-US	90	—
Triclopyr	66	Herbicide	49235	55335-06-3	0.026	na	na	—

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[1] Some of the samples were partially ruined during extraction or analysis.

[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] Value is an MRL rather than an LRL.

[4] 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.

[5] The MCL-US shown is for 2,4-D (2,4-dichlorophenoxyacetic acid); no threshold currently exists for 2,4-D methyl ester.

[6] The median laboratory matrix-spike recovery was greater than 130 percent. High recoveries may indicate that the compound may have been detected in some samples at a higher value than was actually present in the sample.

Table 3D. 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 values as of September 12, 2008. **Other abbreviations**: CAS, Chemical Abstract Service; MDL, method detection limit; na, not available; SRL, study reporting limit; µg/L, micrograms per liter]

Constituent	Primary use or source	USGS parameter code	CAS number	MDL[1] (µg/L)	Threshold type	Threshold value (µg/L)
Acetaminophen	Analgesic	62000	103-90-2	0.180	na	na
Albuterol	Anti-inflammatory; bronchodilator	62020	18559-94-9	0.025	na	na
Caffeine	Stimulant	50305	58-08-2	0.080	na	na
Carbamazapine	Anticonvulsant; analgesic; mood stabilizer	62793	298-46-4	0.023	na	na
Codeine	Opioid narcotic	62003	76-57-3	0.018	na	na
Cotinine	Nicotine metabolite	62005	486-56-6	0.013	na	na
Dehydronifedipine	Antianginal metabolite	62004	67035-22-7	0.033	na	na
Diltiazem	Antianginal; antihypertensive	62008	42399-41-7	0.021	na	na
1,7-Dimethylxanthine	Caffeine metabolite	62030	611-59-6	0.054	na	na
Diphenhydramine	Antihistamine	62796	58-73-1	0.018	na	na
Sulfamethoxazole	Antibacterial, antiprotozoal	62021	723-46-6	0.046	na	na
Thiabendazole	Anthelmintic	62801	148-79-8	0.021	na	na
Trimethoprim	Antibacterial	62023	738-70-5	0.013	na	na
Warfarin	Anticoagulant	62024	81-81-2	0.030	na	na

[1] The California Groundwater Ambient Monitoring and Assessment (GAMA) program uses more conservative reporting limits for the pharmaceutical compounds than those recommended by the USGS National Water Quality Laboratory. For albuterol, carbamazepine, codeine, dehydronifedipine, diltiazem, sulfamethoxazole, thiabendazole, trimethoprim, and warfarin, the MDL corresponds to the long-term method detection limit determined by the USGS Branch of Quality Systems in October 2007 (BQS LT-MDL). For acetaminophen, caffeine, cotinine, diphenhydramine, and 1,7-dimethylxanthine, the MDL corresponds to the study reporting 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-MDL for those compounds. Concentrations reported by the USGS National Water Quality Laboratory that are lower than the BQS LT-MDL or the GAMA SRLs are reported as nondetections by the GAMA program.

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

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of September 12, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** CAS, Chemical Abstract Service; MRL, minimum reporting level; D, detected in groundwater samples (*table 7*); µg/L, micrograms per liter]

Constituent	Primary use or source	USGS parameter code	CAS number	MRL (µg/L)	Threshold type [1]	Threshold value (µg/L)	Detection
Perchlorate	Rocket fuel, fireworks, flares	63790	14797-73-0	0.1	MCL-CA	6	D
N-Nitrosodimethylamine (NDMA)	Disinfection by-product, rocket fuel, plasticizer	34438	62-75-9	0.002	NL-CA	0.010	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 3F. Nutrients and dissolved organic carbon, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2755 and laboratory code 2612.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of September 12, 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 value (mg/L)	Detection
Ammonia (as nitrogen)	00608	7664-41-7	0.010	HAL-US	[2] 25	D
Nitrite (as nitrogen)	00613	14797-65-0	0.002	MCL-US	1	D
Nitrite plus nitrate (as nitrogen)	00631	na	0.060	MCL-US	10	D
Total nitrogen (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
Dissolved organic carbon (DOC)	00681	na	0.33	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] In earlier reports in this series, the HAL-US of 30 mg/L was used as the comparison threshold; however, that represented ammonia "as NH3." Converting ammonia "as NH3" to ammonia "as N" results in a comparison threshold of 25 mg/L.

Table 3G. 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 values as of September 12, 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; 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 value (mg/L)	Detection
Major and minor ions (mg/L)						
Bromide	71870	24959-67-9	0.02	na	na	D
Calcium	00915	7440-70-2	0.02	na	na	D
Chloride	00940	16887-00-6	0.2	SMCL-CA	[2] 250 (500)	D
Fluoride	00950	16984-48-8	0.10	MCL-CA	2	D
Iodide	78165	7553-56-2	0.002	na	na	D
Magnesium	00925	7439-95-4	0.008	na	na	D
Potassium	00935	7440-09-7	0.16	na	na	D
Silica	00955	7631-86-9	0.04	na	na	D
Sodium	00930	7440-23-5	0.20	na	na	D
Sulfate	00945	14808-79-8	0.18	SMCL-CA	[2] 250 (500)	D
Total dissolved solids (TDS), (residue on evaporation)	70300	na	10	SMCL-US	[2] 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	0.2	MCL-US	6	D
Arsenic	01000	7440-38-2	0.12	MCL-US	10	D
Barium	01005	7440-39-3	0.2	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	0.06	MCL-US	4	—
Boron	01020	7440-42-8	8	NL-CA	1,000	D
Cadmium	01025	7440-43-9	0.04	MCL-US	5	D
Chromium	01030	7440-47-3	0.04	MCL-CA	50	D
Cobalt	01035	7440-48-4	0.04	na	na	D
Copper	01040	7440-50-8	0.4	AL-US	1,300	D
Iron	01046	7439-89-6	6	SMCL-CA	300	D
Lead	01049	7439-92-1	0.08	AL-US	15	D
Lithium	01130	7439-93-2	0.6	na	na	D
Manganese	01056	7439-96-5	0.2	SMCL-CA	50	D
Mercury	71890	7439-97-6	0.010	MCL-US	2	D
Molybdenum	01060	7439-98-7	0.4	HAL-US	40	D
Nickel	01065	7440-02-0	0.06	MCL-CA	100	D
Selenium	01145	7782-49-2	0.08	MCL-US	50	D
Silver	01075	7440-22-4	0.20	SMCL-CA	100	—
Strontium	01080	7440-24-6	0.4	HAL-US	4,000	D
Thallium	01057	7440-28-0	0.04	MCL-US	2	—
Tungsten	01155	7440-33-7	0.06	na	na	D
Uranium	22703	7440-61-1	0.04	MCL-US	30	D
Vanadium	01085	7440-62-2	0.10	NL-CA	50	D
Zinc	01090	7440-66-6	0.6	SMCL-CA	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] The recommended SMCL-CA thresholds are listed with the upper SMCL-CA thresholds in parentheses.

Table 3H. Arsenic, chromium, 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 constituent or property. Thresholds and threshold values as of September 12, 2008.**Threshold type**: MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; na, not available; µg/L, micrograms per liter; SMCL-US, California Department of Health secondary maximum contaminant level. **Other abbreviations**: CAS, Chemical Abstract Service; MDL, method detection limit; D, detected in groundwater samples (*table 11*)]

Constituent (valence state)	USGS parameter code	CAS number	MDL (µg/L)	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
Chromium(VI)	01032	18540-29-9	1	na	1	D
Chromium(total)	01030	7440-47-3	1	MCL-CA	50	D
Iron(II)	01047	7439-89-6	2	na	na	D
Iron(total)	01046	7439-89-6	2	SMCL-US	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 3I. Isotopic and radioactive constituents, comparative thresholds, and reporting information for laboratories.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to a more common lighter isotope of that element, relative to a standard reference material. Thresholds and threshold values as of September 12, 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**: C, carbon; CAS, Chemical Abstract Service; 1σ-CSU, combined standard uncertainty; H, hydrogen; ssL$_C$, sample-specific critical level; MRL, minimum reporting level; MU, method uncertainty; N, nitrogen; na, not available; O, oxygen; pCi/L, picocuries per liter; 2σ-CSU, 2-sigma combined uncertainty; D, detected in groundwater samples (*tables 12* and *13*)]

Constituent	USGS parameter code	CAS number	Reporting level type	Reporting level or uncertainty	Threshold type [1]	Threshold value	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^{15}N of nitrate [2]	82690	na	MU	0.50	na	na	D
δ^{18}O of nitrate [2]	63041	na	MU	1.00	na	na	D
δ^{13}C of dissolved carbonates [3]	82081	na	1 sigma	0.05	na	na	D
Radioactive constituents (percent modern)							
Carbon-14 [4]	49933	14762-75-5	1 sigma	0.0015	na	na	D
Radioactive constituents (pCi/L)							
Radon-222 [5]	82303	14859-67-7	ssL$_C$	2σ-CSU	Prop. MCL-US	[6] 300 (4,000)	D
Tritium [7]	07000	10028-17-8	MRL	1	MCL-CA	20,000	D
Gross-alpha radioactivity, 72-hour and 30-day counts [7]	62636, 62639	12587-46-1	ssL$_C$	1σ-CSU	MCL-US	15	D
Gross-beta radioactivity, 72-hour and 30-day counts [7]	62642, 62645	12587-47-2	ssL$_C$	1σ-CSU	MCL-CA	50	D
Radium-226 [8]	09511	13982-63-3	ssL$_C$	1σ-CSU	MCL-US	[9] 5	D
Radium-228 [8]	81366	15262-20-1	ssL$_C$	1σ-CSU	MCL-US	[9] 5	D
Uranium-234 [8]	22610	13966-29-5	ssL$_C$	1σ-CSU	MCL-CA	20	D
Uranium-235 [8]	22620	15117-96-1	ssL$_C$	1σ-CSU	MCL-CA	20	D
Uranium-238 [8]	22603	7440-61-1	ssL$_C$	1σ-CSU	MCL-CA	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.

[3] University of Waterloo (contract laboratory).

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

[5] USGS National Water Quality Laboratory.

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

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

[8] Eberline Analytical Services (contract laboratory).

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of September 12, 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; cm^3 STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water; pCi/L, picocuries per liter; D, detected in groundwater samples]

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

[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 3K. Microbial constituents, comparison thresholds, and reporting information for the U.S. Geological Survey (USGS) Ohio Microbiology Laboratory parameter codes 99335 and 99332.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of September 12, 2008. **Threshold type**: TT-US, U.S. Environmental Protection Agency treatment technique - a required process intended to reduce the level of contamination in drinking water. **Other abbreviations**: MDL, method detection limit; na, not available; —, not detected]

Constituent	USGS parameter code	Primary source	MDL	Threshold type	Threshold value	Detection
F-specific coliphage	99335	Sewage and animal waste indicator	na	TT-US	99.99 percent killed/inactivated	—
Somatic coliphage	99332	Sewage and animal waste indicator	na	TT-US	99.99 percent killed/inactivated	—

Table 4. Water-quality indicators in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification number:** NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding study area understanding well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 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:** °C, degree Celsius; mg/L; milligram per liter; mm, millimeter; 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]

GAMA well identification number	Turbidity, field (NTU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25 °C) (90095)	Specific conductance, field (µS/cm at 25 °C) (00095)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)
Threshold type	na	na	na	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	na	na
Threshold level	[1] 5	na	na	6.5–8.5	6.5–8.5	[2] 900 (1,600)	[2] 900 (1,600)	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[5]	[5]	[1]	[1]
Grid wells (n = 43)									
NSAC-01	0.2	4.7	17.5	7.2	7.1	524	529	210	196
NSAC-02	0.2	2.4	17.5	7.1	6.9	610	608	217	208
NSAC-03	0.6	0.6	20.0	7.8	7.7	578	570	212	181
NSAC-04	0.1	5.8	19.5	7.4	7.2	242	243	100	95.4
NSAC-05	0.1	3.8	19.5	7.9	7.7	351	353	150	nc
NSAC-06	0.1	3.0	19.0	7.4	7.2	316	319	134	nc
NSAC-07	0.5	3.3	20.0	7.8	7.6	372	371	193	nc
NSAC-08	0.3	<0.2	21.0	8.2	8.3	269	269	134	118
NSAC-09	0.3	2.2	20.5	7.9	8.1	272	283	134	126
NSAC-10	0.2	6.0	19.5	7.7	7.7	196	200	91	nc
NSAC-11	0.3	2.5	17.0	6.8	6.6	440	433	120	nc
NSAC-12	0.5	3.5	19.5	8.0	8.0	303	302	148	nc
NSAC-13	0.7	4.7	22.0	8.0	7.9	237	238	103	nc
NSAC-14	0.3	4.1	19.5	7.8	7.9	435	432	192	nc
NSAC-15	0.3	1.3	16.5	7.1	6.9	257	253	86	nc
NSAC-16	0.3	4.9	20.0	7.9	7.8	274	271	115	109
NSAC-17	0.1	<0.2	20.5	8.4	8.6*	854	777	223	nc
NSAC-18	0.3	5.4	19.5	7.9	7.7	268	267	135	nc
NSAC-19	0.3	3.4	18.5	7.8	7.7	389	388	206	nc
NSAC-20	nc	6.1	19.5	7.5	7.4	213	212	95	nc
RED-01	0.2	6.0	20.0	7.8	7.5	198	200	97	nc
RED-02	0.2	6.6	19.5	7.6	7.6	202	203	99	nc
RED-03	0.5	4.5	19.5	6.9	6.6	345	341	137	128
RED-04	0.2	<0.2	16.5	7.4	7.1	229	228	94	nc
RED-05	0.2	4.2	21.5	7.4	7.2	184	185	91	nc
RED-06	0.3	3.6	19.0	7.5	6.4	133	128	61	56.4
RED-07	0.2	7.5	18.0	7.5	7.1	128	129	48	43.2
RED-08	0.2	6.5	20.5	7.3	7.0	222	221	93	nc
RED-09	1.5	5.2	18.0	7.1	7.1	207	204	91	nc
RED-10	0.3	0.6	21.5	8.2	8.3	250	254	91	nc
RED-11	0.3	5.6	18.5	7.2	6.7	148	146	67	nc
RED-12	0.2	<0.2	19.5	7.7	7.6	248	247	113	109
RED-13	0.5	6.0	19.0	7.5	7.1	168	166	81	nc
RED-14	0.3	<0.2	20.0	7.9	7.8	187	187	97	92.8
RED-15	1.8	7.0	19.5	7.0	6.8	173	173	81	nc
RED-16	0.3	7.0	18.0	7.0	6.7	192	178	91	nc

Table 4. Water-quality indicators in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification number:** NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding study area understanding well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 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:** °C, degree Celsius; mg/L; milligram per liter; mm, millimeter; 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]

GAMA well identification number	Turbidity, field (NTU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25 °C) (90095)	Specific conductance, field (µS/cm at 25 °C) (00095)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)
Threshold type	**na**	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**na**	**na**
Threshold level	**[1] 5**	**na**	**na**	**6.5–8.5**	**6.5–8.5**	**[2] 900 (1,600)**	**[2] 900 (1,600)**	**na**	**na**
[RL]	**[0.1]**	**[0.2]**	**[0.0–38.5]**	**[0–14]**	**[0–14]**	**[5]**	**[5]**	**[1]**	**[1]**
RED-17	0.4	3.8	18.0	7.7	7.7	304	302	162	nc
RED-18	0.2	3.7	17.0	7.4	7.2	207	206	68	nc
RED-19	22	4.7	17.5	7.0	6.7	182	181	87	nc
RED-20	0.5	5.2	20.0	7.7	7.6	187	188	92	nc
RED-21	0.1	6.7	18.0	7.7	7.4	256	255	120	nc
RED-22	nc	2.0	16.0	7.2	7.1	259	255	124	nc
RED-23	0.4	4.9	18.0	7.3	7.2	180	177	89	nc
Understanding wells (n = 23)									
NSAC-MW-01	10	0.7	20.0	8.2	8.4	249	244	118	nc
NSAC-MW-02	25	1.2	14.5	7.6	7.9	301	292	148	nc
NSAC-MW-03	5.7	0.6	15.0	8.3	9.2*	207	204	104	nc
NSAC-MW-04	1.5	6.3	18.0	7.8	7.7	371	371	161	nc
NSAC-MW-05	0.6	0.5	21.0	8.6*	8.6*	304	301	140	nc
NSAC-MW-06	0.9	0.3	20.5	8.9*	8.7*	296	292	123	nc
NSAC-U-01	0.4	4.0	19.5	8.1	8.0	277	282	140	nc
NSAC-U-02	0.4	7.8	18.5	7.3	7.0	274	273	96	nc
NSAC-U-03	0.1	3.2	18.0	7.2	7.0	514	503	176	nc
NSAC-U-04	0.5	6.3	18.0	7.9	7.7	397	393	217	nc
NSAC-U-05	nc	3.8	20.0	7.7	7.7	247	243	120	nc
NSAC-U-06	nc	4.6	19.0	7.3	6.9	316	313	140	nc
NSAC-U-07	0.1	<0.2	19.5	8.0	8.0	421	419	220	nc
NSAC-U-08	nc	7.6	18.5	6.9	7.2	251	249	93	nc
RED-MW-01	8.8	1.5	20.5	7.6	7.7	156	155	71	nc
RED-MW-02	0.5	3.7	20.5	7.3	7.2	166	164	70	nc
RED-MW-03	3.6	3.7	18.0	7.4	7.1	175	174	77	nc
RED-MW-04	0.6	0.7	21.5	7.5	8.0	206	205	106	nc
RED-MW-05	0.7	4.8	20.5	7.6	7.1	171	172	87	nc
RED-MW-06	0.7	4.8	21.0	7.3	8.1	216	213	110	nc
RED-MW-07	0.5	2.5	20.5	8.6*	9.2*	389	387	122	nc
RED-U-01	0.4	5.8	20.0	8.0	8.0	300	301	154	nc
RED-U-02	nc	8.2	19.0	7.8	8.1	265	264	139	nc

[*] Value above threshold level.

[1] The SMCL-CA for turbidity only applies to surface-water supplies.

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

Table 5. Volatile organic compounds (VOC) detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all sixty-six wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the forty-three grid wells. All analytes are listed in *table 3A*. **GAMA well identification number:** NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Reddingstudy area understanding well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 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:** E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; —, not detected]

	Disinfection by-product (THM)		Gasoline hydrocarbon			Gasoline oxygenate	Solvents	Disinfection by-product (THM)		Gasoline hydrocarbon			Organic synthesis	Solvents		
GAMA well identification number	**Chloroform, (µg/L) (32106)**	**Bromodichloromethane, (µg/L) (32101)**	**1,2,4-Trimethylbenzene, (µg/L) (77222)**	**Benzene, (µg/L) (34030)**	**Toluene, (µg/L) (34010)**	**Methyl *tert*-butyl ether (MTBE), (µg/L) (78032)**	**Perchloroethene (Tetrachloroethene, (PCE) (µg/L) (34475)**	**Dibromochloromethane, (µg/L) (32105)**	**Tribromomethane, (µg/L) (32104)**	**Ethylbenzene, (µg/L) (34371)**	***m*-Xylene plus *p*-xylene, (µg/L) (85795)**	***o*-Xylene, (µg/L) (77135)**	**Carbon disulfide, (µg/L) (77041)**	**Methyl ethyl ketone (2-butanone, MEK), (µg/L) (81595)**	**Tetrahydrofuran, (µg/L) (81607)**	**VOC detections per well**
Threshold type [1]	**MCL-US**	**MCL-US**	**NL-CA**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**NL-CA**	**HAL-US**	**na**	
Threshold level	**80**	**80**	**330**	**1**	**150**	**13**	**5**	**80**	**80**	**300**	**1,750**	**1750**	**160**	**4,000**	**na**	
[LRL]	**[0.02]**	**[0.04]**	**[0.04]**	**[0.016]**	**[0.018]**	**[0.1]**	**[0.04]**	**[0.12]**	**[0.08]**	**[0.04]**	**[0.08]**	**[0.04]**	**[0.06]**	**[1.6]**	**[1.4]**	
Grid wells (n = 43)																
NSAC-01	—	—	E0.07	—	—	—	—	—	—	—	—	—	—	—	—	1
NSAC-05	E0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
NSAC-09	E0.04	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
NSAC-18	E0.06	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
NSAC-19	2.02	E0.07	—	E0.03	—	—	—	—	—	—	—	—	—	—	—	3
RED-03	0.21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
RED-07	—	—	—	—	E0.03	—	—	—	—	—	—	—	—	—	—	1
RED-12	—	—	—	—	—	E0.1	—	—	—	—	—	—	—	—	—	1
RED-18	E0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
RED-19	—	—	—	—	—	—	E0.04	—	—	—	—	—	—	—	—	1
Number of detections	6	1	1	1	1	1	1									
Detection frequency (percent)	14	2.3	2.3	2.3	2.3	2.3	2.3									[2]23

Table 5. Volatile organic compounds (VOC) detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all sixty-six wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the forty-three grid wells. All analytes are listed in *table 3A*. **GAMA well identification number:** NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding study area understanding well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 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:** E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; —, not detected]

	Disinfection by-product (THM)		**Gasoline hydrocarbon**			**Gasoline oxygenate**	**Solvents**	**Disinfection by-product (THM)**		**Gasoline hydrocarbon**			**Organic synthesis**	**Solvents**		
GAMA well identification number	**Chloroform, (µg/L) (32106)**	**Bromodichloromethane, (µg/L) (32101)**	**1,2,4-Trimethylbenzene, (µg/L) (77222)**	**Benzene, (µg/L) (34030)**	**Toluene, (µg/L) (34010)**	**Methyl *tert*-butyl ether (MTBE), (µg/L) (78032)**	**Perchloroethene (Tetrachloroethene, (PCE) (µg/L) (34475)**	**Dibromochloromethane, (µg/L) (32105)**	**Tribromomethane, (µg/L) (32104)**	**Ethylbenzene, (µg/L) (34371)**	***m*-Xylene plus *p*-xylene, (µg/L) (85795)**	***o*-Xylene, (µg/L) (77135)**	**Carbon disulfide, (µg/L) (77041)**	**Methyl ethyl ketone (2-butanone, MEK), (µg/L) (81595)**	**Tetrahydrofuran, (µg/L) (81607)**	**VOC detections per well**
Threshold type [1]	**MCL-US**	**MCL-US**	**NL-CA**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**NL-CA**	**HAL-US**	**na**	
Threshold level	**80**	**80**	**330**	**1**	**150**	**13**	**5**	**80**	**80**	**300**	**1,750**	**1750**	**160**	**4,000**	**na**	
[LRL]	**[0.02]**	**[0.04]**	**[0.04]**	**[0.016]**	**[0.018]**	**[0.1]**	**[0.04]**	**[0.12]**	**[0.08]**	**[0.04]**	**[0.08]**	**[0.04]**	**[0.06]**	**[1.6]**	**[1.4]**	
							Understanding wells (n = 23)									
NSAC-MW-03	—	—	—	—	—	—	—	—	—	—	—	—	E0.04	—	—	1
NSAC-U-03	E0.02	E0.08	—	—	—	—	—	0.29	0.64	—	—	—	—	—	—	4
RED-MW-01	—	—	0.12	E0.06	0.35	—	—	—	—	E0.05	E0.18	E0.08	—	—	—	6
RED-MW-03	—	—	E0.04	E0.04	0.19	—	—	—	—	E0.04	E0.15	E0.06	—	2.8	—	7
RED-MW-04	E0.02	—	E0.02	E0.01	0.1	—	—	—	—	E0.02	E0.08	E0.04	—	—	—	7
RED-MW-05	—	—	—	—	E0.04	—	—	—	—	—	E0.04	E0.02	—	—	—	3
RED-MW-07	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.0	1

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[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 VOC in the grid wells.

Table 6. Pesticides and pesticide degradates detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples were collected from all sixty-six wells for analysis. Some of samples partually ruined during extraction or analysis (*table 3B* and *3C*). Only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the forty-three grid wells. All analytes are listed in *table 3B* and *3C*. **GAMA well identification number:** NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding study area understanding well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; —, not detected]

GAMA well identification number	Deethylatrazine, (µg/L) (04040)	Atrazine, (µg/L) (39632)	Simazine, (µg/L) (04035)	Prometon, (µg/L) (04037)	Pesticide detections per well
Threshold type [1]	**na**	**MCL-CA**	**MCL-US**	**HAL-US**	
Threshold level	**na**	**1**	**4**	**100**	
[LRL]	**[0.014]**	**[0.007]**	**[0.006]**	**[0.01]**	
Grid wells (n = 43 wells)					
NSAC-01	E 0.008	0.008	E 0.007	0.01	4
NSAC-02	E 0.005	—	—	—	1
NSAC-04	E 0.005	—	—	—	1
NSAC-05	E 0.006	E 0.004	—	—	2
NSAC-07	—	E 0.004	—	—	1
NSAC-11	E 0.005	E 0.004	0.010	E 0.01	4
NSAC-12	—	E 0.004	—	—	1
NSAC-15	—	—	E 0.006	—	1
NSAC-16	—	E 0.007	—	—	1
RED-06	E 0.005	E 0.007	E 0.005	—	3
RED-09	E 0.006	E 0.005	E 0.005	—	3
RED-19	E 0.005	0.009	—	—	2
RED-21	E 0.007	—	—	—	1
RED-22	E 0.006	—	—	—	1
Number of wells with detections	10	9	5	2	
Detection frequency (percent)	23.3	20.9	11.6	4.7	[2] 33
Total detections					26
Understanding wells (n = 23 wells)					
NSAC-U-03	E 0.005	—	—	—	1
NSAC-U-05	E 0.005	—	—	—	1
NSAC-U-06	E 0.006	—	—	—	1
RED-MW-07	E0.005	—	0.008	—	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.

Table 7. Constituents of special interest (perchlorate and *N*-nitrosodimethylamine [NDMA]) detected in samples collected in the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about the analytes given in *table 3E*. Samples from all 66 wells were analyzed for perchlorate; samples from the 12 slow wells were sampled for NDMA. Only wells with at least one detection are listed. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding study area understanding well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: 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, microgram per liter; na, not analyzed; —, sample analyzed but constitutent not detected; *, value above threshold level]

GAMA well identification number	Perchlorate (µg/L) (63790)	*N*-Nitrosodimethylamine (NDMA) (µg/L) (34438)
Threshold type [1]	**MCL-CA**	**NL-CA**
Threshold level	**6**	**0.01**
[MRL]	**[0.1]**	**[0.002]**
Grid wells (n = 43)		
NSAC-01	0.54	—
NSAC-02	0.49	0.034*
NSAC-03	0.35	0.0061
NSAC-04	0.14	0.0053
NSAC-05	0.18	na
NSAC-07	0.94	na
NSAC-08	—	0.0049
NSAC-09	0.21	—
NSAC-10	0.18	na
NSAC-11	0.28	na
NSAC-12	0.26	na
NSAC-13	0.14	na
NSAC-14	0.28	na
NSAC-16	0.16	—
NSAC-18[2]	0.30	na
NSAC-19	0.31	na
NSAC-20	0.15	na
RED-01	0.25	na
RED-02	0.27	na
RED-03	0.26	—
RED-04	0.12	na
RED-05	0.11	na
RED-07	—	0.0034
RED-08	0.29	na
RED-09	0.12	na
RED-13	0.12	na
RED-14	0.17	—
RED-15	0.59	na
RED-16	0.16	na
RED-17	0.15	na
RED-18	0.25	na
RED-20	0.20	na
Number of wells with detections	30	5
Detection frequency (percent)	67	36
Understanding wells [3] (n = 23)		
NSAC-MW-04	0.22	na
NSAC-U-01	0.6	na
NSAC-U-02	0.14	na
NSAC-U-03	0.18	na
NSAC-U-04 [2]	0.23	na
NSAC-U-05	0.17	na
NSAC-U-06	0.15	na
NSAC-U-08	0.2	na
RED-MW-02	0.15	na
RED-MW-03	0.13	na
RED-MW-05	0.14	na
RED-MW-06	0.25	na
RED-MW-07	0.31	na
RED-U-01	0.52	na
RED-U-02	0.48	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] Samples held 17 days past the 14 day holding time.

[3] Understanding wells were not included in statistical calculations.

Table 8. Nutrients detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 66 wells were analyzed. Information about the analytes given in *table 3F*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding Study area grid well; RED-U, Redding study area understanding well; RED-MW, Redding study area monitoring well. Thresholds and threshold values as of September 12, 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, milligram per liter; na, not available; —, not detected; ≤, less than or equal to]

GAMA well identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-nitrogen) as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorus (mg/L) (00671)
Threshold type [1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Threshold level	**[2] 25**	**10**	**1**	**na**	**na**
[LRL]	**[0.02]**	**[0.04]**	**[0.002]**	**[0.06]**	**[0.006]**
Grid wells (n = 43)					
NSAC-01	—	5.51	—	5.74	0.058
NSAC-02	—	4.99	—	5.20	0.067
NSAC-03	—	0.72	—	0.73	0.032
NSAC-04	—	2.27	—	2.31	0.105
NSAC-05	—	1.38	—	1.42	0.040
NSAC-06	—	1.76	—	1.80	0.076
NSAC-07	—	0.93	—	[3] 0.91	0.039
NSAC-08	—	—	—	—	0.055
NSAC-09	—	0.98	—	1.01	0.052
NSAC-10	—	1.51	—	1.55	0.078
NSAC-11	—	2.48	—	2.61	0.042
NSAC-12	—	0.99	—	1.07	0.057
NSAC-13	—	0.83	—	0.89	0.107
NSAC-14	—	1.64	—	1.73	0.074
NSAC-15	—	0.83	—	0.92	0.032
NSAC-16	—	1.06	—	1.14	0.139
NSAC-17	0.061	—	—	E 0.05	0.086
NSAC-18	—	0.95	—	0.97	0.080
NSAC-19	—	0.81	—	0.86	0.035
NSAC-20	—	1.5	E 0.001	1.53	0.087
RED-01	—	0.8	E 0.001	[3] 0.79	0.128
RED-02	—	0.99	—	[3] 0.96	0.106
RED-03	—	4.07	—	4.21	0.065
RED-04	—	1.35	—	1.42	0.044
RED-05	—	0.74	—	0.74	0.184
RED-06	≤0.013	1.1	—	[3] 1.06	0.045
RED-07	—	2.34	—	2.34	0.131
RED-08	—	1.72	—	[3] 1.67	0.161
RED-09	—	1.27	—	1.32	0.103
RED-10	0.041	0.07	0.003	0.10	0.074
RED-11	—	0.84	—	0.86	0.178
RED-12	≤0.012	0.09	0.021	0.09	0.156
RED-13	—	0.99	—	1.03	0.116
RED-14	—	—	—	—	0.064
RED-15	—	1.05	—	[3] 1.01	0.151
RED-16	—	0.92	—	[3] 0.89	0.057
RED-17	—	0.65	—	0.68	0.092
RED-18	—	2.88	—	3.00	0.092

Table 8. Nutrients detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 66 wells were analyzed. Information about the analytes given in *table 3F*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding Study area grid well; RED-U, Redding study area understanding well; RED-MW, Redding study area monitoring well. Thresholds and threshold values as of September 12, 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, milligram per liter; na, not available; —, not detected; ≤, less than or equal to]

GAMA well identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-nitrogen) as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorus (mg/L) (00671)
Threshold type [1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Threshold level	**[2] 25**	**10**	**1**	**na**	**na**
[LRL]	**[0.02]**	**[0.04]**	**[0.002]**	**[0.06]**	**[0.006]**
RED-19	—	0.28	—	0.36	0.056
RED-20	—	1.27	—	[3] 1.21	0.155
RED-21	—	1.81	—	[3] 1.75	0.128
RED-22	—	1.44	E 0.001	1.47	0.107
RED-23	—	0.73	E 0.001	[3] 0.69	0.096
Understanding wells (n = 23)					
NSAC-MW-01	—	0.28	E 0.001	0.29	0.049
NSAC-MW-02	E 0.012	0.97	0.011	1.04	0.043
NSAC-MW-03	—	0.55	0.003	0.59	0.077
NSAC-MW-04	—	1.01	—	1.05	0.062
NSAC-MW-05	0.027	—	—	—	0.076
NSAC-MW-06	0.039	—	—	E 0.04	0.125
NSAC-U-01	—	0.88	—	0.93	0.036
NSAC-U-02	—	0.89	—	0.94	0.042
NSAC-U-03	—	5.49	—	5.92	0.100
NSAC-U-04	—	0.89	—	0.91	0.046
NSAC-U-05	—	0.8	—	0.83	0.110
NSAC-U-06	—	3.18	—	3.32	0.077
NSAC-U-07	≤0.011	0.56	0.007	0.59	0.031
NSAC-U-08	—	3.47	—	3.62	0.091
RED-MW-01	E 0.017	0.72	0.007	[3] 0.72	0.044
RED-MW-02	E 0.011	1.33	≤0.001	1.35	0.177
RED-MW-03	—	1.43	≤0.001	1.46	0.140
RED-MW-04	—	0.41	—	0.41	0.082
RED-MW-05	—	0.68	—	0.68	0.175
RED-MW-06	—	0.68	≤0.002	0.69	0.075
RED-MW-07	0.031	5.93	0.070	[3] 5.98	0.063
RED-U-01	—	0.95	—	1.00	0.034
RED-U-02	—	0.85	—	0.91	0.023

[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 comparison to the analytical results, we have converted and reported this HAL-US as 25 mg/L "as nitrogen."

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

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the sixty-six slow and intermediate wells were analyzed. Information about analytes given in *table 3G*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding Study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding study area monitoring welll. Thresholds and threshold values as of September 12, 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]

GAMA well identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Alkalinity, laboratory (mg/L) (29801)	Bicarbonate, laboratory [1] (mg/L as $CaCO_3$)	Carbonate, laboratory [1] (mg/L as $CaCO_3$)	Bromide (mg/L) (71870)	Chloride [2] (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica (mg/L) (00955)	Sulfate [2] (mg/L) (00945)	Total dissolved solids [2] (TDS) (mg/L) (70300)
Threshold type [3]	na	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	na	250 (500)	2	na	na	250 (500)	500 (1,000)
[LRL]	[0.04]	[0.02]	[0.02]	[0.12]	[5]	1	1	[0.02]	[0.12]	[0.12]	[0.002]	[0.018]	[0.18]	[10]
Grid wells (n = 43)														
NSAC-01	39.6	31.5	2.65	13.7	210	256	—	0.08	16.9	—	E 0.001	55.9	14.5	312
NSAC-02	47.7	40.3	2.18	16.0	217	264	—	0.14	28.4	—	E 0.001	61.2	46.2	405
NSAC-03	35.9	37.7	0.66	22.2	212	257	0.7	0.14	50.7	E 0.1	E 0.001	32.7	11.4	323
NSAC-04	20.2	11.0	0.49	13.9	100	122	—	0.02	5.30	0.22	—	34.0	12.1	170
NSAC-05	27	12.5	1.74	31.2	150	182	0.7	E 0.02	6.24	0.14	—	29.3	23.7	230
NSAC-06	28.8	15.9	0.58	15.4	134	163	—	0.04	8.11	0.27	—	31.8	17.1	202
NSAC-07	28.4	18.3	0.89	24.4	193	234	0.7	E 0.02	5.09	0.17	—	28.3	2.49	225
NSAC-08	23	4.80	1.73	27.0	134	161	1.2	E 0.02	5.76	E 0.1	0.009	31.4	4.66	183
NSAC-09	20.7	8.55	1.93	23.2	134	162	0.6	E 0.02	4.51	0.15	—	42.3	3.31	192
NSAC-10	16.8	6.81	1.27	13.9	91	110	—	E 0.01	3.01	0.27	—	43.1	4.83	151
NSAC-11	20.5	15.4	1.63	45.5	120	146	—	0.12	51.8	—	0.004	43.1	11.4	277
NSAC-12	20.4	15.5	1.80	23.1	148	179	0.8	0.03	5.74	0.15	—	43.7	6.70	200
NSAC-13	11.3	9.48	3.54	24.1	103	124	0.6	0.03	11.2	0.14	E 0.002	67.5	3.08	201
NSAC-14	31	24.6	1.27	25.1	192	233	0.7	0.05	16.3	0.13	0.004	37.2	13.0	260
NSAC-15	17.4	12.8	2.45	13.0	86	105	—	0.04	17.0	—	E 0.002	43.9	14.9	178
NSAC-16	12.7	9.77	3.86	30.0	115	139	0.5	0.03	11.4	0.17	—	69.1	9.30	205
NSAC-17	12.4	6.79	0.54	157	223	266	3.1	0.88	139	E 0.11	0.809	18.0	—	473
NSAC-18	20.9	10.3	1.72	21.8	135	163	0.6	—	3.67	0.20	—	40.8	1.94	189
NSAC-19	28.3	23.0	0.78	21.7	206	250	0.7	—	4.48	0.21	—	28.9	1.25	227
NSAC-20	16.8	9.03	0.39	14.2	95	116	—	E 0.02	3.32	0.23	—	35.6	8.51	151
RED-01	13	8.61	1.39	14.7	97	118	—	E 0.01	3.21	0.17	—	49.0	1.27	151
RED-02	14	9.68	2.54	13.2	99	120	—	E 0.01	3.09	0.15	—	66.8	1.37	170
RED-03	23	21.7	0.63	14.5	137	167	—	0.04	15.7	—	E 0.001	39.8	6.69	213
RED-04	13.6	12.9	0.69	12.6	94	114	—	0.02	9.46	—	—	31.3	6.90	133
RED-05	10.7	8.57	0.81	15.4	91	111	—	E 0.01	2.64	0.16	—	58.0	1.89	146

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008. —Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the sixty-six slow and intermediate wells were analyzed. Information about analytes given in *table 3G*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding Study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding study area monitoring welll. Thresholds and threshold values as of September 12, 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]

GAMA well identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Alkalinity, laboratory (mg/L) (29801)	Bicarbonate, laboratory[1] (mg/L as $CaCO_3$)	Carbonate, laboratory[1] (mg/L as $CaCO_3$)	Bromide (mg/L) (71870)	Chloride[2] (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica (mg/L) (00955)	Sulfate[2] (mg/L) (00945)	Total dissolved solids[2] (TDS) (mg/L) (70300)
Threshold type[3]	na	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	na	250 (500)	2	na	na	250 (500)	500 (1,000)
[LRL]	[0.04]	[0.02]	[0.02]	[0.12]	[5]	1	1	[0.02]	[0.12]	[0.12]	[0.002]	[0.018]	[0.18]	[10]
RED-06	10.9	6.41	0.51	6.65	61	74.2	—	—	2.20	—	—	28.1	3.64	106
RED-07	6.76	6.54	0.70	9.20	48	58.4	—	0.09	4.38	E0.12	—	46.1	3.24	115
RED-08	10.9	12.6	0.55	15.8	93	113	—	0.05	10.8	0.25	—	55.2	2.77	177
RED-09	15.2	9.26	0.65	12.6	91	111	—	0.02	5.28	0.22	—	43.6	5.74	158
RED-10	10.2	3.18	1.70	37.9	91	109	0.8	0.06	21.7	—	0.017	31.3	1.79	153
RED-11	7.99	6.05	0.51	12.7	67	81.6	—	E0.01	2.45	0.23	—	53.6	3.26	126
RED-12	14	8.59	1.76	22.6	113	137	—	0.04	9.53	E0.09	0.010	49.0	4.90	184
RED-13	11.3	7.52	0.77	14.6	81	98.5	—	E0.02	2.78	E0.12	—	51.8	1.34	141
RED-14	12.4	6.81	0.66	16.6	97	117	—	E0.01	2.34	E0.09	0.004	33.1	1.95	138
RED-15	10.3	6.89	0.46	16.7	81	98.7	—	0.04	5.41	E0.09	—	58.4	0.65	147
RED-16	16.8	8.33	0.55	10.6	91	111	—	—	4.04	E0.11	—	42.2	3.98	141
RED-17	20.5	20.1	2.21	14.6	162	197	—	E0.02	2.81	E0.1	—	70.7	0.57	203
RED-18	11.3	11.10	1.07	11.4	68	82.8	—	0.15	14.7	—	—	47.3	5.26	145
RED-19	12.3	8.91	3.15	12.5	87	106	—	—	5.25	E0.07	0.003	54.7	2.40	147
RED-20	14.3	7.61	1.25	13.8	92	112	—	E0.01	2.58	E0.1	—	47.5	1.32	143
RED-21	16.2	14.2	1.82	14.0	120	146	—	—	3.06	0.16	—	61.8	8.19	190
RED-22	16.8	16.10	0.55	15.6	124	151	—	—	3.77	0.16	—	43.7	6.55	179
RED-23	13.8	8.87	1.80	10.4	89	108	—	—	2.16	0.15	—	79.2	1.78	167
Understanding wells (n = 23)														
NSAC-MW-01	18.8	4.13	2.10	30.4	118	142	1.0	0.02	7.14	E0.11	0.004	38.2	4.39	178
NSAC-MW-02	23.3	17.6	3.35	12.5	148	180	—	E 0.01	5.00	E0.08	E0.002	55.4	5.30	210
NSAC-MW-03	3.01	2.20	3.41	41.2	104	124	1.1	E0.02	3.15	0.19	E0.002	55.3	2.65	166
NSAC-MW-04	27.1	21.4	1.02	19.1	161	195	0.6	0.05	18.1	0.19	—	29.5	7.70	218
NSAC-MW-05	8.2	0.74	2.54	62.1	140	164	3.0	0.03	7.26	0.21	0.016	55.8	12.0	238
NSAC-MW-06	3.06	0.19	1.51	65.9	123	139	5.1	0.05	11.6	0.31	0.017	35.6	13.8	209

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008. —Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the sixty-six slow and intermediate wells were analyzed. Information about analytes given in *table 3G*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding Study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding study area monitoring welll. Thresholds and threshold values as of September 12, 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]

GAMA well identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Alkalinity, laboratory (mg/L) (29801)	Bicarbonate, laboratory[1] (mg/L as $CaCO_3$)	Carbonate, laboratory[1] (mg/L as $CaCO_3$)	Bromide (mg/L) (71870)	Chloride[2] (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica (mg/L) (00955)	Sulfate[2] (mg/L) (00945)	Total dissolved solids[2] (TDS) (mg/L) (70300)
Threshold type[3]	**na**	**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**	**na**	**250 (500)**	**2**	**na**	**na**	**250 (500)**	**500 (1,000)**
[LRL]	**[0.04]**	**[0.02]**	**[0.02]**	**[0.12]**	**[5]**	**1**	**1**	**[0.02]**	**[0.12]**	**[0.12]**	**[0.002]**	**[0.018]**	**[0.18]**	**[10]**
NSAC-U-01	19.7	11.5	0.61	23.9	140	169	1.0	E0.02	4.68	E0.09	—	26.4	1.42	169
NSAC-U-02	21.1	11.5	0.54	14.7	96	117	—	E0.01	3.60	0.19	—	33.6	34.2	177
NSAC-U-03	35.3	27.6	3.34	25.0	176	214	—	0.08	37.5	E0.1	0.005	68.0	14.7	343
NSAC-U-04	33.1	23.2	0.92	18.8	217	263	1.0	—	1.53	0.32	—	33.9	1.01	239
NSAC-U-05	20.2	10.7	1.84	15.0	120	146	—	E0.02	3.85	0.16	—	60.1	4.01	202
NSAC-U-06	23.8	14.9	0.60	19.9	140	170	—	0.03	7.71	0.26	—	34.4	4.48	196
NSAC-U-07	25.1	21.9	1.45	36.4	220	266	1.2	E0.01	2.94	0.20	0.017	22.9	8.11	245
NSAC-U-08	14.9	12.5	0.35	16.9	93	113	—	0.04	10.6	0.28	—	30.1	8.11	164
RED-MW-01	9.42	6.82	0.86	13.7	71	86.3	—	—	3.97	0.14	0.003	36.9	3.27	117
RED-MW-02	9.8	9.19	0.93	10.8	70	85.2	—	0.04	3.66	0.18	—	55.1	8.28	141
RED-MW-03	11.2	8.80	0.75	12.1	77	93.7	—	E0.02	3.35	0.16	E0.001	47.6	5.65	145
RED-MW-04	13.3	2.29	1.03	30.9	106	129	—	E0.01	2.75	E0.09	—	32.2	1.22	155
RED-MW-05	10.8	7.95	0.62	15.1	87	106	—	—	2.31	0.13	—	57.1	0.77	150
RED-MW-06	18.8	7.70	0.93	16.6	110	134	—	E0.01	3.43	0.13	E0.001	41.0	2.12	162
RED-MW-07	33.3	8.05	3.66	35.0	122	143	2.6	0.04	14.5	0.18	—	40.7	31.3	283
RED-U-01	26.1	13.2	0.94	19.0	154	186	0.9	E0.01	4.25	0.15	—	30.2	0.77	183
RED-U-02	23.7	11.0	0.79	17.5	139	169	—	E0.01	3.26	E0.1	—	23.8	0.47	167

[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 $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_W = 14$.

[2] The SMCL-CA for chloride, sulfate, and total dissolved solids have recommended and upper threshold values. The upper value is shown in parentheses.

[3] 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 10. Trace elements detected in groundwater samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the 66 slow and intermediate wells were analyzed. All analytes are listed in *table 3H*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; SRL, study unit reporting limit; —, not detected; ≤, less than or equal to]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	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)	Lithium (µg/L) (01130)
Threshold type [1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**MCL-US**	**SMCL-CA**	**MCL-US**	**na**
Threshold level	**1,000**	**6**	**10**	**1,000**	**1,000**	**5**	**50**	**na**	**1,300**	**300**	**15**	**na**
[LRL]	**[1.6]**	**[0.14]**	**[0.06]**	**[0.4]**	**[6]**	**[0.04]**	**[0.12]**	**[0.02]**	**[1]**	**[8]**	**[0.08]**	**[1]**
[SRL]	**[1.6]**	**—**	**—**	**[0.36]**	**—**	**—**	**[0.42]**	**—**	**[1.7]**	**[6]**	**[0.65]**	**—**
Grid wells (n = 43)												
NSAC-01	—	—	1.3	45	42	—	3.0	0.03	≤0.57	—	≤0.06	—
NSAC-02	—	—	0.7	42	219	0.12	2.7	0.03	≤0.63	—	≤0.27	E0.7
NSAC-03	—	—	1.2	152	43	—	7.8	—	≤1.1	—	≤0.52	6.3
NSAC-04	—	—	0.42	42	27	—	1.1	E0.01	—	—	≤0.13	5.6
NSAC-05	3.0	0.15	4.1	22	51	—	0.61	E0.01	≤1.2	—	≤0.26	2.4
NSAC-06	—	—	0.43	62	63	—	0.61	0.29	≤0.53	—	≤0.17	6.4
NSAC-07	≤0.8	—	1.4	142	26	—	6.3	—	≤1.1	—	≤0.44	5.1
NSAC-08	≤1.5	—	7.6	46	46	—	—	—	—	8	≤0.33	E0.8
NSAC-09	1.6	E0.09	2.2	76	35	—	5.2	—	—	—	≤0.21	2.9
NSAC-10	—	—	1.7	41	13	—	3.9	—	—	—	≤0.20	3.5
NSAC-11	—[2]	—	0.47	33	932	—	0.59	0.03	4.3	—	3.73	2.4
NSAC-12	≤1.2	E0.09	3.4	108	35	—	8.6	—	—	—	≤0.09	2.2
NSAC-13	1.7	—	3.3	11	204	—	3.2	—	—	—	≤0.06	—
NSAC-14	≤1.3	—	2.0	135	38	—	6.2	E0.01	≤0.66	6	0.70	5.6
NSAC-15	—	E0.11	1.2	29	351	—	0.62	0.03	≤1.6	26	≤0.19	—
NSAC-16	≤1.4	E0.09	3.4	9.0	248	—	6.0	—	—	—	≤0.22	—
NSAC-17	—	—	3.4	154	179	—	—	E0.01	8.3	32	0.92	6.6
NSAC-18	2.2	E0.07	1.9	94	19	—	5.1	—	≤0.67	≤5	≤0.29	3.4
NSAC-19	—	—	1.5	144	24	—	14.9	E0.02	≤0.53	—	≤0.10	3.4
NSAC-20	≤0.8	—	0.55	45	29	—	2.9	—	≤0.65	9	≤0.17	5.9
RED-01	≤1.3	—	1.4	18	19	—	2.7	—	≤1.2	—	≤0.18	E0.8
RED-02	≤1.1	E0.09	2.5	12	20	—	4.6	—	≤1.1	—	≤0.20	—
RED-03	—	E0.13	1.3	108	20	—	≤0.12	0.03	3.8	10	2.88	6.5
RED-04	—	—	0.49	34	31	—	≤0.22	—	≤1.4	—	1.17	E0.5
RED-05	—	—	0.82	19	7	—	0.51	—	≤1.3	—	0.83	E0.9

Table 10. Trace elements detected in groundwater samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the 66 slow and intermediate wells were analyzed. All analytes are listed in *table 3H*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding study area monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; SRL, study unit reporting limit; —, not detected; ≤, less than or equal to]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	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)	Lithium (µg/L) (01130)
Threshold type [1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**MCL-US**	**SMCL-CA**	**MCL-US**	**na**
Threshold level	**1,000**	**6**	**10**	**1,000**	**1,000**	**5**	**50**	**na**	**1,300**	**300**	**15**	**na**
[LRL]	**[1.6]**	**[0.14]**	**[0.06]**	**[0.4]**	**[6]**	**[0.04]**	**[0.12]**	**[0.02]**	**[1]**	**[8]**	**[0.08]**	**[1]**
[SRL]	**[1.6]**	**—**	**—**	**[0.36]**	**—**	**—**	**[0.42]**	**—**	**[1.7]**	**[6]**	**[0.65]**	**—**
RED-06	—	—	0.26	20	14	—	≤0.11	—	≤0.95	—	≤0.43	E 0.5
RED-07	—	—	1.0	11	10	—	0.99	—	—	—	≤0.17	—
RED-08	—	—	1.0	12	19	—	≤0.24	—	≤0.94	—	≤0.54	—
RED-09	—	—	0.91	40	18	—	1.9	E 0.01	—	28	≤0.12	—
RED-10	≤1.3	—	7.7	50	90	—	—	—	—	8	≤0.22	2
RED-11	—	—	0.68	25	8	—	≤0.31	E 0.01	≤1.1	—	≤0.43	1.1
RED-12	—	—	4.0	123	166	—	0.85	E 0.01	—	≤5	≤0.24	1.1
RED-13	—	—	0.97	29	7	—	2.8	—	≤0.91	—	≤0.46	1.1
RED-14	—	—	2.2	124	11	—	—	E 0.01	—	123	≤0.08	—
RED-15	—	—	0.49	24	E 3	—	≤0.22	—	≤1	7	0.83	1.4
RED-16	—	—	0.37	51	8	—	1.1	—	4.4	—	0.94	2.5
RED-17	≤1.2	—	1.3	13	27	—	3.6	—	—	—	—	—
RED-18	—	—	0.56	18	9	—	≤0.38	—	—	—	≤0.45	E 0.9
RED-19	—	—	0.7	19	108	—	≤0.36	0.04	—	43	—	1.8
RED-20	—	—	2.4	22	9	—	2.3	—	≤1.1	—	≤0.24	E 0.9
RED-21	≤0.8	—	1.2	47	9	—	1.7	0.03	—	—	≤0.10	E 0.7
RED-22	—	—	0.41	30	9	—	≤0.21	E 0.01	≤0.97	—	≤0.33	E 0.8
RED-23	—	—	1.4	14	26	—	4.3	E 0.01	—	—	≤0.42	—
Understanding wells (n=23)												
NSAC-MW-01	≤1.3	E 0.1	3.4	10	23	—	1.1	E 0.01	—	≤5	—	E 0.9
NSAC-MW-02	≤0.8	—	1.1	18	87	E 0.03	0.5	0.11	—	252	—	—
NSAC-MW-03	5.0	0.17	4.5	3.0	88	—	0.6	0.06	—	184	—	3.4
NSAC-MW-04	2.0	—	1.6	120	27	—	5.9	—	—	—	—	5.5
NSAC-MW-05	7.1	—	10.6*	13	59	—	—	—	—	—	—	E 0.9
NSAC-MW-06	15.9	—	19.8*	2.0	90	—	—	—	—	≤5	—	E 0.9
NSAC-U-01	≤0.8	—	1.9	63	40	—	28.9	—	E 0.58	≤6	0.67	3

Table 10. Trace elements detected in groundwater samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the 66 slow and intermediate wells were analyzed. All analytes are listed in *table 3H*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding study area monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; SRL, study unit reporting limit; —, not detected; ≤, less than or equal to]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	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)	Lithium (µg/L) (01130)
Threshold type [1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**MCL-US**	**SMCL-CA**	**MCL-US**	**na**
Threshold level	**1,000**	**6**	**10**	**1,000**	**1,000**	**5**	**50**	**na**	**1,300**	**300**	**15**	**na**
[LRL]	**[1.6]**	**[0.14]**	**[0.06]**	**[0.4]**	**[6]**	**[0.04]**	**[0.12]**	**[0.02]**	**[1]**	**[8]**	**[0.08]**	**[1]**
[SRL]	**[1.6]**	**—**	**—**	**[0.36]**	**—**	**—**	**[0.42]**	**—**	**[1.7]**	**[6]**	**[0.65]**	**—**
NSAC-U-02	—	—	0.15	41	21	—	≤0.27	—	E 0.88	—	≤0.26	3.5
NSAC-U-03	—	—	1.9	36	658	—	1.9	0.04	≤1.3	—	≤0.24	1.7
NSAC-U-04	—	—	0.92	138	19	—	11.3	E 0.02	E 0.74	—	≤0.16	13
NSAC-U-05	—	0.19	8.8	29	18	—	2	—	—	—	≤0.28	1.5
NSAC-U-06	—	—	0.26	56	9	—	0.97	E 0.01	E 0.64	—	≤0.11	10.8
NSAC-U-07	2.0	—	1.5	137	37	—	—	E 0.02	—	—	—	5.4
NSAC-U-08	—	—	0.28	33	23	—	1.4	—	E 0.61	—	≤0.30	4.8
RED-U-01	—	—	1.3	132	26	—	25.3	—	—	≤6	≤0.17	1.8
RED-U-02	2.7	—	1.4	67	38	—	19.6	—	E 0.64	—	≤0.15	4.8
RED-MW-01	2.1	0.17	0.71	21	14	—	≤0.41	≤0.08	—	549	—	E 0.6
RED-MW-02	≤0.8	—	0.79	21	9	—	1.5	≤0.02	—	—	—	E 0.9
RED-MW-03	≤1.6	—	0.66	22	10	—	1.8	≤0.03	—	≤10	—	E 0.7
RED-MW-04	≤1.4	E 0.1	2.1	36	14	—	≤0.38	≤0.02	—	—	—	2.1
RED-MW-05	≤1.5	—	1.6	23	E 5	—	≤0.9	≤0.02	—	—	—	1.5
RED-MW-06	8.6	0.20	2.3	40	13	—	6.8	≤0.02	—	≤6	—	1.4
RED-MW-07	12	1.41	10.1*	35	30	E 0.02	7.2	≤0.05	—	≤9	—	E 0.8

Table 10. Trace elements detected in groundwater samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the sixty-six slow and intermediate wells were analyzed. All analytes are listed in *table 3H*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding Study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; SRL, study unit reporting level; —, not detected; ≤, less than or equal to]

GAMA well identification number	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Strontium (µg/L) (01080)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Threshold type [1]	**SMCL-CA**	**MCL-US**	**HAL-US**	**MCL-CA**	**MCL-US**	**HAL-US**	**na**	**MCL-US**	**NL-CA**	**SMCL-CA**
Threshold level	**50**	**2**	**40**	**100**	**50**	**4,000**	**na**	**30**	**50**	**5,000**
[LRL]	**[0.2]**	**[0.01]**	**[0.2]**	**[0.2]**	**[0.04]**	**[0.8]**	**[0.06]**	**[0.02]**	**[0.04]**	**[1.8]**
[SRL]	**[0.2]**	**[0.012]**	**—**	**[0.36]**	**—**	**—**	**[0.11]**	**—**	**[0.1]**	**[4.8]**
					Grid wells (n = 43)					
NSAC-01	≤0.1	—	E0.1	≤0.17	E0.04	275	≤0.03	2.03	15.5	≤4
NSAC-02	—	—	—	0.41	E0.03	267	—	1.70	20.2	10.5
NSAC-03	—	—	0.3	≤0.18	0.35	430	—	0.20	9.8	7.9
NSAC-04	—	—	0.8	—	0.29	144	—	0.03	3.9	≤2
NSAC-05	—	—	1.4	—	2.40	292	0.12	0.84	8.2	≤2.7
NSAC-06	—	—	0.8	0.91	0.16	202	—	0.07	4.4	≤2.1
NSAC-07	—	—	0.4	—	0.33	511	—	0.48	12.3	5.6
NSAC-08	40.2	—	1.0	—	0.24	261	0.22	0.74	1.4	≤1.6
NSAC-09	0.3	—	0.8	—	0.84	289	≤0.09	0.38	17.2	—
NSAC-10	—	≤0.011	0.6	—	0.32	168	≤0.04	0.13	11.4	5.5
NSAC-11	≤0.1	—	E0.1	0.78	0.10	171	—	0.10	4.6	≤3.9
NSAC-12	—	—	0.9	≤0.16	0.50	267	≤0.08	0.24	16.8	7.8
NSAC-13	0.3	—	1.0	—	0.07	81.1	0.96	0.14	41.2	9.7
NSAC-14	2.6	—	0.9	≤0.28	0.41	292	0.20	0.33	8.9	≤1.2
NSAC-15	1.0	—	E0.1	1.00	E0.03	124	—	0.06	6.3	72.9
NSAC-16	0.8	—	1.2	—	0.06	81.2	0.56	0.23	19.8	≤3.8
NSAC-17	29.7	0.072	4.9	1.20	E0.02	185	0.13	—	0.14	9.7
NSAC-18	0.3	—	0.6	—	0.27	271	≤0.04	0.27	18.0	48.2
NSAC-19	≤0.1	—	0.3	≤0.19	0.40	652	—	0.45	13.1	6.8
NSAC-20	0.4	—	0.7	—	0.44	115	—	E0.01	4.2	13.8
RED-01	—	—	0.4	—	0.46	114	≤0.04	0.10	13.8	≤2.6
RED-02	—	—	0.5	≤0.11	0.29	116	0.12	0.26	17.5	6.4
RED-03	15.6	—	—	0.74	0.21	274	—	0.10	3.8	16.6
RED-04	—	—	E0.2	≤0.28	0.05	111	—	0.02	3.0	≤2.3
RED-05	—	—	0.4	≤0.21	0.43	95.4	—	0.03	10.1	≤2.6

Table 10. Trace elements detected in groundwater samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the sixty-six slow and intermediate wells were analyzed. All analytes are listed in *table 3H*. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding Study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency Lifetime Health Advisory; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: E, estimated value; LRL, laboratory reporting level; na, not available; µg/L, microgram per liter; SRL, study unit reporting level; —, not detected; ≤, less than or equal to]

GAMA well identification number	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Strontium (µg/L) (01080)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Threshold type [1]	**SMCL-CA**	**MCL-US**	**HAL-US**	**MCL-CA**	**MCL-US**	**HAL-US**	**na**	**MCL-US**	**NL-CA**	**SMCL-CA**
Threshold level	**50**	**2**	**40**	**100**	**50**	**4,000**	**na**	**30**	**50**	**5,000**
[LRL]	**[0.2]**	**[0.01]**	**[0.2]**	**[0.2]**	**[0.04]**	**[0.8]**	**[0.06]**	**[0.02]**	**[0.04]**	**[1.8]**
[SRL]	**[0.2]**	**[0.012]**	**—**	**[0.36]**	**—**	**—**	**[0.11]**	**—**	**[0.1]**	**[4.8]**
RED-06	—	—	—	≤0.29	0.10	72.1	—	—	1.5	≤3.6
RED-07	≤0.1	—	0.4	—	0.10	42.8	—	—	9.0	7.8
RED-08	—	—	0.3	≤0.11	0.27	114	—	0.02	9.4	5.1
RED-09	1.5	—	0.3	≤0.17	0.11	187	—	0.07	7.8	15
RED-10	19.9	—	2.3	—	0.09	99.3	0.18	0.03	4.8	11.3
RED-11	0.6	—	0.4	0.54	0.42	67.2	—	—	8.5	5.5
RED-12	313*	—	1.8	≤0.31	1.90	219	≤0.07	0.02	0.59	—
RED-13	—	—	0.3	≤0.17	0.13	87.6	—	0.06	11.7	15.8
RED-14	56*	—	1.0	≤0.10	—	107	≤0.04	—	—	≤1.9
RED-15	0.4	—	0.2	≤0.23	0.17	89	—	0.03	4.7	261
RED-16	0.2	—	0.2	0.36	0.05	209	—	0.05	5.6	8.2
RED-17	—	≤0.008	0.3	—	0.07	124	≤0.09	0.39	24.4	≤3.8
RED-18	0.3	—	E0.1	—	0.04	80.9	—	0.06	5.7	—
RED-19	9.2	—	0.6	0.60	0.05	110	0.17	0.11	4.0	51.2
RED-20	0.5	—	0.3	≤0.30	0.50	138	—	0.11	16.4	39.6
RED-21	≤0.1	—	0.4	≤0.28	E0.03	142	—	0.27	13.8	—
RED-22	—	—	E0.1	≤0.30	—	127	—	0.07	5.7	≤1.6
RED-23	—	—	0.3	≤0.18	0.80	119	≤0.04	0.06	15.2	47.2
Understanding wells (n=23)										
NSAC-MW-01	3.4	—	1.4	≤0.26	0.55	180	0.15	0.48	27.2	—
NSAC-MW-02	37.1	—	1.0	0.84	E0.03	136	≤0.06	0.59	9.5	—
NSAC-MW-03	23.6	—	1.8	2.20	0.35	18.1	0.58	0.09	18.7	—
NSAC-MW-04	0.6	—	0.8	≤0.24	0.39	295	≤0.05	0.21	11.6	—
NSAC-MW-05	8.5	—	3.2	≤0.15	—	43.4	1.2	E0.02	0.41	—

Table 10. Trace elements detected in groundwater samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

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GAMA well identification number	Manganese (µg/L) (01056)	Mercury (µg/L) (71890)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Strontium (µg/L) (01080)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Threshold type [1]	**SMCL-CA**	**MCL-US**	**HAL-US**	**MCL-CA**	**MCL-US**	**HAL-US**	**na**	**MCL-US**	**NL-CA**	**SMCL-CA**
Threshold level	**50**	**2**	**40**	**100**	**50**	**4,000**	**na**	**30**	**50**	**5,000**
[LRL]	**[0.2]**	**[0.01]**	**[0.2]**	**[0.2]**	**[0.04]**	**[0.8]**	**[0.06]**	**[0.02]**	**[0.04]**	**[1.8]**
[SRL]	**[0.2]**	**[0.012]**	**—**	**[0.36]**	**—**	**—**	**[0.11]**	**—**	**[0.1]**	**[4.8]**
NSAC-MW-06	3.7	—	6.3	≤0.12	—	5.92	3.0	—	0.15	—
NSAC-U-01	≤0.2	—	0.6	—	0.34	478	≤0.03	0.22	16.6	15.8
NSAC-U-02	0.2	—	0.8	≤0.20	0.30	196	—	0.05	1.3	≤4.7
NSAC-U-03	≤0.2	—	E0.2	0.37	0.10	283	0.30	0.43	13.8	12.4
NSAC-U-04	—	—	0.5	≤0.18	0.12	511	—	0.54	5.8	22.9
NSAC-U-05	—	—	0.6	≤0.24	2.4	223	≤0.08	1.84	28.8	11
NSAC-U-06	≤0.2	—	0.3	≤0.19	0.06	215	—	0.02	2.2	11.1
NSAC-U-07	11.7	—	0.9	≤0.12	3.30	557	—	0.85	13.6	6.5
NSAC-U-08	0.3	—	1.1	≤0.24	0.20	142	—	—	2.4	≤1.6
RED-U-01	0.4	—	0.3	≤0.15	0.34	292	≤0.03	0.60	16.4	41.9
RED-U-02	1.2	—	0.2	≤0.11	0.12	292	—	0.24	17	6.3
RED-MW-01	60.3*	—	1.0	≤0.73	0.29	73.3	0.28	0.06	6.1	—
RED-MW-02	≤0.9	—	0.6	≤0.51	0.46	70.7	—	0.03	9.6	≤1.2
RED-MW-03	≤0.6	—	0.9	1.20	0.19	75.8	≤0.09	E0.01	7.6	≤2.3
RED-MW-04	≤0.8	—	2.5	≤0.30	0.41	120	0.12	0.23	10	—
RED-MW-05	≤0.5	—	0.5	≤0.49	0.21	85.3	≤0.04	0.06	9.3	—
RED-MW-06	≤0.6	—	1.7	≤0.83	0.27	133	0.68	0.43	16	—
RED-MW-07	≤0.6	—	9.0	≤0.90	0.79	307	5.1	0.70	29.2	—

* Value above threshold level.

[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] Sample was diluted.

Table 11. Species of inorganic arsenic, iron, and chromium in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[Data in this table analyzed at U.S. Geological Survey (USGS) Trace Metal Laboratory in Boulder, Colorado, using research methods and are not stored in the USGS NWIS database. Information about analytes given in *table 3H*. Samples from all 66 wells were analyzed for chromium, arsenic, and iron; only wells with at least one detection are listed. **GAMA well identification number**: NSAC, Northern Sacramento Valley Study Area grid well; RED, Redding Study Area grid well; RED-U, Northern Sacramento Valley Study Unit understanding well; RED-MW, Northern Sacramento Valley Study Unit understanding monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: MDL, method detection limit; na, not available; µg/L, microgram per liter; --, not detected; ≤, less than or equal to]

GAMA well identification number	Arsenic (total) (µg/L)	Arsenic(III) (µg/L)	Iron (total) (µg/L)	Iron(II) (µg/L)	Chromium (total) (µg/L)	Chromium(VI) (µg/L)
Threshold type [1]	**MCL-US**	**na**	**SMCL-CA**	**na**	**MCL-CA**	**na**
Threshold level	**10**	**na**	**300**	**na**	**50**	**na**
[MDL]	**[0.5]**	**[1]**	**[2]**	**[2]**	**[1]**	**[1]**
			Grid wells (n = 43)			
NSAC-01	1.1	—	2	—	3	3
NSAC-02	0.67	—	2	—	2	2
NSAC-03	0.82	—	—	—	6	—
NSAC-05	2.9	—	—	—	—	—
NSAC-07	0.84	—	—	—	7	6
NSAC-08	4.9	—	7	—	—	—
NSAC-09	1.5	—	—	—	5	4
NSAC-10	1.1	—	—	—	4	2
NSAC-12	2.1	—	2	—	8	8
NSAC-13	2.5	—	—	—	3	3
NSAC-14	1.6	—	4	—	6	5
NSAC-15	0.78	—	22	17	—	—
NSAC-16	2.7	—	—	—	6	6
NSAC-17	0.9	—	27	—	—	—
NSAC-18	1.3	—	5	—	5	3
NSAC-19	0.5	—	—	—	15	14
NSAC-20	—	—	7	—	3	3
RED-01	1.5	—	—	—	3	3
RED-02	1.9	—	—	—	5	2
RED-03	1	—	10	7	—	—
RED-04	0.93	—	—	—	—	—
RED-07	0.78	—	—	—	1	—
RED-08	0.75	—	—	—	—	—
RED-09	0.99	—	23	14	2	2
RED-10	4.2	—	6	—	—	—
RED-11	—	—	3	—	—	—
RED-12	2.6	—	4	—	—	—
RED-13	0.65	—	—	—	3	3
RED-14	1.5	—	103	98	—	—
RED-16	—	—	—	—	1	1
RED-17	—	—	—	—	4	4
RED-19	—	—	34	19	—	—

Table 11. Species of inorganic arsenic, iron, and chromium in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[Data in this table analyzed at U.S. Geological Survey (USGS) Trace Metal Laboratory in Boulder, Colorado, using research methods and are not stored in the USGS NWIS database. Information about analytes given in *table 3H*. Samples from all 66 wells were analyzed for chromium, arsenic, and iron; only wells with at least one detection are listed. **GAMA well identification number**: NSAC, Northern Sacramento Valley Study Area grid well; RED, Redding Study Area grid well; RED-U, Northern Sacramento Valley Study Unit understanding well; RED-MW, Northern Sacramento Valley Study Unit understanding monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations**: MDL, method detection limit; na, not available; µg/L, microgram per liter; --, not detected; ≤, less than or equal to]

GAMA well identification number	Arsenic (total) (µg/L)	Arsenic(III) (µg/L)	Iron (total) (µg/L)	Iron(II) (µg/L)	Chromium (total) (µg/L)	Chromium(VI) (µg/L)
Threshold type [1]	**MCL-US**	**na**	**SMCL-CA**	**na**	**MCL-CA**	**na**
Threshold level	**10**	**na**	**300**	**na**	**50**	**na**
[MDL]	**[0.5]**	**[1]**	**[2]**	**[2]**	**[1]**	**[1]**
RED-20	1.5	—	—	—	2	2
RED-21	0.6	—	—	—	2	2
RED-22	—	—	3	3	—	—
RED-23	0.9	—	4	—	4	4
Understanding wells (n = 23)						
NSAC-MW-01	—	—	5	—	1	1
NSAC-MW-02	0.7	—	272	181	1	1
NSAC-MW-03	3.4	—	162	12	—	—
NSAC-MW-04	0.5	—	—	—	6	6
NSAC-MW-05	8.1	6.4	—	—	—	—
NSAC-MW-06	18*	16	4	2	—	—
NSAC-U-01	1.4	—	—	—	31	31
NSAC-U-03	1.1	—	2	2	2	2
NSAC-U-04	0.8	—	—	—	13	13
NSAC-U-05	7.2	—	—	—	2	2
NSAC-U-06	—	—	2	—	1	1
NSAC-U-07	0.6	—	—	—	—	—
NSAC-U-08	—	—	—	—	2	2
RED-MW-01	—	—	438*	89	—	—
RED-MW-02	0.5	—	≤4	≤2	2	1
RED-MW-03	—	—	≤6	≤3	1	—
RED-MW-04	1.5	—	—	—	—	—
RED-MW-05	1.1	—	≤3	—	—	—
RED-MW-06	1.7	—	9	—	6	6
RED-MW-07	9	—	9	≤4	7	6
RED-U-01	0.8	—	4	—	24	22
RED-U-02	0.9	—	2	—	17	17

* Value above threshold level.

[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 of hydrogen, oxygen, and nitrogen, and activities of carbon-14 and tritium activities in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 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 *tables 3I* and *3J*. Samples from all 66 wells were analyzed for stable isotope ratios. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to a more common lighter isotope of that element, relative to a standard reference material. **GAMA well identification number**: NSAC, Northern Sacramento Valley Study Area grid well; RED, Redding Study Area grid well; RED-U, Northern Sacramento Valley Study Unit understanding well; RED-MW, Northern Sacramento Valley Study Unit understanding monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations**: na, not available; nc, not collected; pCi/L, picocuries per liter]

GAMA well identification number	δ^{2}H (per mil) (82082)	δ^{18}O (per mil) (82085)	δ^{15}N of nitrate (per mil) (82690)	δ^{18}O of nitrate (per mil) (63041)	Tritium (pCi/L) (07000)	δ^{13}C (per mil) (82081)	Carbon-14 [1] (percent modern) (49933)
Threshold type [2]	**na**	**na**	**na**	**na**	**MCL-CA**	**na**	**na**
Threshold level	**na**	**na**	**na**	**na**	**20,000.0**	**na**	**na**
Grid wells							
NSAC-01	–73.00	–10.26	7.44	2.77	10.2	–15.25	118.00
NSAC-02	–74.50	–10.45	6.33	4.13	9.9	–15.90	117.50
NSAC-03	–73.10	–10.05	3.69	–1.72	4.8	–13.74	84.19
NSAC-04	–63.70	–8.95	5.10	1.80	5.8	–16.15	89.84
NSAC-05	–74.50	–10.24	4.81	1.03	9.0	–14.00	84.23
NSAC-06	–72.20	–10.13	5.66	1.84	6.7	–15.58	100.50
NSAC-07	–65.50	–9.21	5.74	1.33	1.6	–15.67	65.48
NSAC-08	–66.60	–9.46	nc	nc	<1.0	–18.00	50.92
NSAC-09	–66.00	–9.25	4.53	1.52	1.9	–17.38	57.19
NSAC-10	–64.70	–9.07	3.19	0.33	2.2	–17.67	73.75
NSAC-11	–59.00	–8.38	5.92	2.68	8.0	–18.57	101.40
NSAC-12	–66.20	–9.32	4.15	–0.16	<1.0	–15.07	53.29
NSAC-13	–68.10	–9.68	2.47	0.58	<1.0	–15.64	59.96
NSAC-14	–70.20	–9.88	5.72	1.15	2.6	–13.91	73.56
NSAC-15	–71.20	–9.91	4.30	2.30	7.0	–15.83	105.20
NSAC-16	–71.10	–10.20	3.52	0.16	2.9	–16.19	86.96
NSAC-17	–84.00	–11.36	nc	nc	<1.0	–11.37	2.96
NSAC-18	–63.90	–9.20	3.23	–0.84	1.3	–17.65	72.19
NSAC-19	–64.50	–9.29	6.86	1.79	1.0	–14.45	61.79
NSAC-20	–64.30	–9.15	2.61	0.38	<1.0	–15.43	65.16
RED-01	–64.60	–9.36	2.50	–1.08	<1.0	–19.08	75.60
RED-02	–65.10	–9.38	2.59	–1.28	<1.0	–20.99	76.42
RED-03	–63.70	–9.26	7.98	3.31	7.7	–20.26	114.10
RED-04	–71.90	–10.26	4.04	0.84	9.6	–16.27	116.00
RED-05	–66.60	–9.32	3.03	-0.92	<1.0	–19.61	75.09
RED-06	–75.20	–10.49	3.79	0.90	9.0	–17.86	108.40
RED-07	–67.20	–9.54	3.61	1.27	6.7	–18.87	106.20
RED-08	–63.60	–9.08	6.27	0.97	3.8	–19.50	92.29
RED-09	–71.90	–10.25	4.76	1.29	9.6	–17.60	105.20
RED-10	–69.90	–9.89	–2.00	–5.35	<1.0	–18.10	34.14
RED–11	–72.90	–10.30	4.52	0.64	5.8	–18.87	89.89
RED-12	–65.60	–9.34	25.49	7.00	4.2	–20.60	87.62
RED-13	–65.00	–9.32	3.44	–0.45	1.9	–19.52	83.93
RED-14	–64.70	–9.36	nc	nc	<1.0	–19.45	58.27
RED-15	–65.1	–9.51	4.31	0.36	3.8	–18.72	87.23
RED-16	–65.20	–9.43	3.14	1.21	7.0	–19.04	104.10

Table 12. Results for analyses of stable isotope ratios of hydrogen, oxygen, and nitrogen, and activities of carbon-14 and tritium activities in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 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 analytes given in *tables 3I* and *3J*. Samples from all 66 wells were analyzed for stable isotope ratios. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to a more common lighter isotope of that element, relative to a standard reference material. **GAMA well identification number**: NSAC, Northern Sacramento Valley Study Area grid well; RED, Redding Study Area grid well; RED-U, Northern Sacramento Valley Study Unit understanding well; RED-MW, Northern Sacramento Valley Study Unit understanding monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type**: MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations**: na, not available; nc, not collected; pCi/L, picocuries per liter]

GAMA well identification number	δ^{2}H (per mil) (82082)	δ^{18}O (per mil) (82085)	δ^{15}N of nitrate (per mil) (82690)	δ^{18}O of nitrate (per mil) (63041)	Tritium (pCi/L) (07000)	δ^{13}C (per mil) (82081)	Carbon-14 [1] (percent modern) (49933)
Threshold type [2]	**na**	**na**	**na**	**na**	**MCL-CA**	**na**	**na**
Threshold level	**na**	**na**	**na**	**na**	**20,000.0**	**na**	**na**
RED-17	–67.10	–9.44	3.00	–0.42	<1.0	–19.03	71.85
RED-18	–61.60	–8.71	4.19	2.31	11.5	–18.70	114.60
RED-19	–83.30	–11.81	7.08	47	8.3	–16.47	92.67
RED-20	–65.10	–9.42	3.24	–1.05	<1.0	–19.40	75.64
RED-21	–75.50	–10.65	5.92	0.76	14.4	–17.49	120.10
RED-22	–78.30	–10.99	11.18	2.00	9.3	–16.74	116.70
RED-23	–69.00	–9.93	3.08	0.26	2.6	–19.16	93.07
				Understanding wells			
NSAC-MW-01	–67.80	–9.60	7.10	2.41	<1.0	–18.02	45.26
NSAC-MW-02	–81.10	–11.52	8.21	2.51	3.2	–14.03	101.00
NSAC-MW-03	–67.70	–9.51	3.27	1.11	<1.0	–16.24	43.80
NSAC-MW-04	–70.30	–9.80	3.11	–0.72	<1.0	–13.15	70.10
NSAC-MW-05	–79.40	–10.96	nc	nc	<1.0	–15.26	8.96
NSAC-MW-06	–85.20	–11.69	nc	nc	<1.0	–16.20	4.59
NSAC-U-01	–64.50	–9.19	4.38	–0.22	<1.0	–16.82	37.18
NSAC-U-02	–65.00	–9.17	1.65	–0.36	5.4	–13.89	95.66
NSAC-U-03	–61.90	–8.66	9.18	3.72	10.2	–15.79	113.80
NSAC-U-04	–65.10	–9.26	3.22	–1.40	<1.0	–18.41	81.46
NSAC-U-05	–63.00	–9.22	3.50	0.54	2.2	–13.82	60.17
NSAC-U-06	–62.80	–8.98	5.50	2.34	5.4	–17.43	93.23
NSAC-U-07	–64.90	–9.33	25.73	11.43	<1.0	–14.52	24.07
NSAC-U-08	–66.50	–9.20	4.39	1.70	6.7	–15.64	79.17
RED-MW-01	–77.30	–11.00	3.07	–1.35	<1.0	–16.60	74.38
RED-MW-02	–71.30	–10.16	6.35	1.17	8.0	–19.67	91.74
RED-MW-03	–73.10	–10.42	6.44	0.77	9.6	–24.29	79.61
RED-MW-04	–69.20	–9.62	4.44	0.33	<1.0	–19.11	45.66
RED-MW-05	–64.90	–9.32	3.26	–0.88	<1.0	–20.42	75.20
RED-MW-06	–65.30	–9.28	2.84	–1.44	<1.0	–22.42	67.98
RED-MW-07	–68.00	–9.62	6.63	3.08	9.0	–19.84	104.90
RED-U-01	–62.90	–9.14	3.23	–1.42	<1.0	–18.15	52.62
RED-U-02	–63.70	–9.12	2.69	–1.97	<1.0	–18.16	61.06

[1] Values greater than 100 percent can result from analytical variability.

[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.

Table 13A. Radium isotopes in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 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 12 slow wells were analyzed. *Table 3I* contains additional information about the analytes. Values less than the sample-specific critical level (ssL_C) are reported as nondetections (—). Values less than the activities measured in field blanks (*table A3*) are reported with a less than or equal to sign (≤). **GAMA well identification number:** NSAC, Northern Sacramento Valley Study Unit grid well; RED, Northern Sacramento Valley Study Unit grid well. Thresholds and threshold values as of September 12, 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:** 1σ-CSU, combined standard uncertainty; pCi/L, picocurie per liter; —, not detected]

GAMA well identification number	Radium-226 (pCi/L) (09511)		Radium-228 (pCi/L) (81366)	
Threshold type [1]	**MCL-US**		**MCL-US**	
Threshold value	[2] **5**		[2] **5**	
	result ± 1σ-CSU	**ssL_C**	**result ± 1σ-CSU**	**ssL_C**
Grid wells				
NSAC-01	—	0.015	—	0.19
NSAC-02	≤0.030 ± 0.013	0.015	—	0.25
NSAC-03	≤0.034 ± 0.014	0.018	—	0.22
NSAC-04	≤0.039 ± 0.013	0.018	—	0.23
NSAC-08	0.297 ± 0.024	0.017	—	0.14
NSAC-09	≤0.026 ± 0.012	0.016	—	0.16
NSAC-16	≤0.025 ± 0.011	0.015	—	0.20
RED-03	—	0.014	—	0.22
RED-06	—	0.015	—	0.18
RED-07	≤0.032 ± 0.012	0.016	—	0.21
RED-12	≤0.048 ± 0.013	0.015	—	0.24
RED-14	≤0.073 ± 0.016	0.017	—	0.19

[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 radium is the sum of radium-226 and radium-228.

Table 13B. Gross alpha and beta radioactivity in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 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 12 slow wells were analyzed. *Table 3I* contains additional information about the analytes. The reference nuclide for measurement of gross alpha radioactivity is thorium-230 and the reference nuclide for measurement of gross beta radioactivity is cesium-137. Measured values less than the sample-specific critical level (ssL_c) are reported as nondetections (—). **GAMA well identification number:** NSAC, Northern Sacramento Valley Study Area grid well; RED, Redding Study Area grid well. Thresholds and threshold values as of September 12, 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**: 1σ-CSU, combined standard uncertainty; pCi/L, picocurie per liter; —, not detected]

GAMA well identification number	Gross alpha radioactivity, 72-hour count (pCi/L) (62636)		Gross alpha radioactivity, 30-day count (pCi/L) (62639)		Gross beta radioactivity, 72-hour count (pCi/L) (62642)		Gross beta radioactivity, 30-day count (pCi/L) (62645)	
Threshold type [1]	**MCL-US**		**MCL-US**		**MCL-CA**		**MCL-CA**	
Threshold value	**15**		**15**		**50**		**50**	
	result ± 1σ-CSU	**ssL_c**	**result ± 1σ-CSU**	**ssL_c**	**result ± 1σ-CSU**	**ssL_c**	**result ± 2σ-CSU**	**ssL_c**
Grid wells								
NSAC-01	—	1.3	—	0.92	2.49 ± 0.44	0.52	2.43 ± 0.44	0.53
NSAC-02	—	1.4	—	1.4	1.82 ± 0.58	0.89	1.76 ± 0.82	1.2
NSAC-03	—	1.0	—	1.1	—	0.58	—	0.92
NSAC-04	—	0.85	—	0.56	—	0.95	—	0.45
NSAC-08	—	0.80	—	0.90	1.85 ± 0.39	0.52	1.91 ± 0.36	0.44
NSAC-09	—	0.71	—	0.66	2.00 ± 0.37	0.45	3.68 ± 0.51	0.49
NSAC-16	—	1.2	—	0.90	2.96 ± 0.67	0.86	3.76 ± 0.61	0.66
RED-03	—	0.71	—	1.6	1.10 ± 0.32	0.46	—	0.92
RED-06	—	0.83	—	0.83	0.53 ± 0.29	0.46	—	0.72
RED-07	—	0.96	—	0.57	—	0.93	0.88 ± 0.32	0.49
RED-12	—	1.3	—	0.77	1.51 ± 0.67	0.97	1.23 ± 0.43	0.63
RED-14	—	0.71	—	0.98	—	1.4	—	1.0

[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 13C. Uranium isotopes and radon-222 in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 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 66 wells were analyzed for uranium isotopes; samples from 12 slow wells were analyzed for radon-222. *Table 3I* contains additional information about the analytes. Measured values less than the sample-specific critical level (ssL_C) are reported as nondetections (—). **GAMA well identification number:** NSAC, Northern Sacramento Valley study area grid well; RED, Redding Study area grid well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 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:** 1σ-CSU, combined standard uncertainty; 2σ-CSU, 2-sigma combined uncertainty; pCi/L, picocurie per liter; nc, sample not collected; —, not detected; *, result above threshold value]

GAMA well identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)		Radon-222 (pCi/L) (82303)
Threshold type [1]	**MCL-CA**		**MCL-CA**		**MCL-CA**		**proposed MCL-US**
Threshold value	**[2] 20**		**[2] 20**		**[2] 20**		**[3] 300 (4,000)**
	result ± 1σ-CSU	**ssL_c**	**result ± 1σ-CSU**	**ssL_c**	**result ± 1σ-CSU**	**ssL_c**	**result ± 2σ-CSU**
				Grid wells			
NSAC-01	nc	nc	nc	nc	nc	nc	540* ± 23
NSAC-02	nc	nc	nc	nc	nc	nc	330* ± 20
NSAC-03	nc	nc	nc	nc	nc	nc	280* ± 22
NSAC-04	nc	nc	nc	nc	nc	nc	430* ± 24
NSAC-08	nc	nc	nc	nc	nc	nc	410* ± 25
NSAC-09	nc	nc	nc	nc	nc	nc	380* ± 22
NSAC-16	nc	nc	nc	nc	nc	nc	320* ± 20
RED-01	0.052 ± 0.020	0.018	—	0.0091	0.0356 ± 0.0096	0.0075	nc
RED-01	0.108 ± 0.0200	0.012	—	0.0081	0.0171 ± 0.0085	0.0094	nc
RED-02	0.166 ± 0.024	0.013	—	0.013	0.077 ± 0.016	0.0060	nc
RED-03	0.057 ± 0.014	0.011	—	0.0077	0.035 ± 0.011	0.0063	1,090* ± 31
RED-04	0.040 ± 0.013	0.0072	—	0.0087	0.0123 ± 0.009	0.0072	nc
RED-05	0.023 ± 0.010	0.010	—	0.0071	0.0126 ± 0.0075	0.0059	nc
RED-06	0.030 ± 0.011	0.0091	—	0.011	0.0249 ± 0.0086	0.0064	710* ± 30
RED-07	—	0.018	0.0118 ± 0.0080	0.0091	0.0129 ± 0.0095	0.0075	720* ± 28
RED-08	—	0.016	—	0.0088	0.0093 ± 0.006	0.0072	nc
RED-09	0.059 ± 0.025	0.020	—	0.024	—	0.020	nc
RED-09	0.033 ± 0.013	0.011	—	0.0092	0.026 ± 0.01	0.0076	nc
RED-10	—	0.026	—	0.032	0.034 ± 0.023	0.026	nc
RED-11	—	0.012	—	0.014	—	0.0084	nc
RED-12	0.056 ± 0.034	0.026	—	0.032	0.034 ± 0.023	0.026	400* ± 18
RED-13	0.062 ± 0.014	0.0066	—	0.0079	0.0169 ± 0.0085	0.0066	nc
RED-14	—	0.014	—	0.011	—	0.0064	920* ± 28
RED-15	—	0.033	—	0.028	—	0.023	nc
RED-16	0.084 ± 0.034	0.028	—	0.024	0.059 ± 0.025	0.020	nc
RED-17	0.341 ± 0.037	0.013	0.017 ± 0.010	0.0079	0.187 ± 0.024	0.0065	nc
RED-18	0.031 ± 0.013	0.0072	—	0.0087	0.028 ± 0.013	0.0072	nc
RED-19	0.063 ± 0.017	0.012	—	0.011	0.037 ± 0.012	0.0066	nc
RED-20	0.081 ± 0.022	0.0099	—	0.012	0.038 ± 0.013	0.0099	nc
RED-21	0.149 ± 0.026	0.0083	—	0.010	0.117 ± 0.022	0.0083	nc
RED-22	0.031 ± 0.014	0.011	—	0.0097	0.021 ± 0.011	0.0080	nc
RED-23	—	0.018	—	0.022	0.031 ± 0.016	0.018	nc

Table 13C. Uranium isotopes and radon-222 in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 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 66 wells were analyzed for uranium isotopes; samples from 12 slow wells were analyzed for radon-222. *Table 31* contains additional information about the analytes. Measured values less than the sample-specific critical level (ssL_C) are reported as nondetections (—). **GAMA well identification number:** NSAC, Northern Sacramento Valley study area grid well; RED, Redding Study area grid well; RED-MW, Redding Study area monitoring well. Thresholds and threshold values as of September 12, 2008. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** 1σ-CSU, combined standard uncertainty; 2σ-CSU, 2-sigma combined uncertainty; pCi/L, picocurie per liter; nc, sample not collected; —, not detected; *, result above threshold value]

GAMA well identification number	**Uranium-234 (pCi/L) (22610)**		**Uranium-235 (pCi/L) (22620)**		**Uranium-238 (pCi/L) (22603)**		**Radon-222 (pCi/L) (82303)**
Threshold type [1]	**MCL-CA**		**MCL-CA**		**MCL-CA**		**proposed MCL-US**
Threshold value	**[2] 20**		**[2] 20**		**[2] 20**		**[3] 300 (4,000)**
	result ± 1σ-CSU	**ssL_C**	**result ± 1σ-CSU**	**ssL_C**	**result ± 1σ-CSU**	**ssL_C**	**result ± 2σ-CSU**
Understanding wells							
RED-MW-01	0.059 ± 0.019	0.012	—	0.015	0.0111 ± 0.0075	0.0086	nc
RED-MW-02	—	0.026	—	0.031	—	0.026	nc
RED-MW-03	0.066 ± 0.024	0.022	—	0.019	0.033 ± 0.014	0.011	nc
RED-MW-04	0.051 ± 0.026	0.020	—	0.024	0.067 ± 0.026	0.020	nc
RED-MW-05	0.053 ± 0.027	0.021	—	0.025	—	0.021	nc
RED-MW-05	0.087 ± 0.026	0.020	—	0.024	—	0.020	nc
RED-MW-06	0.214 ± 0.035	0.011	0.017 ± 0.012	0.013	0.114 ± 0.024	0.011	nc
RED-MW-07	0.395 ± 0.038	0.016	0.0096 ± 0.0065	0.0074	0.242 ± 0.028	0.0061	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.

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

Table 14. Results for analyses of noble gas samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 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 66 wells were analyzed for noble gases. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding Study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding Study area monitoring well. Threshold types and threshold levels as of September 12, 2008. **Other abbreviations**: cm^3 STP /g H$_2$0, cubic centimeters at standard temperature and pressure per gram of water; na, not available; nc, sample not collected; pCi/L, picocuries per liter]

GAMA well identification number	Collection date (mm/dd/yy)	Dissolved gas analysis date* (mm/dd/yy)	Helium-3/ Helium-4 (atom ratio) (61040)	Helium-4 (85561)	Neon (61046)	Argon (85563)	Krypton (85565)	Xenon (85567)
				(cm^3 STP/g H$_2$O)				
			x 10^{-6}	x 10^{-7}	x 10^{-7}	x 10^{-4}	x 10^{-8}	x 10^{-8}
Threshold type	na	na	na	na	na	na	na	na
Threshold value	na	na	na	na	na	na	na	na
				Grid wells (n = 43)				
NSAC-01	10-04-07	*						
NSAC-02	10-24-07	03-04-08	1.67	0.50	2.19	3.43	7.48	1.01
NSAC-03	10-29-07	03-05-08	1.67	0.66	3.42	3.94	7.70	1.06
NSAC-04	10-30-07	03-05-08	1.74	0.50	2.14	3.23	6.95	0.95
NSAC-05	10-31-07	03-05-08	1.65	0.61	2.31	3.28	6.89	0.92
NSAC-06	10-31-07	03-06-08	2.03	0.51	2.13	3.31	7.35	1.03
NSAC-07	11-01-07	03-06-08	1.48	0.56	2.32	3.38	7.40	0.99
NSAC-08	11-05-07	03-06-08	1.27	0.52	2.05	3.15	6.93	0.96
NSAC-09	11-06-07	03-07-08	1.36	0.51	2.00	3.12	7.04	0.99
NSAC-10	11-06-07	03-07-08	1.50	0.49	2.14	3.17	7.04	0.99
NSAC-11	11-26-07	05-20-08	1.33	0.56	2.31	3.62	8.04	1.14
NSAC-12	11-27-07	05-20-08	1.35	0.54	2.20	3.27	7.03	0.95
NSAC-13	11-27-07	*						
NSAC-14	11-28-07	*						
NSAC-15	11-28-07	05-21-08	1.37	0.55	2.36	3.45	7.66	1.00
NSAC-16	12-06-07	05-22-08	1.59	0.85	1.98	3.19	6.99	0.97
NSAC-17	12-13-07	*						
NSAC-18	12-18-07	05-30-08	1.40	0.44	1.80	2.99	6.91	0.92
NSAC-19	01-08-08	06-04-08	1.38	0.55	2.17	3.31	7.15	0.95
NSAC-20	01-08-08	*						
RED-01	10-01-07	04-14-08	1.34	0.46	2.00	3.09	6.71	0.92
RED-02	10-01-07	*						
RED-03	10-02-07	*						
RED-04	10-03-07	*						
RED-05	10-03-07	*						
RED-06	10-22-07	03-04-08	1.47	0.46	1.94	3.23	7.26	10.00
RED-07	10-23-07	03-04-08	1.85	0.50	2.07	3.31	7.36	1.00
RED-08	10-23-07	03-04-08	1.58	0.62	2.47	3.57	7.65	0.99
RED-09	10-25-07	03-05-08	2.01	0.47	2.04	3.34	7.33	1.04
RED-10	10-25-07	03-05-08	0.71	3.53	2.00	3.29	7.06	0.98
RED-11	11-07-07	03-07-08	1.62	0.52	2.20	3.38	7.55	1.10
RED-12	11-08-07	03-07-08	0.96	1.87	2.25	3.42	7.35	0.98
RED-13	11-20-07	05-20-08	1.44	0.49	2.01	3.12	6.82	0.93
RED-14	11-29-07	05-21-08	0.88	0.80	2.02	3.12	6.92	0.94
RED-15	12-03-07	05-21-08	1.53	0.65	2.59	3.42	7.26	0.96
RED-16	12-03-07	05-21-08	1.74	0.45	1.94	3.21	7.24	0.97

Table 14. Results for analyses of noble gas samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 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 66 wells were analyzed for noble gases. **GAMA well identification number**: NSAC, Northern Sacramento Valley study area grid well; NSAC-U, Northern Sacramento Valley study area understanding well; NSAC-MW, Northern Sacramento Valley study area monitoring well; RED, Redding Study area grid well; RED-U, Redding Study area understanding well; RED-MW, Redding Study area monitoring well. Threshold types and threshold levels as of September 12, 2008. **Other abbreviations**: cm^3 STP /g H_20, cubic centimeters at standard temperature and pressure per gram of water; na, not available; nc, sample not collected; pCi/L, picocuries per liter]

GAMA well identification number	Collection date (mm/dd/yy)	Dissolved gas analysis date* (mm/dd/yy)	Helium-3/ Helium-4 (atom ratio) (61040)	Helium-4 (85561)	Neon (61046)	Argon (85563)	Krypton (85565)	Xenon (85567)
				(cm^3 STP/g H_2O)				
			x 10^{-6}	x 10^{-7}	x 10^{-7}	x 10^{-4}	x 10^{-8}	x 10^{-8}
Threshold type	na	na	na	na	na	na	na	na
Threshold value	na	na	na	na	na	na	na	na
RED-17	12-05-07	05-22-08	1.19	0.75	1.95	3.23	7.46	1.01
RED-18	12-05-07	05-22-08	1.87	0.44	2.27	3.22	6.73	0.92
RED-19	12-11-07	05-29-08	1.78	1.09	2.07	3.41	7.58	1.06
RED-20	12-12-07	*						
RED-21	12-12-07	*						
RED-22	01-15-08	06-14-08	1.72	0.50	2.24	3.43	7.59	0.99
RED-23	01-16-08	10-24-08	1.36	0.68	2.17	3.34	7.53	1.03
Understanding wells (n = 23)								
NSAC-MW-01	01-07-08	*						
NSAC-MW-02	01-08-08	06-04-08	1.67	0.51	2.21	3.39	7.51	1.03
NSAC-MW-03	01-08-08	06-04-08	1.43	0.61	1.82	0.30	6.83	0.91
NSAC-MW-04	01-09-08	06-05-08	1.43	0.54	2.32	3.37	7.40	0.97
NSAC-MW-05	01-09-08	06-05-08	0.87	0.92	2.46	3.63	7.84	1.07
NSAC-MW-06	01-10-08	*						
NSAC-U-01	12-04-07	05-21-08	1.29	0.53	2.15	3.18	6.89	0.93
NSAC-U-02	12-04-07	05-21-08	1.63	0.58	2.78	3.45	7.20	0.94
NSAC-U-03	12-13-07	05-30-08	1.77	0.58	2.16	3.32	7.50	0.97
NSAC-U-04	12-18-07	05-30-08	1.36	0.55	2.24	3.28	7.29	0.94
NSAC-U-05	01-07-08	*						
NSAC-U-06	01-07-08	*						
NSAC-U-07	01-09-08	06-05-08	1.21	0.62	2.25	0.33	7.15	0.93
NSAC-U-08	01-14-08	06-14-08	1.57	0.45	1.98	3.13	6.91	0.91
RED-MW-01	01-15-08	10-14-08	1.16	0.73	1.99	3.36	7.61	1.05
RED-MW-02	01-15-08	10-23-08	1.96	0.61	2.63	3.53	7.49	1.04
RED-MW-03	01-15-08	10-24-08	2.28	0.62	2.67	3.68	8.23	1.09
RED-MW-04	01-16-08	*						
RED-MW-05	01-16-08	10-24-08	1.36	0.47	2.03	2.99	6.89	0.87
RED-MW-06	01-17-08	10-24-08	1.35	0.53	2.10	3.23	7.28	0.94
RED-MW-07	01-17-08	10-24-08	1.53	0.70	3.02	3.76	7.79	1.04
RED-U-01	01-08-08	05-29-08	1.35	0.44	1.89	2.89	6.40	0.84
RED-U-02	01-14-08	06-14-08	1.39	0.89	3.70	3.87	7.47	9.54

* Results unavailable at time of publication.

Appendix

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

Sample Collection and Analysis

Groundwater samples were collected using standard and modified USGS protocols from the USGS NAWQA program (Koterba and others, 1995) and the USGS National Field Manual (U.S. Geological Survey, variously dated) and protocols described by Weiss (1968), Shelton and others (2001), Ball and McClesky (2003a,b), and Wright and others (2005).

Before being sampled, each well was pumped continuously in order to purge at least three casing-volumes of water from the well (Wilde and others, 1999). Wells were sampled using Teflon tubing with brass and stainless-steel fittings attached to a sampling point on the well discharge pipe as close to the well as possible. The sampling point was always located upstream of any well-head treatment system or water storage tank. If a chlorinating system was attached to the well, the chlorinator was shut off at least 24 hours before purging and sampling the well in order to clear all chlorine out of the system. For the intermediate and slow schedules, the samples were collected inside an enclosed chamber located inside a mobile laboratory and connected to the well head by a 10- to 50- foot length of the Teflon tubing (Lane and others, 2003). All fittings and lengths of tubing were cleaned after each sample was collected (Wilde, 2004).

Samples were collected from monitoring wells (RED-MW, NSAC-MW) using a portable, 2-inch diameter submersible pump (Grundfos Redi-Flo2® pump) attached to reels of approximately 300 feet of Teflon tubing. The 10- to 50-foot Teflon tubing used for intermediate and slow schedules was attached to the outflow section of the reels, and samples were collected inside an enclosed chamber in a mobile laboratory. Two separate submersible pumps and reels were used to collect samples from monitoring wells in REDSAC. All fittings and lengths of tubing were cleaned after each sample was collected (Wilde, 2004).

For the field 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, temperature, pH, turbidity, and specific conductance. 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. Temperature measurements, dissolved oxygen, pH, and specific conductance 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 the laboratory were collected. 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). Before samples were collected, sample bottles were pre-rinsed twice using deionized water, and then once with sample water . Samples requiring acidification were acidified to a pH of 2 or less with the appropriate acids using ampoules of certified, traceable concentrated acids obtained from the USGS National Water Quality Laboratory (NWQL).

The temperature-sensitive samples to be analyzed for volatile organic compounds, pesticides, compounds of special interest, radium isotopes, gross alpha and beta radioactivity, microbial constituents, and radon-222 were stored on ice before and while being shipped daily to the laboratories. The non-temperature sensitive samples to be analyzed for tritium, noble gases, chromium speciation, and stable isotopes of hydrogen and oxygen in water were shipped monthly. The temperature sensitive samples for stable isotopes of nitrogen and oxygen in nitrate and arsenic and iron speciation were stored on ice, archived in a laboratory freezer, and shipped after results for analyses of nitrate and the metal concentrations were received from the NWQL.

Detailed sampling protocols for individual analyses and groups of analytes are described by Koterba and others (1995), in the USGS National Field Manual (Wilde and others, 1999; Wilde and others, 2004), and in the references for analytical methods detailed in table A1; only brief descriptions are given here. Volatile organic compounds (VOC) were collected in 40-mL sample vials that were purged with three vial volumes of sample water before bottom-filling to minimize atmospheric contamination. Six normal (6 N) hydrochloric acid (HCl) was added to preserve the VOC samples. Each perchlorate sample was collected in a high-density polyethylene bottle. Forty mL of the sampled groundwater was then drawn from the bottle with a syringe and then run through a 0.20-µm filter into a 125-mL polystyrene bottle. Tritium samples were collected by bottom-filling two 1-L polyethylene bottles with unfiltered groundwater after overfilling each bottle with three volumes of water. Samples to be analyzed for stable isotopes of hydrogen and oxygen in water were unfiltered, collected in 60-mL clear glass bottles sealed with conical caps, and secured with electrical tape to prevent leakage and evaporation.

Pesticides and pesticide degradation products, pharmaceutical compounds, and *N*-nitrosodimethylamine (NDMA) samples were collected in 1-L baked amber glass bottles. Pesticide and pharmaceutical samples were filtered through a glass-fiber filter during collection, whereas the NDMA samples were filtered at Weck Laboratories, Inc. before analysis.

Groundwater samples to be analyzed for major and minor ions, trace elements, laboratory alkalinity, and total dissolved solids each required filling one 250-mL polyethylene bottle with raw ground water, and one 500-mL and one 250-mL polyethylene bottle with groundwater (Wilde and others, 2004) filtered through a Whatman capsule filter. Each 250-mL filtered sample was then preserved with 7.5 N nitric acid. Mercury samples were collected by filtering groundwater into 250-mL glass bottles and preserving with 6 N hydrochloric acid. Arsenic and iron speciation samples were each filtered into a 250-mL polyethylene bottle that was covered with tape to prevent light exposure and preserved with 6 N hydrochloric acid. The nutrient and nitrate isotopes samples were filtered into separate 125-mL brown polyethylene bottles. Radium isotopes and gross alpha and beta radiation samples were filtered into 1-L polyethylene bottles and acidified with nitric acid. Carbon isotope samples were filtered and collected in two bottom filled 500-mL glass bottles that were first overfilled with three bottle volumes of ground water. These samples had no headspace, and were sealed with conical caps to avoid atmospheric contamination. Samples to be analyzed for field alkalinity titrations were collected by filtering groundwater into 500-mL polyethylene bottles.

Chromium, radon-222, and noble gases were collected from the hose bib at the well head, regardless of the sampling schedule (intermediate, or slow). Chromium speciation samples were collected using a 10-mL syringe with an attached 0.45-µm disk filter. After the syringe was thoroughly rinsed and filled with ground water, 4 mL of the groundwater were forced through the disk filter; the next 2 mL were slowly filtered into a small centrifuge vial to be analyzed for total chromium. Hexavalent chromium, Cr(VI), was then collected by attaching a small cation-exchange column to the syringe filter, and after conditioning the column with 2 mL of sample water, 2 mL were collected in a second centrifuge vial. Both vials were preserved with 10 µL of 7.5 N nitric acid (Ball and McClesky, 2003a,b). To collect radon-222, a stainless steel and Teflon valve assembly was attached to the sampling port at the well head (Wilde and others, 2004). The valve was partially closed to create back pressure, and a 10-mL sample was collected through a Teflon septum on the valve assembly using a glass syringe affixed with a stainless-steel needle. The sample was then injected into a 25-mL vial partially filled with scintillation mixture (mineral oil) and the vial was shaken. It was then placed in an insulated cardboard tube in order to protect the sample during shipping. Noble gases were collected in 3/8-in. copper tubes using reinforced nylon tubing connected to the hose bib at the wellhead. Groundwater was flushed through the tubing to dislodge bubbles before flow was restricted with a back pressure valve. Clamps on either side of the copper tube were then tightened, trapping a sample of groundwater for analyses of noble gases (Weiss, 1968).

Samples to be analyzed for microbial constituents also were collected at the well head (Bushon, 2003; Myers, 2004) regardless of the sampling schedule (intermediate, or slow). Before the samples were collected, the sampling port was sterilized using isopropyl alcohol, and groundwater was run through the sampling port for at least 3 minutes to remove any traces of the sterilizing agent. One sterilized 3-L carboy was filled for coliphage analyses (F specific and somatic coliphage determinations).

Turbidity and field alkalinity were measured in the mobile laboratory at the well site. Turbidity was measured in the field with a calibrated turbidity meter. Alkalinity of filtered samples was measured by using Gran's titration method (Gran, 1952; Stumm and Morgan, 1996; Rounds, 2006). Field titration data were entered directly into PCFF-GAMA and the concentrations of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) were automatically calculated using the advanced speciation method. Concentrations of HCO_3^- and CO_3^{2-} were calculated from the laboratory alkalinity and pH measurements also using the advanced speciation method (*http://or.water.usgs.gov/alk/methods.html*) with pK_1 (–log $_{10}$ of the first acid dissociation constant for H_2CO_3) = 6.35, pK_2 (–log $_{10}$ of the second acid dissociation constant for H_2CO_3) = 10.33, and pK_W (–log $_{10}$ of the acid dissociation constant for water) = 14.

Ten laboratories did chemical and microbial analyses for this study (see *table A1*), although most of the analyses were done at the NWQL or by laboratories contracted by the NWQL. The NWQL maintains a rigorous quality-assurance program (Pirkey and Glodt, 1998; Maloney, 2005). Laboratory quality-control samples, including method blanks, continuing calibration verification standards, standard reference samples, reagent spikes, external certified reference materials, and external blind proficiency samples, are analyzed regularly. Method detection limits are continuously tested and laboratory reporting levels updated accordingly. NWQL maintains the National Environmental Laboratory Accreditation Program (NELAP) and other certifications (*http://www.nelac-institute.org/accred-labs.php*). In addition, the Branch of Quality Systems within the USGS Office of Water Quality maintains independent oversight of quality assurance at the NWQL and laboratories contracted by the NWQL. The Branch of Quality Systems runs the National Field Quality Assurance Program also 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 directly into NWIS by the NWQL.

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 reporting false negatives (not detecting a compound when it is actually present in a sample) to less than 1 percent (Childress and others, 1999). The LRL is almost always set at two times the long-term method detection level (LT-MDL). The LT-MDL is derived from the standard deviation of at least 24 MDL determinations made over an extended period of time. LT-MDLs are continually monitored and updated. The method detection limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the concentration is greater than zero (at 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 REDSAC study were analyzed (October 2007 through January 2008).

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). E-coded values may result also from concentrations detected outside the range of calibration standards, for concentrations that did not meet all laboratory quality-control criteria, and for samples that were diluted before analysis (Childress and others, 1999).

Some constituents in this study are reported using minimum reporting levels (MRL) 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. Results for some constituents are presented using raised study reporting limits (SRLs) derived from assessing data from quality-control samples associated with groundwater samples collected as part of the GAMA project. The SRLs were determined by statistical assessment of results from the field blanks collected in the first 21 GAMA study units (May 2004 through January 2008) (Olsen and others, in press). The statistical analysis used order statistics and binomial probabilities to construct an upper confidence limit for the amount of contamination potentially in field blanks and, by inference, in groundwater samples (Hahn and Meeker, 1991). L.D. Olsen and M. Fram set the resulting SRLs at concentrations representing a confidence limit of 90 percent for the 90th percentile of the 86 field blanks used in the assessment. There is at least 90 percent confidence that not more than 10 percent of the groundwater samples would have contamination due to field or laboratory processes greater than these SRLs. For constituents with SRLs greater than the respective LT-MDLs, concentrations at or below the SRL concentrations were reported as "≤" (less than or equal to) the reported concentration. Concentrations with the " ≤" symbol are considered nondetections in this report.

The methods used to analyze radiochemical constituents (gross-alpha radioactivity, gross-beta radioactivity, radium isotopes, and uranium isotopes) measure activities by counting techniques (*table A1*). The reporting limits used 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. Sample-specific critical levels are used for radiochemical measurements because the critical level is sensitive to sample size and sample yield during analytical processing and depends on instrument background, counting times for the sample and background, and the characteristics of the instrument being used and the nuclide being measured. 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 nondetections.

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 are reported with sample-specific combined standard uncertainties (CSU). Therefore, measured activities of radioactive constituents are reported with sample-specific uncertainties. Activities of radium isotopes and gross alpha and beta radiation are reported with sample-specific combined standard uncertainties (CSU). The CSU is reported at the 68 percent confidence level (1-sigma). Radon activities are measured by a different laboratory than the other radioactive constituents, and the laboratory reports results with 2-sigma (95 percent confidence level) standard combined uncertainties (*table 13C*).

Notation

Stable isotopic compositions of oxygen, nitrogen, 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 the element;
E is the element (O for oxygen, C for carbon, or H for hydrogen);
R_{sample} is the ratio of the abundance of the heavier isotope of the element (^{18}O, ^{13}C, or ^{2}H) to the lighter isotope of the element, (^{16}O, ^{12}C, or ^{1}H) in the sample; and,
$R_{\text{reference}}$ is the ratio of the abundance of the heavier isotope of the element to the lighter isotope of the element to the lighter isotope hydrogen.

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned δ^{18}O and δ^{2}H values of 0 per mil (note than δ^{2}H is sometimes written 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 δ^{13}C value of 0 per mil. Positive values indicate enrichment of the heavier isotope, and negative values indicate depletion of the heavier isotope compared to the ratios observed in the standard reference material.

Constituents on Multiple Analytical Schedules

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 (U.S. Geological Survey, 2008). 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 generally preferred. However, the method having higher LRLs may be selected as the preferred method to provide consistency with historical data analyzed by the same method.

Six of the constituents appear on two different NWQL analytical schedules: pesticides (Schedule 2032; *table 3B*), and polar pesticides and pesticide degradates (Schedule 2060; *table 3C*). The preferred method is the method used for Schedule 2032, because it has greater precision and accuracy for most of the six compounds, and for consistency (all samples collected for the GAMA Priority Basin Project are analyzed using Schedule 2032 or an equivalent method, but only a limited number of samples are analyzed using Schedule 2060).

Some of the water-quality indicators—pH, specific conductance, and alkalinity—were measured in the field and at the NWQL. The field measurements are the preferred method for all three constituents; however, both are reported. Bicarbonate and carbonate results calculated from field alkalinity and pH data are preferred over the results calculated from the laboratory data.

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

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

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).

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, or laboratory analysis. Four types of quality-control (QC) tests were used in this study: blank samples were collected to assess contamination from handling or analyzing samples, replicate samples were collected to assess reproducibility, matrix-spike tests were done to assess accuracy of laboratory analytical methods, and surrogate compounds were added to samples analyzed for organic constituents to assess bias of laboratory analytical methods. In this report, detections of organic constituents in groundwater samples that may have resulted from contamination during sample handling or analysis were flagged with a "V" remark code and were not considered detections for calculations of detection frequencies in water-quality assessments. Detections of inorganic constituents in groundwater samples that may have resulted from contamination were flagged with a "≤" remark code to indicate that the amount of potential contamination may have been sufficient to change a nondetection into a false positive detection 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 REDSAC and on results for QC samples for the 21 GAMA study units sampled from May 2004 through January 2008.

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

Blanks

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

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 while being collected, processed, transported, and analyzed. Blanks were collected using blank water certified by the NWQL to contain less than the LRL or MRL of the analytes investigated in the study. 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. For REDSAC, field blanks and source-solution blanks were collected at 11 percent of the wells sampled (note: source-solution blanks were only analyzed if a constituent was detected in the corresponding field blank). Field blanks were analyzed for VOCs; gasoline oxygenates and degradates; pesticides; pharmaceuticals; perchlorate; NDMA; nutrients; major and minor ions; trace elements; iron, arsenic, and chromium species; and radioactive constituents (*table A3*). Certified blank water is not available for tritium or noble gases; thus field blanks were not collected for these constituents.

Source-solution blanks were collected at the sampling site by pouring blank water directly into sample containers; these blanks 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 ground water, then processed and transported using the same protocols as those used for the groundwater samples. Approximately 12 liters of blank water was pumped or poured through the sampling equipment before each field blank was collected.

Assessment of Blank Results

All detections of the constituents of interest in field blanks required investigation of the magnitude and potential source of the contamination. Detections in groundwater samples with concentrations less than the highest concentration measured in a blank plus the LT-MDL were marked with a "V" in the data tables (LRL equals twice the LT-MDL). The highest concentration measured in a blank was assumed to represent the highest potential amount of contamination. Thus, the V remark code flags concentrations that may have been greater than the LT-MDL only because of contamination and therefore a "detection" was actually a nondetection.

For organic constituents, results marked with V codes were not considered to be detections of the constituent when detection frequencies for groundwater quality assessments were calculated. For inorganic constituents, results marked with V codes were considered to have concentrations less than or equal to (≤) the reported value (including the possibility of the concentration being less than the LT-MDL).

Potential Sources of Contamination during Sample Handling or Analysis

Contamination in blanks may originate from several different types of sources that require different strategies for assessment of potential contamination of groundwater samples. Three primary sources of contamination are analyzed if a constituent is unexpectedly detected in a field-blank or a groundwater sample: (1) contamination from a known source, (2) carry-over contamination from the previously collected samples, and (3) random contamination from field and laboratory equipment and processes. The third mode of contamination is being addressed by using a larger set of field blank results from multiple studies. The development of this approach and its methods are described by Olsen and others (in press).

The first potential mode evaluated was contamination from identifiable, known sources present at a specific field site. Contamination from specific sources may produce distinctive patterns of detections in field blanks and groundwater samples, particularly for the VOCs. 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 evidence of the probable contaminant source. If the constituents were present in the field blank and 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 that constituent in the groundwater sample were V-coded and all other groundwater samples collected at sites where the same condition may have existed were considered for V-coding. For example, detections of fuel-related compounds in a field blank and groundwater sample collected from a site with a notable atmosphere of diesel fumes would be V-coded. If no probable contaminant sources were identified in the field notes or photographs, V-codes were not applied on this basis.

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

The third potential source of contamination evaluated was random contamination from field or laboratory equipment or processes. All detections in field blanks which could not be accounted for by source-solution contamination, specific known conditions at field sites, or carry-over contamination were evaluated for random contamination. Random contamination has an equal chance of affecting each groundwater sample; thus, strategies for flagging detections of constituents subject to random contamination must be applied to all groundwater samples. Different notation was used for flagging detections of organic and inorganic constituents that may have been subject to random contamination.

For organic constituents, V-codes were applied. The V-coded 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. Detections of the constituent in groundwater samples at concentrations less than this V-coded level were flagged with a “V” in front of the reported value in the data tables. The highest concentration measured in a blank was assumed to be the highest potential amount of contamination. Thus, the V-code flags results that could have changed from detection to a nondetection relative to the LT-MDL because of contamination. Results that were V-coded were not considered detections of the constituent for this study and were not included in calculations of detection frequencies for organic constituents.

Inorganic constituents can be naturally present in ground water, and the concerns about inorganic constituents generally are related to concentration rather than detection (presence or absence). In contrast, concerns about organic constituents generally are related to both detection and concentration. A ≤ symbol was applied to low-concentration detections of inorganic constituents that may have been affected by contamination. The ≤ symbol means that the concentration of the constituent in the groundwater sample is less than or equal to the measured concentration (it may be less than the LT-MDL and therefore a nondetection). For trace elements, the concentration threshold for applying the ≤ symbol was determined from a statistical assessment of results for 86 field blanks collected between May 2004 and January 2008 (Olsen and others, in press). For all other inorganic constituents, the concentration threshold (a study reporting limit, or “SRL”) for applying the ≤ symbol was determined from assessing the field blanks collected at REDSAC sites only.

For trace elements, the concentration threshold for applying the ≤ symbol was equal to the concentration of the field blank ranked at the 90 percent confidence level for the 90th percentile of the binomial distribution of the 86 field blanks. For all other inorganic constituents, the concentration threshold for applying the ≤ symbol was equal to the highest concentration measured in the seven field blanks collected at REDSAC sites plus one-half the LRL. In the data tables, a ≤ symbol was assigned to measured values that were less than the threshold concentration.

Replicates

Sequential replicate samples were collected to assess the variability that may result from processing and analyzing inorganic and organic constituents. Relative standard deviation (RSD) of the measured values was used in determining the variability between replicate pairs for each compound (*tables A4A–D*). The RSD is defined as 100 times the standard deviation divided by the mean concentration for each replicate pair of samples. If one value in a sample pair was reported as a nondetection and the other value was reported as an estimate below the LRL or MRL, the RSD was set to zero because the values were analytically identical. If one value in a sample pair was reported as a nondetection and the other value was greater than the LRL or MRL, the non-detection value was set equal to one-quarter of the LRL and the RSD was calculated (Hamlin and others, 2002). Values of RSD less than 20 percent are considered acceptable in this study. An RSD value of 20 percent corresponds to a relative percent difference (RPD) value of 29 percent. High RSD values for a compound may indicate analytical uncertainty at low concentrations, particularly for concentrations within an order of magnitude of the LT-MDL or, its MDL. Sequential replicate samples were collected at 11 percent of the wells (7 of 66) sampled.

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 ground water, on the analytical technique used to measure the constituent. The known compounds added to matrix spikes are the same as those being analyzed in the method. This enables matrix interferences to be analyzed on a compound-by-compound basis. Matrix spikes were added at the laboratory making 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.

Acceptable ranges for matrix-spike recoveries are based on the acceptable ranges established for laboratory “set” spike recoveries. Laboratory set spikes are aliquots of laboratory blank water to which the same spike solution as that used for the matrix spikes has been added. One set spike is analyzed with each set of samples. Acceptable ranges for set spike recoveries are 70 to 130 percent for NWQL Schedules 2020 (Connor and others, 1998; Rose and Sandstrom, 2003), 60 to 120 percent for NWQL Schedules 2032, and 2060 (Sandstrom and others, 2001), and 60 to 130 percent for Schedule 2080 (Kolpin and others, 2002). On the basis of these ranges, 70 to 130 percent was defined as the acceptable range for matrix-spike recoveries for organic compounds in this study.

Matrix spike recovery tests were done for VOCs, pesticides, and NDMA, because the analytical methods for these constituents are chromatographic methods that may be susceptible to matrix interferences. Replicate samples for matrix-spike additions were collected at 11 percent of the wells sampled, although not all analyte classes were tested at every well (*tables A5A–E*).

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 to all groundwater and quality-control samples that were analyzed for VOCs, pesticides, and pharmaceuticals. Most of the surrogate compounds were 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

Field blanks were collected at approximately 11 percent of the sites sampled in REDSAC. *Table A3* gives a summary of detections in field blanks. Three separate equipment configurations were used to collect groundwater samples in REDSAC. Fifty-three production wells that were equipped with pumps were sampled, and 13 monitoring wells were sampled using portable submersible pumps. Two separate portable submersible pumps were used; the first pump (hereinafter referred to as “pump A”) was used to sample the first 6 monitoring wells (NSAC-MW-01 through NSAC-MW-06), while the second pump (“pump B”) was used to sample the remaining

7 monitoring wells (RED-MW-01 through RED-MW-07). After the field blank was collected using pump B, precipitates within the pump's sampling line (not from the well itself) were observed while an environmental sample was being collected. This in conjunction with detections of constituents in inorganic blanks collected using pump B being notably higher than those collected in the other equipment configurations (production wells and pump A) resulted in handling the pump B data separately.

Production Well and Pump A Blank Results

Field blanks to be analyzed for VOCs were collected at 6 of the 59 production and monitoring wells. The concentration of acetone was E2.0 µg/L in one of the six production and monitoring well field blanks and E1.0 µg/L in the associated source-solution blank. Acetone was not detected in any groundwater samples collected in REDSAC.

Field blanks to be analyzed for nutrients were collected at 6 of the 59 production and monitoring wells. The concentration of ammonia detected in one field blank was 0.014 mg/L. Concentrations of ammonia in three groundwater samples were less than 0.024 mg/L (0.014 mg/L plus one-half the LRL of 0.02 mg/L) and were therefore coded as ≤ (*tables 8* and *A3*). Field blanks to be analyzed for major and minor ions and trace elements were collected at 6 of the 59 production and monitoring wells sampled. Trace-element data were assessed for potential flagging of results using the GAMA study reporting limits (SRL), which are based on results for 86 field blanks collected between May 2004 and January 2008 in conjunction with the 6 field blanks collected at REDSAC production well and pump A sites. Measured values that are less than the SRLs are flagged with the ≤ symbol in *table 10*.

The concentration of aluminum detected in the field blank was E0.09 µg/L, which was less than the SRL. Aluminum was not detected in the associated source-solution blank. Boron and silica were detected in one of the field blanks and the associated source-solution blank. The concentration of boron detected in the field blank was 21.76 µg/L and 23.49 µg/L in the source-solution blank. Silica was detected at a concentration of 0.04 µg/L in the field blank and at 0.034 µg/L in the source-solution blank. However, the NWQL which supplied the inorganic-free blank water used for the field blank and source-solution blank has stated that this water contained approximately 20 µg/L of boron and approximately 0.035 µg/L of silica (U.S. Geological Survey, 2007). Since the other five field blanks had no detections of boron or silica, the environmental results were considered to be free from any contamination bias. Lead was detected in 1 of the 5 field blanks at a concentration of E0.07 µg/L, which is below the SRL of 0.65 µg/L; all detections of lead below 0.65 µg/L in environmental samples were reported as ≤ the measured value. Mercury was detected in one of the six field blanks at a concentration of 0.012 µg/L, equal to the SRL. Mercury was not detected in the associated source-solution blank. All concentrations of mercury below 0.012 µg/L were reported as ≤ the measured value. Total dissolved solids were detected in one of the field blanks at a concentration of 10.0 mg/L.

Field blanks to be analyzed for radioactive constituents were collected at 6 of the 59 production wells sampled. Radium-226 was detected in 2 field blanks and 1 of the associated source solution blanks; the maximum activity was 0.065 + 0.015 pCi/L (*table A3*). Eight groundwater samples had radium-226 activities less than 0.08 pCi/L, the upper confidence limit of the maximum activity measured in a blank. These data were flagged with a ≤ symbol (*table 13A*).

Field blanks to be analyzed for compounds of special interest were collected at 6 of the 59 production wells sampled. Perchlorate was detected in one of the six field blanks at a concentration of 0.17 µg/L (*table A3*). However, perchlorate was not detected in the associated source-solution blank or the corresponding environmental sample. In addition, perchlorate was not detected in any of the field blanks before or after the detection; therefore, this detection was considered to indicate a random contamination and no perchlorate detections were flagged with a ≤ symbol.

Pump B Blank Results

Field blanks to be analyzed for VOCs were collected at 1 of the 7 monitoring wells sampled using pump B (*table A3*). Acetone was detected in the field blank at a concentration of E4.0 µg/L. Acetone was not detected in the associated source-solution blank or in any groundwater samples collected in REDSAC. Toluene was detected in the field blank at a concentration of E0.02 µg/L. Toluene was not detected in the associated source-solution blank. The minimum concentration of toluene in groundwater samples collected in REDSAC was 0.04 µg/L, which is twice the maximum field blank concentration. Therefore, no V-codes were applied to the toluene detections.

Field blanks to be analyzed for nutrients were collected at 1 of the 7 monitoring wells sampled using pump B. Nitrite as nitrogen was detected in the field blank at a concentration of E0.0012 mg/L (*table A3*). Three detections of nitrite as nitrogen in groundwater samples with concentrations less than 0.0022 mg/L (0.0012 mg/L plus one-half the LRL of 0.002 mg/L) were therefore flagged with the ≤ symbol (*tables 8* and *A3*).

Field blanks to be analyzed for major ions and trace elements were collected at 1 of the 7 monitoring wells using pump B. Trace-element data were assessed for potential flagging of results using the GAMA study reporting limits (SRL), which are based on results for 86 field blanks collected between May 2004 and January 2008 in conjunction with the 1 field blank collected at a pump B site. Measured values that are less than the SRLs are flagged with the ≤ symbol in table 10. However, because of the precipitates observed in pump B, the blank concentration was used instead of the GAMA SRL to flag a trace-element value when the trace-element concentration in the blank from pump B exceeded the GAMA SRL for a given constituent.

Aluminum was detected in the field blank at a concentration of E1.0 µg/L. The aluminum field blank concentration was less than the SRL (1.6 µg/L). Aluminum was not detected in the corresponding source-solution blank. Chromium was detected in the field blank at a concentration of 1.15 µg/L, exceeding the GAMA SRL for chromium (0.42 µg/L). Concentrations of chromium detected in three groundwater samples were less than 1.21 µg/L (1.15 µg/L plus one-half the LRL of 0.12 µg/L) and were therefore coded as ≤ (*tables 10*, *A3*). Cobalt was detected in the field blank at a concentration of 0.21 µg/L. Cobalt was not detected in the associated source-solution blank. Concentrations of cobalt in seven groundwater samples were less than 0.22 µg/L (0.21 µg/L plus one-half the LRL of 0.02 µg/L) and were therefore treated as ≤ the measured value (note: cobalt does not have a GAMA SRL). Iron was detected in the field blank at a concentration of 15 µg/L, exceeding the GAMA SRL for iron (6 µg/L). Iron was not detected in the corresponding source-solution blank. Concentrations of iron in three groundwater samples were less than 19 µg/L (15 µg/L plus one-half the LRL of 8 µg/L) and were therefore coded as ≤. Manganese was detected in the field blank at a concentration of 1.3 µg/L, exceeding the GAMA SRL for manganese (0.2 µg/L). Concentrations of manganese in six groundwater samples were less than 1.4 µg/L (1.3 µg/L plus one-half the LRL of 0.2 µg/L) and were therefore treated as ≤ the measured value. Nickel was detected in the field blank at a concentration of 1.1 µg/L, exceeding the GAMA SRL for nickel (0.36 µg/L). Concentrations of nickel in six groundwater samples were less than 1.2 µg/L (1.1 µg/L plus one-half the LRL of 0.2 µg/L) and were therefore treated as ≤ the measured value. Tungsten was detected in the field blank at a concentration of E0.06 µg/L. The field blank concentration for tungsten was less than the SRL (0.11 µg/L). Tungsten was not detected in the corresponding source-solution blank.

Field blanks to be analyzed for arsenic and iron by the USGS Trace Metal Laboratory (TML) were collected at 1 of the 7 sites using pump B. Iron(II) was detected in the field blank at a concentration of 4.0 µg/L. Concentrations of iron(II) in three groundwater samples were less than 5.0 µg/L (4.0 µg/L plus one-half the LRL of 2 µg/L) and were therefore treated as ≤ the measured value. Total iron was detected in the field blank at a concentration of 7.0 µg/L. Concentrations of total iron in three samples were less than 8.0 µg/L (7.0 µg/L plus one-half the LRL of 2.0 µg/L) and were therefore treated as ≤ the measured value.

Variability in Replicate Samples

Tables A4A–D summarize the results of replicate analyses for constituents detected in groundwater samples collected in REDSAC. Nearly 300 replicate analyses were made for each replicate sample pair collected. A total of seven pairs of replicate samples were collected in REDSAC. Results for replicate analyses for constituents that were not detected are not reported in *tables A4A–D*. Concentrations or activities in the environmental and replicate samples are reported for all replicate analyses yielding RSD values greater than zero. Most replicate analyses yielded RSD values less than 5 percent and only 22 yielded RSD values greater than the acceptable limit of 20 percent. Constituents whose replicate pairs had RSD values greater than 20 percent include bromide (*table A4B*), aluminum (*table A4C*), chromium (*table A4C*), lithium (*table A4C*), selenium (*table A4C*), total arsenic (*table A4C*), total chromium (*table A4C*), chromium(VI) (*table A4C*), oxygen-18 to oxygen-16 ratio in nitrate fraction (*table A4D*), radium-226 (*table A4D*), alpha radioactivity, 72-hour count (*table A4D*), uranium-234 (*table A4D*), uranium-235 (*table A4D*), and uranium-238 (*table A4D*).

The magnitudes of the concentrations of the replicate pairs with RSD greater than 20 percent were within a factor of five of their respective LRLs except one total arsenic replicate pair (*table A4C*) analyzed at the USGS Trace Metal Laboratory (*table 3H*). At these low concentrations, small deviations in measured values result in large RSDs. Analyses of only three replicate pairs, chromium (analyzed at the USGS National Water Quality Laboratory), chromium(VI) and total chromium (analyzed at the USGS Trace Metal Laboratory), combined a detection and a nondetection in each pair. No environmental detections were affected by the results of the replicate analysis.

Matrix-Spike Recoveries

Tables A5A–B summarize matrix-spike recoveries for the REDSAC study. Adding a spike or known concentration of a constituent to an environmental sample enables the analyzing laboratory to determine the effect of the matrix, in this case ground water, on the analytical technique used to measure the constituent. Seven environmental samples were spiked with VOCs to calculate matrix-spike recoveries (*table A5A*). The median recoveries for all of the 85 VOC spike compounds were within the acceptable range of 70 to 130 percent.

Seven groundwater samples were spiked with pesticide and pesticide degradate compounds in order to calculate matrix-spike recoveries. The median recoveries for 94 of the 122 spike compounds were within the acceptable range of 70 and 130 percent (*table A5B*). The median spike recoveries for 3 of the 4 compounds detected in groundwater samples were within the acceptable range. Deethylatrazine was detected in groundwater samples and had a median spike recovery of 46 percent. [NOTE – low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations.] Two spike compounds had a median recovery greater than 130 percent and 26 spike compounds had median recoveries below 70 percent.

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

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 the surrogate, the analytical schedule on which it was applied, the number of analyses of blanks and environmental samples, the number of surrogate recoveries below 70 percent, and the number of surrogate recoveries above 130 percent for the blank and non-blank samples. Blanks and environmental samples were considered separately to assess whether the matrices in non-blank samples affect surrogate recoveries. No systematic differences between surrogate recoveries in blanks and environmental samples were observed. Ninety-four percent of the surrogate recoveries for VOCs and 77 percent of the surrogate recoveries for pesticides were in the acceptable range.

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

Analyte	Analytical method	Laboratory and analytical schedule	Citation(s)
		Water-quality indicators	
Field parameters	Calibrated field meters and test kits	USGS field measurement	U.S. Geological Survey, variously dated
		Organic constituents	
VOCs	Purge and trap capillary gas chromatography/mass spectrometry	NWQL, Schedule 2020	Connor and others, 1998
Pesticides and degradates	Solid-phase extraction and gas chromatography/mass spectrometry	NWQL, Schedule 2032	Zaugg and others, 1995; Lindley and others, 1996; Sandstrom and others, 2001 Madsen and others, 2003
Polar pesticides and degradates	Solid-phase extraction and high-performance liquid chromatography (HPLC) /mass spectrometry	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	
Perchlorate	Chromatography/mass spectrometry	Weck Laboratories, Inc., standard operating procedure ORG099.R01	U.S. Environmental Protection Agency, 2005
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
		Inorganic constituents	
Nutrients	Alkaline persulfate digestion, Kjedahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
Major and minor ions, trace elements and nutrients	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

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

Analyte	Analytical method	Laboratory and analytical schedule	Citation(s)
Chromium, 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; Ball and McCleskey, 2003a,b; McCleskey and others, 2003
		Stable isotopes	
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
Nitrogen and oxygen isotopes of nitrate	Denitrifier method and mass spectrometry	USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA), RSIL Lab Code 2900	Révész, K., and Casciotti, K., 2007
Carbon isotopes	Accelerator mass spectrometry	University of Waterloo, Environmental Isotope Laboratory (CAN-UWIL); University of Arizona Accelerator Mass Spectrometry Laboratory (AZ-UAMSL), NWQL Schedule 2015	Donahue and others, 1990; Jull and others, 2004
		Radioactivity and gases	
Tritium	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA)	Thatcher and others, 1977
Tritium and noble gases	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory (CA-LLNL)	Moran and others, 2002; Eaton and others, 2004
Radon-222	Liquid scintillation counting	NWQL, Schedule 1369	American Society for Testing and Materials, 1998
Radium isotopes	Alpha activity counting	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1262	Krieger and Whittaker, 1980 (USEPA methods 903 and 904)
Uranium isotopes	Chemical separations and alpha-particle spectrometry	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1130	ASTM D3972
Gross alpha and beta radioactivity	Alpha and beta activity counting	Eberline Analytical Services, NWQL Schedule 1792	Krieger and Whittaker, 1980 (USEPA method 900.0)
		Microbial constituents	
F-specific and somatic coliphage	Single-agar layer (SAL) and two-step enrichment methods	USGS Ohio Water Microbiology Laboratory (USGSOHML)	U.S. Environmental Protection Agency, 2001

Table A2. Preferred analytical schedules for constituents appearing on multiple schedules for samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 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; SITL, U.S. Geological Survey Stable Isotope and Tritium Laboratory; TML, U.S. Geological Survey Trace Metal Laboratory; VOC, volatile organic compound; Weck, Weck Laboratories, Inc.; —, no preference]

Constituent	Primary constituent classification	Analytical schedules	Preferred analytical schedule
Results from preferred method reported			
Atrazine	Pesticide	2032, 2060	2032
Caffeine	Wastewater indicator	2080, 2060	2080
Carbaryl	Insecticide	2032, 2060	2032
Carbofuran	Herbicide	2032, 2060	2032
Deethylatrazine (2-Chloro-4-isopropyl -amino-6-amino-*s*-triazine)	Pesticide degradate	2032, 2060	2032
Metalaxyl	Fungicide	2032, 2060	2032
Tebuthiuron	Pesticide	2032, 2060	2032
Results from both methods reported			
Alkalinity	Water-quality indicator	field, 1948	field
Arsenic, total	Trace element	1948, TML	1948
Chromium, total	Trace element	1948, TML	1948
Iron, total	Trace element	1948, TML	1948
pH	Water-quality indicator	field, 1948	field
Specific conductance	Water-quality indicator	field, 1948	field
Tritium	Inorganic tracer	LLNL, SITL	—

Table A3. Constituents detected in field blanks collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[V-coded data are reported but not used in summary statistics; E, estimated value; pCi/L, picocuries per liter; mg/L, milligrams per liter; SRL, study unit reporting level; ssL_C, sample-specific critical level; µg/L, micrograms per liter, — not detected]

Constituent	Production wells and monitoring well pump A			Monitoring well pump B (backup)		
	Number of field blank detections/ analyses	Concentration detected in field blanks	Number of groundwater samples coded as ≤ or V-coded	Number of field blank detections/ analyses	Concentration detected in field blanks	Number of groundwater samples coded as ≤ or V-coded
Organic constituents (µg/L)						
Acetone	1/6	E2.0	0	1/1	E4.0	0
Toluene	0/6	—	0	1/1	E0.02	0
Nutrients and major ions (mg/L)						
Ammonia as nitrogen	1/6	0.014	3	0/1	—	0
Nitrite as nitrogen	0/6	—	0	1/1	E0.0012	3
Total dissolved solids (TDS), (residue on evaporation)	1/6	10.0	0	0/1	—	0
Inorganic constituents (µg/L)						
Aluminum*	1/6	E0.9	14	1/1	E1.0	4
Boron	1/6	22.00	0			
Chromium*	0/6	—	10	1/1	1.15	3
Cobalt	0/6	—	0	1/1	0.21	7
Iron*	0/6	—	6	1/1	15.0	3
Lead*	1/6	E0.07	41	0/1	—	0
Manganese*	0/6	—	8	1/1	1.3	6
Mercury*	1/6	0.01	2	0/1	—	0
Nickel*	0/6	—	31	1/1	1.1	6
Silica	1/6	0.04	0			
Tungsten*	0/6	—	15	1/1	E0.06	2
Iron(II) [1]	0/6	—	0	1/1	4.0	3
Iron(total) [1]	0/6	—	0	1/1	7.0	5
Radioactive constituents(pCi/L)						
Radium-226	1/6	0.065 ± 0.015 (ssL_C = 0.016)	8	0/1	—	0
Compounds of Special Interest (µg/L)						
Perchlorate	1/6	0.17	0	0/1	—	0

* Constituents have a study reporting limit (SRL) defined based on examination of GAMA quality-control samples collected from May 2004 through January 2008.

[1] Arsenic analyses made by U.S. Geological Survey Trace Metal Laboratory (80093).

Table A4A. Quality-control summary of replicate analyses of organic constituents detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[Only detected constituents are shown. **Abbreviations**: nv, no values in category; RSD, relative standard deviation in percent; µg, microgram per liter]

Constituent	Number of RSDs greater than zero/ number of replicates	Maximum RSD (percent)	Median RSD (percent)	Concentrations for replicates with RSD greater than zero [1] (environmental, replicate) (µg/L)
Volatile organic compounds and gasoline oxygenates (Schedules 2020)				
Benzene	0/7	0	0	nv
Bromodichloromethane	0/7	0	0	nv
Bromoform (Tribromomethane)	0/7	0	0	nv
Carbon disulfide	0/7	0	0	nv
Chloroform (Trichloromethane)	0/7	0	0	nv
Dibromochloromethane	0/7	0	0	nv
Ethylbenzene	0/7	0	0	nv
Methyl *tert*-butyl ether (MTBE)	0/7	0	0	nv
Methyl ethyl ketone (2-butanone, MEK)	0/7	0	0	nv
Perchloroethene (PCE)	0/7	0	0	nv
Tetrahydrofuran	0/7	0	0	nv
Toluene	1/7	7	0	(0.043, 0.039)
1,2,4-Trimethylbenzene	0/7	0	0	nv
m- and *p*-Xylene	1/7	11	0	(0.04, 0.04)
o-Xylene	1/7	4	0	(0.02, 0.02)
Pesticides and pesticide degradates (Schedule 2003 and 2060)				
Atrazine	1/7	4	0	(0.005, 0.005)
Deethylatrazine (2-Chloro-4-isopropyl - amino-6-amino-*s*-triazine)	1/7	9	0	(0.006,0.007)
Prometon	0/7	0	0	nv
Simazine	1/7	4	0	(0.005, 0.005)

[1] RSDs are calculated using unrounded data; therefore an RSD can be greater than zero for results that appear to be identical when rounded.

Table A4B. Quality-control summary of replicate analyses of major and minor ions and nutrients detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[RSD, relative standard deviation in percent; TDS, total dissolved solids; mg/L, milligrams per liter]

Constituent	Number of RSDs greater than zero/ number of replicates	Maximum RSD (percent)	Median RSD (percent)	Concentrations for replicates with RSD greater than zero [1] (environmental, replicate) (mg/L)
				Major and minor ions
Bromide	5/7	28.1	1.0	(0.01, 0.01), (0.01, 0.02), (0.02, 0.02), (0.02, 0.02), (0.03, 0.03)
Calcium	7/7	4.3	1.0	(10.82, 10.72), (12.71, 12.85), (12.96, 13.36), (15.15, 14.85), (23.02, 23.33), (23.33, 23.65), (25.05, 23.57)
Chloride	7/7	1.9	0.2	(2.31, 2.32), (2.94, 2.86), (3.21, 3.21), (5.01, 5.01), (5.28, 5.28), (5.76, 5.73), (11.43, 11.39)
Fluoride	7/7	11.6	2.1	(0.08, 0.07), (0.10, 0.10), (0.13, 0.15), (0.17, 0.15), (0.17, 0.16), (0.20, 0.20), (0.22, 0.22)
Iodide	2/7	3.8	0.0	(0.002, 0.002), (0.017, 0.017)
Magnesium	6/7	1.7	1.0	(4.81, 4.87), (7.95, 8.05), (8.61, 8.71), (9.26, 9.40), (9.77, 9.55), (21.92, 21.39)
Potassium	7/7	3.4	0.7	(0.62, 0.61), (0.65, 0.65), (1.39, 1.45), (1.45, 1.43), (1.73, 1.74), (3.35, 3.37), (3.86, 3.90)
Silica	7/7	3.1	0.9	(22.92, 22.28), (31.4, 31.49), (43.64, 43.73), (49.03, 47.93), (55.41, 53.02), (57.14, 56.45), (69.09, 69.7)
Sodium	7/7	1.9	1.0	(12.46, 12.62), (12.55, 12.9), (14.67, 14.76), (15.1, 14.98), (26.99, 27.37), (29.99, 29.44), (36.37, 37.32)
Sulfate	7/7	2.4	1.0	(0.77 ,0.80), (1.3, 1.2), (5.3, 5.4), (5.7, 5.8), (4.7, 4.8), (8.1, 8.2), (9.3, 9.3)
Residue on evaporation (total dissolved solids, TDS)	7/7	2.1	0.7	(150, 150), (150, 150), (160, 150), (180, 180), (210, 210), (210, 200), (250, 240)
				Nutrients and dissolved organic carbon
Ammonia (as nitrogen)	2/7	1.9	0.0	(0.01,0.01), (0.01,0.01)
Nitrite (as nitrogen)	3/7	17.1	0.0	(0.001, 0.001), (0.01, 0.01), (0.007, 0.007)
Nitrite plus nitrate (as nitrogen)	6/7	1.1	0.3	(0.6, 0.6), (0.7, 0.7), (0.8, 0.8), (1, 1), (1, 1), (1, 1)
Total nitrogen (ammonia, nitrite, nitrate, organic nitrogen)	6/7	3.2	0.1	(0.79, 0.83), (1.14, 1.11)
Orthophosphate (as phosphorus)	7/7	1.2	0.5	(0.03, 0.03), (0.04, 0.04), (0.05, 0.06), (0.1, 0.1), (0.1, 0.1), (0.1, 0.1), (0.2, 0.2)

[1] RSDs are calculated using unrounded data; therefore, an RSD can be greater than zero for results that appear to be identical when rounded.

Table A4C. Quality-control summary of replicate analyses of trace elements detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[RSD, relative standard deviation in percent; nd, not detected; nv, no values in category; µg/L, micrograms per liter; — not detected]

Constituent	Number of RSDs greater than zero/ number of replicates	Maximum RSD (percent)	Median RSD (percent)	Concentrations for replicates with RSD greater than zero [1] (environmental, replicate) (µg/L)
		USGS National Water Quality Laboratory (Schedule 1948)		
Aluminum	5/7	41.5	3.8	(1.3, 0.98), (1.4, 1.4), (1.4, 1.4), (1.5, 2.7), (1.5, 1.6)
Antimony	1/7	15.7	0	(0.09, 0.11)
Arsenic	7/7	2.5	1.1	(0.91, 0.9), (1.1, 1.1), (1.4, 1.4), (1.5, 1.5), (1.6, 1.6), (3.4, 3.5), (7.6, 7.6)
Barium	7/7	1.5	0.4	(9, 9), (18, 18), (18, 18), (23, 23), (40, 40), (46, 46), (137, 135)
Boron	7/7	13.6	3.2	(5, 6), (19, 19), (18, 20), (37, 31), (46, 48), (87, 86), (247, 237)
Cadmium	0/7	0	0	nv
Chromium	6/7	43.5	1.5	(—, 0.06), (0.5, 0.51), (0.9, 0.92), (1.9, 1.9), (2.7, 2.7), (6, 5.8)
Cobalt	3/7	8.0	0	(0.01, 0.01), (0.11, 0.12), (0.02, 0.02)
Copper	1/7	2.9	0	(1.2, 1.2)
Iron	3/7	13.2	0	(8, 10), (28, 28), (252, 265)
Lead	4/7	17.8	0.7	(0.12, 0.16), (0.18, 0.18), (0.22, 0.21), (0.33, 0.32)
Lithium	5/7	87.1	5.3	(0.8, 0.8), (—, 1.1), (0.8, 0.9), (5.4, 6.4), (1.5, 1.6)
Manganese	6/7	13.4	2.3	(0.5, 0.5), (0.8, 0.7), (1.5, 1.6), (11.7, 11.7), (37.1, 40.7), (40.2, 39)
Mercury	0/7	0	0	nv
Molybdenum	7/7	6.3	2.1	(0.3, 0.4), (0.4, 0.4), (0.5, 0.5), (0.9, 0.8), (1, 1), (1, 1), (1.2, 1.2)
Nickel	4/7	9.7	0.7	(0.12, 0.13), (0.17, 0.18), (0.49, 0.56), (0.84,0.92)
Selenium	7/7	22.6	4.7	(0.03, 0.02), (0.06, 0.07), (0.11, 0.09), (0.21, 0.22), (0.24, 0.24), (0.46, 0.46), (3.3, 3.4)
Strontium	7/7	17.7	1.6	(81, 83), (85, 81), (114, 114), (136, 137), (187, 146), (261, 262), (557, 592)
Tungsten	5/7	6.5	1.1	(0.04, 0.04), (0.04, 0.03), (0.06, 0.06), (0.22, 0.23), (0.56, 0.57)
Uranium	7/7	4.2	1.4	(0.06, 0.06), (0.07, 0.08), (0.1, 0.09), (0.23, 0.25), (0.59, 0.6), (0.74, 0.75), (0.85, 0.9)
Vanadium	7/7	11.6	1.3	(1.4, 1.4), (7.8, 9.2), (9.3, 9.4), (9.5, 9.4), (13.6, 12.5), (13.8, 13.7), (19.8, 19.2)
Zinc	5/7	4.8	1.1	(1.6, 1.8), (2.6, 2.5), (3.8, 3.9), (6.5, 6.5), (15, 15.4)

Table A4C. Quality-control summary of replicate analyses of trace elements detected in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[RSD, relative standard deviation in percent; nd, not detected; nv, no values in category; µg/L, micrograms per liter; — not detected]

Constituent	Number of RSDs greater than zero/ number of replicates	Maximum RSD (percent)	Median RSD (percent)	Concentrations for replicates with RSD greater than zero [1] (environmental, replicate) (µg/L)
USGS Trace Metals Laboratory				
Arsenic(total)	4/7	31.8	4.9	(0.6, 0.5), (1.0, 1.0)(1.5, 1.4), (2.7, 2.9), (4.9, 3.1)
Arsenic(III)	0/7	0	0	nv
Chromium(total)	1/7	47.1	0.0	(—, 1)
Chromium(VI)	1/7	47.1	0.0	(—, 1)
Iron(total)	3/6	10.9	0.9	(7, 6), (23, 24), (272, 265)
Iron(II)	1/6	3.1	0.0	(181, 189)

[1] RSDs are calculated using unrounded data; therefore, an RSD can be greater than zero for results that appear to be identical when rounded.

Table A4D. Quality-control summary of replicate analyses of constituents of special interest and radioactive constituent samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to a more common lighter isotope of that element, relative to a standard reference material. pCi/L, picocurie per liter; RSD, percent relative standard deviation; µg/L, micrograms per liter]

Constituent	Number of RSDs greater than zero/ number of replicates	Maximum RSD (percent)	Median RSD (percent)	Concentrations for replicates with RSD greater than zero [1] (environmental, replicate) (µg/L)
Constituents of special interest (µg/L)				
Perchlorate	0/4	0	0	
NDMA	0/2	0	0	
Radioactive constituents (pCi/L)				
Carbon-14 (percent modern)	7/7	0.9	0.3	(24.1, 24.4), (50.9, 51.0), (75.6, 74.7), (75.2, 75.7), (87.0, 86.8), (101.1, 101.5), (105.2, 105.5)
δ^{13}C of dissolved carbonates (per mil)	7/7	1.5	0.8	(–14.0, –13.9), (–14.5, –14.2), (–16.2, –16.4), (–17.6, –17.6), (–18.0, –18.1), (–19.1, –19.4), (–20.4, –20.1)
δ^{2}H of water	7/7	1.8	0.7	(–64.6, –65), (–64.9, –63.4), (–64.9, –65.7), (–66.6, –66.7), (–71.1, –71.5), (–71.9, –73.8), (–81.1, –81.3)
δ^{18}O of water	6/7	0.5	0.2	(–9.33, –9.39), (–9.36, –9.35), (–9.46, –9.44), (–10.2, –10.24), (–10.25, –10.24), (–11.52, –11.47)
δ^{15}N of nitrate	6/7	3.1	1.4	(2.50, 2.54), (3.26, 3.12), (3.52, 3.60), (4.76, 4.59), (8.21, 8.23), (25.73, 25.71)
δ^{18}O of nitrate	6/7	28.3	18.2	(–0.88, –1.19), (–1.08, –1.4), (0.16, 0.24), (1.29, 1.08), (2.51, 2.60)
Tritium	5/7	141.0	4.6	(0.0, –0.3), (0.0, 0.6), (0.3, 0.6), (3.2, 3.5), (9, 9.6)
Radium-226	2/2	127.8	71.8	(0.025, 0.02), (0.297, 0.015)
Radium-228	2/2	5.1	4.8	(0.30, 0.32), (0.43, 0.40)
Radon-222	2/2	7.3	5.9	(320, 300), (410, 370)
Alpha radioactivity, 30-day count	2/2	17.7	10.8	(1.9, 1.8), (2.1, 2.7)
Alpha radioactivity, 72-hour count	2/2	21.2	17.0	(1.7, 2.3), (3.0, 2.5)
Beta radioactivity, 30-day count	2/2	4.7	3.0	(1.91, 2.04), (3.76, 3.69)
Beta radioactivity, 72-hour count	2/2	19.6	15.7	(1.85, 1.40), (2.96, 3.50)
Uranium-234	3/3	49.5	40.0	(0.033, 0.059), (0.087, 0.053), (0.108, 0.052)
Uranium-235	3/3	62.6	10.5	(0.025, 0.029), (0.029, 0.075), (0.077, 0.079)
Uranium-238	3/3	57.9	49.6	(0.0171, 0.0356), (0.026, 0.062), (0.064, 0.065)

[1] RSDs are calculated using unrounded data; therefore, an RSD can be greater than zero for results that appear to be identical when rounded.

Table A5A. Quality-control summary of matrix-spike recoveries of volatile organic compounds (VOC) and gasoline oxygenates and degradates in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetone	7	84	130	103
Acrylonitrile	7	85	124	103
tert-Amyl methyl ether (TAME)	7	86	116	103
Benzene [1]	7	90	117	102
Bromobenzene	7	83	125	102
Bromochloromethane	7	92	138	107
Bromodichloromethane [1]	7	90	125	109
Bromoform (Tribromomethane) [1]	7	91	142	107
Bromomethane (Methyl bromide)	7	102	137	115
n-Butylbenzene	7	70	98	84
sec-Butylbenzene	7	84	114	96
tert-Butylbenzene	7	86	125	104
Carbon disulfide [1]	7	69	94	72
Carbon tetrachloride (Tetrachloromethane)	7	87	140	109
Chlorobenzene	7	89	110	100
Chloroethane	7	99	127	109
Chloroform (Trichloromethane) [1]	7	99	139	116
Chloromethane	7	96	120	99
3-Chloropropene	7	94	127	107
2-Chlorotoluene	7	87	134	104
4-Chlorotoluene	7	87	124	96
Dibromochloromethane [1]	7	90	125	102
1,2-Dibromo-3-chloropropane (DBCP)	7	78	124	98
1,2-Dibromoethane (EDB)	7	90	120	102
Dibromomethane	7	96	128	103
1,2-Dichlorobenzene	7	88	142	103
1,3-Dichlorobenzene	7	86	132	99
1,4-Dichlorobenzene	7	86	124	102
trans-1,4-Dichloro-2-butene	7	81	129	106

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) and gasoline oxygenates and degradates in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Dichlorodifluoromethane (CFC-12)	7	71	118	84
1,1-Dichloroethane (1,1-DCA)	7	93	130	106
1,2-Dichloroethane (1,2-DCA)	7	88	132	109
1,1-Dichloroethene (1,1-DCE)	7	90	108	97
cis-1,2-Dichloroethene (*cis*-1,2-DCE)	7	93	119	105
trans-1,2-Dichloroethene (*trans*-1,2-DCE)	7	95	130	101
1,2-Dichloropropane	7	88	119	101
1,3-Dichloropropane	7	93	129	107
2,2-Dichloropropane	7	77	111	92
1,1-Dichloropropene	7	85	115	94
cis-1,3-Dichloropropene	7	82	101	91
trans-1,3-Dichloropropene	7	80	101	90
Diethyl ether	7	100	123	106
Diisopropyl ether (DIPE)	7	89	116	104
Ethylbenzene [1]	7	87	107	96
Ethyl *tert*-butyl ether (ETBE)	7	82	108	93
Ethyl methacrylate	7	86	116	101
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	7	79	108	91
Hexachlorobutadiene	7	65	101	79
Hexachloroethane	7	79	131	98
2-Hexanone (*n*-Butyl methyl ketone)	7	83	127	106
Iodomethane (Methyl iodide)	7	99	130	110
Isopropylbenzene	7	82	110	93
4-Isopropyl-1-methyl benzene	7	76	101	89
Methyl acrylate	7	90	131	112
Methyl acrylonitrile	7	95	136	107
Methyl *tert*-butyl ether (MTBE) [1]	7	87	113	102
Methyl *iso*-butyl ketone (MIBK)	7	82	113	100
Methylene chloride (Dichloromethane)	7	95	118	99
Methyl ethyl ketone (2-butanone, MEK) [1]	7	87	129	106
Methyl methacrylate	7	88	105	95
Naphthalene	7	74	101	86
Perchloroethene (PCE) [1]	7	86	118	101
n-Propylbenzene	7	79	107	91
Styrene	7	85	107	92
1,1,1,2-Tetrachloroethane	7	91	137	106

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) and gasoline oxygenates and degradates in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
1,1,2,2-Tetrachloroethane	7	97	147	107
Tetrahydrofuran [1]	7	84	117	99
1,2,3,4-Tetramethylbenzene	7	72	94	87
1,2,3,5-Tetramethylbenzene	7	78	100	97
Toluene [1]	7	88	117	100
1,2,3-Trichlorobenzene	7	83	113	97
1,2,4-Trichlorobenzene	7	73	101	91
1,1,1-Trichloroethane (1,1,1-TCA)	7	87	140	102
1,1,2-Trichloroethane (1,1,2-TCA)	7	91	129	105
Trichloroethene (TCE)	7	84	111	100
Trichlorofluoromethane (CFC-11)	7	88	131	106
1,2,3-Trichloropropane (1,2,3-TCP)	7	82	133	107
Trichlorotrifluoroethane (CFC-113)	7	79	106	91
1,2,3-Trimethylbenzene	7	86	122	105
1,2,4-Trimethylbenzene [1]	7	86	126	102
1,3,5-Trimethylbenzene	7	81	119	95
Vinyl bromide (Bromoethene)	7	95	119	106
Vinyl chloride (Chloroethene)	7	99	124	110
m- and *p*-Xylene[1]	7	89	122	102
o-Xylene [1]	7	85	104	94

[1] Constituents detected in groundwater samples.

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetochlor	7	92	115	108
Acifluorfen	5	70	99	80
Alachlor	7	97	114	103
Aldicarb	5	16	79	66*
Aldicarb sulfone	4	57	116	88
Aldicarb sulfoxide	4	66	133	118
Atrazine [1,2]	7	87	101	99
Azinphos-methyl	7	18	69	35*
Azinphos-methyl-oxon	7	58	112	77
Bendiocarb	4	63	77	69*
Benfluralin	7	48	73	66*
Benomyl	6	42	102	58*
Bensulfuron	6	68	106	94
Bentazon	6	69	154	93
Bromacil	6	59	117	95
Bromoxynil	5	55	109	83
Caffeine	6	49	121	71
Carbaryl [2]	7	70	117	101
Carbofuran [2]	7	70	106	97
Chloramben methyl ester	5	40	94	89
Chlorimuron	5	98	125	106
2-Chloro-2,6-diethylacetanilide	7	78	112	102
2-Chloro-6-ethylamino-4-amino-*s*-triazine [1,2]	5	50	101	60*
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine) [1]	7	26	56	46*
4-Chloro-2-methylphenol	7	38	90	69*
3-(4-Chlorophenyl)-1-methyl urea	6	58	103	70*
Chlorpyrifos	7	88	105	96
Chlorpyrifos oxon	7	9	22	15*
Clopyralid	6	15	75	45*
Cycloate	6	63	90	75
Cyfluthrin	7	40	88	54*
λ-Cyhalothrin	7	30	62	50*
Cypermethrin	7	40	89	57*

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Dacthal monoacid	6	34	107	87
Dacthal (DCPA)	7	93	109	104
Desulfinylfipronil	7	64	97	88
Desulfinylfipronil amide	7	59	98	79
Diazinon	7	92	103	94
Dicamba	6	21	98	79
3,4-Dichloroaniline	7	76	101	92
2,4-D methyl ester + 2,4-D [3]	6	60	109	90
2,4-DB	6	25	103	79
Dichlorprop	6	74	115	93
Dichlorvos	7	22	35	28*
Dicrotophos	7	33	53	45*
Dieldrin	7	89	108	96
2,6-Diethylaniline	7	83	104	98
Dimethoate	7	28	41	35*
Dinoseb	6	61	97	78
Diphenamid	5	61	106	90
Diuron	6	67	111	90
Ethion	7	62	110	93
Ethion monoxon	7	80	106	95
2-Ethyl-6-methylaniline	7	80	98	91
Fenamiphos	7	45	97	65*
Fenamiphos sulfone	7	12	59	38*
Fenamiphos sulfoxide	7	77	124	88
Fenuron	6	67	177	86
Fipronil	7	69	120	89
Fipronil sulfide	7	59	100	87
Fipronil sulfone	7	39	76	66*
Flumetsulam	5	51	100	75
Fluometuron	6	76	110	90
Fonofos	7	86	101	96
Hexazinone	7	55	93	75
3-Hydroxy carbofuran	4	55	87	82
2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine	6	67	164	108

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Imazaquin	5	72	128	102
Imazethapyr	6	68	105	86
Imidacloprid	6	51	89	78
Iprodione	7	34	82	6*
Isofenphos	7	93	117	108
Linuron	6	65	96	79
Malaoxon	7	65	99	73
Malathion	7	88	120	97
Metalaxyl [2]	7	79	111	98
Methidathion	7	87	123	105
Methiocarb	4	61	84	79
Methomyl	4	62	108	94
MCPA (2-Methyl-4-chlorophenoxyacetic acid)	6	54	112	90
MCPB (4-(2-Methyl-4-chlorophenoxy)butyric acid)	6	60	98	77
1-Naphthol	7	37	65	54*
Metolachlor	7	92	110	99
Metribuzin	7	70	91	84
Metsulfuron	4	76	102	89
Molinate	7	106	148	108
Myclobutanil	7	86	114	101
Neburon	6	65	91	83
Nicosulfuron	5	106	235	169*
Norflurazon	6	64	101	90
Oryzalin	6	67	86	78
Oxamyl	4	58	86	82
Paraoxon-methyl	7	49	72	51*
Parathion-methyl	7	65	92	80
Pendimethalin	7	76	94	88
cis-Permethrin	7	58	93	77
Phorate	7	76	97	82
Phorate oxon	7	74	120	99
Phosmet	7	0	49	9*
Phosmet oxon	7	8	23	16*
Picloram	5	46	148	81
Prometon [1]	7	81	107	99

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Northern Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Prometryn	7	85	118	106
Propanil	7	84	117	105
Propham	6	67	102	79
Propiconazole	6	63	87	75
cis-Propiconazole	7	91	117	111
trans-Propiconazole	7	87	114	100
Propoxur (Baygon)	4	61	92	86
Propyzamide	7	85	107	98
Siduron	6	66	103	94
Simazine [1]	7	81	107	103
Sulfometuron	5	78	96	82
Tebuthiuron [2]	7	75	135	105
Terbacil	6	58	105	73
Terbufos	7	56	106	66*
Terbufos oxon sulfone	7	103	240	183*
Terbuthylazine	7	95	114	105
Thiobencarb	7	109	132	117
Tribuphos	7	56	86	71
Triclopyr	6	27	109	88
Trifluralin	7	57	82	72

* Median recovery percentage is outside of acceptable range.

[1] Constituents detected in groundwater samples.

[2] Constituents on schedules 2032 and 2060; only values from schedule 2032 are reported because it is the preferred analytical schedule.

[3] 2,4-D and 2,4-D methyl ester summed on a molar basis and reported as 2,4-D.

Table A6. Quality-control summary of surrogate recoveries of volatile organic compounds, pesticides and pesticide degradates, and constituents of special interest in samples collected for the Northern Sacramento Valley Ground-Water Ambient Monitoring and Assessment (GAMA) study, California, October 2007 to January 2008.

Surrogate	Analytical schedule	Constituent or constiuent class analyzed	Results for field blanks and source-solution blanks				Results for environmental samples			
			Number of blank analyses	Median recovery in blanks (percent)	Number of surrogate recoveries below 70 percent in blanks	Number of surrogate recoveries above 130 percent in blanks	Number of sample analyses	Median recovery in samples (percent)	Number of surrogate recoveries below 70 percent in samples	Number of surrogate recoveries above 130 percent in samples
1-Bromo-4-fluorobenzene	2020	VOC	10	82	2	0	66	80	11	0
1,2-Dichloroethane-*d*4	2020	VOC	10	116	0	1	66	121	0	27
Toluene-*d*8	2020	VOC	10	94	0	0	66	94	0	0
Diazinon-*d*10	2032	Pesticide	7	85	1	0	66	86	9	0
α-HCH-*d*6	2032	Pesticide	7	81	0	0	66	81	3	0
Barban	2060	Pesticide	7	54	5	0	66	71	33	0
Caffeine-^{13}C	2060	Pesticide	7	80	2	0	66	82	20	0
2,4,5-Trichlorophenoxyacetic acid	2060	Pesticide	7	79	2	0	66	83	10	0

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