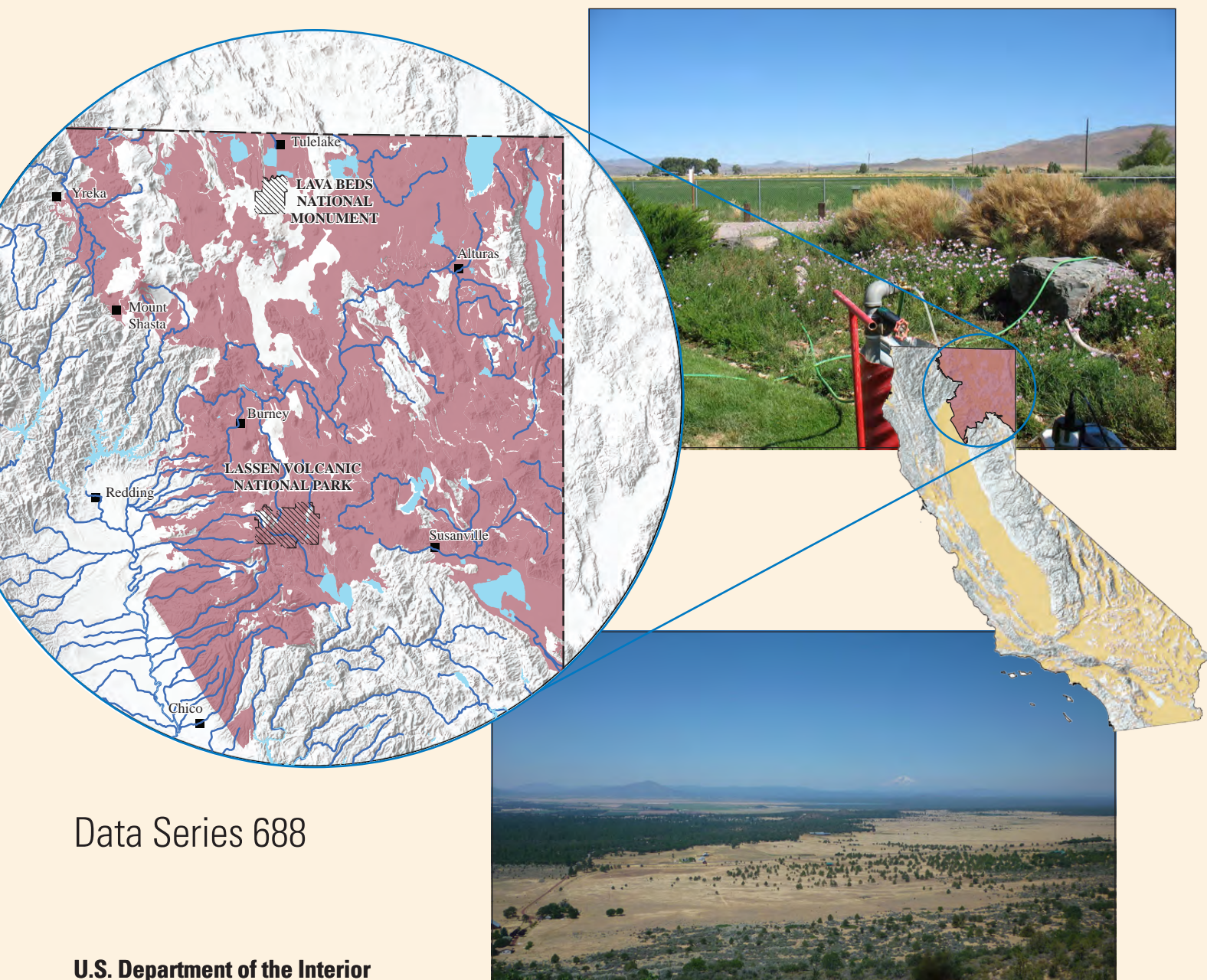


Prepared in cooperation with the California State Water Resources Control Board

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

## Groundwater-Quality Data in the Cascade Range and Modoc Plateau Study Unit, 2010: Results from the California GAMA Program



Data Series 688

Top cover photo: Well in Lassen County, California. Photograph taken by Stephen Schmitt, U.S. Geological Survey.

Bottom cover photo: View looking west toward Mount Shasta. Photograph taken by George Bennett, U.S. Geological Survey.

# **Groundwater-Quality Data in the Cascade Range and Modoc Plateau Study Unit, 2010: Results from the California GAMA Program**

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

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

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Data Series 688

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

**U.S. Department of the Interior**

KEN SALAZAR, Secretary

**U.S. Geological Survey**

Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2013

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# Contents

Abstract .....	1
Introduction .....	2
Purpose and Scope .....	3
Hydrogeologic Setting .....	5
Sacramento Valley Eastside Study Area (ES) .....	9
Honey Lake Valley Study Area (HL) .....	9
Shasta Valley and Mount Shasta Volcanic Area Study Area (SH) .....	17
Cascade Range and Modoc Plateau Low Use Basins Study Area (LU) .....	17
Quaternary Volcanic Areas (QV) and Tertiary Volcanic Areas (TV) Study Areas .....	19
Methods .....	19
Study Design .....	19
Sample Collection and Analysis .....	20
Data Reporting .....	21
Quality Assurance .....	21
Water-Quality Results .....	21
Quality-Control Results .....	21
Comparison Benchmarks .....	21
Groundwater-Quality Data .....	22
Water-Quality Indicators .....	23
Organic and Special-Interest Constituents .....	23
Volatile Organic Compounds (VOCs) .....	23
Pesticides .....	24
Perchlorate .....	24
Inorganic Constituents .....	24
Nutrients .....	24
Trace Elements .....	24
Uranium and Radioactive Constituents .....	24
Inorganic Constituents with SMCL Benchmarks .....	25
Geochemical and Age-Dating Tracers .....	25
Microbial Indicators .....	26
Future Work .....	26
Summary .....	26
Acknowledgments .....	27
References Cited .....	27
Appendix .....	100

## Figures

Figure 1. Map showing the hydrogeologic provinces of California and the location of the Cascade Range and Modoc Plateau (CAMP) study unit, California GAMA Priority Basin Project.....	4
Figure 2. Map showing simplified geology of northeastern California, and the boundaries of hydrogeologic provinces, geomorphic provinces, and counties ...	6
Figure 3. Map showing boundaries of the six study areas in the Cascade Range and Modoc Plateau (CAMP) study unit, California GAMA Priority Basin Project, boundaries of study area buffers, and locations of wells in the California Department of Public Health database and wells sampled for this study .....	10
Figure 4. Maps showing the northwestern, north-central, northeastern, west-central, southwestern, and southeastern parts of the Cascade Range and Modoc Plateau (CAMP) study unit, California GAMA Priority Basin Project, boundaries of study areas and study area buffers, and locations of selected hydrologic and geologic features, wells sampled for this study, and other wells in the California Department of Public Health (CDPH) database .....	11

## Tables

Table 1. Study area names, study area and grid cell sizes, and numbers of CDPH wells and USGS-grid wells in each study area, Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project .....	38
Table 2. Identification, sampling, and construction information for wells sampled for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project .....	38
Table 3. Classes of chemical constituents and field water-quality indicators collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project .....	41
Table 4A. Volatile organic compounds (VOCs), primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2020. ....	42
Table 4B. Pesticides and pesticide degradates, primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2003 .....	46
Table 4C. Perchlorate, primary uses or sources, comparative benchmarks, and reporting information for Weck Laboratories, Inc., analyses .....	48
Table 4D. Nutrients, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2755 .....	48
Table 4E. Trace elements, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 1948 .....	49
Table 4F. Major and minor ions, silica, total dissolved solids (TDS), and alkalinity, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 1948 .....	50
Table 4G. Radioactive constituents, comparative benchmarks, and reporting information for laboratory analyses .....	51
Table 4H. Arsenic and iron species, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) Trace Metal Laboratory, Boulder, Colorado, analyses .....	51

## Tables—Continued

Table 4I. Dissolved gases and isotope tracers, comparison benchmarks and reporting information for laboratory analyses .....	52
Table 4J. Microbial indicators, comparative benchmarks, and reporting information for the IDEXX Colilert® field test kit analyses.....	52
Table 5. Field water-quality indicators in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.....	53
Table 6. Volatile organic compounds (VOCs) detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project .....	58
Table 7. Pesticides and pesticide degradates detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project .....	65
Table 8. Results for analyses of perchlorate in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.....	68
Table 9. Nutrients detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.....	70
Table 10. Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project .....	73
Table 11. Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project .....	82
Table 12. Uranium isotopes detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.....	86
Table 13. Radon-222 detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.....	87
Table 14. Gross alpha and gross beta particle activities detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project .....	89
Table 15. Results for analyses of species of inorganic arsenic and iron in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, July through October 2010, California GAMA Priority Basin Project .....	92
Table 16. Results for analyses of stable isotope ratios, tritium activity, and carbon-14 abundance detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, July through October 2010, California GAMA Priority Basin Project ...	95
Table 17. Microbial indicator constituents detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.....	98

## Conversion Factors, Datums, and Abbreviations

### Conversion Factors

#### Inch/Pound to SI

Multiply	By	To obtain
Length		
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi <sup>2</sup> )	2.590	square kilometer (km <sup>2</sup> )
Flow rate		
cubic foot per second (ft <sup>3</sup> /s)	0.02832	cubic meter per second (m <sup>3</sup> /s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
Mass		
pound, avoirdupois (lb)	0.4536	kilogram (kg)
Radioactivity		
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)
Transmissivity*		
foot squared per day (ft <sup>2</sup> /d)	0.09290	meter squared per day (m <sup>2</sup> /d)

#### SI to Inch/Pound

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.2808399	foot (ft)
kilometer (km)	0.6214	mile (mi)
Area		
square kilometer (km <sup>2</sup> )	0.3861	square mile (mi <sup>2</sup> )
Volume		
liter (L)	1.0567	quart (qt)
Mass		
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound, avoirdupois (lb)

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

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

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

Turbidity is given in nephelometric turbidity units (NTU).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

## Conversion Factors, Datums, and Abbreviations—Continued

Milligrams per liter is equivalent to parts per million (ppm), and micrograms per liter is equivalent to parts per billion (ppb).

Concentrations of radioactive constituents in water are given in picocuries per liter (pCi/L).

\*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [(ft<sup>3</sup>/d)/ft<sup>2</sup>]ft. In this report, the mathematically reduced form, foot squared per day (ft<sup>2</sup>/d), is used for convenience.

### Datums

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

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

Altitude, as used in this report, refers to distance above the vertical datum and is reported as feet above mean sea level (ft above msl) and feet below mean sea level (ft below msl).

### Selected Terms and Symbols

$\alpha$	confidence level
cm <sup>3</sup> STP/gH <sub>2</sub> O	cubic centimeters of gas at standard temperature and pressure (0 degrees Celsius and 1 atmosphere of pressure) per gram of water
$\delta E$	delta notation, the ratio of a heavier isotope of an element (E) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil
=	equal to
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
M	detected presence of microbial indicator (total coliform or <i>Escherichia coli</i> [ <i>E. coli</i> ])
N	Normal (1-gram-equivalent per liter of solution)
--	not detected
p	significant level
pH	measure of the acidity of water
pK <sub>1,2</sub>	acid dissociation constants of carbonic acid
pK <sub>w</sub>	acid dissociation constant of water
U	absence detected or presence not detected of microbial indicator (total coliform or <i>E. coli</i> )
z	test statistic
±	plus or minus
*	value is greater than benchmark level or outside benchmark range
**	value is greater than upper benchmark level



## Conversion Factors, Datums, and Abbreviations—Continued

### Abbreviations and Acronyms

AL-US	action level (USEPA)
APE	Alternate Place Entry Form program designed for USGS sampling
CAMP	Cascade Range and Modoc Plateau study unit
CAS	Chemical Abstract Service (American Chemical Society)
CASRN	Chemical Abstract Service (American Chemical Society) Registry Number®
CSU	combined standard uncertainty
DWP	Domestic Well Project
E	estimated or having a higher degree of uncertainty
R	radioactive constituent not detected
ES	Sacramento Valley Eastside study area
GAMA	Groundwater Ambient Monitoring and Assessment Program
GIS	geographic information system
GPS	Global Positioning System
HAL-US	lifetime health advisory level (USEPA)
HL	Honey Lake Valley study area
HPLC	high-performance liquid chromatography
IBSP	Inorganic Blind Sample Project (USGS BQS)
LRL	laboratory reporting level
LSD	land surface datum
LT-MDL	long-term method detection level
LU	Cascade Range and Modoc Plateau Low Use Basins study area
MCL-US	maximum contaminant level (USEPA)
MCL-CA	maximum contaminant level (CDPH)
MDL	method detection limit
MRL	minimum reporting level
MU	method uncertainty
na	not available
nc	not collected
NL-CA	notification level (CDPH)
nv	no measured value or no value in category
np	no preference
NWIS	National Water Information System (USGS)
PBP	Priority Basin Project
PCFF	Personal Computer Field Form program designed for USGS sampling
QA	quality assurance
QC	quality control
QV	Quaternary Volcanic Areas study area
RL	reporting level
RPD	relative percent difference
RSD	relative standard deviation
RSD5-US	risk-specific dose at $10^{-5}$ (USEPA)
SD	standard deviation
SH	Shasta Valley and Mount Shasta Volcanic Area study area

## Conversion Factors, Datums, and Abbreviations—Continued

### Abbreviations and Acronyms—Continued

SMCL-CA	secondary maximum contaminant level (CDPH)
SMCL-US	secondary maximum contaminant level (USEPA)
SRL	study reporting level (concentration cutoff for applying the $\leq$ symbol)
ssL <sub>c</sub>	sample-specific critical level
TT-US	treatment technique action level established by the USEPA
TV	Tertiary Volcanic Areas study area
U.S.	United States
UV	ultraviolet
VPDB	Vienna Pee Dee Belemnite (the international reference standard for carbon isotopes)
VSMOW	Vienna Standard Mean Ocean Water (an isotopic water standard defined in 1968 by the International Atomic Energy Agency)

### Organizations

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

### Selected Chemical Names

CaCO <sub>3</sub>	calcium carbonate
CO <sub>3</sub> <sup>-2</sup>	carbonate
CFC	chlorofluorocarbon
DO	dissolved oxygen
H <sub>2</sub> O	water
HCl	hydrochloric acid
HCO <sub>3</sub> <sup>-</sup>	bicarbonate
MTBE	methyl <i>tert</i> -butyl ether
PCE	perchloroethene (tetrachloroethene)
SiO <sub>2</sub>	silicon dioxide
TCE	trichloroethene
TDS	total dissolved solids
THM	trihalomethane
VOC	volatile organic compound



# Groundwater-Quality Data in the Cascade Range and Modoc Plateau Study Unit, 2010: Results from the California GAMA Program

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

## Abstract

Groundwater quality in the 39,000-square-kilometer Cascade Range and Modoc Plateau (CAMP) study unit was investigated by the U.S. Geological Survey (USGS) from July through October 2010, as part of the California State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment (GAMA) Program's Priority Basin Project (PBP). The GAMA PBP was developed in response to the California Groundwater Quality Monitoring Act of 2001 and is being conducted in collaboration with the SWRCB and Lawrence Livermore National Laboratory (LLNL). The CAMP study unit is the thirty-second study unit to be sampled as part of the GAMA PBP.

The GAMA CAMP study was designed to provide a spatially unbiased assessment of untreated-groundwater quality in the primary aquifer system and to facilitate statistically consistent comparisons of untreated-groundwater quality throughout California. The primary aquifer system is defined as that part of the aquifer corresponding to the open or screened intervals of wells listed in the California Department of Public Health (CDPH) database for the CAMP study unit. The quality of groundwater in shallow or deep water-bearing zones may differ from the quality of groundwater in the primary aquifer system; shallow groundwater may be more vulnerable to surficial contamination.

In the CAMP study unit, groundwater samples were collected from 90 wells and springs in 6 study areas (Sacramento Valley Eastside, Honey Lake Valley, Cascade Range and Modoc Plateau Low Use Basins, Shasta Valley and Mount Shasta Volcanic Area, Quaternary Volcanic Areas, and Tertiary Volcanic Areas) in Butte, Lassen, Modoc, Plumas, Shasta, Siskiyou, and Tehama Counties. Wells and springs were selected by using a spatially distributed, randomized grid-based method to provide statistical representation of the study unit (grid wells).

Groundwater samples were analyzed for field water-quality indicators, organic constituents, perchlorate, inorganic constituents, radioactive constituents, and microbial indicators. Naturally occurring isotopes and dissolved noble gases also were measured to provide a dataset that will be used to help interpret the sources and ages of the sampled groundwater in subsequent reports. In total, 221 constituents were investigated for this study.

Three types of quality-control samples (blanks, replicates, and matrix spikes) were collected at approximately 10 percent of the wells in the CAMP study unit, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Blanks rarely contained detectable concentrations of any constituent, suggesting that contamination from sample collection procedures was not a significant source of bias in the data for the groundwater samples. Replicate samples generally were within the limits of acceptable analytical reproducibility. Matrix-spike recoveries were within the acceptable range (70 to 130 percent) for approximately 90 percent of the compounds.

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

All organic constituents and most inorganic constituents that were detected in groundwater samples from the 90 grid wells in the CAMP study unit were detected at concentrations less than drinking-water benchmarks.

Of the 148 organic constituents analyzed, 27 were detected in groundwater samples; concentrations of all detected constituents were less than regulatory and nonregulatory health-based benchmarks, and all were less than 1/10 of benchmark levels. One or more organic constituents were detected in 52 percent of the grid wells in the CAMP study unit: VOCs were detected in 30 percent, and pesticides and pesticide degradates were detected in 31 percent.

Trace elements, major ions, nutrients, and radioactive constituents were sampled for at 90 grid wells in the CAMP study unit, and most detected concentrations were less than health-based benchmarks. Exceptions include three detections of arsenic greater than the USEPA maximum contaminant level (MCL-US) of 10 micrograms per liter ( $\mu\text{g/L}$ ), two detections of boron greater than the CDPH notification level (NL-CA) of 1,000  $\mu\text{g/L}$ , two detections of molybdenum greater than the USEPA lifetime health advisory level (HAL-US) of 40  $\mu\text{g/L}$ , two detections of vanadium greater than the CDPH notification level (NL-CA) of 50  $\mu\text{g/L}$ , one detection of nitrate, as nitrogen, greater than the MCL-US of 10 milligrams per liter ( $\text{mg/L}$ ), two detections of uranium greater than the MCL-US of 30  $\mu\text{g/L}$  and the MCL-CA of 20 picocuries per liter ( $\text{pCi/L}$ ), one detection of radon-222 greater than the proposed MCL-US of 4,000  $\text{pCi/L}$ , and two detections of gross alpha particle activity greater than the MCL-US of 15  $\text{pCi/L}$ .

Results for inorganic constituents with non-regulatory benchmarks set for aesthetic concerns showed that iron concentrations greater than the CDPH secondary maximum contaminant level (SMCL-CA) of 300  $\mu\text{g/L}$  were detected in four grid wells. Manganese concentrations greater than the SMCL-CA of 50  $\mu\text{g/L}$  were detected in nine grid wells. Chloride and TDS were detected at concentrations greater than the upper SMCL-CA benchmarks of 500  $\text{mg/L}$  and 1,000  $\text{mg/L}$ , respectively, in one grid well.

Microbial indicators (total coliform and *Escherichia coli* [*E. coli*]) were detected in 11 percent of the 83 grid wells sampled for these analyses in the CAMP study unit. The presence of total coliform was detected in nine grid wells, and the presence of *E. coli* was detected in one of these same grid wells.

## Introduction

About one-half of the water used for public and domestic drinking-water supply in California is groundwater (Kenny and others, 2009). To assess the quality of ambient groundwater in aquifers used for public drinking-water

supply and to establish a baseline groundwater-quality monitoring program, the California State Water Resources Control Board (SWRCB) in cooperation with the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL) implemented the Groundwater Ambient Monitoring and Assessment (GAMA) Program (website at [http://www.waterboards.ca.gov/water\\_issues/programs/gama/](http://www.waterboards.ca.gov/water_issues/programs/gama/)). The main goals of the GAMA Program are to improve groundwater monitoring and to increase the availability of groundwater-quality data to the public. The GAMA Program currently consists of four Projects: (1) the GAMA Priority Basin Project (PBP) conducted by the USGS (website at <http://ca.water.usgs.gov/gama/>); (2) the GAMA Domestic Well Project conducted by the SWRCB; (3) the GAMA Special Studies Project conducted by LLNL; and (4) the GeoTracker GAMA online database conducted by the SWRCB. The GAMA PBP primarily focuses on the deep part of the groundwater resource, which is typically used for public drinking-water supply. The GAMA Domestic Well Project generally focuses on the shallow aquifer systems, which may be particularly at risk as a result of surficial contamination. The GAMA Special Studies Project focuses on using research methods to help explain the source, fate, transport, and occurrence of chemicals that can affect groundwater quality.

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

The GAMA Program was initiated by the SWRCB in 2000 and later expanded by the Groundwater Quality Monitoring Act of 2001 (State of California, 2001a, 2001b). The GAMA PBP assesses groundwater quality in groundwater basins and areas outside of basins that account for most of the groundwater resources used for public drinking-water supply in the State. For the GAMA PBP, 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; California State Water Resources Control Board, 2003). Additional partners in the GAMA PBP include LLNL, CDPH, CDWR, CDPR, local water agencies, and well owners (Kulongoski and Belitz, 2004). Participation in the project is entirely voluntary.

The GAMA PBP is unique in California because it includes many chemical analyses that are not otherwise available in statewide water-quality monitoring datasets.



Groundwater samples collected for the project are typically analyzed for approximately 200 to 300 chemical constituents by using analytical methods with lower detection limits than required by the CDPH for regulatory monitoring of drinking-water wells. These analyses will be especially useful for providing an early indication of changes in groundwater quality. In addition, the GAMA PBP analyzes samples for a suite of constituents more extensive than that required by CDPH and for a suite of chemical and isotopic tracers for exploring hydrologic and geochemical processes. A broader understanding of groundwater composition is useful for identifying the natural and human factors affecting water quality. Understanding the occurrence and distribution of chemical constituents of significance to water quality is important for the long-term management and protection of groundwater resources.

The ranges of hydrologic, geologic, and climatic conditions in California were considered in this assessment of groundwater quality. Belitz and others (2003) partitioned the State into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics: Cascade Range and Modoc Plateau, Klamath Mountains, Northern Coast Ranges, Central Valley, Sierra Nevada, Basin and Range, Southern Coast Ranges, Transverse Ranges and selected Peninsular Ranges, Desert, and San Diego Drainages ([fig. 1](#)). These 10 hydrogeologic provinces include groundwater basins designated by the CDWR (California Department of Water Resources, 2003). Groundwater basins generally consist of relatively permeable, unconsolidated deposits of alluvial or volcanic origin. Eighty percent of California's approximately 16,000 active and standby drinking-water wells listed in the statewide database maintained by the CDPH (hereinafter referred to as CDPH wells) are located in groundwater basins within the 10 hydrogeologic provinces.

Groundwater basins were prioritized for sampling on the basis of the number of CDPH wells in the basin, with secondary consideration given to municipal groundwater use, agricultural pumping, the number of formerly leaking underground fuel tanks, and registered pesticide applications (Belitz and others, 2003). Of the 472 basins designated by the CDWR, 116 priority basins were selected and grouped into 35 GAMA study units, representing approximately 95 percent of the CDPH wells in groundwater basins. In addition, some areas outside of the defined groundwater basins were included in the nearest respective study unit to achieve representation of the 20 percent of the CDPH wells not located in the groundwater basins. The Cascade Range and Modoc Plateau study unit (hereinafter referred to as the CAMP study unit) corresponds to the Cascade Range and Modoc Plateau hydrologic province, and includes groundwater basins and areas outside of basins.

The data collected in each study unit are used for three types of water-quality assessments: (1) *Status*: assessment of the current quality of the groundwater resource;

(2) *Understanding*: identification of the natural and human factors affecting groundwater quality; and (3) *Trends*: detection of changes in groundwater quality (Kulongoski and Belitz, 2004). The assessments are intended to characterize the quality of groundwater in the primary aquifer systems of the study units, not the treated drinking water delivered to consumers by water purveyors. The primary aquifer system is defined as that part of the aquifer corresponding to the open or screened intervals of wells listed in the CDPH databases for the study units. The CDPH database lists wells used for municipal and community drinking-water supplies, and includes wells from systems classified as non-transient (such as those in cities, towns, and mobile-home parks) and transient (such as those in schools, campgrounds, and restaurants). Collectively, the CDPH refers to these wells as "public-supply" wells. Groundwater quality in shallow or deep parts of the aquifer systems may differ from that in the primary aquifer system. In particular, shallow groundwater may be more vulnerable to surface contamination. As a result, samples from shallow wells (such as many private domestic wells and environmental monitoring wells) can have higher concentrations of constituents from anthropogenic sources (such as volatile organic compounds and nitrate) than samples from wells screened in the underlying primary aquifer system (Landon and others, 2010).

This USGS Data Series Report is the first in a series of reports presenting the water-quality data collected in the CAMP study unit and is similar to other USGS Data Series Reports written for the GAMA PBP study units sampled to date. Data Series Reports and additional reports addressing the status, understanding, and trends aspects of the water-quality assessments of each study unit are available from the U.S. Geological Survey (2011b), at [http://ca.water.usgs.gov/gama/includes/GAMA\\_publications.html](http://ca.water.usgs.gov/gama/includes/GAMA_publications.html).

## Purpose and Scope

The purposes of this report are to describe (1) the study design, including the hydrogeologic setting of the CAMP study unit and the study methods; (2) the analytical results for groundwater samples collected in the CAMP study unit, and (3) the results of QC analyses. Groundwater samples were analyzed for field water-quality indicators, organic, special-interest, inorganic, and radioactive constituents, naturally occurring isotopes, and dissolved gases. The chemical data presented in this report were evaluated by comparison to State and Federal drinking-water regulatory and other non-regulatory standards that are applied to treated drinking water. Regulatory and non-regulatory benchmarks considered for this report are those established by the U.S. Environmental Protection Agency (USEPA) and (or) the CDPH. Discussion of the factors that influence the distribution and occurrence of the constituents detected in groundwater samples will be the subject of subsequent publications.



Shaded relief derived from U.S. Geological Survey  
National Elevation Dataset, 2006.  
Albers Equal Area Conic Projection  
North American Datum of 1983 (NAD 83)

Provinces from Belitz and others (2003)

**Figure 1.** Hydrogeologic provinces of California and the location of the Cascade Range and Modoc Plateau (CAMP) study unit, California GAMA Priority Basin Project.

## Hydrogeologic Setting

The CAMP study unit corresponds to the Cascade Range and Modoc Plateau hydrogeologic province in the northeastern corner of the State ([fig. 1](#); Belitz and others, 2003). The study unit covers an area of 39,000 square kilometers (km<sup>2</sup>) in Modoc, Lassen, Siskiyou, Shasta, Butte, Tehama, and Plumas Counties ([fig. 2A](#)). The province is defined on the basis of geologic and State boundaries; it is bounded to the west by the Mesozoic and Paleozoic rocks of the Klamath Mountains province, to the south by Mesozoic and Paleozoic rocks of the Sierra Nevada province, to the southwest by the Cenozoic sediment deposits of the Central Valley province, and to the north by the Oregon State line, and to the east by the Nevada State line. The Cascade Range and Modoc Plateau hydrogeologic province consists of Cenozoic volcanic rocks and sediment deposits. The hydrogeologic province includes three geomorphic provinces ([fig. 2A](#)): the western part is part of the Cascade Range, the central and eastern part is the Modoc Plateau, and two basins on the eastern edge are considered part of the Basin and Range (California Department of Conservation, California Geological Survey, 2002).

Hydrologic features of the CAMP study unit belong to three major watersheds: the Sacramento River watershed (CDWR basin numbers beginning with “5-”), the Klamath River watershed (CDWR basin numbers beginning with “1-”), and closed basins of the north Lahontan region (CDWR basin numbers beginning with “6-”) ([fig. 2B](#)) (California Department of Water Resources, 2003). The largest river in the study unit, the Pit River, flows across the study unit from Goose Lake in the northeast to Lake Shasta on the Sacramento River. The headwaters of the Sacramento River are on the southwestern slopes of Mount Shasta. Creeks in the southwestern part of the study unit flow into the main stem of the Sacramento River. Along the Oregon border, the Lost River drainage, including Clear Lake and Tule Lake, is connected to the Klamath River by a man-made canal. The Shasta River flows through Shasta Valley and enters the Klamath River below Iron Gate Dam. In the North Lahontan region along the Nevada border, the basins are closed basins; rivers drain into perennial or intermittent lakes in the basins.

Climate in the study area varies with elevation and longitude. Land-surface elevations in the study unit range from approximately 1,500 feet (ft) along the margin of the Sacramento Valley to 14,179 ft on Mount Shasta. Precipitation is greatest on the western side of the study unit, reaching up to 80 inches per year (in/yr) on Mount Shasta and up to 120 in/yr in high elevations in Lassen Volcanic National Park (PRISM Group, Oregon State University, 2010). Elevation ranges from 4,000 to 5,500 ft throughout most of the central and eastern parts of the study unit, and climate is classified as the Great

Basin desert (defined as high, cold desert). The central and eastern parts of the study unit are in the rain shadow of the Cascade Range and therefore receive much less precipitation than the western parts of the study unit. Average annual precipitation is 10–20 in/yr in most of the area and 20–40 in/yr at higher elevations (Western Regional Climate Center, 2010). Much of the precipitation in the entire study unit falls as snow, particularly at elevations above 4,500 ft, and nearly all of the precipitation occurs in the winter (between November and May). Summers are hot and dry.

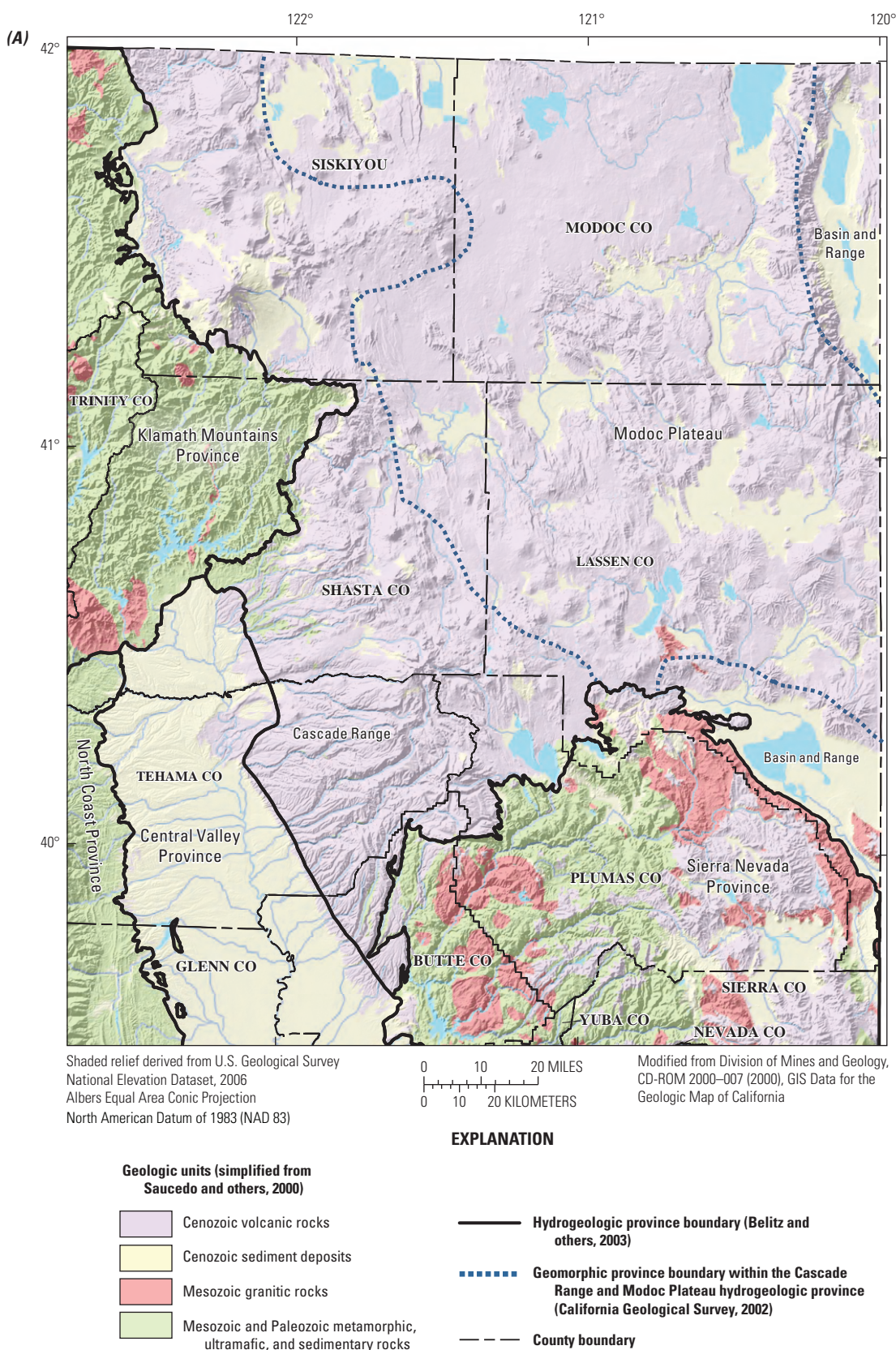
Geologically, the CAMP study unit consists entirely of Cenozoic-age volcanic and sedimentary rocks and deposits. The western part of the study unit is part of the Cascade Range ([fig. 2A](#)), a volcanic arc extending from southern British Columbia to northern California. The Cascade Range has been an active volcanic arc for the last approximately 36 million years (Ma) as a result of subduction of the Juan de Fuca plate under the North American plate (Bally and Palmer, 1989). The oldest rocks in the study unit are mid-Tertiary (33 Ma to 20 Ma) volcanic rocks of the Western Cascade Range, an old, deeply eroded ancestor of the modern High Cascade Range volcanoes, and these rocks are exposed north of Shasta Valley.

The High Cascade Range in California consists of three volcanic areas: Mount Shasta, the Lassen area, and the Medicine Lake Volcano. The Mount Shasta magmatic system has been active for approximately 600,000 years, and the current mountain is a composite of four major cones erupted over the last 250,000 years (Wood and Kienle, 1990). The most recent eruption in the youngest cone was in 1786, and there are still active fumeroles and hot springs on the summit. The mountain is formed primarily of andesitic lava flows and pyroclastic deposits. Mount Shasta also has five glaciers on it.

The Lassen volcanic area, much of which is in Lassen Volcanic National Park, has a complex eruptive history, with 537 volcanic vents younger than 7 Ma (Guffanti and others, 1990). On a regional scale, the area consists of hundreds of coalescing small volcanoes primarily formed of basalt and basaltic andesite lavas, and superimposed on the regional volcanism is a series of five volcanic centers (Clynne, 1990; Guffanti and others, 1990). Lassen is the most recent volcanic center and has been active for approximately 600,000 years. The youngest feature is a dacite dome field on the flank of the now-eroded main andesitic cone. One of these domes, Lassen Peak, last erupted during 1915–1921.

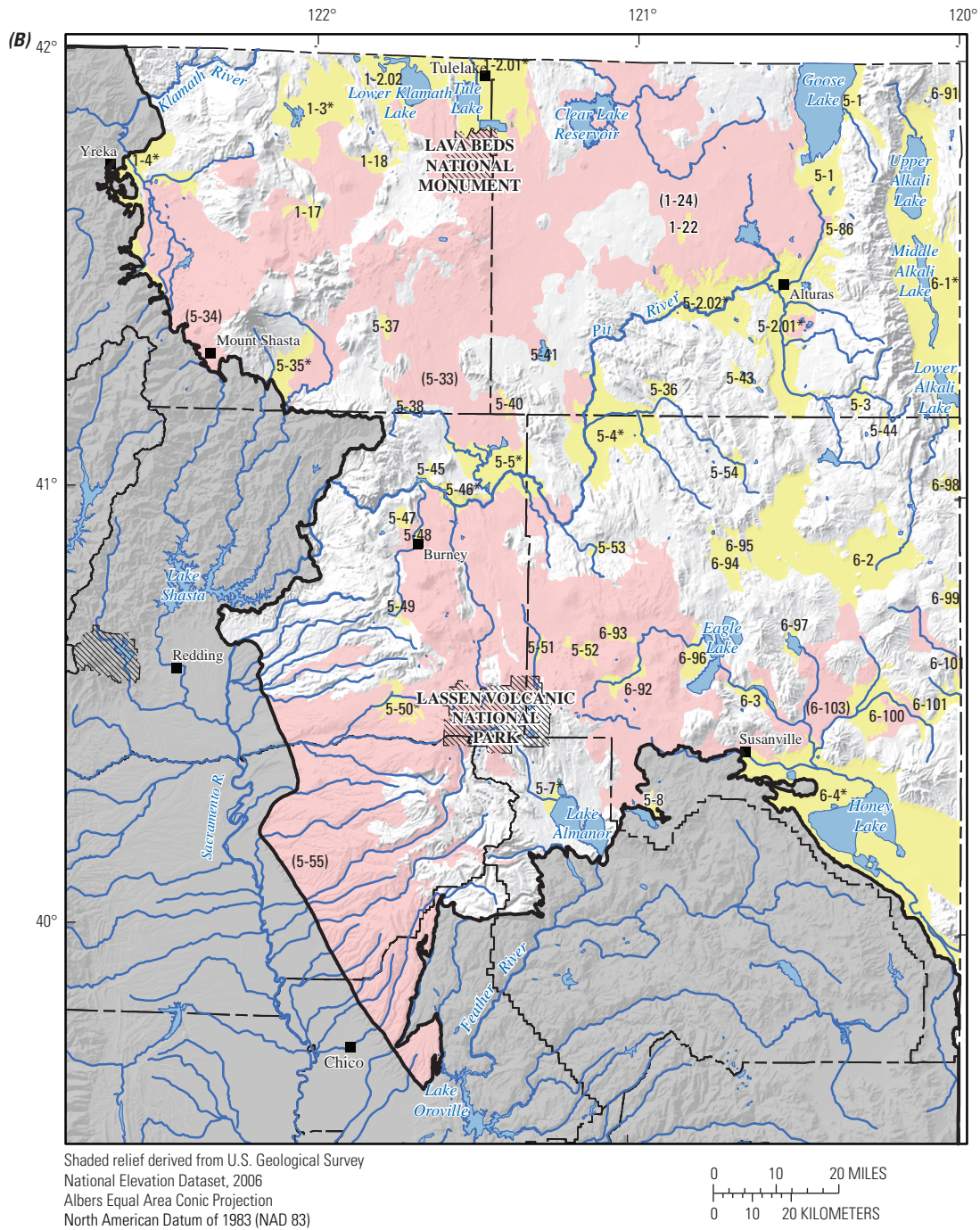
Medicine Lake Volcano is located behind the main line of Cascade Range volcanic arc volcanoes. It is a large shield volcano covering approximately 2,000 km<sup>2</sup> and formed primarily of basalt and basaltic andesite lavas erupted during the late Pleistocene (<1 Ma) (Donnelly-Nolan, 1988). The most recent eruptions were small rhyolite flows occurring approximately 900 years ago (Donnelly-Nolan and others, 1990).





**Figure 2.** (A) Simplified geology of northeastern California, and the boundaries of hydrogeologic provinces, geomorphic provinces, and counties. (B) Map showing locations of California Department of Water Resources groundwater basins in the Cascade Range and Modoc Plateau (CAMP) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, and the locations of counties, major cities, topographic features, and hydrogeologic features.











## EXPLANATION

(5-55)

**Volcanic groundwater basins defined by CDWR (1980) and discontinued in CDWR (2003)**

Basin no.	Discontinued basin name
5-34	Mount Shasta Volcanic Area
5-55	Sacramento Valley Eastside Tuscan Formation Highlands
5-33	Modoc Plateau Pleistocene Volcanic Areas
1-24	Modoc Plateau Pleistocene Volcanic Areas
6-103	Modoc Plateau Pleistocene Volcanic Areas

-  Other areas in the Cascade Range and Modoc Plateau hydrogeologic province
-  Other hydrogeologic provinces
-  National monument and park
-  County boundary

6-4\*

**CDWR-defined groundwater basins that contain CDPH wells**

Basin no.	Basin name	Study area	Reference
6-4	Honey Lake Valley	HL	CDWR, 2004a
1-4	Shasta Valley	SH	CDWR, 2004b
1-2.01	Upper Klamath basin-Tule Lake subbasin	LU	CDWR, 2004c
1-3	Butte Valley	LU	CDWR, 2004d
5-2.01	Alturas basin, South Fork Pit River subbasin	LU	CDWR, 2004e
5-2.02	Alturas basin, Warm Springs Valley subbasin	LU	CDWR, 2004f
5-4	Big Valley	LU	CDWR, 2004g
5-5	Fall River Valley	LU	CDWR, 2004h
5-7	Lake Almanor Valley	LU	CDWR, 2004i
5-35	McCloud Area	LU	CDWR, 2004j
5-46	Lake Britton Area	LU	CDWR, 2004k
5-50	North Battle Creek	LU	CDWR, 2004l
6-1	Surprise Valley	LU	CDWR, 2004m

6-2

**CDWR-defined groundwater basins that do not contain CDPH wells**

Basin no.	Basin name	Basin no.	Basin name	Basin no.	Basin name
1-2.02	Upper Klamath basin - Lower Klamath Lake subbasin	5-43	Rock Prairie Valley	6-3	Willow Creek Valley
1-17	Bray Town Area	5-44	Long Valley	6-91	Cow Head Lake Valley
1-18	Red Rock Valley	5-45	Clayton Valley	6-92	Pine Creek Valley
1-22	Fairchild Swamp Area	5-47	Goose Valley	6-93	Harvey Valley
5-1	Goose Lake	5-48	Burney Creek Area	6-94	Grasshopper Valley
5-3	Jess Valley	5-49	Dry Burney Creek Valley	6-95	Dry Valley
5-8	Mountain Meadows Valley	5-51	Butte Creek Valley	6-96	Eagle Lake Area
5-36	Round Valley	5-52	Grays Valley	6-97	Horse Lake Valley
5-37	Toad Well Area	5-53	Dixie Valley	6-98	Tuledad Canyon Valley
5-38	Pondosa Town Area	5-54	Ash Valley	6-99	Painters Flat
5-40	Hot Springs Valley	5-86	Joseph Creek	6-100	Secret Valley
5-41	Egg Lake Valley	6-2	Madeline Plains	6-101	Bull Flat

Figure 2.—Continued

The central and eastern parts of the CAMP study unit are in the Modoc Plateau. The Modoc Plateau is the northern extension of the Walker Lane belt, a 100–300-km-wide zone of distributed late Cenozoic dextral strike-slip and normal faulting between the Sierra Nevada and the Basin and Range provinces (Friends of the Pleistocene, 1995; Oldow and Cashman, 2009). The Modoc Plateau is covered with volcanic rocks, primarily basalt and basaltic andesite lava flows, ranging in age from late Miocene to Holocene (approximately 15 Ma to present). Locally, there are also pyroclastic deposits and more silicic volcanic features. Fault-bounded basins within the Modoc Plateau are filled with late Miocene to Holocene alluvial, pyroclastic, and lacustrine sediments. The Honey Lake and Surprise Valley basins on the California-Nevada State line generally are considered Basin and Range basins, and the Honey Lake and Surprise Valley Faults are major faults in the region.

The CAMP study unit was divided into six study areas ([fig. 3](#)). The aquifer systems in the six study areas are geologically different. The objective of dividing the study unit into study areas was to evaluate potential differences in groundwater quality between these geologically distinct aquifer systems. Four of the study areas correspond to CDWR-defined groundwater basins, and two correspond to mapped geologic units on the State geologic map (Jennings, 1977; Saucedo and others, 2000).

- CAMP-ES study area: Sacramento Valley Eastside,
- CAMP-HL study area: Honey Lake Valley groundwater basin,
- CAMP-LU study area: Cascade Range and Modoc Plateau Low Use Basins,
- CAMP-QV study area: Quaternary Volcanic Areas mapped as Qv on the State geologic map,
- CAMP-SH study area: Shasta Valley and Mount Shasta Volcanic Area, and
- CAMP-TV study area: Tertiary Volcanic Areas mapped as Tv on the State geologic map.

## Sacramento Valley Eastside Study Area (ES)

The ES corresponds to the former CDWR-defined volcanic groundwater basin 5-55, the Sacramento Valley Eastside Tuscan Formation Highlands ([fig. 2B](#); California Department of Water Resources, 1980). It is no longer designated as a CDWR basin because volcanic areas statewide were reclassified as groundwater source areas rather than basins (California Department of Water Resources, 2003). The boundary between the ES study area and the Sacramento Valley is defined by the Chico Monocline ([fig. 4E](#)), a normal fault active within the last 1 Ma moving the Sierra Nevada

up relative to the Central Valley. East of the Monocline, the Tuscan Formation dips less than 5 degrees, and west of the Monocline, the Tuscan Formation dips at least 20 degrees, disappearing beneath the younger valley sediments (Harwood and Helley, 1987). The other boundaries of the ES study area are defined by the extent of surface outcrops of the Tuscan Formation.

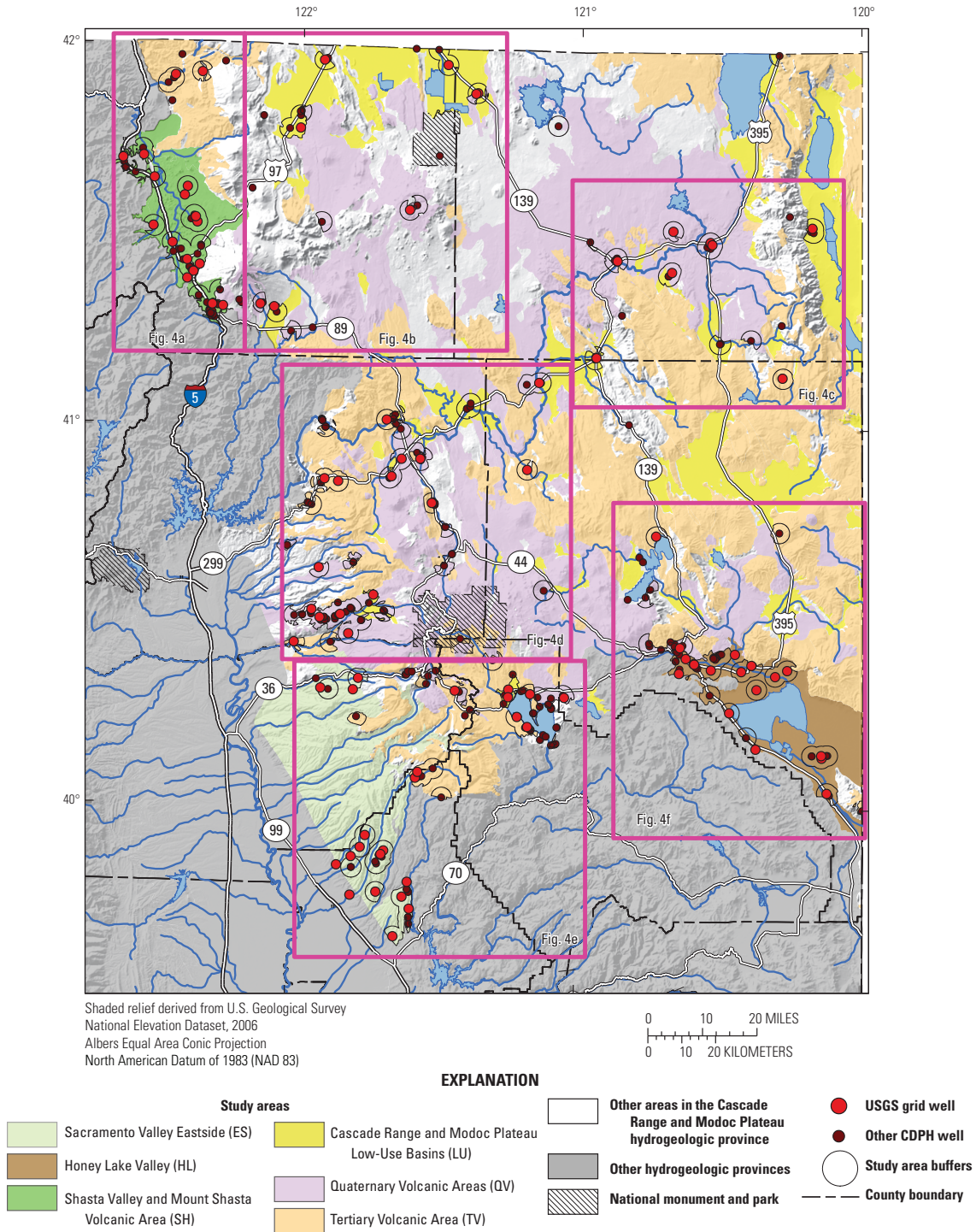
The Tuscan Formation in the ES study area consists of many volcanic mudflows, or lahars. About three-fourths of the exposed area is tuff breccia, a massive chaotic assemblage of boulder- to pebble-size fragments of andesitic lava in a clastic matrix of volcanic ash and fine volcanic debris (Lydon, 1968). The Formation grades westward from lahar deposits to volcanic sediments, and in the Central Valley, the Tuscan Formation sediments are a significant aquifer. The lahars erupted approximately 3 Ma from vents on the flanks of now-extinct volcanoes in areas west and south of Lassen Volcanic National Park, and form a unit up to 1,700 ft thick (Lydon, 1968).

Wells in the ES study area are completed in the Tuscan Formation. The tuff breccia is less permeable than the volcanic sediments, resulting in variable well yields. Several communities in the southern part of the ES study area have had to rely on drinking water brought in by tanker trucks (California Department of Water Resources, 2003).

## Honey Lake Valley Study Area (HL)

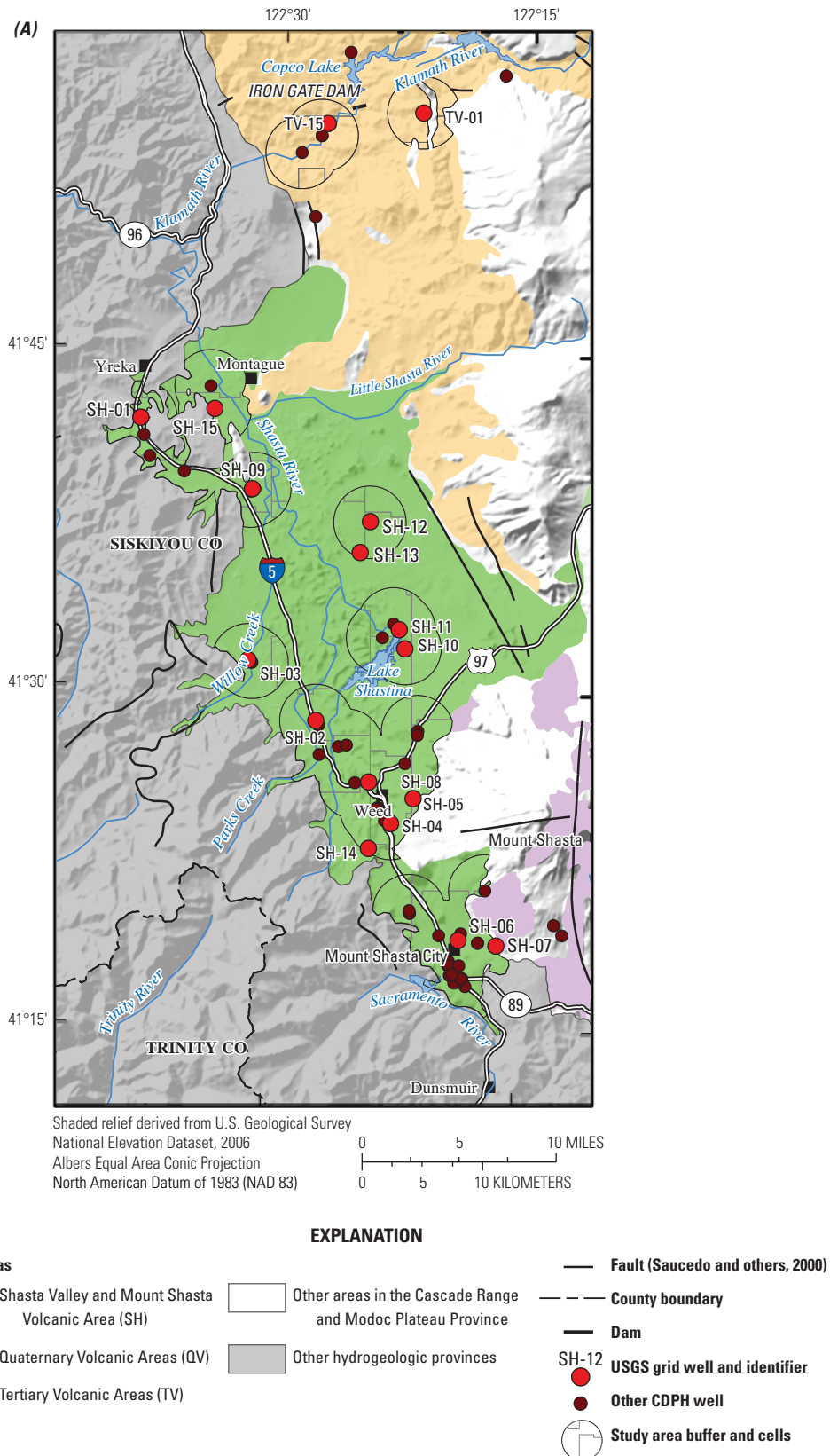
The HL study area corresponds to the CDWR-defined Honey Lake Valley groundwater basin ([fig. 2B](#); CDWR basin number 6-4; California Department of Water Resources, 2004a). The Honey Lake Valley is a topographically closed basin that is geologically part of the Basin and Range. The basin is bounded on the south by the Honey Lake Fault, which separates it from the Mesozoic granitic rocks of the Sierra Nevada, and on the other sides by Quaternary and Tertiary lava flows ([fig. 4F](#)).

The Honey Lake Valley is a down-faulted basin containing up to 6,000 ft of Pliocene to Holocene (5 Ma to present) sediments with interbedded lava flows and pyroclastic deposits (California Department of Water Resources, 1963; Handman and others, 1990). The primary water-bearing units are the Pleistocene to Holocene lacustrine and alluvial sediments. Honey Lake was on the western edge of glacial Lake Lahontan, a large lake that covered most of northwestern Nevada during the last glacial period. Near-shore deposits from this large lake are relatively coarse-grained and highly permeable, and are an important source of groundwater to wells. Pleistocene volcanic rocks interbedded with the lake sediments on the north side of the basin act as conduits for groundwater recharge of the basin.



**Figure 3.** Boundaries of the six study areas in the Cascade Range and Modoc Plateau (CAMP) study unit, California GAMA Priority Basin Project, boundaries of study area buffers, and locations of wells in the California Department of Public Health database and wells sampled for this study.





**Figure 4.** The (A) northwestern, (B) north-central, (C) northeastern, (D) west-central, (E) southwestern, and (F) southeastern parts of the Cascade Range and Modoc Plateau (CAMP) study unit, California GAMA Priority Basin Project, boundaries of study areas and study area buffers, and locations of selected hydrologic and geologic features, wells sampled for this study, and other wells in the California Department of Public Health (CDPH) database.

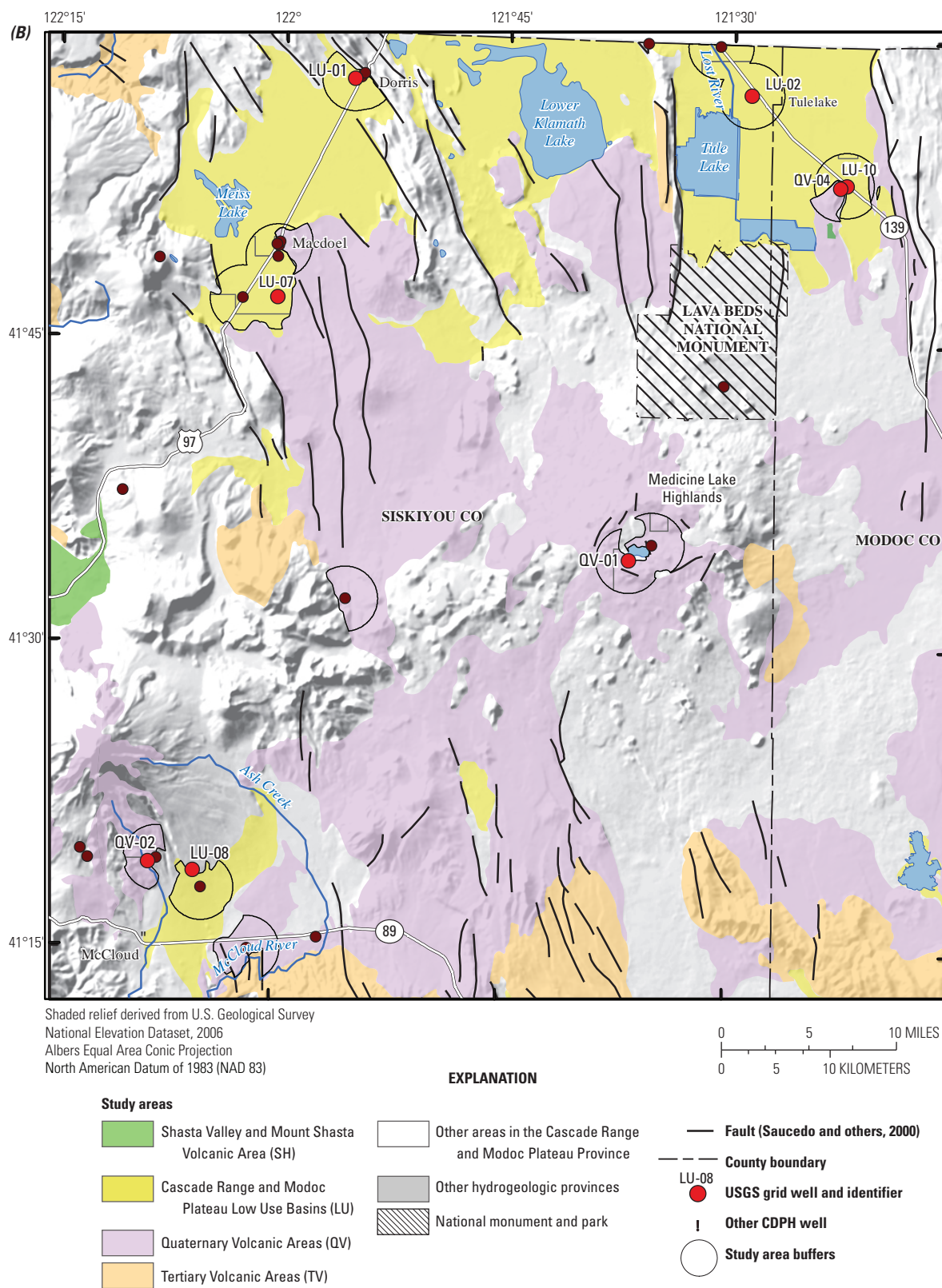


Figure 4.—Continued



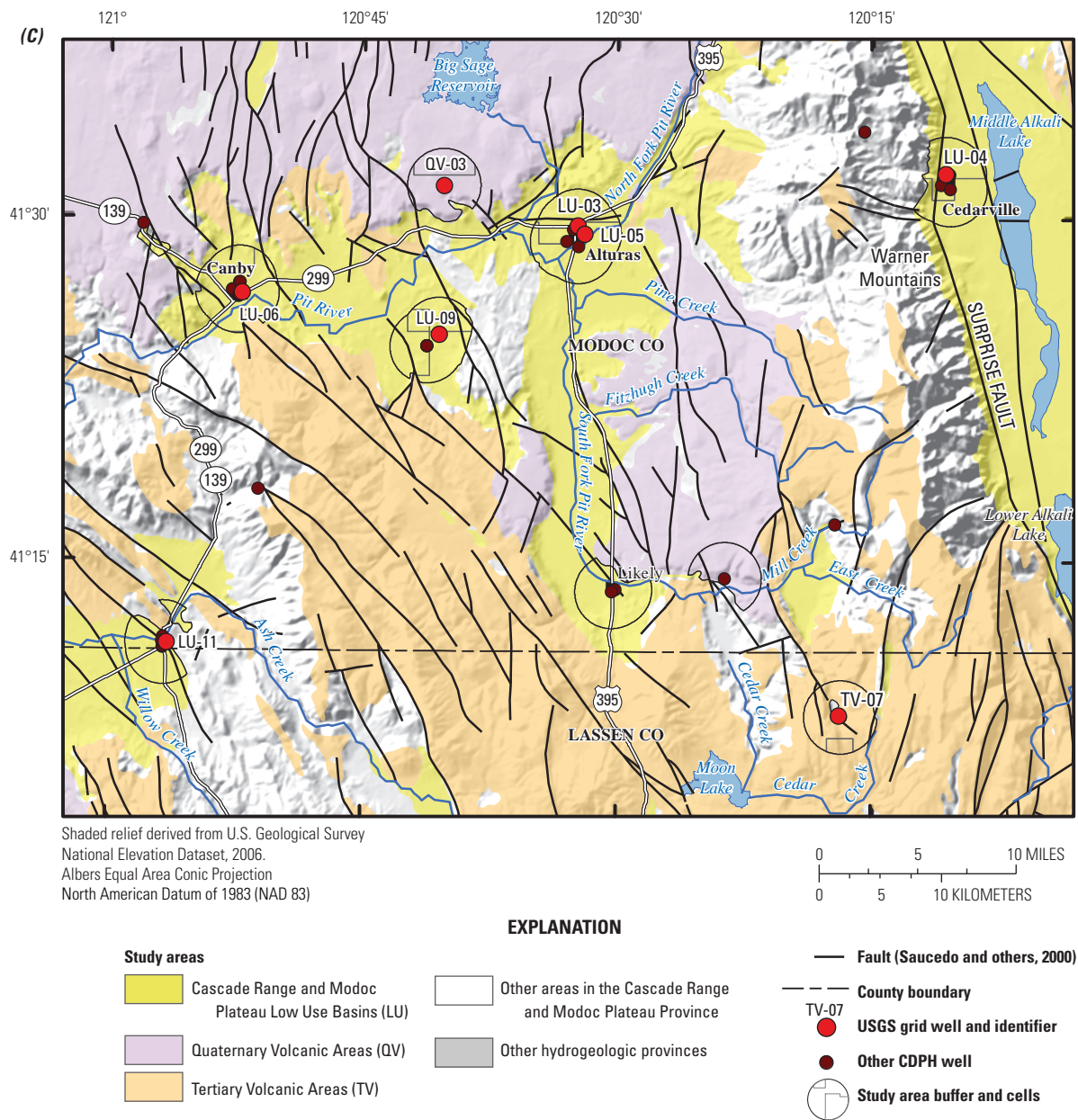


Figure 4.—Continued

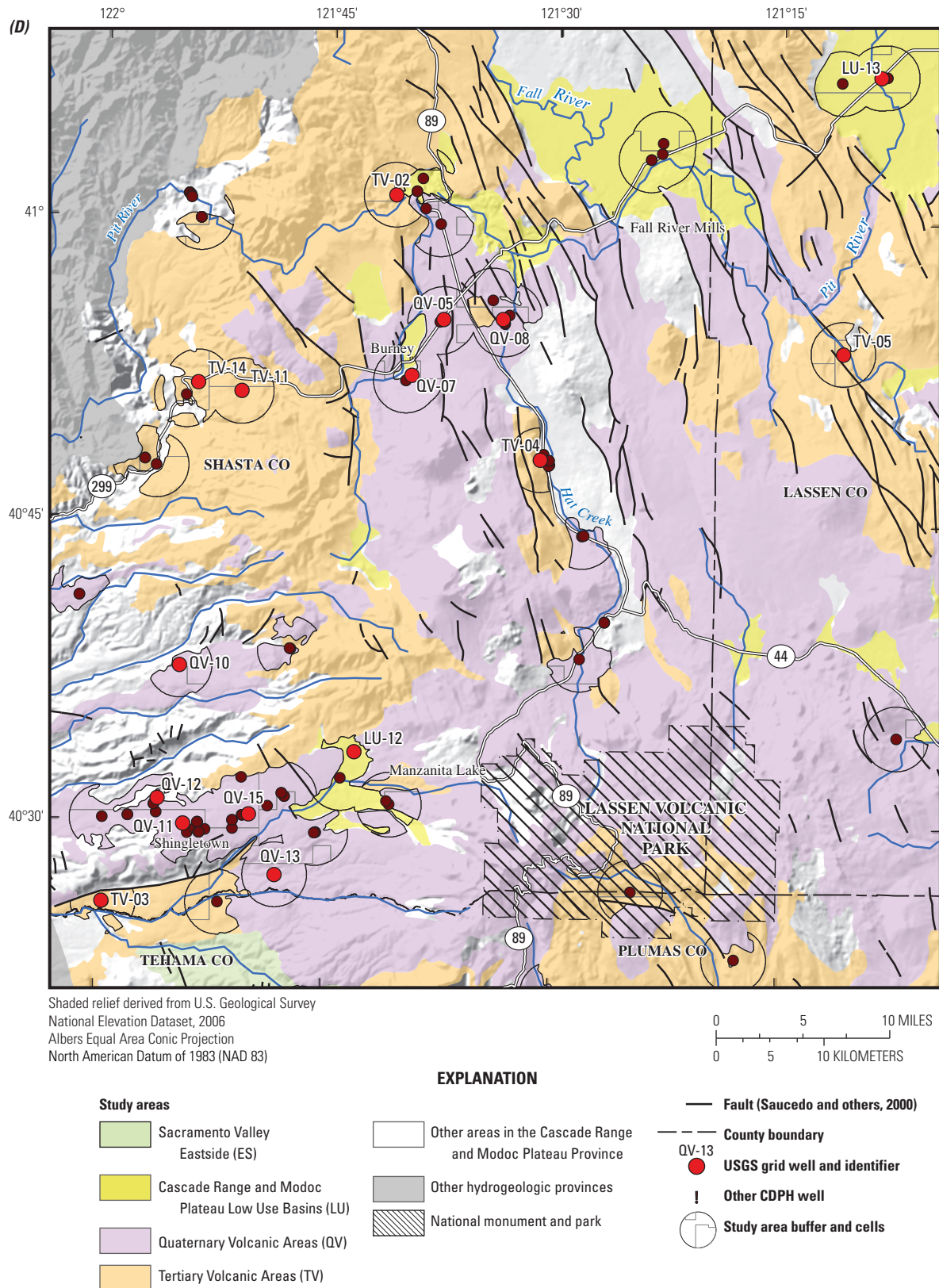
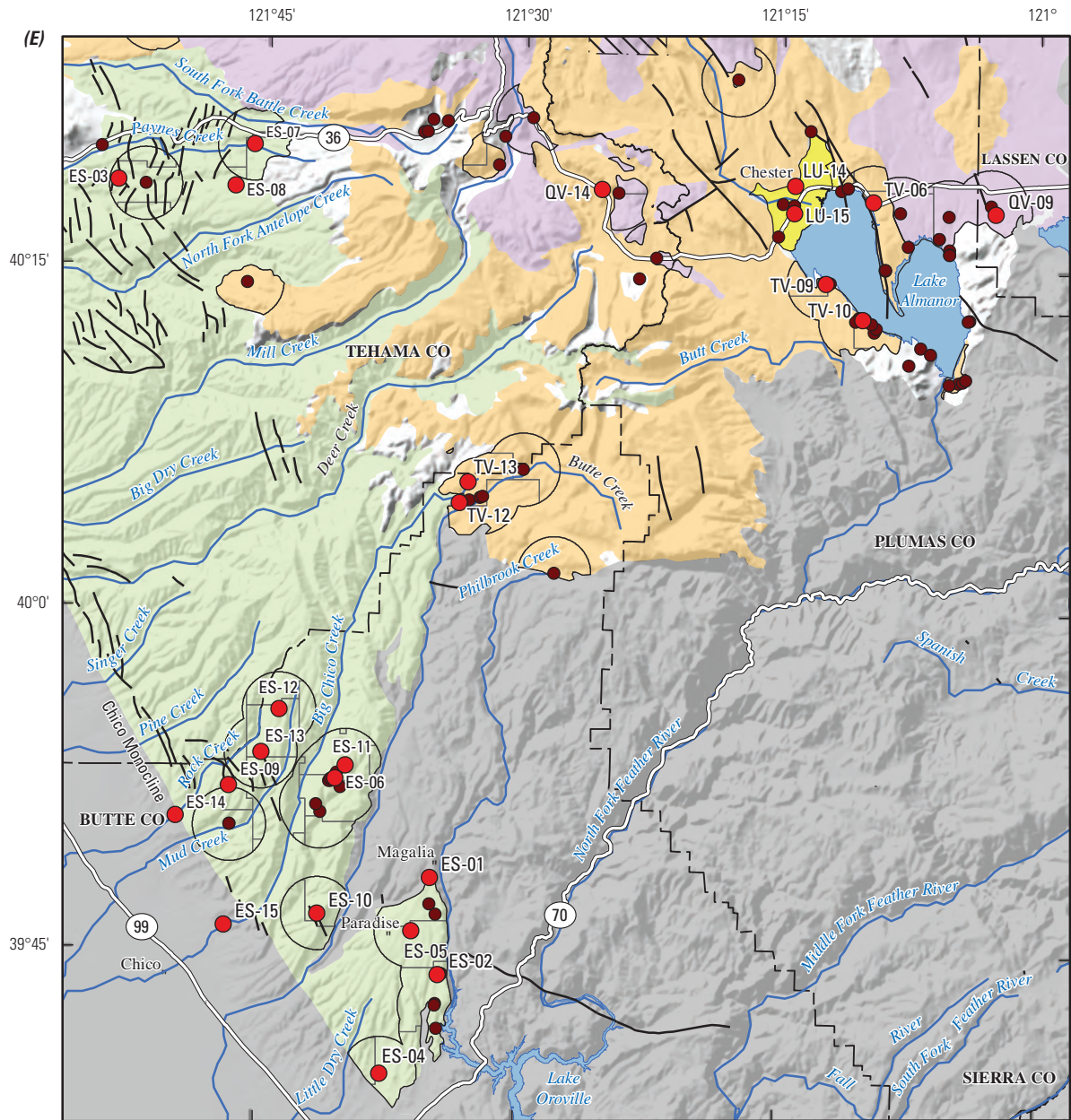


Figure 4.—Continued





Shaded relief derived from U.S. Geological Survey  
 National Elevation Dataset, 2006  
 Albers Equal Area Conic Projection  
 North American Datum of 1983 (NAD 83)

#### EXPLANATION

##### Study areas

- Sacramento Valley Eastside (ES)
- Cascade Range and Modoc Plateau Low Use Basins (LU)
- Quaternary Volcanic Areas (QV)
- Tertiary Volcanic Areas (TV)

- Other areas in the Cascade Range and Modoc Plateau Province
- Other hydrogeologic provinces
- National monument and park

- Fault (Saucedo and others, 2000)
- County boundary
- USGS grid well and identifier
- Other CDPH well
- Study area buffer and cells

Figure 4.—Continued

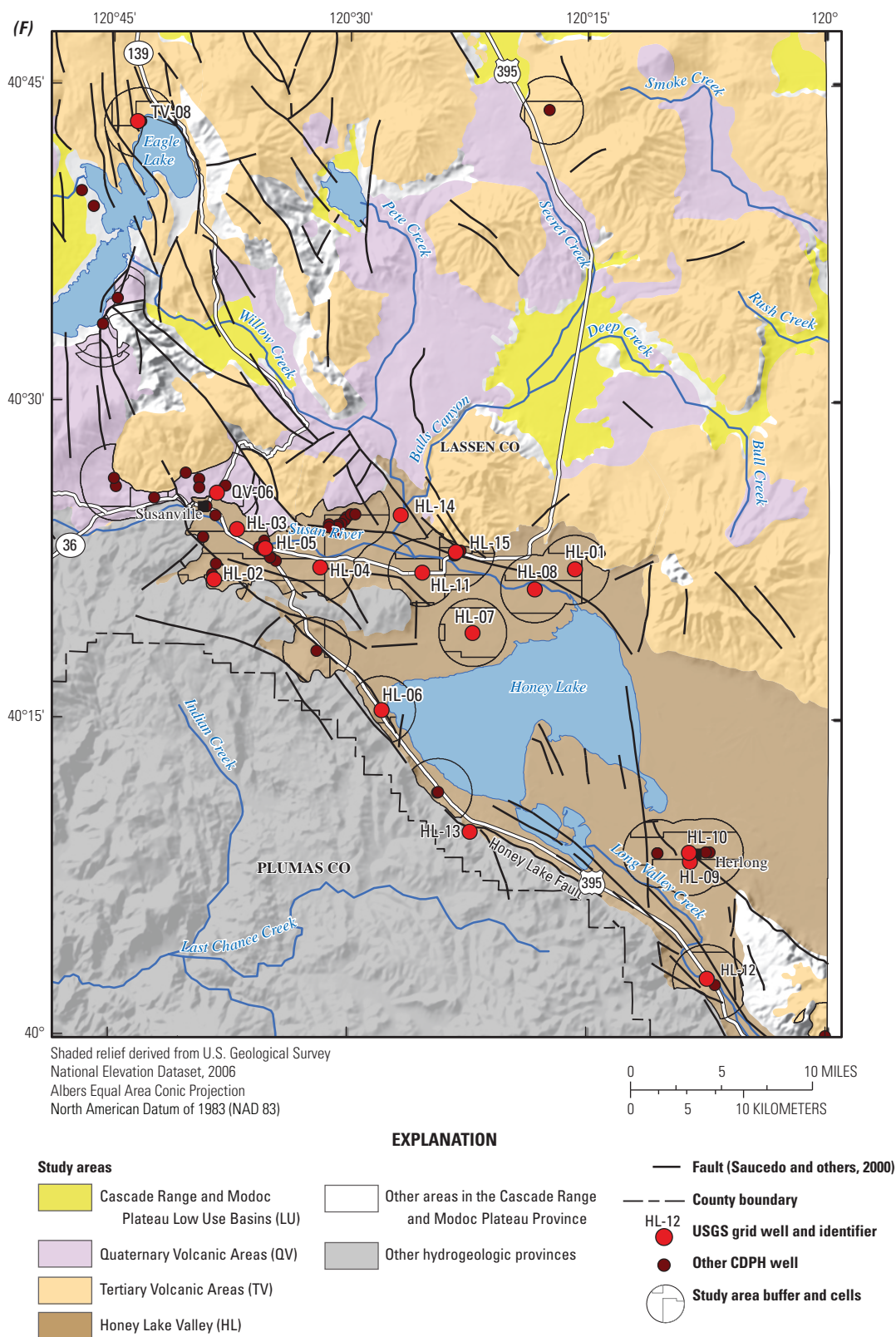


Figure 4.—Continued



More than 40 intermittent and perennial streams flow into the valley and terminate at Honey Lake. However, the amount of groundwater recharge is low because about 90 percent of the total precipitation and stream inflow to the basin is lost by evapotranspiration (Handman and others, 1990). The sources of groundwater recharge are direct infiltration of precipitation at higher elevations in the watershed, infiltration of streamflow on alluvial fans on the valley margins, and infiltration of irrigation return water. In addition, upwelling of thermal waters along the faults bounding the basin may contribute up to 40 percent of recharge locally (Mayo and others, 2010). Faults within the basin limit lateral groundwater flow (Rose and others, 1997). Groundwater discharge is by evapotranspiration and by pumping. Most of the groundwater extraction is for irrigation, although geothermal waters associated with the faults bounding the basin are extracted for power generation (Lassen County Board of Supervisors, 2007). Groundwater levels have declined in parts of the basin due to pumping.

### **Shasta Valley and Mount Shasta Volcanic Area Study Area (SH)**

The SH study area corresponds to the CDWR-defined Shasta Valley groundwater basin (CDWR basin number 1-4; California Department of Water Resources, 2004b) and former CDWR-defined volcanic groundwater basin 5-34, the Mount Shasta Volcanic Area (California Department of Water Resources, 1980) ([figs. 2B, 4A](#)). The CDWR Shasta Valley groundwater basin is defined by Quaternary alluvial deposits up to 140 ft thick along the western and northern sides of Shasta Valley. However, the groundwater basin appears to be hydrologically continuous with the volcanic rocks of the Mount Shasta Volcanic Area (Mack, 1960).

Most of the SH study area consists of the Mount Shasta Volcanic Area. Approximately two-thirds of the Valley is covered by a debris-avalanche that fell from Mount Shasta between 300,000 and 380,000 years ago (Crandell, 1989). The avalanche deposits are up to 300 ft thick and consist of two facies: a block facies containing blocks of andesite lava flows and volcanoclastic deposits up to many hundreds of feet in maximum dimension, and a matrix facies consisting of an unsorted, unstratified mix of boulders through clay-size material, primarily from andesite lava flows and material scoured from the valley floor. The principal aquifer in the valley is the Holocene Pluto's Cave basalt lava flow from Mount Shasta (Mack, 1960; California Department of Water Resources, 2004b). This basalt is exposed on the surface in the southeastern part of the study unit.

The Shasta River is listed as impaired under the Clean Water Act due to elevated stream temperatures and low dissolved oxygen levels that have a detrimental effect on fish populations, and the river has a total maximum daily load (TMDL) action plan (North Coast Regional Water Quality Control Board, 2006). The source of cold flows in the Shasta

River is inflow from groundwater and spring discharges. Groundwater pumping, primarily for agricultural uses, has become a contentious issue in the valley because pumping may decrease spring discharge and increase the depth to the water table.

Groundwater recharge is mostly by infiltration of streamflow and snowmelt into permeable lava flows, dominantly in the southern part of the valley on the slopes of Mount Shasta. Much of the valley floor receives less than 15 in/yr of precipitation, thus direct infiltration from precipitation is minimal. Some groundwater recharge occurs by percolation of irrigation water and seepage of water behind impoundments. Groundwater discharge is by seepage to streams (Shasta River empties into the Klamath River), pumping, and evapotranspiration.

### **Cascade Range and Modoc Plateau Low Use Basins Study Area (LU)**

The LU study area includes 47 CDWR-defined groundwater basins ([fig. 2B](#)). Of these 47 basins, 11 contain wells listed in the CDPH database of wells used for public drinking-water supply. Hydrologic features of those 11 basins are discussed briefly here.

The Tule Lake subbasin of the Upper Klamath River groundwater basin is bounded on the east and west by north-south trending normal faults, on the south by Pleistocene and Holocene lava flows of the Medicine Lake volcano, and on the north by the Oregon State line ([figs. 2B, 4B](#); CDWR basin number 1-2.01; California Department of Water Resources, 2004c). The subbasin is filled with Pliocene to Holocene lacustrine deposits that have low permeability and interbedded Miocene, Pliocene, and Pleistocene basalt lava flows. The principal aquifer is highly permeable Miocene/Pliocene basalt lava flows beneath the lake sediments. In 2001, ten deep irrigation wells were drilled into this aquifer and have yields ranging from 4,000 to 12,000 gallons per minute (gal/min). Recharge to the subbasin occurs primarily by subsurface flow through permeable basalt lava flows that are exposed in the highlands north and east of the subbasin, and by subsurface flow from the adjacent Lower Klamath Lake subbasin (Gannett and others, 2007).

The surface-water hydrology of the subbasin has been extensively modified as part of the U.S. Bureau of Reclamation Klamath Project (Gannett and others, 2007). Prior to the Klamath Project, Tule Lake was much larger, surrounded by vast wetlands, and fed by the Lost River. Hydraulic head gradients suggest that the lake drains in the subsurface southward through the Medicine Lake Highlands towards the Pit River (Gannett and others, 2007). The Lost River is now connected to the Klamath River by a man-made canal, and much of the subbasin has been drained for agricultural use. The existing Tule Lake Sump collects irrigation return water that is then pumped out of the basin into Lower Klamath Lake. The subbasin is extensively irrigated

with surface water from Upper Klamath Lake (in Oregon). Pumpage of groundwater has increased dramatically since 2001, largely due to the use of groundwater to augment surface-water supplies to help maintain fish populations (National Research Council, 2008).

Butte Valley is a closed basin within the Klamath River watershed. The basin was formed by faulting and is defined by the surface extent of alluvial fill ([figs. 2B, 4B](#); CDWR basin number 1-3; California Department of Water Resources, 2004d). The main aquifer units are coarse-grained lake deposits and interbedded volcanic units, particularly the Butte Valley Basalt in the southeastern part of the basin (Planert and Williams, 1995). Major sources of groundwater recharge include subsurface flow in volcanic units, percolation of precipitation and streamflow, and irrigation return water. Major sources of groundwater discharge include subsurface flow in volcanic units, pumping for agriculture, municipal, and environmental uses, and evapotranspiration.

The South Fork Pit River and Warm Springs Valley subbasins of the Alturas area are defined by surface exposure of Holocene alluvial deposits and the Plio-Pleistocene Alturas Formation ([figs. 2B, 4C](#); CDWR basin numbers 5-2.01 and 5-2.02; California Department of Water Resources, 2004e,f). The basins are surrounded by Quaternary and Tertiary lava flows and are separated by surface exposure of the Plio-Pleistocene Warm Springs Tuff. The basins are dissected by many northwest-southwest-trending faults, and the Alturas Formation is folded into three synclines with northwest-southwest-trending axes (California Department of Water Resources, 1963). These structures affect groundwater flow in the basin. The Warm Springs subbasin has hot springs located on faults that permit deep circulation of groundwater. The main water-bearing units in the basins are permeable beds of tuff, ashy sandstone, and diatomite in the lacustrine Alturas Formation. Basalt lava flows which are exposed around the basins and also are interbedded with the Alturas Formation serve as primary recharge areas.

The boundaries of the Big Valley groundwater basin are defined by the surface extent of Holocene alluvial deposits and the Pleistocene Bieber Formation, and the basin is surrounded by Pliocene (TV) and Pleistocene (QV) lava flows ([figs. 2B, 4C](#); CDWR basin number 5-4; California Department of Water Resources, 2004g). The Pit River flows through the western side of the valley. The principal water-bearing units are pumiceous sand and volcanic sand layers in the lacustrine Bieber Formation.

The Fall River Valley is defined by surface exposure of Pleistocene and Holocene alluvial and lacustrine deposits, and is surrounded by Pliocene, Pleistocene, and Holocene volcanic rocks ([figs. 2B, 4D](#); CDWR basin number 5-5; California Department of Water Resources, 2004h). The Fall River Springs, which are among the largest springs in the United States at 1,400 to 2,000 cubic feet per second (ft<sup>3</sup>/s) of discharge (Meinzer, 1927), discharge into the valley from the north and provide most of the base flow for the

surface-water features in the valley. The source of the water for the springs appears to be precipitation on the vast Medicine Lake Highlands 60 kilometers (km) to the north (Rose and others, 1996).

The Lake Almanor Valley groundwater basin is located on the northwest shore of Lake Almanor ([figs. 2B, 4E](#); CDWR basin number 5-7; California Department of Water Resources, 2004i). The basin consists of Quaternary alluvial and lacustrine deposits and is bounded by Pliocene volcanic rocks. The North Fork of the Feather River, which is the southern drainage for the highlands in the Lassen area, passes through the valley and provides 50 percent of the inflow to Lake Almanor (Plumas County Flood Control and Conservation District, 2007). Another 25 percent comes from submerged springs in the Pliocene volcanic rocks. The lake is a reservoir operated for power generation by Pacific Gas & Electric.

The McCloud Area groundwater basin is located on the southeast slope of Mount Shasta between approximately 3,000 and 6,000 ft above mean sea level ([figs. 2B, 4B](#); CDWR basin number 5-35; California Department of Water Resources, 2004j). The basin is defined by the surface extent of a thin veneer of mostly Holocene alluvial and glacial deposits. The basin is underlain and bounded on the north and east by Pliocene and Pleistocene volcanic rocks, and bounded on the south by Paleozoic metasedimentary deposits of the Klamath Mountains. The area has many springs.

The Lake Britton Area groundwater basin is located where Hat Creek joins the Pit River ([figs. 2B, 4D](#); CDWR basin number 5-46; California Department of Water Resources, 2004k). The basin is defined by the surface extent of Holocene alluvial deposits and is surrounded and underlain by Pliocene (TV study area) and Pleistocene (QV study area) lava flows.

The North Fork Battle Creek Valley groundwater basin is located just west of Lassen Volcanic National Park ([figs. 2B, 4D](#); CDWR basin number 5-50; California Department of Water Resources, 2004l). The basin is defined by the surface extent of Holocene alluvial deposits and is surrounded and underlain by Pliocene (TV study area) and Pleistocene (QV study area) lava flows. These alluvial deposits are approximately 32 ft thick and overlie a succession of lava flows. The main water-bearing unit is the interbedded layer of sand, gravel, ash, and cinder between the lava flows.

The Surprise Valley groundwater basin is located on the northeastern edge of the study unit ([figs. 2B, 4C](#); CDWR basin number 6-1; California Department of Water Resources, 2004m). The long, narrow basin is a graben bounded on all sides by normal faults. The Surprise Valley fault is the westernmost large-offset normal fault in the northwestern Basin and Range, and there has been more than 4.5 km of vertical offset between the Warner Mountains and the Surprise Valley in the last 14 Ma (Egger and Miller, 2011). The valley is filled with more than 5,000 ft of alluvial and lacustrine deposits, most of which are lacustrine sediments from Pleistocene Lake Surprise.

The Surprise Valley is a closed basin. Streams entering the valley, primarily from the Warner Mountains to the west, terminate in the three seasonal, shallow, saline lakes along the central axis of the valley. The primary source of groundwater recharge is infiltration of surface water through alluvial fans along the base of the Warner Mountains and through coarse stream deposits at the northern end of the valley (California Department of Water Resources, 1963). The principal aquifers are the Holocene alluvial fans and near-shore deposits from Pleistocene Lake Surprise. Groundwater discharge is by evapotranspiration and pumping, primarily for agricultural uses. The Surprise Valley has numerous hot springs associated with the Surprise Valley and other faults, and heated groundwater is extracted for geothermal power generation.

## Quaternary Volcanic Areas (QV) and Tertiary Volcanic Areas (TV) Study Areas

The QV and TV study areas consist of areas on the State geologic map (Saucedo and others, 2000) that are mapped as Quaternary volcanic rocks (Qv) and Tertiary volcanic rocks (Tv), respectively ([fig. 3](#)). The QV study area includes the former CDWR-defined volcanic groundwater basins 5-33, 1-24, and 6-103, which are the Modoc Plateau Pleistocene Volcanic Areas ([fig. 2B](#); California Department of Water Resources, 1980). The former CDWR-defined volcanic groundwater basins 5-32, 1-23, and 6-102, the Modoc Plateau Recent Volcanic Areas, are mapped as Holocene volcanic rocks (Qrv) on the State geologic map and are not included in the QV study area. The QV and TV study areas each include both Cascade Range and Modoc Plateau volcanic rocks. Mount Shasta and Medicine Lake Volcano are composed of Quaternary and Holocene volcanic rocks, and thus are partially included in the QV study area ([figs. 4A, 4B](#)). Most of Lassen Volcanic National Park is in the QV study area, some is in the TV study area, and a small sliver is Holocene volcanic rocks ([fig. 4D](#)).

The QV and TV study areas were defined as separate areas in order to examine potential relations between groundwater quality and age of the aquifer materials. The basalt and basaltic andesite lava flows that compose most of the QV and TV study areas undergo changes in mineralogy with time. Primary igneous minerals and volcanic glass may be oxidized and hydrated, and new minerals may be deposited in voids. These differences in aquifer mineralogy may result in differences in groundwater composition and water quality.

Groundwater in volcanic rocks primarily is contained in fractures, tuff beds, rubble zones at the tops of lava flows, volcanic pipes, and interbedded sand layers. The distribution of permeable zones is unpredictable, although the probability of large groundwater yields generally is greater in areas near fault zones (Planert and Williams, 1995). Well yields commonly vary from 100 to 1,000 gal/min, and yields as high as 4,000 gal/min have been measured. The younger volcanic rocks generally are more permeable because secondary

mineralization from hydrothermal alteration tends to lower permeability in older volcanic rocks. Volcanic aquifer units in the Upper Klamath River basin generally have higher and more variable transmissivity than sedimentary units, with aquifer tests in volcanic rocks yielding values from 2,700 to 610,000 feet squared per day ( $\text{ft}^2/\text{d}$ ) (Gannett and others, 2007).

Groundwater recharge in the QV and TV study areas is by infiltration of precipitation, particularly in the upland areas, and capture of streamflow. Because the volcanic units are highly permeable and have little soil or sediment on top of them, surface streams and groundwater interchange easily: streams disappear into the ground and reappear as spring discharge downstream. The CAMP study unit contains a number of first magnitude springs, springs with discharge greater than 100  $\text{ft}^3/\text{s}$  (Meinzer, 1927). For example, five springs discharging in the QV study area near where Hat Creek joins the Pit River ([fig. 4D](#)) have a combined discharge of more than 700  $\text{ft}^3/\text{s}$ , and isotopic data indicate the recharge area was 50 km to the south in the high elevations in Lassen Volcanic National Park (Rose and others, 1996).

## Methods

Methods used for the GAMA PBP were selected to achieve the following objectives: (1) design a sampling plan for suitable statistical representation; (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](#) contains detailed descriptions of the sample-collection protocols and analytical methods, the QA plan, and the results of analyses of QC samples.

## Study Design

The wells sampled in this study were selected by using a spatially distributed, randomized grid-based approach (Scott, 1990). For most GAMA PBP study units, a set of grid cells is generated within each study area by dividing the study area into equal-area grid cells. One well in each cell is then randomly selected for sampling. However, the CAMP study unit contains a relatively low density of CDPH wells compared to most other study units, and these wells are not evenly distributed across the study unit ([fig. 3](#)). If the study areas were divided into equal-area cells, it is likely that many cells would not contain any wells. As in previous GAMA PBP study units with few and (or) unevenly distributed CDPH wells, the subset of each study area representing the portion of the groundwater resource used for public drinking-water supply is identified, and only those subset areas are included in the grid cells (for example, Fram and Belitz, 2007). The



portion of the groundwater resource used for public drinking-water supply was defined by delineating 3-km radius circles around the locations of wells in the CDPH database (3-km buffers). The total area within these 3-km buffers was then divided into equal-area grid cells.

The six study areas in the CAMP study unit have total areas ranging from 878 km<sup>2</sup> to 10,985 km<sup>2</sup>, and buffered areas ranging from 287 km<sup>2</sup> to 711 km<sup>2</sup> ([table 1](#)). The buffered areas for each study area were divided into 15 equal-area grid cells. The sizes of the grid cells range from 19 km<sup>2</sup> in the ES study area to 47 km<sup>2</sup> in the QV study area. The randomized grid-based method divides the buffered area into equal-area grid cells; however, geographic features may force a grid cell to be divided into multiple pieces to obtain the designated coverage area for each cell. For instance, a portion of a grid cell may be located on either side of a mountain range, but the grid cell is still considered to be one grid cell. The average size of grid cells (25 km<sup>2</sup>) in the CAMP study unit is similar to the design objective for grid-cell size in areas of the State outside of the Central Valley (Belitz and others, 2003).

The objective was to sample one CDPH well in each grid cell. If a cell contained more than one CDPH well, each well was randomly assigned a rank. The highest ranking well that was accessible for sampling and for which permission to sample could be obtained was sampled. If a grid cell contained a well sampled for the GAMA California Aquifer Susceptibility project in 2003 (Moran and others, 2005), then that well was promoted to the highest ranking well. If a grid cell contained no accessible CDPH wells, then other types of wells, such as domestic wells, irrigation, and (or) industrial, were considered for sampling. These “alternative” wells were identified from wells listed in USGS databases or by door-to-door canvassing. Wells with depths and screened intervals similar to those in CDPH wells in the area were selected. In this fashion, one well was selected in each cell to provide a spatially distributed, randomized monitoring network of 90 USGS-grid wells.

One well was sampled in each of the 90 grid cells in the CAMP study unit. The wells were given GAMA identification numbers consisting of the prefix “CAMP,” followed by a second prefix indicating the study area [ES ([fig. 4E](#)), HL ([fig. 4F](#)), LU ([figs. 4B–E](#)), QV ([figs. 4B–F](#)), SH ([fig. 4A](#)), or TV ([figs. 4A, C–F](#))], followed by a suffix numbered in the order of sample collection within each study area. For ease of use, the prefix “CAMP” is dropped from the maps presented in this report.

Approximately 8 percent of the wells listed in the CDPH database for the CAMP study unit were springs; however, this may be a minimum estimate of the percentage of springs. Springs are sites where groundwater naturally flows from below ground to above land surface, sometimes through a

horizontal well bore. In the CDPH database, a spring with a horizontal well bore may be given a name that identifies it as a well. All sites are referred to as wells in this report, unless the difference between a well and a spring is important to the discussion.

The GAMA alphanumeric identification number for each well, along with the date sampled, elevation of well site, well type, and available well-construction information, is shown in [table 2](#). Groundwater samples were collected from 81 production wells (74 CDPH wells, 6 domestic wells, and 1 irrigation well) and 9 springs (8 CDPH springs and 1 spring used for irrigation) during the time period from July 12 through October 14, 2010.

Well locations were verified using a global positioning system (GPS), 1:24,000-scale USGS topographic maps, existing well information in USGS and CDPH databases, and information provided by well owners. Drillers’ logs or other sources of construction information were obtained when available. Well information and location were recorded by hand on field sheets and electronically on field laptop computers using the Alternate Place Entry Form (APE) program designed by the USGS. All information was verified and then uploaded into the USGS National Water Information System (NWIS). Well owner, well use, and well location information is confidential.

## 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 are followed so that representative samples of groundwater are collected at each site and so that the samples are collected and handled in ways that minimize the potential for contamination.

All 90 USGS-grid wells in the CAMP study unit were sampled for the same classes of constituents ([table 3](#)). [Tables 4A–J](#) list the compounds analyzed in each constituent class. Groundwater samples were analyzed for 85 volatile organic compounds (VOCs; [table 4A](#)); 63 pesticides and pesticide degradates ([table 4B](#)); 1 constituent of special interest ([table 4C](#)); 5 nutrients ([table 4D](#)); 24 trace elements ([table 4E](#)); total dissolved solids (TDS) and 10 major ions ([table 4F](#)); 7 radioactive constituents, including tritium ([table 4G](#)); species of iron and arsenic ([table 4H](#)); 5 dissolved noble gases, helium stable isotopic ratios, 5 isotope ratios of water and dissolved constituents, and carbon-14 abundance ([table 4I](#)); and 2 microbial indicators ([table 4J](#)). The methods used for sample collection and analysis are described in the appendix section titled “[Sample Collection and Analysis](#).”

## Data Reporting

The methods and conventions used for reporting the data are described in the appendix section titled “[Data Reporting](#).” Three field water-quality indicators—alkalinity, pH, and specific conductance—were measured in the field and at the USGS National Water Quality Laboratory (NWQL), and both results are reported (see the appendix section titled “[Constituents on Multiple Analytical Schedules](#)”). Arsenic (total) and iron (total) were measured at the USGS NWQL and at the USGS Trace Metal Laboratory (TML), and both results are reported.

## Quality Assurance

The QA/QC 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 QA plan followed by the USGS NWQL, the primary laboratory used to analyze samples for this study, is described in Pirkey and Glodt (1998) and Maloney (2005). QC samples collected in the CAMP study unit are as follows: blanks, replicates, matrix spikes, and surrogates. QC samples were collected to evaluate potential contamination, as well as bias and variability of the data that may have resulted from sample collection, processing, storage, transportation, and laboratory analysis. QA/QC procedures and results are described in the appendix section titled “[Quality-Control Methods and Results](#).”

## Water-Quality Results

### Quality-Control Results

Results of QC analyses (blanks, replicates, matrix spikes, and surrogates) were used to evaluate the quality of the data for the groundwater samples. On the basis of detections in field blanks collected for this and previous GAMA PBP study units, the reporting levels for several volatile organic compounds and trace elements were raised to higher concentrations than those used by the laboratory. Detections of 10 trace elements with low concentrations below the raised reporting limits are flagged with a less-than or equal-to symbol ( $\leq$ ) in this report. All detections of two VOCs were at concentrations below the raised reporting limits; these data are presented as non-detections in this report (see [table A3](#) and additional discussion in the appendix section titled “[Detections in Field Blanks and Application of SRLs](#)”). Results from the replicates confirm that the procedures used to collect and analyze the samples were consistent. Variability was within the acceptable limits for greater than 99 percent of the replicate

pairs for constituents detected in samples ([tables A4A–C](#)). Median matrix-spike recoveries were within acceptable limits for 134 of the 148 organic constituents analyzed; 13 constituents had recoveries lower than the acceptable limit ([tables 4B](#) and [A5B](#)). Low matrix-spike recoveries may indicate that the pesticides and pesticide degradates for which low recoveries occurred might not have been detected in some samples if they were present in the samples at concentrations near the laboratory reporting levels (LRLs). The QC results are described in the appendix section titled “[Other Quality-Control Results](#).”

## Comparison Benchmarks

Concentrations of constituents detected in groundwater samples were compared with CDPH and USEPA regulatory and nonregulatory drinking-water health-based benchmarks and benchmarks established for aesthetic purposes (California Department of Public Health, 2010, 2011a; U.S. Environmental Protection Agency, 1999, 2009, 2011). The chemical data presented in this report are meant to characterize the quality of the untreated groundwater within the primary aquifer system of the CAMP study unit and are not intended to represent the treated drinking water delivered to consumers by water purveyors. The chemical composition of treated drinking water may differ from untreated groundwater because treated drinking water may be subjected to disinfection, filtration, mixing with other waters, and (or) exposure to the atmosphere prior to its delivery to consumers. Comparisons of untreated groundwater to benchmarks are for illustrative purposes only and are not indicative of compliance or noncompliance with drinking-water regulations. The following benchmarks were used for comparisons:

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

- **AL–Action Level.** Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of copper and lead in drinking water. Detections of copper or lead greater than the action-level benchmarks trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and CDPH are the same; thus, the benchmarks 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. TT requirements are applied when water delivered to consumers exceeds specified action levels. Detections of microbial constituents greater than benchmarks trigger requirements for mandatory additional disinfection during water treatment. The action levels established by the USEPA and CDPH are the same; thus, these benchmarks 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 the technical qualities of drinking water, such as scaling and staining. Both the USEPA and CDPH define SMCLs, but unlike MCLs, SMCLs established by the CDPH are not required to be at least as stringent as those established by the USEPA. SMCLs established by the CDPH are used in this report (SMCL-CA) for all constituents that have SMCL-CA values. The SMCL-US is used for pH because no SMCL-CA has been defined.
- **NL–Notification Level.** Health-based notification levels established by CDPH for some of the constituents in drinking water that lack MCLs (NL-CA). If a constituent is detected at concentrations greater than its NL-CA, California State law requires timely notification of local governing bodies and recommends consumer notification.
- **HAL–Lifetime Health Advisory Level.** The maximum concentration of a constituent at which its presence in drinking water is not expected to cause any adverse carcinogenic effects for a lifetime of exposure. HALs are established by the USEPA (HAL-US) and are calculated assuming consumption of 2 liters (2.1 quarts) of water per day over a 70-year lifetime by a 70-kilogram (154-pound) adult and that 20 percent of a person’s exposure comes from drinking water.

- **RSD5–Risk-Specific Dose.** The concentration of a constituent in drinking water corresponding to an 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 10 (RSD5-US).

For constituents with MCLs, detections in groundwater samples were compared with the MCL-US or MCL-CA. The legally enforceable standards AL-US and TT-US were included in the same category as MCLs for the purpose of comparison between standards and detections in groundwater samples. Constituents with SMCLs were compared with the SMCL-CA. For chloride, sulfate, specific conductance, and TDS, CDPH defines a “recommended” and an “upper” SMCL-CA; detections of these constituents in groundwater samples were compared with both levels. The SMCL-US values for these constituents correspond to the recommended SMCL-CAs. Detected concentrations of constituents without an MCL or an SMCL were compared with the NL-CA. For constituents without an MCL, SMCL, or NL-CA, detected concentrations were compared with the HAL-US. For constituents without an MCL, SMCL, NL-CA, or HAL-US, detected concentrations were compared with the RSD5-US. Note that using this hierarchy to select the comparison benchmark for a constituent with more than one type of established benchmark will not necessarily result in selection of the benchmark with the lowest concentration. For example, for zinc the SMCL-CA is 5,000 micrograms per liter ( $\mu\text{g/L}$ ) and the HAL-US is 2,000  $\mu\text{g/L}$ , but the comparison benchmark selected by this hierarchy is the SMCL-CA. The comparison benchmarks used in this report are listed in [tables 4A–J](#) for all constituents and in [tables 5–17](#) for constituents detected in groundwater samples from the CAMP study unit. Established benchmarks are not available for all constituents analyzed for this study. Detections of constituents at concentrations greater than the selected comparison benchmark are marked with asterisks in [tables 5, 9–15](#).

## Groundwater-Quality Data

Results from analyses of untreated groundwater samples from the CAMP study unit are presented in [tables 5–17](#). These results are separated into the six study areas that make up the CAMP study unit (ES, HL, LU, QV, SH, and TV). Groundwater samples collected in the CAMP study unit were analyzed for 221 constituents; 121 of those constituents were not detected in any of the samples, and 100 constituents were detected ([table 4A–J](#)). Results for isotopic ratios of boron and strontium and results for dissolved noble gases and tritium from LLNL are not presented in this report; they will be included in a subsequent publication.

For organic and special-interest (perchlorate) constituent classes, the results tables list only those wells at which constituents were detected and include the following summary statistics: the number of wells in the study unit or study area at which each analyte was detected, the frequency at which it was detected (in relation to the number of grid wells in the study unit or study area), and the total number of constituents detected at each well. For the inorganic and tracer constituent classes, the results tables list all wells sampled and all constituents analyzed. For the microbial indicators, the table lists only those wells at which detections occurred.

Water-quality indicators measured in the field and at the NWQL are included in [table 5](#). The results of groundwater analyses organized by constituent classes are presented in [tables 6–17](#):

#### Organic and special-interest constituents

- VOCs ([table 6](#))
- Pesticides and pesticide degradates ([table 7](#))
- Perchlorate ([table 8](#))

#### Inorganic constituents

- Nutrients ([table 9](#))
- Trace elements ([table 10](#))
- Major and minor ions and TDS ([table 11](#))
- Uranium activity ([table 12](#))
- Radon-222 activity ([table 13](#))
- Gross alpha and gross beta particle activity ([table 14](#))

#### Geochemical and age-dating tracers

- Species of arsenic and iron ([table 15](#))
- Stable isotopes, tritium, and carbon-14 ([table 16](#))

#### Microbial constituents

- Microbial indicators ([table 17](#))

## Water-Quality Indicators

Field measurements of dissolved oxygen and water temperature, and field and laboratory measurements of pH, specific conductance, and alkalinity are presented in [table 5](#). Bicarbonate and carbonate concentrations are calculated from the pH and alkalinity results (see [appendix](#)). Dissolved oxygen and alkalinity are used as indicators of natural processes that affect water chemistry. The pH value indicates the acidity of the water. Specific conductance is the measure of electrical conductivity of the water and is proportional to the amount of total dissolved solids in the water.

Field pH values were outside of the SMCL-US range for 20 percent of the CAMP study-unit grid well samples. Fifteen well samples had field pH values less than 6.5, and three well samples had field pH values greater than 8.5 ([table 5](#)). Low pH in water may contribute to corrosion of pipes, and high pH in water may contribute to scaling. Laboratory pH values may differ from field pH values because the pH of groundwater may change upon removal from the ambient environment and exposure to the atmosphere.

Field specific-conductance values were greater than the recommended SMCL-CA of 900 microsiemens per centimeter ( $\mu\text{S}/\text{cm}$ ) for 7 of the 90 grid well samples ([table 5](#)). The field specific-conductance value in one TV study area grid well was also greater than the upper benchmark of 1,600 microsiemens per centimeter at 25 degrees Celsius ( $\mu\text{S}/\text{cm}$  at 25°C).

## Organic and Special-Interest Constituents

### Volatile Organic Compounds (VOCs)

VOCs are present in paints, solvents, fuels, fuel additives, refrigerants, fumigants, and disinfected water, and are characterized by their tendency to evaporate. VOCs generally persist longer in groundwater than in surface water because groundwater is isolated from the atmosphere.

Of the 85 VOCs analyzed, 18 were detected in the CAMP study-unit groundwater samples; all detections in samples were less than health-based benchmarks ([table 6](#)). One or more VOCs were detected in 27 of the 90 CAMP study-unit grid well samples (about 30 percent detection frequency). The trihalomethane chloroform was detected in more than 10 percent of the samples. Chloroform is a byproduct of drinking-water disinfection and is the most commonly detected VOCs in groundwater nationally (Zogorski and others, 2006).

The six study areas of the CAMP study unit had different detection frequencies of VOCs. Four VOCs had detection frequencies greater than 10 percent in at least one study area. The detection frequency of chloroform was greater than 10 percent in the ES, HL, SH, and TV study areas ([table 5](#)). Perchloroethene (PCE), a solvent primarily used for dry-cleaning and metal-degreasing applications, was detected in more than 10 percent of the samples from the ES and HL study areas. Another solvent, 1,1-dichloroethene (1,1-DCE), also was detected in more than 10 percent of the samples from the HL study area. The detection frequency of the gasoline oxygenate methyl *tert*-butyl ether (MTBE) was greater than 10 percent in the SH study area.



## Pesticides

Pesticides include herbicides, insecticides, and fungicides and are used to control weeds, insects, fungi, and other pests in agricultural, urban, and suburban settings. Of the 63 pesticides and pesticide degradates analyzed, 9 were detected in groundwater samples; all detections were less than health-based benchmarks ([table 7](#)). One or more pesticides or pesticide degradates were detected in 28 of the 90 CAMP study-unit grid well samples (about 31 percent detection frequency). The herbicide atrazine and its degradation product deethylatrazine were detected in more than 10 percent of the samples. Atrazine and deethylatrazine are among the nation's most commonly detected pesticide compounds in groundwater (Gilliom and others, 2006).

The six study areas of the CAMP study unit had different detection frequencies of pesticides. Five pesticides or pesticide degradates had detection frequencies greater than 10 percent in at least one study area: deethylatrazine (HL, LU, SH, and TV); atrazine (HL, SH, and TV); the herbicide hexazinone (QV, SH, and TV); and the herbicides simazine and prometon (SH) ([table 7](#)). No pesticide or pesticide degradate was detected in any of the 15 grid well samples in the ES study area in the CAMP study unit.

## Perchlorate

Perchlorate is a constituent of special interest in California because recent advances in analytical methods have resulted in detections of low concentrations in water supplies in many parts of the State (California Department of Public Health, 2011b). California established an MCL-CA for perchlorate in 2007. Perchlorate was detected in 40 of the 84 grid wells (47 percent) from which samples were collected, and all detections had concentrations less than the MCL-CA ([table 8](#)).

## Inorganic Constituents

Unlike the organic constituents, inorganic constituents generally are naturally present in groundwater, although their concentrations may be influenced by human activities. Inorganic constituents were sampled for at all 90 grid wells in the CAMP study unit.

## Nutrients

Nutrients (nitrogen and phosphorus) present in groundwater can affect biological activity in aquifers and in surface-water bodies that receive groundwater discharge. Inorganic nitrogen may be present in the form of ammonia, nitrite, or nitrate, depending on the oxidation-reduction state of the groundwater. High concentrations of nitrate or nitrite can adversely affect human health, particularly the health of infants.

All concentrations of ammonia and nitrite measured in the 90 CAMP study-unit grid wells were less than health-based benchmarks. For samples from the CAMP study unit, the measured nitrite plus nitrate concentration is equal to the nitrate concentration because all detections of nitrite had concentrations less than the reporting level for nitrite plus nitrate ([table 9](#)). Nitrate was detected at a concentration greater than the MCL-US of 10 milligrams per liter (mg/L), as nitrogen, in one HL study area grid well sample ([table 9](#)).

## Trace Elements

Seventeen of the 24 trace elements and one of the major ions analyzed and detected in the CAMP study unit have regulatory or non-regulatory health-based benchmarks ([tables 4E, F](#)). Of these 18 constituents with health-based benchmarks, five constituents were detected at concentrations greater than benchmarks: arsenic, boron, molybdenum, uranium, and vanadium ([table 10](#)). Detections of trace elements at concentrations greater than benchmarks occurred in at least one sample from the HL, SH, and TV study areas. Trace elements were not detected at concentrations greater than health-based benchmarks in the ES, LU, and QV study area well samples ([table 10](#)).

Arsenic concentrations greater than the MCL-US of 10 µg/L were detected in two HL study area grid well samples and one SH study area grid well sample ([table 10](#)). Boron concentrations greater than the NL-CA of 1,000 µg/L were detected in two TV study area grid well samples ([table 10](#)). Molybdenum concentrations greater than the HAL-US of 40 µg/L were detected in one HL and one TV study area grid well sample ([table 10](#)). Vanadium concentrations greater than the NL-CA of 50 µg/L were detected in one HL and one SH study area grid well sample ([table 10](#)).

## Uranium and Radioactive Constituents

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

Activity often is 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 1 pCi/L 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.

Twenty grid well samples from the CAMP study unit were analyzed for uranium isotopes (uranium-234, uranium-235, and uranium-238). Uranium isotope activities for two HL study area grid well samples were greater than the MCL-CA of 20 pCi/L ([table 12](#)). Uranium concentrations in these two samples were also greater than the MCL-US benchmark of 30 µg/L ([table 10](#)).

Samples from all 90 grid wells in the CAMP study unit were analyzed for radon-222. Radon-222 activity was greater than the proposed MCL-US of 4,000 pCi/L in one HL study area grid well ([table 13](#)). The proposed MCL-US applies if the state or local water agency has an approved multimedia mitigation program to address radon levels in indoor air (U.S. Environmental Protection Agency, 1999).

Samples from all 90 grid wells in the CAMP study unit were analyzed for gross alpha and gross beta particle activities; activities for almost all grid well samples were less than established health-based benchmarks. Gross alpha particle activity was detected in two HL study area grid well samples at activities greater than the MCL-US of 15 pCi/L ([table 14](#)).

### Inorganic Constituents with SMCL Benchmarks

The levels of certain trace elements, major-ion composition, and total dissolved solids (TDS) content in groundwater affect the aesthetic properties of water, such as taste, color, and odor, and the technical properties of water, 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. The CDPH has established non-enforceable benchmarks (SMCL-CAs) that are based on aesthetic properties rather than on human-health concerns for iron, manganese, silver, zinc, chloride, sulfate, and TDS. Iron and manganese are trace elements whose concentrations are affected by the oxidation-reduction state of the groundwater. Precipitation of minerals containing iron or manganese may cause orange, brown, or black staining of surfaces.

Iron concentrations greater than the SMCL-CA of 300 µg/L were detected in four grid well samples in the CAMP study unit—one from each of the ES and HL study areas and two from the LU study area ([table 10](#)). Manganese concentrations greater than the SMCL-CA of 50 µg/L were detected in nine grid well samples—four from the HL study area, two each from the LU and QV study areas, and one from the SH study area ([table 10](#)). Silver, zinc, and sulfate were not detected at concentrations greater than the SMCL-CAs in any of wells in the CAMP study unit.

TDS concentration was greater than the upper SMCL-CA of 1,000 mg/L in one TV study area grid well sample ([table 11](#)). This sample also had a chloride concentration greater than the upper SMCL-CA of 500 mg/L. Six HL, one LU, one QV, and two SH study area grid well samples had TDS concentrations between the recommended and upper SMCL-CAs.

### Geochemical and Age-Dating Tracers

Arsenic and iron occur as different species depending on the oxidation-reduction state of the groundwater. The oxidized and reduced species have different solubilities in groundwater and may have different effects on human health. The relative proportions of the oxidized and reduced species of each element can be used to aid in interpretation of the oxidation-reduction conditions of the aquifer, which affect the mobility of many constituents.

Concentrations of total dissolved arsenic and iron and the dissolved concentrations of the reduced species of the elements are reported in [table 15](#). The concentrations of the other species can be calculated by difference. The concentrations of total dissolved arsenic and iron reported in [table 10](#) are considered to be more accurate than the concentrations reported in [table 15](#) (see the appendix section titled “[Constituents on Multiple Analytical Schedules](#)”).

The isotopic ratios of water and dissolved constituents, indicators of groundwater age, and the concentrations of dissolved noble gases may be used as tracers of hydrologic processes (Clark and Fritz, 1997). The isotopic ratios of hydrogen and oxygen in water ([table 16](#)) aid in the interpretation of the sources of groundwater recharge. These stable isotopic ratios reflect the altitude, latitude, and temperature of precipitation and also the extent of evaporation of the water in surface-water bodies or soils prior to infiltration into the aquifer.

Tritium activities and carbon-14 abundance ([table 16](#)) also provide information about the age (time since recharge) of groundwater. Tritium is a short-lived radioactive isotope of hydrogen that is incorporated into the water molecule. Low levels of tritium are produced continuously by interaction of cosmic radiation with the Earth’s atmosphere, and a large amount of tritium was produced as a result of atmospheric testing of nuclear weapons between 1952 and 1963. Thus, concentrations of tritium greater than background levels generally indicate the presence of water recharged after the early 1950s. Helium isotope ratios are used in conjunction with tritium concentrations to estimate ages for young groundwater. Helium isotope ratio analyses were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

Carbon-14 is a radioactive isotope of carbon. Low levels of carbon-14 are produced continuously by interaction of cosmic radiation with the Earth’s atmosphere and are incorporated into atmospheric carbon dioxide. 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 a presence of groundwater that is several thousands of years old.

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

Of the isotopic tracer constituents analyzed for this study, tritium is the only one with a health-based benchmark. All measured tritium activities in samples from CAMP study-unit grid well samples were less than 1/100 of the MCL-CA benchmark ([table 16](#)).

## 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 bacteria responsible for diseases generally are not measured because routine analytical methods are not available. Measurements are made of more easily analyzed microbial constituents that serve as indicators of the presence of human or animal waste in water. Drinking-water purveyors respond to detections of microbial indicators by applying additional disinfection agents to the water.

The presence of the microbial indicator total coliform was detected in 9 of the 83 grid wells (11 percent) sampled for analysis of microbial indicators in the CAMP study unit: one groundwater sample from each of the ES, HL, QV, and TV study areas; two samples from the LU study area, and three samples from the SH study area ([table 17](#)). The presence of *E. coli* was also detected in the same TV grid well sample. The health-based benchmarks for microbial indicators are based on recurring detections in treated drinking water, thus, the detections reported here do not constitute a violation of the benchmarks.

## Future Work

Subsequent reports will be focused on assessment of the data presented in this report by using a variety of statistical, qualitative, and quantitative approaches to evaluate the natural and human factors affecting groundwater quality in the CAMP study unit. Water-quality data contained in the CDPH databases will be compiled, evaluated, and used in combination with the data that are presented in this report.

Additionally, these subsequent reports will include the dissolved noble gas, LLNL tritium, and helium isotope ratio results for the CAMP study unit.

## Summary

Groundwater quality in the 39,000-square-kilometer Cascade Range and Modoc Plateau (CAMP) study unit was investigated by the U.S. Geological Survey (USGS) from July through October 2010, as part of the California State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment (GAMA) Program's Priority Basin Project (PBP). The GAMA PBP was created as a result of the Groundwater Quality Monitoring Act of 2001 to assess and monitor the quality of groundwater and to provide a comprehensive baseline of groundwater quality in California. The GAMA PBP is being conducted by the USGS in cooperation with the SWRCB and Lawrence Livermore National Laboratory (LLNL).

The GAMA CAMP study unit was designed to provide a spatially unbiased assessment of untreated-groundwater quality within the primary aquifer system and to facilitate statistically consistent comparisons of untreated-groundwater quality throughout California. The primary aquifer system is defined as the depth interval of the wells listed in the California Department of Public Health (CDPH) database for the CAMP study unit. The quality of groundwater in shallow or deep water-bearing zones may differ from that in the primary aquifer system; shallow groundwater may be more vulnerable to surficial contamination.

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

The CAMP study unit is located within the Cascade Range and Modoc Plateau hydrogeologic province and includes 55 groundwater basins and subbasins defined by the California Department of Water Resources. The study unit also includes areas outside of the defined groundwater basins. The CAMP study included assessment of groundwater quality for samples from 90 wells and springs in Butte, Lassen, Modoc, Plumas, Shasta, Siskiyou, and Tehama Counties. All sites are referred to as wells in this report, unless the difference between a well and a spring is important to the discussion.



Wells were selected using a randomized grid approach to achieve a statistically unbiased representation of groundwater used for public drinking-water supplies (grid wells). Fifteen grid wells were sampled in each of the six study areas that compose the CAMP study unit: Sacramento Valley Eastside (ES), Honey Lake Valley (HL), Cascade Range and Modoc Plateau Low Use Basins (LU), Quaternary Volcanic Areas (QV), Shasta Valley and Mount Shasta Volcanic Area (SH), and Tertiary Volcanic Areas (TV).

Groundwater samples were analyzed for field water-quality indicators, organic constituents, perchlorate, inorganic constituents, radioactive constituents, and microbial indicators. Naturally occurring isotopes and dissolved noble gases also were measured to provide a dataset that will be used to help interpret the sources and ages of the sampled groundwater in subsequent reports. In total, 221 constituents were investigated for this study.

All organic constituents and most inorganic constituents that were detected in groundwater samples from the 90 grid wells in the CAMP study unit were detected at concentrations less than drinking-water benchmarks.

Of the 148 organic constituents analyzed, 27 were detected in groundwater samples; concentrations of all detected constituents were less than regulatory and nonregulatory health-based benchmarks. One or more organic constituents were detected at concentrations less than 1/10 of benchmark levels in 52 percent of the grid wells in the CAMP study unit: VOCs were detected in 30 percent, and pesticides and pesticide degradates were detected in 31 percent.

Most of the samples analyzed for inorganic and radioactive constituents had concentrations or activities less than the regulatory and the nonregulatory health-based benchmarks. All samples from the ES, LU, and QV study areas had concentrations of inorganic constituents and activities of radioactive constituents less than the regulatory and the nonregulatory health-based benchmarks. Arsenic was detected at concentrations greater than the USEPA maximum contaminant level (MCL-US) in samples from two wells in the HL study area and one well in the SH study area. Boron was detected at concentrations greater than the CDPH notification level (NL-CA) in samples from two wells in the TV study area. Molybdenum was detected at concentrations greater than the USEPA lifetime health advisory level (HAL-US) in samples from one well in the HL study area and one well in the TV study area. Vanadium was detected at concentrations greater than the NL-CA in samples from one well in the HL study area and one well in the SH study area. Uranium was detected at concentrations greater than the MCL-US and at activities greater than the CDPH maximum contaminant level (MCL-CA) in two wells from the HL study area. These HL study area samples also had gross alpha particle activities greater than the MCL-US. Radon was detected at activities greater than the proposed MCL-US in a sample from one well in the HL study area. Nitrate was detected at a concentration greater than the MCL-US in a sample from one well in the HL study area.

Most of the samples analyzed for inorganic constituents had concentrations less than the non-enforceable benchmarks set for aesthetic concerns (CDPH secondary maximum contaminant levels, SMCL-CA). Manganese was detected at concentrations greater than the SMCL-CA in samples from a total of nine wells in the HL, LU, QV, and SH study areas, and iron was detected at concentrations greater than the SMCL-CA in samples from a total of four wells in the ES, HL, and LU study areas. Total dissolved solids (TDS) and chloride were detected at concentrations greater than their respective upper SMCL-CAs in one well from the TV study area. Samples from a total of 10 wells in the HL, LU, QV, and SH study areas had concentrations of TDS between the recommended and upper SMCL-CAs.

Microbial indicator (total coliform and *Escherichia coli* [*E. coli*]) samples were collected from 83 grid wells. Total coliform was detected in 9 of the 83 grid wells (1 from each of the ES, HL, QV, and TV study areas, 2 from the LU study area, and 3 from the SH study area). *E. coli* was also detected in the same grid well sample from the TV study area in which total coliform was detected.

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## Tables

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**Table 1.** Study area names, study area and grid cell sizes, and numbers of CDPH wells and USGS-grid wells in each study area, Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.[CDPH, California Department of Public Health; USGS, U.S. Geological Survey; km<sup>2</sup>, square kilometers]

Study area	Code	Area (km <sup>2</sup> )	Buffered area (km <sup>2</sup> )	Cell area (km <sup>2</sup> )	Number of CDPH wells	Number of USGS-grid wells
Sacramento Valley Eastside	CAMP-ES	2,004	287	19	33	15
Honey Lake Valley	CAMP-HL	1,261	270	18	50	15
Cascade Range and Modoc Plateau Low Use Basins	CAMP-LU	4,826	510	34	68	15
Quaternary Volcanic Areas	CAMP-QV	10,399	711	47	98	15
Shasta Valley and Mount Shasta Volcanic Area	CAMP-SH	878	369	25	61	15
Tertiary Volcanic Areas	CAMP-TV	10,985	517	34	59	15

**Table 2.** Identification, sampling, and construction information for wells sampled for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[GAMA well identification number: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area. **Other abbreviations:** >, greater than; ≥, greater than or equal to; ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum of 1988; na, not available]

Sampling information				Construction information		
GAMA well identification number	Date sampled (mm-dd-yy)	Altitude of LSD (ft above NAVD 88) <sup>1</sup>	Well type	Well depth (ft below LSD)	Top of open or screened interval (ft below LSD)	Bottom of open or screened interval (ft below LSD)
<b>CAMP Sacramento Valley Eastside study area (15 grid wells sampled)</b>						
CAMP-ES-01	09-13-10	2,351	Production	400	65	400
CAMP-ES-02	09-13-10	1,686	Production	325	60	325
CAMP-ES-03	09-14-10	2,267	Spring	na	na	na
CAMP-ES-04	09-16-10	383	Production	475	160	475
CAMP-ES-05	09-20-10	1,934	Production	550	395	525
CAMP-ES-06	09-20-10	2,602	Production	930	823	930
CAMP-ES-07	09-21-10	3,089	Production	80	60	80
CAMP-ES-08	10-04-10	3,328	Production	386	346	386
CAMP-ES-09	10-04-10	1,524	Production	730	500	730
CAMP-ES-10	10-05-10	1,520	Production	770	495	760
CAMP-ES-11	10-05-10	2,306	Production	480	440	480
CAMP-ES-12	10-06-10	2,821	Production	995	93	995
CAMP-ES-13	10-06-10	2,054	Production	96	na	na
CAMP-ES-14	10-07-10	413	Production	<sup>2</sup> > 285	na	na
CAMP-ES-15	10-12-10	294	Production	480	206	470
<b>CAMP Honey Lake Valley study area</b>						
CAMP-HL-01	08-10-10	4,031	Production	300	50	300
CAMP-HL-02	08-11-10	4,344	Production	240	140	240
CAMP-HL-03	08-11-10	4,144	Production	<sup>2</sup> > 180	na	na
CAMP-HL-04	08-12-10	4,097	Production	600	55	600
CAMP-HL-05	08-18-10	4,139	Production	190	190	190
CAMP-HL-06	08-18-10	4,106	Production	56	40	56
CAMP-HL-07	08-19-10	4,011	Production	200	60	200
CAMP-HL-08	08-19-10	4,006	Production	208	60	208



**Table 2.** Identification, sampling, and construction information for wells sampled for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—Continued

[GAMA well identification number: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area. **Other abbreviations:** >, greater than; ≥, greater than or equal to; ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum of 1988; na, not available]

Sampling information				Construction information		
GAMA well identification number	Date sampled (mm-dd-yy)	Altitude of LSD (ft above NAVD 88) <sup>1</sup>	Well type	Well depth (ft below LSD)	Top of open or screened interval (ft below LSD)	Bottom of open or screened interval (ft below LSD)
<b>CAMP Honey Lake Valley study area—Continued</b>						
CAMP-HL-09	08-23-10	4,133	Production	530	220	520
CAMP-HL-10	08-23-10	4,123	Production	545	na	na
CAMP-HL-11	08-24-10	4,050	Production	225	165	205
CAMP-HL-12	08-24-10	4,223	Production	246	50	246
CAMP-HL-13	08-31-10	4,474	Production	130	na	na
CAMP-HL-14	08-31-10	4,093	Production	102	na	na
CAMP-HL-15	09-01-10	4,058	Production	120	110	120
<b>CAMP Cascade Range and Modoc Plateau Low Use Basins study area</b>						
CAMP-LU-01	07-19-10	4,247	Production	1,236	840	1,236
CAMP-LU-02	07-19-10	4,038	Production	2,664	2,546	2,664
CAMP-LU-03	07-21-10	4,379	Production	670	350	670
CAMP-LU-04	07-21-10	4,666	Production	353	126	350
CAMP-LU-05	07-22-10	4,391	Production	500	220	500
CAMP-LU-06	07-22-10	4,317	Production	220	180	220
CAMP-LU-07	07-27-10	4,259	Production	87	59	87
CAMP-LU-08	07-29-10	4,184	Spring	na	na	na
CAMP-LU-09	08-02-10	4,400	Production	310	100	310
CAMP-LU-10	08-03-10	4,052	Production	343	100	338
CAMP-LU-11	08-04-10	4,225	Production	184	na	na
CAMP-LU-12	08-05-10	4,127	Production	146	54	146
CAMP-LU-13	08-09-10	4,124	Production	<sup>3</sup> 345	95	110
CAMP-LU-14	08-30-10	4,549	Production	235	162	222
CAMP-LU-15	08-30-10	4,528	Production	371	228	360
<b>CAMP Quaternary Volcanic Areas study area</b>						
CAMP-QV-01	07-20-10	6,887	Spring	na	na	na
CAMP-QV-02	07-29-10	4,919	Spring	na	na	na
CAMP-QV-03	08-02-10	5,014	Production	740	400	740
CAMP-QV-04	08-03-10	4,090	Production	325	211	325
CAMP-QV-05	08-09-10	3,200	Production	226	226	226
CAMP-QV-06	08-12-10	4,197	Production	<sup>2</sup> ≥ 800	<sup>2</sup> 800	<sup>2</sup> ≥ 800
CAMP-QV-07	08-17-10	3,258	Production	300	250	300
CAMP-QV-08	08-17-10	3,218	Production	244	184	244
CAMP-QV-09	08-25-10	4,985	Spring	na	na	na
CAMP-QV-10	09-13-10	2,260	Production	174	47	174
CAMP-QV-11	09-13-10	3,338	Production	170	110	170
CAMP-QV-12	09-14-10	2,588	Production	232	3	232
CAMP-QV-13	09-14-10	2,957	Production	184	164	184
CAMP-QV-14	09-15-10	4,715	Production	465	240	465
CAMP-QV-15	09-20-10	3,728	Production	150	22	150

**Table 2.** Identification, sampling, and construction information for wells sampled for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—Continued

[GAMA well identification number: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area. **Other abbreviations:** >, greater than; ≥, greater than or equal to; ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum of 1988; na, not available]

Sampling information				Construction information		
GAMA well identification number	Date sampled (mm-dd-yy)	Altitude of LSD (ft above NAVD 88) <sup>1</sup>	Well type	Well depth (ft below LSD)	Top of open or screened interval (ft below LSD)	Bottom of open or screened interval (ft below LSD)
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area</b>						
CAMP-SH-01	07-12-10	2,744	Production	120	12	120
CAMP-SH-02	07-13-10	2,952	Production	232	80	232
CAMP-SH-03	07-13-10	2,779	Production	107	na	na
CAMP-SH-04	07-14-10	3,721	Production	450	200	450
CAMP-SH-05	07-14-10	3,778	Spring	na	na	na
CAMP-SH-06	07-15-10	3,684	Production	328	288	328
CAMP-SH-07	07-15-10	4,465	Spring	na	na	na
CAMP-SH-08	07-26-10	3,302	Production	<sup>2</sup> > 40	na	na
CAMP-SH-09	07-27-10	2,576	Production	230	30	225
CAMP-SH-10	07-28-10	2,841	Production	309	132	267
CAMP-SH-11	07-28-10	2,762	Production	<sup>6</sup> > 52	52	na
CAMP-SH-12	09-22-10	2,642	Production	150	na	na
CAMP-SH-13	09-23-10	2,604	Spring	na	na	na
CAMP-SH-14	10-13-10	3,844	Production	140	120	140
CAMP-SH-15	10-14-10	2,568	Production	<sup>4</sup> 121	na	na
<b>CAMP Tertiary Volcanic Areas study area</b>						
CAMP-TV-01	07-12-10	2,690	Production	218	175	218
CAMP-TV-02	08-04-10	2,953	Production	<sup>4</sup> > 450	na	na
CAMP-TV-03	08-05-10	978	Spring <sup>5</sup>	na	na	na
CAMP-TV-04	08-16-10	3,455	Production	300	na	na
CAMP-TV-05	08-16-10	4,266	Production	300	210	290
CAMP-TV-06	08-25-10	4,823	Production	380	305	380
CAMP-TV-07	08-26-10	6,262	Production	230	50	230
CAMP-TV-08	09-01-10	5,173	Production	200	na	na
CAMP-TV-09	09-02-10	4,564	Production	403	158	400
CAMP-TV-10	09-02-10	4,551	Production	<sup>2</sup> > 300	na	na
CAMP-TV-11	09-15-10	3,767	Production	202	87	202
CAMP-TV-12	09-15-10	4,321	Production	210	170	210
CAMP-TV-13	09-16-10	4,220	Production	<sup>2</sup> 135	na	na
CAMP-TV-14	09-21-10	3,284	Production	175	155	170
CAMP-TV-15	10-13-10	2,273	Production	275	54	275

<sup>1</sup> Land surface datum (LSD) is a datum plane that is approximately at land surface at each well. The altitude of the LSD is described in feet above the North American Vertical Datum of 1988.

<sup>2</sup> Estimated from well owner records; no driller's log available.

<sup>3</sup> Driller's log (1978) gives initial well depth as 500 ft; well owner reported video log (2005) showing current depth of 345 ft.

<sup>4</sup> Estimated from measurement of well depth by USGS; no driller's log available.

<sup>5</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

<sup>6</sup> Driller's log (1972) reports installation of sanitary seal to depth of 52 ft in an existing well. Owner reports hole depth and well depth greater than 52 ft.

**Table 3.** Classes of chemical constituents and field water-quality indicators collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

Constituent classes	Constituent list table	Results table
<b>Field water-quality indicators</b>		
Dissolved oxygen, temperature, pH, and specific conductance		5
<b>Organic and special-interest constituents</b>		
Volatile organic compounds (VOC)	<a href="#">4A</a>	6
Pesticides and pesticide degradates	<a href="#">4B</a>	7
Perchlorate	<a href="#">4C</a>	8
<b>Inorganic constituents</b>		
Nutrients	<a href="#">4D</a>	9
Trace elements	<a href="#">4E</a>	10
Major and minor ions, silica, and total dissolved solids (TDS)	<a href="#">4F</a>	11
Alkalinity (measured in field and laboratory)	<a href="#">4F</a>	5
Uranium isotopes	<a href="#">4G</a>	12
Radon-222	<a href="#">4G</a>	13
Gross alpha and gross beta particle activities	<a href="#">4G</a>	14
<b>Geochemical and age-dating tracers</b>		
Arsenic and iron species	<a href="#">4H</a>	15
Stable isotopes of hydrogen ( $\delta^2\text{H}$ ) and oxygen ( $\delta^{18}\text{O}$ ) of water	<a href="#">4I</a>	16
$\delta^{13}\text{C}$ of inorganic carbon dissolved in water and carbon-14 abundance	<a href="#">4I</a>	16
$\delta^{11}\text{B}$ of boron and $^{87}\text{Sr}/^{86}\text{Sr}$ of strontium dissolved in water	<a href="#">4I</a>	none <sup>(1)</sup>
Tritium	<a href="#">4G</a>	16
Dissolved noble gases	<a href="#">4I</a>	none <sup>(1)</sup>
<b>Microbial constituents</b>		
<i>Escherichia coli</i> ( <i>E. coli</i> ) and total coliform	<a href="#">4J</a>	17

<sup>1</sup> Results will be presented in a subsequent publication.

**Table 4A.** Volatile organic compounds (VOCs), primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2020.

[The five-digit **USGS** parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk specific dose at a risk factor of  $10^{-5}$ . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples ([table 6](#)); na, not available;  $\mu\text{g/L}$ , micrograms per liter; –, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number <sup>1</sup>	LRL ( $\mu\text{g/L}$ ) <sup>2</sup>	Benchmark type	Benchmark level ( $\mu\text{g/L}$ )	Detection
Acetone	Solvent	81552	67-64-1	3.4	na	na	– <sup>(3)</sup>
Acrylonitrile	Organic synthesis	34215	107-13-1	0.8	RSD5-US	0.6	–
<i>tert</i> -Amyl methyl ether (TAME)	Gasoline oxygenate	50005	994-05-8	0.06	na	na	–
Benzene	Gasoline hydrocarbon	34030	71-43-2	0.026	MCL-CA	1	D
Bromobenzene	Solvent	81555	108-86-1	0.022	na	na	–
Bromochloromethane	Fire retardant	77297	74-97-5	0.06	HAL-US	90	–
Bromodichloromethane	Disinfection byproduct (THM)	32101	75-27-4	0.034	MCL-US	<sup>5</sup> 80	–
Bromoform (Tribromomethane)	Disinfection byproduct (THM)	32104	75-25-2	0.1	MCL-US	<sup>5</sup> 80	–
Bromomethane (Methyl bromide)	Fumigant	34413	74-83-9	0.2, 0.20	HAL-US	10	–
<i>n</i> -Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	0.08	NL-CA	260	–
<i>sec</i> -Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	0.034	NL-CA	260	–
<i>tert</i> -Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	0.06, 0.060	NL-CA	260	–
Carbon disulfide	Natural, organic synthesis	77041	75-15-0	0.04, 0.08	NL-CA	160	D
Carbon tetrachloride (Tetrachloromethane)	Solvent	32102	56-23-5	0.052, 0.06	MCL-CA	0.5	–
Chlorobenzene	Solvent	34301	108-90-7	0.016, 0.026	MCL-CA	70	–
Chloroethane	Solvent	34311	75-00-3	0.06	na	na	–
Chloroform (Trichloromethane)	Disinfection byproduct (THM)	32106	67-66-3	0.03	MCL-US	<sup>5</sup> 80	D
Chloromethane	Solvent	34418	74-87-3	0.14	HAL-US	30	–
3-Chloropropene	Organic synthesis	78109	107-05-1	0.08	na	na	–
2-Chlorotoluene	Solvent	77275	95-49-8	0.028	NL-CA	140	–
4-Chlorotoluene	Solvent	77277	106-43-4	0.042	NL-CA	140	–
Dibromochloromethane	Disinfection byproduct (THM)	32105	124-48-1	0.12	MCL-US	<sup>5</sup> 80	–
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	0.34, 0.40	MCL-US	0.2	–
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.05, 0.028	MCL-US	0.05	–
Dibromomethane	Solvent	30217	74-95-3	0.05, 0.050	na	na	–
1,2-Dichlorobenzene	Solvent	34536	95-50-1	0.028	MCL-CA	600	–
1,3-Dichlorobenzene	Solvent	34566	541-73-1	0.024	HAL-US	600	–
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	0.026	MCL-CA	5	D
<i>trans</i> -1,4-Dichloro-2-butene	Organic synthesis	73547	110-57-6	0.36	na	na	–
Dichlorodifluoromethane (CFC-12)	Refrigerant	34668	75-71-8	0.1	NL-CA	1,000	–
1,1-Dichloroethane (1,1-DCA)	Solvent	34496	75-34-3	0.044	MCL-CA	5	–



**Table 4A.** Volatile organic compounds (VOCs), primary uses or sources, comparative benchmarks, 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. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk specific dose at a risk factor of 10<sup>-5</sup>. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples ([table 6](#)); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number <sup>1</sup>	LRL (µg/L) <sup>2</sup>	Benchmark type	Benchmark level (µg/L)	Detection
1,2-Dichloroethane (1,2-DCA)	Solvent	32103	107-06-2	0.08	MCL-CA	0.5	—
1,1-Dichloroethene (1,1-DCE)	Organic synthesis	34501	75-35-4	0.022	MCL-CA	6	D
<i>cis</i> -1,2-Dichloroethene ( <i>cis</i> -1,2-DCE)	Solvent	77093	156-59-2	0.022	MCL-CA	6	—
<i>trans</i> -1,2-Dichloroethene ( <i>trans</i> -1,2-DCE)	Solvent	34546	156-60-5	0.018	MCL-CA	10	—
1,2-Dichloropropane	Fumigant	34541	78-87-5	0.026	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	0.03, 0.040	na	na	—
<i>cis</i> -1,3-Dichloropropene	Fumigant	34704	10061-01-5	0.1	RSD5-US	<sup>6</sup> 4	—
<i>trans</i> -1,3-Dichloropropene	Fumigant	34699	10061-02-6	0.14	RSD5-US	<sup>6</sup> 4	—
Diethyl ether	Solvent	81576	60-29-7	0.08, 0.1	na	na	—
Diisopropyl ether (DIPE)	Gasoline oxygenate	81577	108-20-3	0.06	na	na	—
Ethylbenzene	Gasoline hydrocarbon	34371	100-41-4	0.036	MCL-CA	300	—
Ethyl <i>tert</i> -butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.032	na	na	—
Ethyl methacrylate	Organic synthesis	73570	97-63-2	0.14	na	na	—
2-Ethyltoluene	Gasoline hydrocarbon	77220	611-14-3	0.032	na	na	D
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 ( <i>n</i> -Butyl methyl ketone)	Solvent	77103	591-78-6	0.46, 0.4	na	na	—
Iodomethane (Methyl iodide)	Organic synthesis	77424	74-88-4	0.26	na	na	—
Isopropylbenzene	Gasoline hydrocarbon	77223	98-82-8	0.042	NL-CA	770	D
4-Isopropyltoluene	Gasoline hydrocarbon	77356	99-87-6	0.06	na	na	D
Methyl acrylate	Organic synthesis	49991	96-33-3	0.56, 0.8	na	na	—
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	0.26	na	na	—
Methyl <i>tert</i> -butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.1	MCL-CA	13	D
Methyl <i>iso</i> -butyl ketone (MIBK)	Solvent	78133	108-10-1	0.32	NL-CA	120	—
Methylene chloride (Dichloromethane)	Solvent	34423	75-09-2	0.038, 0.04	MCL-US	5	D

**Table 4A.** Volatile organic compounds (VOCs), primary uses or sources, comparative benchmarks, 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. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk specific dose at a risk factor of 10<sup>-5</sup>. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples ([table 6](#)); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number <sup>1</sup>	LRL (µg/L) <sup>2</sup>	Benchmark type	Benchmark level (µg/L)	Detection
Methyl ethyl ketone (2-butanone, MEK)	Solvent	81595	78-93-3	1.6	HAL-US	4,000	—
Methyl methacrylate	Organic synthesis	81597	80-62-6	0.22	na	na	—
Naphthalene	Gasoline hydrocarbon	34696	91-20-3	0.18	NL-CA	17	—
Perchloroethene (PCE, Tetrachloroethene)	Solvent	34475	127-18-4	0.026	MCL-US	5	D
<i>n</i> -Propylbenzene	Gasoline hydrocarbon	77224	103-65-1	0.036	NL-CA	260	D
Styrene	Gasoline hydrocarbon	77128	100-42-5	0.03, 0.042	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	0.14	MCL-CA	1	—
Tetrahydrofuran	Solvent	81607	109-99-9	1.4	na	na	— <sup>(3)</sup>
1,2,3,4-Tetramethylbenzene	Gasoline hydrocarbon	49999	488-23-3	0.08, 0.1	na	na	D
1,2,3,5-Tetramethylbenzene	Gasoline hydrocarbon	50000	527-53-7	0.08	na	na	D
Toluene	Gasoline hydrocarbon	34010	108-88-3	0.018	MCL-CA	150	— <sup>(4)</sup>
1,2,3-Trichlorobenzene	Organic synthesis	77613	87-61-6	0.06	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	0.03, 0.030	MCL-CA	200	D
1,1,2-Trichloroethane (1,1,2-TCA)	Solvent	34511	79-00-5	0.046, 0.028	MCL-CA	5	—
Trichloroethene (TCE)	Solvent	39180	79-01-6	0.022	MCL-US	5	—
Trichlorofluoromethane (CFC-11)	Refrigerant	34488	75-69-4	0.08	MCL-CA	150	—
1,2,3-Trichloropropane (1,2,3-TCP)	Fumigant, solvent	77443	96-18-4	0.12	HAL-US <sup>7</sup>	40	—
Trichlorotrifluoroethane (CFC-113)	Refrigerant	77652	76-13-1	0.034	MCL-CA	1,200	D
1,2,3-Trimethylbenzene	Gasoline hydrocarbon	77221	526-73-8	0.06, 0.060	na	na	D
1,2,4-Trimethylbenzene	Gasoline hydrocarbon	77222	95-63-6	0.032	NL-CA	330	— <sup>(4)</sup>
1,3,5-Trimethylbenzene	Gasoline hydrocarbon	77226	108-67-8	0.032	NL-CA	330	D
Vinyl bromide (Bromoethene)	Organic synthesis	50002	593-60-2	0.12	na	na	—
Vinyl chloride (Chloroethene)	Organic synthesis	39175	75-01-4	0.06	MCL-CA	0.5	—
<i>m</i> - and <i>p</i> -Xylene	Gasoline hydrocarbon	85795	108-38-3 / 106-42-3	0.08	MCL-CA	<sup>8</sup> 1,750	—
<i>o</i> -Xylene	Gasoline hydrocarbon	77135	95-47-6	0.032	MCL-CA	<sup>8</sup> 1,750	—

**Table 4A.** Volatile organic compounds (VOCs), primary uses or sources, comparative benchmarks, 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. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk specific dose at a risk factor of 10<sup>-5</sup>. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples ([table 6](#)); na, not available; µg/L, micrograms per liter; –, not detected]

**Footnotes:**

<sup>1</sup> This report contains CAS Registry Numbers® (CASRNs), which is a Registered Trademark of the American Chemical Society. CAS recommends the verification of the CASRNs through CAS Client Services<sup>SM</sup>.

<sup>2</sup> For constituents with two LRLs listed, the first value was in use before 10/01/2010, and the second value was in use after 10/01/2010. The highest LRL is used for this report.

<sup>3</sup> All detections of these constituents were reviewed and rejected (Fram and others, 2012).

<sup>4</sup> All detections of these constituents in samples from the CAMP study unit had concentrations less than the study reporting levels (SRLs). The SRLs are 0.69 µg/L for toluene and 0.56 µg/L for 1,2,4-trimethylbenzene (Fram and others, 2012).

<sup>5</sup> The MCL-US benchmark for trihalomethanes is the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

<sup>6</sup> The RSD5-US benchmark for 1,3-dichloropropene is the sum of its isomers (*cis* and *trans*).

<sup>7</sup> In earlier reports in this series, the NL-CA (0.005 µg/L) was used as the comparison benchmark for 1,2,3-TCP.

<sup>8</sup> The MCL-CA benchmark for *m*- and *p*-Xylene and *o*-Xylene is the sum of all three xylene compounds.

**Table 4B.** Pesticides and pesticide degradates, primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2003.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Laboratory reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, USEPA maximum contaminant level; RSD5-US, USEPA 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 7](#)); na, not available;  $\mu\text{g/L}$ , micrograms per liter; –, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL ( $\mu\text{g/L}$ ) <sup>1</sup>	Benchmark type	Benchmark level ( $\mu\text{g/L}$ )	Detection
Acetochlor	Herbicide	49260	34256-82-1	0.010	na	na	–
Alachlor	Herbicide	46342	15972-60-8	0.008	MCL-US	2	–
Atrazine	Herbicide	39632	1912-24-9	0.007, 0.008	MCL-CA	1	D
Azinphos-methyl	Insecticide	82686	86-50-0	0.12	na	na	–
Azinphos-methyl oxon	Insecticide degradate	61635	961-22-8	0.042	na	na	–
Benfluralin	Herbicide	82673	1861-40-1	0.014	na	na	–
Carbaryl	Insecticide	82680	63-25-2	0.06	RSD5-US	400	D
2-Chloro-2,6-diethylacetanilide	Herbicide degradate	61618	6967-29-9	0.010	na	na	–
4-Chloro-2-methylphenol	Herbicide degradate	61633	1570-64-5	0.0032, 0.0046	na	na	–
Chlorpyrifos	Insecticide	38933	2921-88-2	0.010, 0.036	HAL-US	2	–
Chlorpyrifos oxon	Insecticide degradate	61636	5598-15-2	0.05, 0.06	na	na	– <sup>(2)</sup>
Cyfluthrin	Insecticide	61585	68359-37-5	0.016	na	na	– <sup>(2)</sup>
Cypermethrin	Insecticide	61586	52315-07-8	0.020	na	na	– <sup>(2)</sup>
Dacthal (DCPA)	Herbicide	82682	1861-32-1	0.0076	HAL-US	70	–
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino- <i>s</i> -triazine)	Herbicide degradate	04040	6190-65-4	0.014, 0.006	na	na	D
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, 0.0060	NL-CA	1.2	–
3,4-Dichloroaniline	Herbicide degradate	61625	95-76-1	0.0042	na	na	D
Dichlorvos	Insecticide	38775	62-73-7	0.02, 0.04	na	na	– <sup>(2)</sup>
Dicrotophos	Insecticide	38454	141-66-2	0.08	na	na	– <sup>(2)</sup>
Dieldrin	Insecticide	39381	60-57-1	0.009, 0.008	RSD5-US	0.02	–
2,6-Diethylaniline	Herbicide degradate	82660	579-66-8	0.006, 0.0060	na	na	–
Dimethoate	Insecticide	82662	60-51-5	0.006	na	na	– <sup>(2)</sup>
Ethion	Insecticide	82346	563-12-2	0.008	na	na	–
Ethion monoxon	Insecticide degradate	61644	17356-42-2	0.021	na	na	–
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	0.0098, 0.010	na	na	–
Fenamiphos	Insecticide	61591	22224-92-6	0.030	HAL-US	0.7	–
Fenamiphos sulfone	Insecticide degradate	61645	31972-44-8	0.053, 0.054	na	na	–
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	0.08	na	na	– <sup>(2)</sup>
Fipronil	Insecticide	62166	120068-37-3	0.018	na	na	–
Fipronil sulfide	Insecticide degradate	62167	120067-83-6	0.013, 0.012	na	na	–
Fipronil sulfone	Insecticide degradate	62168	120068-36-2	0.024	na	na	–
Fonofos	Insecticide	04095	944-22-9	0.0044, 0.0048	HAL-US	10	–



**Table 4B.** Pesticides and pesticide degradates, primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2003.—Continued

[The five-digit **USGS parameter code** is used to uniquely identify a specific constituent or property. Laboratory reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, USEPA maximum contaminant level; RSD5-US, USEPA 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 7](#)); na, not available; µg/L, micrograms per liter; –, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L) <sup>1</sup>	Benchmark type	Benchmark level (µg/L)	Detection
Hexazinone	Herbicide	04025	51235-04-2	0.008	HAL-US	400	D <sup>(2)</sup>
Iprodione	Fungicide	61593	36734-19-7	0.014	na	na	–
Isofenphos	Insecticide	61594	25311-71-1	0.006	na	na	–
Malaoxon	Insecticide degradate	61652	1634-78-2	0.08, 0.022	na	na	–
Malathion	Insecticide	39532	121-75-5	0.016	HAL-US	100	–
Metalaxyl	Fungicide	61596	57837-19-1	0.007, 0.014	na	na	D
Methidathion	Insecticide	61598	950-37-8	0.006, 0.012	na	na	–
Metolachlor	Herbicide	39415	51218-45-2	0.014, 0.020	HAL-US	700	–
Metribuzin	Herbicide	82630	21087-64-9	0.012	HAL-US	70	–
Myclobutanil	Fungicide	61599	88671-89-0	0.010	na	na	–
1-Naphthol	Insecticide degradate	49295	90-15-3	0.036	na	na	– <sup>(2)</sup>
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	0.010, 0.014	na	na	–
Parathion-methyl	Insecticide	82667	298-00-0	0.008	HAL-US	1	–
Pendimethalin	Herbicide	82683	40487-42-1	0.012	na	na	–
<i>cis</i> -Permethrin	Insecticide	82687	54774-45-7	0.014, 0.010	na	na	– <sup>(2)</sup>
Phorate	Insecticide	82664	298-02-2	0.02, 0.020	na	na	–
Phorate oxon	Insecticide degradate	61666	2600-69-3	0.027	na	na	–
Phosmet	Insecticide	61601	732-11-6	0.034, 0.14	na	na	– <sup>(2)</sup>
Phosmet oxon	Insecticide degradate	61668	3735-33-9	0.0511	na	na	– <sup>(2)</sup>
Prometon	Herbicide	04037	1610-18-0	0.012	HAL-US	100	D
Prometryn	Herbicide	04036	7287-19-6	0.006	na	na	–
Pronamide (Propyzamide)	Herbicide	82676	23950-58-5	0.0036	RSD5-US	20	–
Simazine	Herbicide	04035	122-34-9	0.006	MCL-US	4	D
Tebuthiuron	Herbicide	82670	34014-18-1	0.028	HAL-US	500	D <sup>(3)</sup>
Terbufos	Insecticide	82675	13071-79-9	0.018	HAL-US	0.4	–
Terbufos oxon sulfone	Insecticide degradate	61674	56070-15-6	0.045	na	na	–
Terbuthylazine	Herbicide	04022	5915-41-3	0.006, 0.0060	na	na	–
Tribufos	Defoliant	61610	78-48-8	0.018	na	na	– <sup>(2)</sup>
Trifluralin	Herbicide	82661	1582-09-8	0.018	HAL-US	10	–

<sup>1</sup> For constituents with two LRLs listed, the first value was in use before 10/01/2010, and the second value was in use after 10/01/2010. The highest LRL is used for this report.

<sup>2</sup> 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.

<sup>3</sup> The median matrix-spike recovery was greater than 130 percent. High recoveries may indicate that reported values could be greater than what is in the sample.

**Table 4C.** Perchlorate, primary uses or sources, comparative benchmarks, and reporting information for Weck Laboratories, Inc., analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; MRL, minimum reporting level; µg/L, micrograms per liter D, detected in groundwater samples ([table 8](#))]

Constituent	Primary use or source	USGS parameter code	CAS number	MRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Perchlorate	Rocket fuel, fireworks, natural	63790	14797-73-0	0.10	MCL-CA	6	D

**Table 4D.** Nutrients, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2755.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-US, USEPA maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LT-MDL, long-term method detection level; D, detected in groundwater samples ([table 9](#)); na, not available; mg/L, milligrams per liter]

Constituent	USGS parameter code	CAS number	LT-MDL (mg/L) <sup>1</sup>	Benchmark type	Benchmark level (mg/L)	Detection
Ammonia (as nitrogen)	00608	7664-41-7	0.01, 0.010	HAL-US	<sup>2</sup> 24.7	D
Nitrite (as nitrogen)	00613	14797-65-0	0.001, 0.0010	MCL-US	1	D
Nitrate plus nitrite (as nitrogen)	00631	na	0.02, 0.020	MCL-US	10	D
Total nitrogen (ammonia, nitrite, nitrate, organic nitrogen)	62854	17778-88-0	0.05	na	na	D
Phosphate, orthophosphate (as phosphorus)	00671	14265-44-2	0.004	na	na	D

<sup>1</sup> For constituents with two LT-MDLs listed, the first value was in use before 10/01/2010, and the second value was in use after 10/01/2010. The highest LT-MDL is used for this report. Nitrite has a method detection level (MDL), rather than an LT-MDL.

<sup>2</sup> The HAL-US is 30 mg/L “as ammonia.” To facilitate comparison to the analytical results, this HAL-US has been converted and reported as 24.7 mg/L “as nitrogen.”

**Table 4E.** Trace elements, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; LT-MDL, long-term method detection level; D, detected in groundwater samples ([table 10](#)); na, not available; µg/L, micrograms per liter]

Constituent	USGS parameter code	CAS number	LT-MDL (µg/L) <sup>1</sup>	Benchmark type	Benchmark level (µg/L)	Detection
Aluminum	01106	7429-90-5	1.7	MCL-CA	1,000	D
Antimony	01095	7440-36-0	0.027	MCL-US	6	D
Arsenic	01000	7440-38-2	0.022	MCL-US	10	D
Barium	01005	7440-39-3	0.07	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	0.006	MCL-US	4	D
Boron	01020	7440-42-8	1.4, 3	NL-CA	1,000	D
Cadmium	01025	7440-43-9	0.01, 0.016	MCL-US	5	D
Chromium	01030	7440-47-3	0.06	MCL-CA	50	D
Cobalt	01035	7440-48-4	0.005, 0.02	na	na	D
Copper	01040	7440-50-8	0.5	AL-US	1,300	D
Iron	01046	7439-89-6	3, 3.2	SMCL-CA	300	D
Lead	01049	7439-92-1	0.015	AL-US	15	D
Lithium	01130	7439-93-2	0.22	na	na	D
Manganese	01056	7439-96-5	0.13	SMCL-CA	50	D
Molybdenum	01060	7439-98-7	0.014	HAL-US	40	D
Nickel	01065	7440-02-0	0.06, 0.09	MCL-CA	100	D
Selenium	01145	7782-49-2	0.020, 0.03	MCL-US	50	D
Silver	01075	7440-22-4	0.005	SMCL-CA	100	D
Strontium	01080	7440-24-6	0.20, 0.2	HAL-US	4,000	D
Thallium	01057	7440-28-0	0.010	MCL-US	2	D
Tungsten	01155	7440-33-7	0.010	na	na	D
Uranium	22703	7440-61-1	0.004	MCL-US	30	D
Vanadium	01085	7440-62-2	0.08	NL-CA	50	D
Zinc	01090	7440-66-6	1.4	SMCL-CA <sup>2</sup>	5,000	D

<sup>1</sup> For constituents with two LT-MDLs listed, the first value was in use before 10/01/2010, and the second value was in use after 10/01/2010. The highest LT-MDL is used for this report.

<sup>2</sup> The secondary maximum contaminant level (SMCL) for zinc is listed as SMCL-CA because SMCLs established by CDPH are used in this report for all constituents that have SMCL-CA values.

**Table 4F.** Major and minor ions, silica, total dissolved solids (TDS), and alkalinity, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Laboratory reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LT-MDL, long-term method detection level; D, detected in groundwater samples ([table 11](#)); na, not available; mg/L, milligrams per liter]

Constituent	USGS parameter code	CAS number	LT-MDL (mg/L) <sup>1</sup>	Benchmark type	Benchmark level (mg/L)	Detection
Bromide	71870	24959-67-9	0.01, 0.010	na	na	D
Calcium	00915	7440-70-2	0.022	na	na	D
Chloride	00940	16887-00-6	0.06	SMCL-CA	<sup>2</sup> 250 (500)	D
Fluoride	00950	16984-48-8	0.04	MCL-CA	2	D
Iodide	71865	7553-56-2	0.001, 0.0010	na	na	D
Magnesium	00925	7439-95-4	0.008	na	na	D
Potassium	00935	7440-09-7	0.032, 0.022	na	na	D
Silica (as SiO <sub>2</sub> )	00955	7631-86-9	0.029	na	na	D
Sodium	00930	7440-23-5	0.05, 0.06	na	na	D
Sulfate	00945	14808-79-8	0.09	SMCL-CA	<sup>2</sup> 250 (500)	D
Total dissolved solids (TDS)	70300	na	10, 12	SMCL-CA	<sup>2</sup> 500 (1,000)	D
Laboratory alkalinity (as CaCO <sub>3</sub> ) <sup>3</sup>	29801	na	4, 4.0	na	na	D

<sup>1</sup> For constituents with two LT-MDLs listed, the first value was in use before 10/01/2010, and the second value was in use after 10/01/2010. The highest LT-MDL is used for this report. Total dissolved solids has a method reporting level (MRL), rather than an LT-MDL.

<sup>2</sup> The recommended SMCL-CA benchmarks for chloride, sulfate, and TDS are listed with the upper SMCL-CA benchmarks in parentheses.

<sup>3</sup> Laboratory alkalinity results are presented in [table 5](#).



**Table 4G.** Radioactive constituents, comparative benchmarks, and reporting information for laboratory analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CAS, chemical Abstract Service; ssL<sub>C</sub>, sample-specific critical level; CSU, combined standard uncertainty; pCi/L, picocuries per liter; D, detected in groundwater samples ([tables 12, 13, 14, and 16](#))]

Constituent <sup>1</sup>	USGS parameter code	CAS number	Reporting level	Reporting uncertainty	Benchmark type	Benchmark level	Detection
Radon-222 <sup>2</sup>	82303	14859-67-7	ssL <sub>C</sub>	CSU	Proposed MCL-US	4,000	D
Gross alpha particle activity, 72-hour and 30-day counts <sup>3</sup>	62636, 62639	12587-46-1	ssL <sub>C</sub>	CSU	MCL-US	<sup>5</sup> 15	D
Gross beta particle activity, 72-hour and 30-day counts <sup>3</sup>	62642, 62645	14587-47-2	ssL <sub>C</sub>	CSU	MCL-US	50	D
Uranium-234 <sup>3</sup>	22610	13966-29-5	ssL <sub>C</sub>	CSU	MCL-CA	<sup>6</sup> 20	D
Uranium-235 <sup>3</sup>	22620	15117-96-1	ssL <sub>C</sub>	CSU	MCL-CA	<sup>6</sup> 20	D
Uranium-238 <sup>3</sup>	22603	7440-61-1	ssL <sub>C</sub>	CSU	MCL-CA	<sup>6</sup> 20	D
Tritium <sup>4</sup>	07000	10028-17-8	ssL <sub>C</sub>	CSU	MCL-CA	20,000	D

<sup>1</sup> All radioactive constituents are reported as activities in units of picocuries per liter (pCi/L).

<sup>2</sup> USGS National Water Quality Laboratory (USGSNWQL).

<sup>3</sup> Eberline Analytical Services (contract laboratory, CA-EBERL).

<sup>4</sup> Tritium was measured by the USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA) and by the Lawrence Livermore National Laboratory (LLNL). Data from LLNL were not available in time for inclusion in this report.

<sup>5</sup> The MCL-US benchmark for gross alpha particle activity applies to adjusted gross alpha, which is equal to measured gross alpha activity minus uranium activity.

<sup>6</sup> The MCL-CA benchmark for uranium applies to the sum of uranium-234, uranium-235, and uranium-238.

**Table 4H.** Arsenic and iron species, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) Trace Metal Laboratory, Boulder, Colorado, analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark types and benchmark values as of January 10, 2012. **Benchmark type:** SMCL-CA, California Department of Public Health secondary maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; na, not available; µg/L, microgram per liter. **Other abbreviations:** CAS, Chemical Abstract Service; MDL, method detection limit; D, detected in groundwater samples ([table 15](#))]

Constituent (valence state)	USGS parameter code	CAS number	MDL (µg/L)	Benchmark type <sup>1</sup>	Benchmark level (µg/L)	Detection
Arsenic (total)	99033	7440-38-2	0.15	MCL-US	10	D
Arsenic (III)	99034	22569-72-8	0.5	na	na	D
Iron (total)	01046	7439-89-6	2	SMCL-CA	300	D
Iron (II)	01047	7439-89-6	2	na	na	D

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

**Table 4I.** Dissolved gases and isotope tracers, comparison benchmarks and reporting information for laboratory analyses.

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. 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. **Elements:** H, hydrogen; O, oxygen; B, boron; Sr, strontium; C, carbon. **Reporting units:** cm<sup>3</sup> STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water; pmc, percent modern carbon. **Other abbreviations:** CAS, Chemical Abstract Service; na, not available; D, detected in groundwater samples ([table 16](#)); %, percent]

Constituent	USGS parameter code	CAS number	Method uncertainty	Reporting units	Benchmark type	Benchmark level (pCi/L)	Detection
<b>Dissolved noble gases <sup>1</sup></b>							
Argon	85563	7440-37-1	2%	cm <sup>3</sup> STP/g	na	na	D <sup>5</sup>
Helium-4	85561	7440-59-7	2%	cm <sup>3</sup> STP/g	na	na	D <sup>5</sup>
Krypton	85565	7439-90-9	2%	cm <sup>3</sup> STP/g	na	na	D <sup>5</sup>
Neon	61046	7440-01-09	2%	cm <sup>3</sup> STP/g	na	na	D <sup>5</sup>
Xenon	85567	7440-63-3	2%	cm <sup>3</sup> STP/g	na	na	D <sup>5</sup>
<b>Isotope tracers</b>							
Helium-3 / Helium-4 <sup>1</sup>	61040	na / 7440-59-7	0.75%	atom ratio	na	na	D <sup>5</sup>
δ <sup>2</sup> H in water <sup>2</sup>	82082	na	2	per mil	na	na	D
δ <sup>18</sup> O in water <sup>2</sup>	82085	na	0.20	per mil	na	na	D
δ <sup>11</sup> B in water <sup>3</sup>	62648	na	na	per mil	na	na	D <sup>5</sup>
Strontium isotope ratio (87Sr/86Sr) <sup>3</sup>	75978	na	0.000	atom ratio	na	na	D <sup>5</sup>
δ <sup>13</sup> C in dissolved inorganic carbon <sup>4</sup>	82081	na	0.05	per mil	na	na	D
Carbon-14 <sup>4</sup>	49933	14762-75-5	0.3	pmc	na	na	D

<sup>1</sup> Lawrence Livermore National Laboratory, Livermore, California (CA-LLNL).

<sup>2</sup> USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA).

<sup>3</sup> USGS NRP Metals Isotope Research Laboratory, Menlo Park, California (USGSMICA).

<sup>4</sup> Woods Hole Oceanographic Institution, National Ocean Sciences Accelerator Mass Spectrometry Facility [NOMAS], Woods Hole, Massachusetts (MA-WHAMS).

<sup>5</sup> Constituent was detected, but data were not available in time for inclusion in this report.

**Table 4J.** Microbial indicators, comparative benchmarks, and reporting information for the IDEXX Colilert® field test kit analyses.

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Method detection limit, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. TT-US, U.S. Environmental Protection Agency (USEPA) treatment technique—a required process intended to reduce the level of contamination in drinking water; MCL-US, USEPA maximum contaminant level. **Other abbreviations:** MDL, method detection limit; D, detected in groundwater samples ([table 17](#))]

Constituent	USGS parameter code	Primary source	MDL	Benchmark type	Benchmark value	Detection
<i>Escherichia coli</i> ( <i>E. coli</i> )	99596	Sewage and animal waste indicator	presence / absence	TT-US	Zero	D
Total coliform (including fecal coliform and <i>E. coli</i> )	99595	Sewage and animal waste indicator	presence / absence	MCL-US	5 percent of samples positive per month	D

**Table 5.** Field water-quality indicators in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. GAMA well identification number: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degrees Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, not collected; na, not available; RL, reporting limit or range; MRL, minimum reporting level; LT-MDL, long-term method detection level; µS/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO<sub>3</sub>, calcium carbonate; \*, value greater than benchmark level or outside benchmark range; \*\*, value greater than upper benchmark level; –, not detected]

GAMA well identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, lab (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as CaCO <sub>3</sub> ) (29802)	Bicarbonate, field <sup>2</sup> (mg/L) (63786)	Carbonate, field <sup>2</sup> (mg/L) (63788)	Alkalinity, lab (mg/L as CaCO <sub>3</sub> ) (29801)	Bicarbonate <sup>2</sup> (mg/L)	Carbonate <sup>2</sup> (mg/L)
Benchmark type	na	na	SMCL-US <6.5 or >8.5	SMCL-US <6.5 or >8.5	SMCL-US [0–14]	SMCL-CA 1 900 (1,600)	na	na	na	na	na	na
Benchmark level	na	na	[0–14]	[0–14]	[0–14]	1 900 (1,600)	na	na	na	na	na	na
[RL, MRL, or LT-MDL]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[0–14]	[5]	[4.0]	[1]	[0.1]	[4.0]	[1]	[0.1]
CAMP Sacramento Valley Eastside study area (15 grid wells sampled)												
CAMP-ES-01	5.6	14.0	* 6.2	* 6.2	6.7	211	92.2	112	–	100	122	–
CAMP-ES-02	9.8	16.0	* 6.2	* 6.2	6.8	178	nc	nc	nc	86	105	–
CAMP-ES-03	4.7	19.0	7.2	7.2	7.7	224	112	136	0.2	120	146	0.3
CAMP-ES-04	1.3	22.0	7.2	7.2	7.6	367	nc	nc	nc	178	216	0.4
CAMP-ES-05	9.8	14.0	6.7	6.7	7.3	161	nc	nc	nc	89	108	0.1
CAMP-ES-06	10.3	13.5	6.8	6.8	7.3	191	nc	nc	nc	106	129	0.1
CAMP-ES-07	6.6	12.5	6.6	6.6	7.2	203	100	122	–	109	133	0.1
CAMP-ES-08	6.2	13.0	6.6	6.6	6.8	192	nc	nc	nc	104	127	–
CAMP-ES-09	6.0	21.0	7.5	7.5	7.7	274	nc	nc	nc	146	177	0.4
CAMP-ES-10	7.4	17.0	6.7	6.7	6.8	214	104	126	0.1	113	138	–
CAMP-ES-11	7.4	13.5	6.6	6.6	6.9	188	92.2	112	–	101	123	–
CAMP-ES-12	5.3	12.5	* 5.8	* 5.8	* 6.2	157	nc	nc	nc	75	92	–
CAMP-ES-13	5.5	14.0	* 6.0	* 6.0	* 6.3	205	nc	nc	nc	95	116	–
CAMP-ES-14	6.2	19.5	7.2	7.2	7.7	234	nc	nc	nc	121	147	0.3
CAMP-ES-15	6.8	20.0	7.1	7.1	7.5	207	nc	nc	nc	102	124	0.2
CAMP Honey Lake Valley study area (15 grid wells sampled)												
CAMP-HL-01	6.7	20.5	* 8.8	* 8.8	* 8.8	361	nc	nc	nc	122	140	4.1
CAMP-HL-02	1.0	13.0	7.6	7.6	7.9	201	72.8	88.3	0.2	82	99	0.4
CAMP-HL-03	0.9	18.0	7.7	7.7	7.9	569	95.8	116	0.4	98	119	0.4
CAMP-HL-04	4.2	14.0	7.6	7.6	7.8	485	nc	nc	nc	158	192	0.6
CAMP-HL-05	8.3	14.5	7.0	7.0	7.3	291	nc	nc	nc	112	136	0.1

**Table 5.** Field water-quality indicators in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater study unit, July through October 2010, California GAMA Priority Basin Project—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: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degrees Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, not collected; na, not available; RL, reporting limit or range; MRL, minimum reporting level; LT-MDL, long-term method detection level; µS/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO<sub>3</sub>, calcium carbonate; \*, value greater than benchmark level or outside benchmark range; \*\*, value greater than upper benchmark level; –, not detected]

GAMA well identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, lab (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as CaCO <sub>3</sub> ) (29802)	Bicarbonate, field <sup>2</sup> (mg/L) (63786)	Carbonate, field <sup>2</sup> (mg/L) (63788)	Alkalinity, lab (mg/L as CaCO <sub>3</sub> ) (29801)	Bicarbonate <sup>2</sup> (mg/L)	Carbonate <sup>2</sup> (mg/L)
Benchmark type	na	na	SMCL-US <6.5 or >8.5	SMCL-US <6.5 or >8.5	SMCL-CA 1 900 (1,600)	SMCL-CA 1 900 (1,600)	na	na	na	na	na	na
Benchmark level	na	na	[0–14]	[0–14]	[5]	[5]	[4.0]	[1]	[0.1]	[4.0]	[1]	[0.1]
CAMP Honey Lake Valley study area (15 grid wells sampled)—Continued												
[RL, MRL, or LT-MDL]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[5]	[5]	[4.0]	[1]	[0.1]	[4.0]	[1]	[0.1]
CAMP-HL-06	7.8	14.5	* 6.4	7.3	291	303	nc	nc	nc	66	80	0.1
CAMP-HL-07	<sup>3</sup> 0.6	13.0	7.9	8.1	* 1,160	* 1,180	nc	nc	nc	288	347	2.0
CAMP-HL-08	<sup>3</sup> 0.4	12.5	* 9.2	* 9.2	* 1,070	* 1,090	nc	nc	nc	548	581	42.4
CAMP-HL-09	6.4	18.0	7.6	7.8	469	481	152	184	0.2	160	194	0.6
CAMP-HL-10	1.5	17.0	7.0	7.5	725	727	148	181	0.2	191	232	0.3
CAMP-HL-11	<0.2	17.0	7.8	8.0	* 1,110	* 1,160	nc	nc	nc	336	406	1.9
CAMP-HL-12	4.4	15.0	7.3	7.4	775	817	nc	nc	nc	174	212	0.2
CAMP-HL-13	7.5	14.0	6.5	7.6	186	192	nc	nc	nc	97	118	0.2
CAMP-HL-14	0.4	15.0	7.8	7.8	897	896	nc	nc	nc	249	302	0.9
CAMP-HL-15	1.1	15.5	8.0	8.4	* 1,100	* 1,120	nc	nc	nc	502	598	6.9
CAMP Cascade Range and Modoc Plateau Low Use Basins study area (15 grid wells sampled)												
CAMP-LU-01	<sup>3</sup> 0.2	26.5	8.4	8.5	343	339	nc	nc	nc	170	201	2.9
CAMP-LU-02	<sup>3</sup> <0.2	22.0	7.3	7.6	875	865	nc	nc	nc	380	462	0.8
CAMP-LU-03	1.5	23.0	8.0	8.2	344	333	138	166	0.7	145	174	1.3
CAMP-LU-04	8.5	13.5	7.8	8.0	296	289	142	171	1.1	131	158	0.7
CAMP-LU-05	1.9	18.0	7.5	7.8	372	359	nc	nc	nc	157	190	0.6
CAMP-LU-06	<sup>3</sup> 0.2	22.0	7.9	8.1	367	364	nc	nc	nc	157	189	1.1
CAMP-LU-07	5.7	11.0	7.0	7.1	256	256	nc	nc	nc	114	139	0.1
CAMP-LU-08	10.9	5.5	* 6.3	E7.4	58	E58	25.1	30.6	nc	31	38	–
CAMP-LU-09	1.6	19.5	8.0	8.2	312	314	127	152	1.1	135	162	1.2
CAMP-LU-10	<sup>3</sup> 0.2	16.5	7.8	8.0	* 1,120	* 1,120	644	770	8.0	621	751	3.5



**Table 5.** Field water-quality indicators in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater study unit, July through October 2010, California GAMA Priority Basin Project.—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: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degrees Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, not collected; na, not available; RL, reporting limit or range; MRL, minimum reporting level; LT-MDL, long-term method detection level; µS/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO<sub>3</sub>, calcium carbonate; \*, value greater than benchmark level or outside benchmark range; \*\*, value greater than upper benchmark level; —, not detected]

GAMA well identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, lab (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as CaCO <sub>3</sub> ) (29802)	Bicarbonate, Carbonate, Alkalinity, lab field <sup>2</sup> (mg/L) (63786)			Bicarbonate <sup>2</sup> (mg/L) (29801)	Carbonate <sup>2</sup> (mg/L)
								field <sup>2</sup> (mg/L) (63786)	field <sup>2</sup> (mg/L) (63788)	as CaCO <sub>3</sub> (29801)		
Benchmark type	na	na	SMCL-US <6.5 or >8.5	SMCL-US <6.5 or >8.5	SMCL-US [0–14]	SMCL-CA 1 900 (1,600)	na	na	na	na	na	na
Benchmark level	na	na	[0–14]	[0–14]	[0–14]	1 900 (1,600)	na	na	na	na	na	na
[RL, MRL, or LT-MDL]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[0–14]	[5]	[4.0]	[1]	[0.1]	[4.0]	[1]	[0.1]
CAMP Cascade Range and Modoc Plateau Low Use Basins study area (15 grid wells sampled)—Continued												
CAMP-LU-11	<sup>3</sup> 7.0	14.5	7.0	7.4	207	206	nc	nc	nc	91	111	0.1
CAMP-LU-12	<sup>3</sup> 8.9	8.5	6.6	7.0	136	138	nc	nc	nc	71	87	—
CAMP-LU-13	1.0	14.0	6.9	7.2	351	353	nc	nc	nc	161	196	0.1
CAMP-LU-14	7.9	9.0	7.1	7.5	113	115	56.4	68.8	nc	65	79	0.1
CAMP-LU-15	7.2	8.5	7.3	7.7	153	156	75.4	91.9	nc	80	97	0.2
CAMP Quaternary Volcanic Areas study area (15 grid wells sampled)												
CAMP-QV-01	12.0	3.5	* 5.7	E7.4	41	E40	nc	nc	nc	22	27	—
CAMP-QV-02	11.0	5.0	* 6.3	E7.2	44	E44	18.5	22.6	—	24	29	—
CAMP-QV-03	<sup>3</sup> 0.8	25.5	7.3	7.7	306	303	nc	nc	nc	133	161	0.4
CAMP-QV-04	<sup>3</sup> 1.0	14.5	7.9	8.1	872	887	nc	nc	nc	361	435	2.5
CAMP-QV-05	10.4	10.0	7.5	7.8	117	125	nc	nc	nc	63	76	0.2
CAMP-QV-06	3.0	27.0	8.5	8.5	161	160	nc	nc	nc	78	92	1.3
CAMP-QV-07	9.8	8.0	7.6	8.0	102	108	nc	nc	nc	56	68	0.3
CAMP-QV-08	7.3	11.0	7.4	7.8	155	162	nc	nc	nc	81	98	0.3
CAMP-QV-09	10.0	9.0	7.2	7.7	146	150	nc	nc	nc	78	95	0.2
CAMP-QV-10	<sup>3</sup> 7.4	14.0	6.8	7.4	240	247	nc	nc	nc	135	164	0.2
CAMP-QV-11	6.3	10.5	* 6.4	7.1	203	208	nc	nc	nc	111	135	0.1
CAMP-QV-12	4.6	12.0	* 6.3	7.1	173	178	nc	nc	nc	94	115	0.1
CAMP-QV-13	8.7	12.0	6.7	7.5	187	189	nc	nc	nc	98	119	0.2
CAMP-QV-14	3.6	14.5	8.5	* E8.6	81	E86	nc	nc	nc	45	53	1.0
CAMP-QV-15	9.8	9.0	6.5	7.5	151	155	nc	nc	nc	79	96	0.1

**Table 5.** Field water-quality indicators in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater study unit, July through October 2010, California GAMA Priority Basin Project—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: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degrees Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, not collected; na, not available; RL, reporting limit or range; MRL, minimum reporting level; LT-MDL, long-term method detection level; µS/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO<sub>3</sub>, calcium carbonate; \*, value greater than benchmark level or outside benchmark range; \*\*, value greater than upper benchmark level; –, not detected]

GAMA well identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, lab (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as CaCO <sub>3</sub> ) (29802)	Bicarbonate, field <sup>2</sup> (mg/L) (63786)	Carbonate, field <sup>2</sup> (mg/L) (63788)	Alkalinity, lab (mg/L as CaCO <sub>3</sub> ) (29801)	Bicarbonate <sup>2</sup> (mg/L)	Carbonate <sup>2</sup> (mg/L)
Benchmark type	na	na	SMCL-US <6.5 or >8.5	SMCL-US <6.5 or >8.5	SMCL-CA 1 900 (1,600)	SMCL-CA 1 900 (1,600)	na	na	na	na	na	na
Benchmark level	na	na	[0–14]	[0–14]	[5]	[5]	[4.0]	[1]	[0.1]	[4.0]	[1]	[0.1]
CAMP Shasta Valley and Mount Shasta Volcanic Area study area (15 grid wells sampled)												
CAMP-SH-01	5.0	15.0	6.8	7.2	437	435	nc	nc	nc	226	275	0.2
CAMP-SH-02	4.7	16.0	6.6	7.0	538	536	224	273	0.1	237	289	0.1
CAMP-SH-03	4.7	13.5	7.3	7.7	520	521	248	300	1.0	255	310	0.7
CAMP-SH-04	4.4	11.5	7.2	7.5	166	169	nc	nc	nc	74	90	0.1
CAMP-SH-05	10.6	7.5	* 6.4	7.1	101	105	nc	nc	nc	54	66	–
CAMP-SH-06	9.3	9.0	6.5	7.0	99	102	nc	nc	nc	53	65	–
CAMP-SH-07	10.8	6.5	* 6.3	E6.8	50	E52	nc	nc	nc	28	34	–
CAMP-SH-08	4.0	13.0	6.7	7.1	259	263	nc	nc	nc	120	146	0.1
CAMP-SH-09	5.8	15.5	6.9	7.2	503	513	nc	nc	nc	222	270	0.2
CAMP-SH-10	3.2	13.0	6.8	7.2	341	340	nc	nc	nc	165	201	0.1
CAMP-SH-11	0.3	14.0	7.2	7.3	303	303	nc	nc	nc	150	183	0.2
CAMP-SH-12	7.2	14.0	7.1	7.2	867	868	nc	nc	nc	384	468	0.3
CAMP-SH-13	9.3	11.5	6.6	7.0	267	270	nc	nc	nc	122	149	0.1
CAMP-SH-14	10.5	8.0	* 6.3	7.5	119	120	60.5	73.7	–	66	80	0.1
CAMP-SH-15	0.2	16.5	7.3	7.7	* 1,120	* 1,130	nc	nc	nc	399	484	1.1
CAMP Tertiary Volcanic Areas study area (15 grid wells sampled)												
CAMP-TV-01	0.8	19.0	7.9	8.0	** 2,300	** 2,390	nc	nc	nc	104	126	0.6
CAMP-TV-02	8.2	16.0	7.2	7.5	158	156	nc	nc	nc	78	95	0.1
CAMP-TV-03 <sup>4</sup>	11.2	14.0	6.9	7.1	184	185	nc	nc	nc	96	117	0.1
CAMP-TV-04	7.4	13.5	7.6	8.0	133	140	61.1	74.4	–	67	81	0.4
CAMP-TV-05	6.9	17.5	7.5	7.8	203	209	97.0	118	–	106	129	0.4

**Table 5.** Field water-quality indicators in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater study unit, July through October 2010, California GAMA Priority Basin Project—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: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** °C, degrees Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, not collected; na, not available; RL, reporting limit or range; MRL, minimum reporting level; LT-MDL, long-term method detection level; µS/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO<sub>3</sub>, calcium carbonate; \*, value greater than benchmark level or outside benchmark range; \*\*, value greater than upper benchmark level; –, not detected]

GAMA well identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, lab (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as CaCO <sub>3</sub> ) (29802)	Bicarbonate, field <sup>2</sup> (mg/L) (63786)	Carbonate, field <sup>2</sup> (mg/L) (63788)	Alkalinity, lab (mg/L as CaCO <sub>3</sub> ) (29801)	Bicarbonate <sup>2</sup> (mg/L)	Carbonate <sup>2</sup> (mg/L)
Benchmark type	na	na	SMCL-US [0–14]	SMCL-US [0–14]	SMCL-CA [0–14]	SMCL-CA [0–14]	na	na	na	na	na	na
Benchmark level	na	na	<6.5 or >8.5	<6.5 or >8.5	1 900 (1,600)	1 900 (1,600)	na	na	na	na	na	na
[RL, MRL, or LT-MDL]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[5]	[5]	[4.0]	[1]	[0.1]	[4.0]	[1]	[0.1]
CAMP Tertiary Volcanic Areas study area (15 grid wells sampled)—Continued												
CAMP-TV-06	9.4	9.5	8.0	7.7	118	121	nc	nc	nc	64	78	0.2
CAMP-TV-07	7.5	8.5	7.8	8.1	170	176	nc	nc	nc	95	114	0.7
CAMP-TV-08	5.9	17.0	8.3	8.1	162	162	nc	nc	nc	82	99	0.6
CAMP-TV-09	4.9	10.5	7.5	8.4	301	311	nc	nc	nc	166	198	2.3
CAMP-TV-10	8.1	8.0	* 6.2	7.5	106	116	nc	nc	nc	62	75	0.1
CAMP-TV-11	7.9	8.0	7.0	7.7	118	122	56.6	68.9	0.1	63	76	0.2
CAMP-TV-12	8.6	7.5	6.8	7.6	128	133	nc	nc	nc	71	86	0.2
CAMP-TV-13	8.6	8.5	6.6	6.7	151	157	75.2	91.7	–	85	104	–
CAMP-TV-14	7.8	10.0	* 5.8	E7.2	62	E64	26.3	32.1	–	31	38	–
CAMP-TV-15	4.9	19.0	* 9.3	* 9.2	280	287	nc	nc	nc	119	126	9.2

<sup>1</sup> The SMCL-CA for specific conductance has recommended and upper benchmark levels. The upper benchmark level is shown in parentheses.

<sup>2</sup> Bicarbonate and carbonate concentrations were calculated from alkalinity and pH values using the advanced speciation method (<http://or.water.usgs.gov/alk/methods.html>) with  $pK_1 = 6.35$ ,  $pK_2 = 10.33$ , and  $pK_w = 14$ . Field values used field measurements, and lab values used laboratory measurements.

<sup>3</sup> Hydrogen sulfide smell noted during sampling.

<sup>4</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 90 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency within each class of primary use or source. All analytes are listed in [table 4A](#). GAMA well identification number: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; TSH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level;  $\mu\text{g/L}$ , micrograms per liter; na, not available; –, not detected;  $\leq$ , less than or equal to the CAMP SRL; NWIS, USGS National Water Information System]

[illegible]



**Table 6.** Volatile organic compounds (VOCs) detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 90 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency within each class of primary use or source. All analytes are listed in [table 4A](#). GAMA well identification number: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to the CAMP SRL; NWIS, USGS National Water Information System]

Primary use or source	Disinfection byproduct	Solvent			Gasoline oxygenate	Natural	Fumigant	Refrigerant	Summaries by study unit, well, and study area	
GAMA identification number	Chloroform (µg/L) (32106)	Perchloroethene (PCE) (µg/L) (34475)	Dichloromethane (µg/L) (34423)	1,1-Dichloroethene (1,1-DCE) (µg/L) (34501)	1,1,1-Trichloroethane (1,1,1-TCA) (µg/L) (34506)	Methyl tert-butyl ether (MTBE) (µg/L) (78032)	Carbon disulfide (µg/L) (77041)	1,4-Dichlorobenzene (µg/L) (34571)	1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113) (µg/L) (77652)	Detections per well summary <sup>1</sup>
Benchmark type	MCL-US	MCL-US	MCL-US	MCL-CA	MCL-US	MCL-CA	NL-CA	MCL-CA	MCL-CA	VOC detection summary <sup>1</sup>
Benchmark level	<sup>2</sup> 80			6	200	13	160	5	1,200	
[LRL] or [SRL]	[0.03]	[0.03]	[0.04]	[0.02]	[0.03]	[0.1]	<sup>3</sup> [0.04]	[0.03]	[0.03]	
CAMP Honey Lake Valley study area (15 grid wells sampled)										
CAMP-HL-02	–	–	–	E0.02	–	–	–	–	–	1
CAMP-HL-03	–	–	–	E0.01	–	0.69	–	–	–	2
CAMP-HL-05	–	E0.02	–	–	–	–	–	–	–	1
CAMP-HL-08	–	–	–	–	–	–	0.11	–	–	1
CAMP-HL-10	0.03	–	–	–	–	–	–	–	–	1
CAMP-HL-12	E0.02	–	–	–	–	–	–	–	–	1
CAMP-HL-15	–	0.10	–	–	–	–	–	–	–	1
Number of wells with detections	2	2	0	2	0	1	1	0	0	7
Detection frequency (percent)	13.3	13.3	0	13.3	0	6.7	6.7	0	0	47
Total detections										8
CAMP Cascade Range and Modoc Plateau Low Use Basins study area (15 grid wells sampled)										
CAMP-LU-02	–	–	–	–	–	–	E0.31	–	–	2
CAMP-LU-13	<sup>4</sup> 0.06	–	–	–	–	–	–	–	–	1
Number of wells with detections	1	0	0	0	0	0	1	0	0	2
Detection frequency (percent)	6.7	0	0	0	0	0	6.7	0	0	13
Total detections										3

[The five-digit USGS parameter **code** below the constituent name is used to uniquely identify a specific constituent or property. Samples from 90 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency within each class of primary use or source. All analytes are listed in [table 4A](#). GAMA well identification number: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level;  $\mu\text{g/L}$ , micrograms per liter; na, not available; –, not detected;  $\leq$ , less than or equal to the CAMP SRL; NWIS, USGS National Water Information System]

[illegible]



[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 90 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency within each class of primary use or source. All analytes are listed in [table 4A](#). GAMA well identification number: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level;  $\mu\text{g/L}$ , micrograms per liter; na, not available; –, not detected;  $\leq$ , less than or equal to the CAMP SRL; NWIS, USGS National Water Information System]

[illegible]





**Table 6.** Volatile organic compounds (VOCs) detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 90 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency within each class of primary use or source. All analytes are listed in [table 4A](#). GAMA well identification number: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to the CAMP SRL; NWIS, USGS National Water Information System]

Primary use or source		Gasoline hydrocarbon								Summaries by study unit, well, and study area	
GAMA identification number	Benzene (µg/L) (34030)	2-Ethyl-toluene (µg/L) (77220)	Isopropyl-benzene (µg/L) (77223)	4-Isopropyl-toluene (µg/L) (77356)	n-Propyl-benzene (µg/L) (77224)	1,2,3,4-Tetra-methyl-benzene (µg/L) (49999)	1,2,3,5-Tetra-methyl-benzene (µg/L) (50000)	1,2,3-Tri-methyl-benzene (µg/L) (77221)	1,3,5-Tri-methyl-benzene (µg/L) (77226)	Detections per well	VOC detection summary <sup>1</sup>
Benchmark type	MCL-CA	na	NL-CA	na	NL-CA	na	na	na	NL-CA		
Benchmark level	1	na	770	na	260	na	na	na	330		
[LRL] or [SRL]	[0.03]	[0.03]	[0.04]	[0.06]	[0.04]	[0.1]	[0.1]	[0.1]	[0.03]		
CAMP Tertiary Volcanic Areas study area (15 grid wells sampled)											
CAMP-TV-10	–	–	–	–	–	–	–	–	–	3	
CAMP-TV-12	–	–	–	–	–	–	–	–	–	2	
CAMP-TV-15	–	–	–	–	–	–	–	–	–	2	
Number of wells with detections	0	0	0	0	0	0	0	0	0	3	
Detection frequency (percent)	0	0	0	0	0	0	0	0	0	20	
Total detections										7	

<sup>1</sup> Study reporting levels (SRLs) for acetone (no detections are reported), tetrahydrofuran (no detections are reported), toluene (detections with concentrations <0.69 µg/L are reported as non-detections), and 1,2,4-trimethylbenzene (detections with concentrations <0.56 µg/L are reported as non-detections) are from Fram and others (2012). All detections of these four constituents in samples from the CAMP study unit had concentrations less than the SRLs: acetone (QV-10, 0.6 µg/L), tetrahydrofuran (TV-15, 3 µg/L), toluene (HL-01, E0.02 µg/L and TV-15, 0.03 µg/L), and 1,2,4-trimethylbenzene (55 samples at concentrations ranging from E0.02 µg/L to 0.5 µg/L; median = 0.06 µg/L).

<sup>2</sup> The MCL-US benchmark level for trihalomethanes is for the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

<sup>3</sup> All detections of carbon disulfide had concentrations greater than the SRL of 0.04 µg/L defined by Fram and others (2012).

<sup>4</sup> Wells treated with chlorine that have chloroform detections: downhole chlorination in LU-13 and TV-10; wellhead chlorination downstream from sampling point in ES-04, ES-11, SH-02, and SH-09; downhole bleach treated: ES-13.

**Table 7.** Pesticides and pesticide degradates detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 90 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency. All analytes are listed in [table 4B](#). **GAMA well identification number:** HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Laboratory reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA; California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; –, not detected]

Primary use or source	Herbicide or herbicide degradeate										Insecticide		Fungicide	Summaries by study unit, well, and study area	
	GAMA well identification number	Deethylatrazine (µg/L) (04040)	Atrazine (µg/L) (39632)	Hexazinone (µg/L) (04025)	Simazine (µg/L) (04035)	3,4-Dichloro-aniline (µg/L) (61625)	Prometon (µg/L) (04037)	Tebuthiuron (µg/L) (82670)	Carbaryl (µg/L) (82680)	Metalaxyl (µg/L) (61596)					
Benchmark type	na	MCL-CA	HAL-US	MCL-US	na	HAL-US	HAL-US	HAL-US	RSD5-US	na					
Benchmark level	na	1	400	4	na	400	400	500	400	na					
[LRL]	[0.014]	[0.008]	[0.008]	[0.006]	[0.0042]	[0.012]	[0.028]	[0.06]	[0.014]						
CAMP study unit (90 grid wells sampled)															
Number of wells with detections	23	14	8	8	3	2	1	1	1	1				28	
Detection frequency (percent)	25.6	15.6	8.9	8.9	3.3	2.2	1.1	1.1	1.1	1.1				31	
Total detections														61	
CAMP Honey Lake Valley study area (15 grid wells sampled)															
CAMP-HL-05	E0.016	E0.005	-	-	-	-	-	-	-	-				2	
CAMP-HL-11	E0.011	-	-	-	-	-	-	-	-	-				1	
CAMP-HL-12	E0.087	0.029	-	0.009	E0.002	-	-	-	-	-				4	
CAMP-HL-15	E0.019	-	-	-	-	-	-	-	-	-				1	
Number of wells with detections	4	2	0	1	1	0	0	0	0	0				4	
Detection frequency (percent)	26.7	13.3	0	6.7	6.7	0	0	0	0	0				27	
Total detections														8	
CAMP Cascade Range and Modoc Plateau Low Use Basins study area (15 grid wells sampled)															
CAMP-LU-04	E0.015	-	-	-	-	-	-	-	-	-				1	
CAMP-LU-07	E0.011	-	-	-	-	-	-	-	-	-				1	
CAMP-LU-12	-	-	0.022	-	-	-	-	-	-	-				1	
CAMP-LU-15	E0.064	0.019	-	-	-	E0.002	-	-	-	-				3	
Number of wells with detections	3	1	1	0	0	1	0	0	0	0				4	
Detection frequency (percent)	20.0	6.7	6.7	0	0	6.7	0	0	0	0				27	
Total detections														6	

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 90 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency. All analytes are listed in [table 4B](#). **GAMA well identification number:** HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Laboratory reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA: California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level;  $\mu\text{g/L}$ , micrograms per liter; na, not available; not detected.

[illegible]



**Table 7.** Pesticides and pesticide degradates detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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 90 grid wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency. All analytes are listed in [table 4B](#). **GAMA well identification number:** HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Laboratory reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA; California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; –, not detected]

Primary use or source	Herbicide or herbicide degradate										Insecticide	Fungicide	Summaries by study unit, well, and study area
	GAMA well identification number	Deethylatrazine (µg/L) (04040)	Atrazine (µg/L) (39632)	Hexazinone (µg/L) (04025)	Simazine (µg/L) (04035)	3,4-Dichloro-aniline (µg/L) (61625)	Prometon (µg/L) (04037)	Tebuthiuron (µg/L) (82670)	Carbaryl (µg/L) (82680)	Metaxyl (µg/L) (61596)			
Benchmark type	na	MCL-CA	HAL-US	MCL-US	na	HAL-US	HAL-US	HAL-US	RSD5-US	na			
Benchmark level	na	1	400	4	na	na	400	500	400	na			
[LRL]	[0.014]	[0.008]	[0.008]	[0.006]	[0.0042]	[0.012]	[0.028]	[0.06]	[0.014]				
CAMP Tertiary Volcanic Areas study area (15 grid wells sampled)													
CAMP-TV-01	E0.007	E0.005	–	–	–	–	–	–	–	–	2		
CAMP-TV-03 <sup>2</sup>	E0.005	0.009	–	–	–	–	–	–	–	–	2		
CAMP-TV-11	–	–	0.062	–	–	–	–	–	–	–	1		
CAMP-TV-14	–	–	E0.298	–	–	–	–	–	–	–	1		
Number of wells with detections	2	2	2	0	0	0	0	0	0	0	4		
Detection frequency (percent)	13.3	13.3	13.3	0	0	0	0	0	0	0	27		
Total detections											6		

<sup>1</sup> The median matrix-spike recovery is 143 percent for tebuthiuron which is greater than the high end of the acceptable range, 130 percent. High matrix spike recoveries may indicate that reported values could be greater than what is in the groundwater sample.

<sup>2</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

**Table 8.** Results for analyses of perchlorate in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 analyte given in [table 4C](#). Samples from 84 wells were analyzed for perchlorate (samples were not collected at wells CAMP-ES-01, -ES-02, -ES-03, -ES-04, -QV-14, and -TV-12). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Minimum reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** MRL, minimum reporting level; µg/L, micrograms per liter; –, not detected]

GAMA well identification number	Perchlorate (µg/L) (63790)	GAMA well identification number	Perchlorate (µg/L) (63790)
<b>Benchmark type</b>	<b>MCL-CA</b>	<b>Benchmark type</b>	<b>MCL-CA</b>
<b>Benchmark level</b>	<b>6</b>	<b>Benchmark level</b>	<b>6</b>
<b>[MRL]</b>	<b>[0.10]</b>	<b>[MRL]</b>	<b>[0.10]</b>
<b>CAMP study unit (84 grid wells sampled)</b>		<b>CAMP Cascade Range and Modoc Plateau Low Use Basins study area (15 grid wells sampled)</b>	
Number of wells with detections	40	CAMP-LU-01	–
Detection frequency (percent)	48	CAMP-LU-02	0.12
<b>CAMP Sacramento Valley Eastside study area (11 grid wells sampled)</b>		CAMP-LU-03	0.10
CAMP-ES-05	0.11	CAMP-LU-04	0.20
CAMP-ES-06	–	CAMP-LU-05	0.13
CAMP-ES-07	0.11	CAMP-LU-06	–
CAMP-ES-08	0.13	CAMP-LU-07	0.14
CAMP-ES-09	0.18	CAMP-LU-08	–
CAMP-ES-10	0.14	CAMP-LU-09	0.23
CAMP-ES-11	0.11	CAMP-LU-10	–
CAMP-ES-12	0.29	CAMP-LU-11	1.29
CAMP-ES-13	0.27	CAMP-LU-12	–
CAMP-ES-14	0.16	CAMP-LU-13	–
CAMP-ES-15	0.27	CAMP-LU-14	–
Number of wells with detections	10	CAMP-LU-15	–
Detection frequency (percent)	91	Number of wells with detections	7
<b>CAMP Honey Lake Valley study area (15 grid wells sampled)</b>		Detection frequency (percent)	47
CAMP-HL-01	0.36	<b>CAMP Quaternary Volcanic Areas study area (14 grid wells sampled)</b>	
CAMP-HL-02	–	CAMP-QV-01	–
CAMP-HL-03	0.19	CAMP-QV-02	–
CAMP-HL-04	0.26	CAMP-QV-03	–
CAMP-HL-05	0.16	CAMP-QV-04	–
CAMP-HL-06	0.41	CAMP-QV-05	–
CAMP-HL-07	–	CAMP-QV-06	0.21
CAMP-HL-08	–	CAMP-QV-07	–
CAMP-HL-09	–	CAMP-QV-08	–
CAMP-HL-10	0.31	CAMP-QV-09	–
CAMP-HL-11	–	CAMP-QV-10	0.13
CAMP-HL-12	0.65	CAMP-QV-11	0.11
CAMP-HL-13	0.14	CAMP-QV-12	–
CAMP-HL-14	–	CAMP-QV-13	–
CAMP-HL-15	0.34	CAMP-QV-15	–
Number of wells with detections	9	Number of wells with detections	3
Detection frequency (percent)	60	Detection frequency (percent)	21

**Table 8.** Results for analyses of perchlorate in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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. Information about the analyte given in [table 4C](#). Samples from 84 wells were analyzed for perchlorate (samples were not collected at wells CAMP-ES-01, -ES-02, -ES-03, -ES-04, -QV-14, and -TV-12). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Minimum reporting level, benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** MRL, minimum reporting level; µg/L, micrograms per liter; –, not detected]]

GAMA well identification number	Perchlorate (µg/L) (63790)	GAMA well identification number	Perchlorate (µg/L) (63790)
<b>Benchmark type</b>	<b>MCL-CA</b>	<b>Benchmark type</b>	<b>MCL-CA</b>
<b>Benchmark level</b>	<b>6</b>	<b>Benchmark level</b>	<b>6</b>
<b>[MRL]</b>	<b>[0.10]</b>	<b>[MRL]</b>	<b>[0.10]</b>
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area (15 grid wells sampled)</b>		<b>CAMP Tertiary Volcanic Areas study area (14 grid wells sampled)</b>	
CAMP-SH-01	0.12	CAMP-TV-01	–
CAMP-SH-02	0.22	CAMP-TV-02	–
CAMP-SH-03	0.16	CAMP-TV-03 <sup>1</sup>	–
CAMP-SH-04	–	CAMP-TV-04	0.12
CAMP-SH-05	–	CAMP-TV-05	0.27
CAMP-SH-06	–	CAMP-TV-06	–
CAMP-SH-07	–	CAMP-TV-07	0.10
CAMP-SH-08	0.18	CAMP-TV-08	0.35
CAMP-SH-09	0.38	CAMP-TV-09	–
CAMP-SH-10	–	CAMP-TV-10	–
CAMP-SH-11	–	CAMP-TV-11	–
CAMP-SH-12	–	CAMP-TV-13	–
CAMP-SH-13	0.16	CAMP-TV-14	–
CAMP-SH-14	0.13	CAMP-TV-15	–
CAMP-SH-15	–		
Number of wells with detections	7	Number of wells with detections	4
Detection frequency (percent)	47	Detection frequency (percent)	29

<sup>1</sup>Conveyance from the TV-03 spring source to the point of use is an open channel.

**Table 9.** Nutrients detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 90 wells were analyzed. Information about the analytes given in [table 4D](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-US, USEPA maximum contaminant level. **Other abbreviations:** LT-MDL, long-term method detection level; MDL, method detection level; mg/L, milligrams per liter; na, not available; –, not detected; \*, value above benchmark]

GAMA well identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite, as nitrogen (mg/L) (00613)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Total nitrogen (ammonia + nitrate + nitrite + organic nitrogen) as nitrogen (mg/L) (62854) <sup>2</sup>	Orthophosphate (as phosphorus) (mg/L) (00671)
<b>Benchmark type</b>	<b>HAL-US</b>	<b>MCL-US</b>	<b>MCL-US</b>	<b>na</b>	<b>na</b>
<b>Benchmark level</b>	<b><sup>1</sup> 24.7</b>	<b>1</b>	<b>10</b>	<b>na</b>	<b>na</b>
<b>[LT-MDL] or [MDL]</b>	<b>[0.01]</b>	<b>[0.001]</b>	<b>[0.02]</b>	<b>[0.05]</b>	<b>[0.004]</b>
<b>CAMP Sacramento Valley Eastside study area</b>					
CAMP-ES-01	–	–	1.87	2.02	0.134
CAMP-ES-02	–	–	1.04	1.07	0.083
CAMP-ES-03	–	–	0.27	0.27	0.107
CAMP-ES-04	–	–	0.25	0.27	0.072
CAMP-ES-05	–	–	0.06	–	0.097
CAMP-ES-06	–	–	0.07	0.07	0.103
CAMP-ES-07	–	–	0.07	0.05	0.110
CAMP-ES-08	–	–	0.09	0.07	0.112
CAMP-ES-09	–	–	0.48	0.46	0.116
CAMP-ES-10	–	–	0.19	0.19	0.112
CAMP-ES-11	–	–	0.08	0.13	0.117
CAMP-ES-12	–	0.002	2.06	2.07	0.018
CAMP-ES-13	–	–	1.64	1.68	0.065
CAMP-ES-14	–	–	0.51	0.52	0.100
CAMP-ES-15	–	–	0.47	0.49	0.107
<b>CAMP Honey Lake Valley study area</b>					
CAMP-HL-01	–	–	1.12	1.17	0.213
CAMP-HL-02	–	–	0.20	0.19	0.032
CAMP-HL-03	–	–	0.26	0.25	0.062
CAMP-HL-04	–	–	0.77	0.77	0.100
CAMP-HL-05	–	–	3.55	3.80	0.282
CAMP-HL-06	–	–	* 11.2	11.60	0.041
CAMP-HL-07	0.41	0.002	–	0.47	0.440
CAMP-HL-08	0.35	–	–	0.43	1.030
CAMP-HL-09	0.40	0.007	0.03	0.41	0.077
CAMP-HL-10	0.06	–	0.94	1.07	0.086
CAMP-HL-11	2.42	0.011	1.65	4.31	0.319
CAMP-HL-12	–	0.001	3.93	4.01	0.091
CAMP-HL-13	–	–	0.41	0.39	0.082
CAMP-HL-14	–	–	0.26	0.25	0.110
CAMP-HL-15	–	–	2.11	2.17	1.220
<b>CAMP Cascade Range and Modoc Plateau Low Use Basins study area</b>					
CAMP-LU-01	1.13	–	–	1.20	0.073
CAMP-LU-02	17.50	–	–	19.70	0.366



**Table 9.** Nutrients detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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 90 wells were analyzed. Information about the analytes given in [table 4D](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-US, USEPA maximum contaminant level. **Other abbreviations:** LT-MDL, long-term method detection level; MDL, method detection level; mg/L, milligrams per liter; na, not available; –, not detected; \*, value above benchmark]

GAMA well identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite, as nitrogen (mg/L) (00613)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Total nitrogen (ammonia + nitrate + nitrite + organic nitrogen) as nitrogen (mg/L) (62854) <sup>2</sup>	Orthophosphate (as phosphorus) (mg/L) (00671)
<b>Benchmark type</b>	<b>HAL-US</b>	<b>MCL-US</b>	<b>MCL-US</b>	<b>na</b>	<b>na</b>
<b>Benchmark level</b>	<b><sup>1</sup> 24.7</b>	<b>1</b>	<b>10</b>	<b>na</b>	<b>na</b>
<b>[LT-MDL] or [MDL]</b>	<b>[0.01]</b>	<b>[0.001]</b>	<b>[0.02]</b>	<b>[0.05]</b>	<b>[0.004]</b>
<b>CAMP Cascade Range and Modoc Plateau Low Use Basins study area—Continued</b>					
CAMP-LU-03	—	—	0.62	0.65	0.079
CAMP-LU-04	—	—	2.31	2.35	0.048
CAMP-LU-05	—	0.001	0.97	1.03	0.071
CAMP-LU-06	0.64	0.001	—	0.75	0.551
CAMP-LU-07	—	—	1.90	1.97	0.087
CAMP-LU-08	—	—	0.09	0.07	0.053
CAMP-LU-09	—	—	0.48	<sup>3</sup> 0.43	0.114
CAMP-LU-10	0.53	0.001	—	0.96	0.176
CAMP-LU-11	—	—	2.25	2.25	0.173
CAMP-LU-12	—	—	0.12	<sup>3</sup> 0.05	0.061
CAMP-LU-13	0.73	—	—	0.83	0.149
CAMP-LU-14	—	—	0.06	—	0.079
CAMP-LU-15	—	—	0.43	0.40	0.032
<b>CAMP Quaternary Volcanic Areas study area</b>					
CAMP-QV-01	—	—	0.02	—	0.063
CAMP-QV-02	—	—	0.10	0.07	0.049
CAMP-QV-03	0.04	—	—	—	0.182
CAMP-QV-04	0.11	0.011	0.14	0.45	0.194
CAMP-QV-05	0.01	—	0.11	0.11	0.042
CAMP-QV-06	—	—	0.27	0.26	0.046
CAMP-QV-07	—	—	0.06	—	0.036
CAMP-QV-08	—	—	0.23	0.23	0.073
CAMP-QV-09	—	—	0.21	0.21	0.031
CAMP-QV-10	—	—	0.07	0.06	0.060
CAMP-QV-11	—	—	0.17	0.16	0.046
CAMP-QV-12	—	—	0.07	0.06	0.050
CAMP-QV-13	—	—	0.07	0.05	0.093
CAMP-QV-14	—	—	0.03	—	0.164
CAMP-QV-15	—	—	0.18	0.16	0.056
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area</b>					
CAMP-SH-01	0.02	—	1.70	1.69	0.033
CAMP-SH-02	—	—	2.18	2.15	0.247
CAMP-SH-03	—	—	3.78	3.78	0.038
CAMP-SH-04	—	—	0.09	<sup>3</sup> —	0.187

**Table 9.** Nutrients detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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 90 wells were analyzed. Information about the analytes given in [table 4D](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-US, USEPA maximum contaminant level. **Other abbreviations:** LT-MDL, long-term method detection level; MDL, method detection level; mg/L, milligrams per liter; na, not available; –, not detected; \*, value above benchmark]

GAMA well identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite, as nitrogen (mg/L) (00613)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Total nitrogen (ammonia + nitrate + nitrite + organic nitrogen) as nitrogen (mg/L) (62854) <sup>2</sup>	Orthophosphate (as phosphorus) (mg/L) (00671)
<b>Benchmark type</b>	<b>HAL-US</b>	<b>MCL-US</b>	<b>MCL-US</b>	<b>na</b>	<b>na</b>
<b>Benchmark level</b>	<b><sup>1</sup> 24.7</b>	<b>1</b>	<b>10</b>	<b>na</b>	<b>na</b>
<b>[LT-MDL] or [MDL]</b>	<b>[0.01]</b>	<b>[0.001]</b>	<b>[0.02]</b>	<b>[0.05]</b>	<b>[0.004]</b>
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area—Continued</b>					
CAMP-SH-05	—	—	0.12	<sup>3</sup> 0.08	0.186
CAMP-SH-06	—	—	0.15	0.12	0.081
CAMP-SH-07	—	—	0.07	—	0.037
CAMP-SH-08	—	—	0.70	0.69	0.120
CAMP-SH-09	—	—	5.14	5.26	0.050
CAMP-SH-10	—	—	0.39	0.41	0.181
CAMP-SH-11	—	—	0.19	0.21	0.193
CAMP-SH-12	—	—	7.04	7.33	0.322
CAMP-SH-13	—	—	0.66	0.69	0.167
CAMP-SH-14	0.01	—	0.02	—	0.059
CAMP-SH-15	0.57	0.001	—	0.66	0.011
<b>CAMP Tertiary Volcanic Areas study area</b>					
CAMP-TV-01	0.04	—	0.13	0.14	0.015
CAMP-TV-02	—	—	0.23	<sup>3</sup> 0.19	0.086
CAMP-TV-03 <sup>4</sup>	—	—	0.15	<sup>3</sup> 0.09	0.083
CAMP-TV-04	—	0.002	0.09	0.08	0.077
CAMP-TV-05	—	—	0.44	0.45	0.064
CAMP-TV-06	—	0.001	0.10	0.10	0.028
CAMP-TV-07	—	—	0.16	0.15	0.038
CAMP-TV-08	0.04	—	0.53	0.53	0.038
CAMP-TV-09	—	—	0.06	—	0.055
CAMP-TV-10	0.01	—	0.40	0.39	0.022
CAMP-TV-11	—	—	0.59	0.57	0.019
CAMP-TV-12	—	—	0.09	0.08	0.044
CAMP-TV-13	—	—	0.08	—	0.032
CAMP-TV-14	—	—	0.65	0.67	0.013
CAMP-TV-15	—	—	—	—	0.011

<sup>1</sup>The HAL-US is 30 mg/L “as ammonia.” To facilitate comparison to the analytical results, this HAL-US has been converted and reported as 24.7 mg/L “as nitrogen.”

<sup>2</sup> Total nitrogen concentration was compared with the sum of ammonia concentration and nitrite plus nitrate concentration with the same criteria used to evaluate acceptability of replicates: for total nitrogen concentration greater than 0.25 µg/L (5 times LT-MDL), relative percent difference less than 10 percent indicates acceptable replication; for total nitrogen concentration less than or equal to 0.25 µg/L, standard deviation less than 0.025 µg/L (1/2 LT-MDL) indicates acceptable replication. For samples with total nitrogen concentration greater than the sum of ammonia and nitrite plus nitrate concentrations and unacceptable replication by these criteria, organic nitrogen is assumed to be present.

<sup>3</sup> Total nitrogen concentration is less than sum of ammonia and nitrite plus nitrate concentrations, and replication is considered unacceptable. However, the six samples all have total nitrogen concentration less than 0.5 µg/L, thus, the unacceptable replication is unlikely to affect interpretation of the data.

<sup>4</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

**Table 10.** Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 90 grid wells were analyzed. Information about the analytes given in [table 4E](#); **GAMA well identification number**: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; \*, value above benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron <sup>1</sup> (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Benchmark level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LT-MDL] or [SRL]	[1.7]	[0.027]	[0.022]	<sup>2</sup> [0.4]	[0.006]	[3]	<sup>3</sup> [0.016]	<sup>2</sup> [0.42]	<sup>3</sup> [0.38]	<sup>2</sup> [1.7]	<sup>2</sup> [6]	<sup>3</sup> [1.04]
CAMP Sacramento Valley Eastside study area												
CAMP-ES-01	2.3	–	0.68	4	–	4	–	1.1	–	≤0.66	–	≤0.44
CAMP-ES-02	1.8	–	0.28	3	–	4	–	0.64	–	6.7	–	≤0.72
CAMP-ES-03	3.2	0.03	1.3	13	–	8	–	0.87	–	≤0.59	–	≤0.15
CAMP-ES-04	3.7	0.75	3.2	106	–	229	–	≤0.09	≤0.04	3.9	–	2.62
CAMP-ES-05	2.9	0.03	0.33	3	–	5	–	3.1	–	1.8	–	≤0.60
CAMP-ES-06	2.5	–	0.43	5	–	4	–	0.49	–	1.9	–	≤0.33
CAMP-ES-07	2.7	0.04	0.75	6	–	4	–	1.0	≤0.04	≤1.7	–	1.10
CAMP-ES-08	2.4	–	0.51	9	–	5	–	1.1	–	≤0.80	≤5	≤0.15
CAMP-ES-09	3.3	–	0.86	19	–	19	–	0.65	–	≤1.6	–	≤0.53
CAMP-ES-10	2.7	–	0.39	10	–	7	–	1.0	–	≤1.5	–	≤0.15
CAMP-ES-11	2.4	–	0.31	5	–	4	–	0.48	–	2.3	–	1.31
CAMP-ES-12	1.9	–	0.04	2	–	5	–	≤0.25	≤0.06	5.5	* 483	1.35
CAMP-ES-13	2.0	–	0.08	2	–	3	–	1.2	–	≤1.1	12	≤0.20
CAMP-ES-14	2.8	0.04	0.85	19	–	8	–	1.0	–	≤0.77	–	≤0.66
CAMP-ES-15	2.6	–	0.79	9	–	45	–	0.75	–	≤0.76	≤3	≤0.34
CAMP Honey Lake Valley study area												
CAMP-HL-01	13.3	0.13	8.7	6	–	201	–	3.4	–	–	≤4	≤0.35
CAMP-HL-02	–	0.05	2.7	45	–	3	–	–	–	2.5	16	1.29
CAMP-HL-03	– <sup>(4)</sup>	0.06	6.9	37	0.01	628	0.03	0.99	≤0.02	–	≤5	≤0.02
CAMP-HL-04	–	0.03	1.1	84	–	126	–	5.3	≤0.02	≤0.83	–	1.27
CAMP-HL-05	4.9	0.14	1.9	64	–	32	–	≤0.09	≤0.02	–	–	≤0.06
CAMP-HL-06	4.1	0.04	1.4	71	–	38	–	≤0.29	≤0.05	≤1.0	≤6	≤0.02
CAMP-HL-07	2.6	–	8.6	56	0.01	535	–	–	≤0.03	–	92	≤0.03
CAMP-HL-08	50.9	0.04	0.95	7	0.02	836	–	≤0.12	1.4	–	21	≤0.15

**Table 10.** Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project—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 90 grid wells were analyzed. Information about the analytes given in [table 4E](#): **GAMA well identification number**: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; \*, value above benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron <sup>1</sup> (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Benchmark level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LT-MDL] or [SRL]	[1.7]	[0.027]	[0.022]	[0.4]	[0.006]	[3]	<sup>3</sup> [0.016]	<sup>2</sup> [0.42]	<sup>3</sup> [0.38]	<sup>2</sup> [1.7]	<sup>2</sup> [6]	<sup>3</sup> [1.04]
CAMP Honey Lake Valley study area—Continued												
CAMP-HL-09	1.8	–	3.6	66	–	208	0.03	–	≤0.04	–	78	≤0.69
CAMP-HL-10	–	0.04	3.2	54	–	237	–	≤0.09	≤0.06	–	* 383	≤0.18
CAMP-HL-11	2.0	0.11	* 93.9	161	0.03	932	0.12	≤0.32	≤0.05	≤0.68	25	≤0.22
CAMP-HL-12	–	0.11	3.7	85	–	196	0.05	0.70	≤0.05	≤0.68	≤4	≤0.81
CAMP-HL-13	2.7	0.08	0.37	51	0.01	9	0.02	–	–	4.3	–	≤0.13
CAMP-HL-14	1.9	0.03	6.1	108	0.01	530	–	0.43	≤0.03	≤0.70	≤5	≤0.04
CAMP-HL-15	2.8	0.48	* 199	33	0.02	917	0.04	1.9	≤0.04	6.5	–	≤0.15
CAMP Cascade Range and Modoc Plateau Low Use Basins study area												
CAMP-LU-01	3.8	–	0.11	5	0.01	205	–	–	≤0.03	–	≤5	≤0.04
CAMP-LU-02	7.7	–	0.17	17	0.02	672	–	≤0.31	≤0.10	2.7	* 325	1.12
CAMP-LU-03	3.5	0.03	4.0	9	–	83	–	1.1	≤0.02	≤0.73	–	≤0.22
CAMP-LU-04	2.3	0.05	1.3	4	–	30	–	1.3	≤0.02	≤1.3	≤4	≤0.26
CAMP-LU-05	2.3	0.03	5.8	88	–	83	0.02	1.4	≤0.02	2.0	–	≤0.10
CAMP-LU-06	12.9	–	0.15	18	0.01	470	–	≤0.07	≤0.23	≤1.0	20	≤0.36
CAMP-LU-07	2.4	–	0.28	4	–	11	–	2.4	≤0.10	2.8	–	≤0.57
CAMP-LU-08	5.7	0.03	0.36	1	–	5	–	≤0.14	≤0.11	2.5	–	≤0.14
CAMP-LU-09	4.3	–	3.9	17	–	60	–	0.81	≤0.02	–	7	≤0.08
CAMP-LU-10	4.8	–	0.49	7	–	94	–	≤0.08	≤0.23	≤1.1	235	≤0.15
CAMP-LU-11	2.7	0.04	1.6	45	–	11	–	1.9	≤0.03	≤0.68	–	≤0.04
CAMP-LU-12	2.1	–	1.0	4	–	33	–	0.49	–	–	–	≤0.09
CAMP-LU-13	7.4	–	2.7	83	–	37	–	–	≤0.03	≤0.97	* 674	≤0.04
CAMP-LU-14	1.8	0.04	2.0	5	–	20	–	0.71	–	≤0.95	–	≤0.12
CAMP-LU-15	2.8	–	0.75	10	–	13	–	1.3	–	–	–	≤0.10



**Table 10.** Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMMA Priority Basin Project—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 90 grid wells were analyzed. Information about the analytes given in [table 4E](#); **GAMMA well identification number**: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; \*, value above benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

GAMMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron <sup>1</sup> (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Benchmark level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LT-MDL] or [SRL]	[1.7]	[0.027]	[0.022]	<sup>2</sup> [0.4]	[0.006]	[3]	<sup>3</sup> [0.016]	<sup>2</sup> [0.42]	<sup>3</sup> [0.38]	<sup>2</sup> [1.7]	<sup>2</sup> [6]	<sup>3</sup> [1.04]
CAMP Quaternary Volcanic Areas study area												
CAMP-QV-01	2.3	–	–	1	–	–	–	–	–	≤0.79	–	≤0.05
CAMP-QV-02	2.2	0.15	0.46	2	–	5	–	≤0.10	5.5	≤1.2	–	≤0.03
CAMP-QV-03	4.9	–	0.35	82	–	29	–	–	–	–	114	–
CAMP-QV-04	6.3	–	7.8	4	–	110	0.02	≤0.12	≤0.06	–	71	≤0.02
CAMP-QV-05	14.6	–	0.16	2	–	4	–	1.0	–	≤0.67	–	≤0.18
CAMP-QV-06	8.7	0.11	3.6	1	–	22	–	0.90	–	–	≤4	≤0.32
CAMP-QV-07	5.5	–	0.07	2	–	–	–	0.55	–	–	–	≤0.06
CAMP-QV-08	2.1	0.03	0.77	12	–	36	–	1.0	–	3.7	–	≤0.06
CAMP-QV-09	5.0	–	0.09	3	–	–	–	1.6	–	–	–	–
CAMP-QV-10	2.0	–	0.14	1	–	5	–	5.4	–	2.4	–	≤0.47
CAMP-QV-11	1.8	–	0.07	1	–	–	–	2.1	–	≤1.1	–	≤0.47
CAMP-QV-12	2.1	–	–	0.8	–	–	–	8.9	–	≤1.3	≤5	1.08
CAMP-QV-13	3.6	0.05	3.1	8	–	46	0.02	0.85	–	3.6	–	≤0.68
CAMP-QV-14	7.7	0.23	4.8	3	–	23	–	3.0	–	–	23	≤0.14
CAMP-QV-15	–	–	0.58	2	–	43	–	1.4	–	–	≤4	≤0.07
CAMP Shasta Valley and Mount Shasta Volcanic Area study area												
CAMP-SH-01	–	–	0.04	26	–	10	–	0.45	≤0.17	6.4	–	≤0.53
CAMP-SH-02	3.0	0.04	* 108	10	0.02	929	–	1.8	≤0.07	4.6	≤6	≤0.53
CAMP-SH-03	2.5	0.05	0.73	49	–	52	–	8.4	≤0.18	≤1.3	–	≤1.04
CAMP-SH-04	1.8	0.04	3.3	3	–	82	0.02	0.47	–	≤0.56	–	≤0.09
CAMP-SH-05	5.5	0.04	0.90	3	–	12	–	0.69	≤0.02	–	9	≤0.03
CAMP-SH-06	2.8	–	0.41	4	–	16	–	≤0.26	–	≤1.2	–	≤0.22
CAMP-SH-07	1.8	–	0.05	0.8	–	–	–	≤0.10	–	≤1.4	–	≤0.23
CAMP-SH-08	2.0	–	2.4	6	–	36	–	0.52	–	–	–	≤0.07

**Table 10.** Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project—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 90 grid wells were analyzed. Information about the analytes given in [table 4E](#): **GAMA well identification number**: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; \*, value above benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron <sup>1</sup> (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
Benchmark type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Benchmark level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LT-MDL] or [SRL]	[1.7]	[0.027]	[0.022]	2 [0.4]	[0.006]	[3]	3 [0.016]	2 [0.42]	3 [0.38]	2 [1.7]	2 [6]	3 [1.04]
CAMP Shasta Valley and Mount Shasta Volcanic Area study area—Continued												
CAMP-SH-09	–	0.03	0.28	31	–	117	–	1.4	≤0.07	6.0	–	1.75
CAMP-SH-10	–	0.03	2.4	3	–	136	–	≤0.20	≤0.07	4.9	–	2.12
CAMP-SH-11	1.7	–	2.5	3	–	110	–	–	≤0.05	2.1	≤4	≤0.22
CAMP-SH-12	2.3	0.04	5.1	44	0.01	449	–	1.0	≤0.13	5.8	–	≤0.75
CAMP-SH-13	3.4	0.03	4.6	7	0.01	150	–	0.72	≤0.02	≤0.88	–	–
CAMP-SH-14	3.0	–	0.04	3	–	–	–	2.1	–	≤1.3	23	≤0.05
CAMP-SH-15	–	–	0.28	126	0.01	444	–	–	≤0.04	≤0.64	19	≤0.07
CAMP Tertiary Volcanic Areas study area												
CAMP-TV-01	2.8	–	3.9	13	0.12	* 5,520	0.12	0.51	≤0.13	–	≤4	≤0.04
CAMP-TV-02	16.2	0.05	3.3	6	–	62	–	0.89	≤0.02	≤0.89	20	≤0.05
CAMP-TV-03 <sup>5</sup>	9.9	0.03	2.7	8	–	41	–	0.95	–	2.7	–	≤0.54
CAMP-TV-04	2.3	0.03	1.6	3	–	65	–	1.2	–	–	–	≤0.18
CAMP-TV-05	5.0	–	0.36	15	–	7	–	1.5	–	–	–	≤0.21
CAMP-TV-06	5.6	–	0.23	2	–	11	–	0.98	≤0.02	≤1.0	–	1.19
CAMP-TV-07	7.2	–	0.12	11	–	3	–	≤0.20	–	≤0.57	–	≤0.69
CAMP-TV-08	4.0	0.03	0.86	8	–	14	–	2.2	–	–	–	≤0.10
CAMP-TV-09	3.0	–	0.96	12	–	61	–	1.2	–	≤1.1	–	≤0.34
CAMP-TV-10	5.1	–	–	6	–	–	–	0.87	–	2.6	–	≤0.94
CAMP-TV-11	–	–	–	≤0.4	–	–	–	3.3	–	≤1.3	–	1.53
CAMP-TV-12	–	–	0.12	6	–	3	–	0.49	–	–	8	≤0.15
CAMP-TV-13	2.0	–	0.05	5	–	4	–	1.3	–	2.2	–	≤0.13
CAMP-TV-14	–	–	–	–	–	–	–	1.7	≤0.02	2.5	10	≤0.77
CAMP-TV-15	10.2	–	3.2	12	0.03	* 1,640	0.03	– <sup>(4)</sup>	–	≤0.67	≤4	≤0.91

**Table 10.** Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMMA Priority Basin Project—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 90 grid wells were analyzed. Information about the analytes given in [table 4E](#); **GAMMA well identification number**: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; \*, value above benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

GAMMA well identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type	na	SMCL-CA	HAL-US	MCL-CA	MCL-US	SMCL-CA	HAL-US	MCL-US	na	MCL-US	NL-CA	SMCL-CA
Benchmark level	na	50	40	100	50	100	4,000	2	na	30	50	5,000
[LT-MDL] or [SRL]	[0.22]	<sup>3</sup> [0.7]	[0.014]	<sup>2</sup> [0.36]	[0.03]	[0.005]	[0.2]	[0.010]	<sup>2</sup> [0.11]	[0.004]	<sup>2</sup> [0.10]	<sup>2</sup> [4.8]
CAMP Sacramento Valley Eastside study area												
CAMP-ES-01	1.3	≤0.7	0.1	2.40	0.18	–	121	–	–	0.07	11.2	–
CAMP-ES-02	0.3	≤0.2	0.1	0.39	–	–	112	–	–	0.03	11.7	≤1.9
CAMP-ES-03	5.2	–	0.3	–	0.11	–	106	–	≤0.04	0.28	20.5	20.8
CAMP-ES-04	13.3	2.8	0.8	0.76	0.08	–	221	–	≤0.01	0.20	13.7	51.8
CAMP-ES-05	0.3	–	0.1	≤0.33	–	–	104	–	≤0.02	0.04	15.9	≤2.5
CAMP-ES-06	0.9	≤0.2	0.1	≤0.30	0.03	–	119	–	≤0.02	0.11	19.2	16.5
CAMP-ES-07	1.5	–	0.1	≤0.22	0.10	–	139	–	≤0.01	0.12	15.0	21.8
CAMP-ES-08	2.1	≤0.2	0.1	0.59	0.07	–	132	–	≤0.01	0.14	11.6	≤3.7
CAMP-ES-09	4.1	–	0.3	0.55	0.08	–	127	–	≤0.07	0.17	28.5	58.7
CAMP-ES-10	4.3	≤0.4	0.2	0.54	0.04	–	143	–	≤0.01	0.04	19.3	10.8
CAMP-ES-11	0.8	–	0.1	≤0.25	–	–	122	–	–	0.06	17.0	5.4
CAMP-ES-12	0.4	9.9	0.03	≤0.25	–	–	100	–	0.18	0.02	1.8	482
CAMP-ES-13	0.3	≤0.2	0.03	≤0.12	–	–	128	–	–	0.02	7.4	≤3.0
CAMP-ES-14	1.6	–	0.3	≤0.15	0.07	–	122	–	≤0.03	0.28	26.1	–
CAMP-ES-15	5.8	≤0.3	0.2	≤0.28	0.05	–	135	–	≤0.02	0.12	20.0	≤2.0
CAMP Honey Lake Valley study area												
CAMP-HL-01	3.4	≤0.2	5.5	–	0.51	0.01	28.1	–	3.2	0.40	35.4	–
CAMP-HL-02	3.7	1.7	2.4	≤0.11	0.04	–	136	–	≤0.04	1.69	5.7	8.8
CAMP-HL-03	5.1	11.5	12.5	≤0.09	0.08	–	170	–	3.4	0.64	15.6	–
CAMP-HL-04	0.7	–	9.3	–	0.91	–	200	–	≤0.09	1.87	19.4	≤1.7
CAMP-HL-05	–	–	3.6	≤0.09	1.0	–	226	–	≤0.03	0.53	12.9	–
CAMP-HL-06	7.9	≤0.2	2.5	≤0.27	0.18	–	223	–	0.75	0.93	3.8	–
CAMP-HL-07	1.8	* 102	7.4	≤0.12	0.03	–	205	–	11.4	0.45	0.80	≤1.9
CAMP-HL-08	0.6	8.2	3.2	≤0.15	0.03	–	20.9	–	41.4	0.14	0.90	–

**Table 10.** Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project—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 90 grid wells were analyzed. Information about the analytes given in [table 4E](#): **GAMA well identification number**: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; \*, value above benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

GAMA well identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type	na	SMCL-CA 50	HAL-US 40	MCL-CA 100	MCL-US 50	SMCL-CA 100	HAL-US 4,000	MCL-US 2	na	MCL-US 30	NL-CA 50	SMCL-CA 5,000
Benchmark level [LT-MDL] or [SRL]	[0.22]	<sup>3</sup> [0.7]	[0.014]	<sup>2</sup> [0.36]	[0.03]	[0.005]	[0.2]	[0.010]	<sup>2</sup> [0.11]	[0.004]	<sup>2</sup> [0.10]	<sup>2</sup> [4.8]
CAMP Honey Lake Valley study area—Continued												
CAMP-HL-09	33.9	* 196	10.7	—	—	—	222	—	1.1	0.06	0.15	10.4
CAMP-HL-10	52	* 182	5.7	≤0.12	0.42	—	386	—	0.95	1.91	1.4	6.1
CAMP-HL-11	2.4	* 89.2	* 56.6	≤0.22	1.8	—	278	—	3.2	* 35.8	19.1	12.5
CAMP-HL-12	3.4	≤0.2	20.0	≤0.21	1.8	—	389	—	0.93	* 34.2	17.2	8.5
CAMP-HL-13	11.8	—	1.1	—	0.21	0.01	209	—	≤0.03	1.37	1.6	≤4.4
CAMP-HL-14	0.8	≤0.4	3.8	≤0.19	0.28	—	390	—	1.2	4.32	13.6	≤2.0
CAMP-HL-15	4.6	≤0.4	13.6	≤0.29	1.5	—	80.7	—	15.7	5.01	* 146	8.2
CAMP Cascade Range and Modoc Plateau Low Use Basins study area												
CAMP-LU-01	1.6	10.3	3.9	≤0.12	—	—	78.5	—	0.46	—	—	—
CAMP-LU-02	29.7	28.1	1.4	0.55	—	—	98.7	—	0.19	0.01	0.57	37.4
CAMP-LU-03	11.3	≤0.6	2.3	—	0.35	—	98.0	—	0.28	0.99	15.6	≤1.5
CAMP-LU-04	—	—	0.4	—	0.13	—	157	—	≤0.05	0.86	7.9	—
CAMP-LU-05	3.9	—	3.0	—	0.38	—	207	0.01	0.26	2.36	18.3	—
CAMP-LU-06	17.4	14.1	5.0	≤0.33	—	—	4.59	—	5.7	0.01	0.17	≤3.7
CAMP-LU-07	—	≤0.2	0.1	≤0.27	0.49	—	142	—	—	0.84	12.9	≤3.1
CAMP-LU-08	4.2	≤0.2	0.1	—	—	—	40.4	—	≤0.02	0.03	4.0	7.8
CAMP-LU-09	22.8	0.8	2.3	—	0.44	—	65.6	—	≤0.07	1.76	13.8	12.3
CAMP-LU-10	5.0	* 166	3.6	≤0.28	0.04	—	202	—	0.11	0.01	0.70	52.7
CAMP-LU-11	2.5	—	0.7	≤0.12	0.15	—	118	—	≤0.02	0.55	31.6	≤3.8
CAMP-LU-12	6.0	—	2.3	—	0.03	—	73.4	—	≤0.03	0.19	7.9	—
CAMP-LU-13	1.3	* 461	2.8	≤0.12	—	—	155	—	≤0.07	—	0.12	6.9
CAMP-LU-14	7.5	—	0.5	—	—	—	52.9	—	≤0.05	0.26	6.9	—
CAMP-LU-15	1.3	—	0.2	—	—	—	73.0	—	≤0.02	0.61	2.8	≤2.4

**Table 10.** Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project—Continued

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GAMA well identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
<b>Benchmark type</b>	na	SMCL-CA	HAL-US	MCL-CA	MCL-US	SMCL-CA	HAL-US	MCL-US	na	MCL-US	NL-CA	SMCL-CA
<b>Benchmark level</b>	na	50	40	100	50	100	4,000	2	na	30	50	5,000
[LT-MDL] or [SRL]	[0.22]	<sup>3</sup> [0.7]	[0.014]	<sup>2</sup> [0.36]	[0.03]	[0.005]	[0.2]	[0.010]	<sup>2</sup> [0.11]	[0.004]	<sup>2</sup> [0.10]	<sup>2</sup> [4.8]
<b>CAMP Quaternary Volcanic Areas study area</b>												
CAMP-QV-01	–	–	0.03	–	–	–	24.8	–	–	–	7.5	≤2.1
CAMP-QV-02	3.9	7.8	0.2	0.70	–	–	41.7	0.01	≤0.04	0.06	11.7	≤2.9
CAMP-QV-03	0.5	* 144	5.6	–	–	–	88.0	–	0.22	–	–	–
CAMP-QV-04	5.3	* 67.7	13.0	0.48	0.15	–	107	–	0.16	0.45	26.6	24.3
CAMP-QV-05	0.9	–	0.4	–	–	0.01	66.5	–	≤0.04	0.33	5.5	≤2.1
CAMP-QV-06	1.5	≤0.4	1.9	–	0.15	–	24.1	–	0.41	0.55	29.4	–
CAMP-QV-07	0.5	–	0.1	–	–	–	67.4	–	–	0.16	2.8	–
CAMP-QV-08	2.0	–	0.7	–	0.05	–	57.3	–	≤0.05	0.56	9.6	–
CAMP-QV-09	0.5	–	0.2	–	–	–	78.8	–	≤0.01	0.42	3.2	–
CAMP-QV-10	–	–	0.04	≤0.09	–	–	99.4	0.01	–	0.04	9.4	8.5
CAMP-QV-11	–	–	–	–	–	–	79.0	–	–	0.02	8.2	≤2.5
CAMP-QV-12	–	≤0.2	–	–	–	–	54.7	–	–	0.01	8.7	–
CAMP-QV-13	7.3	–	1.6	≤0.20	0.04	–	86.9	–	≤0.05	0.32	11.9	24.9
CAMP-QV-14	4.6	1.0	2.4	–	0.09	–	14.5	0.02	0.66	0.08	29.6	12.3
CAMP-QV-15	2.4	≤0.4	2.1	–	0.03	–	66.3	–	≤0.02	0.10	7.6	≤1.4
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area</b>												
CAMP-SH-01	5.8	≤0.2	0.1	1.00	0.13	–	388	–	–	0.95	0.23	8.7
CAMP-SH-02	39.9	5.2	0.5	0.80	0.90	–	170	–	≤0.06	1.45	31.1	39.7
CAMP-SH-03	1.4	≤0.6	0.4	1.10	0.30	–	332	–	≤0.01	1.22	2.5	≤3.6
CAMP-SH-04	22.0	–	1.4	–	0.08	–	66.1	0.01	≤0.03	0.09	25.4	–
CAMP-SH-05	16.4	–	0.4	–	0.03	–	52.7	–	≤0.05	0.14	* 54.3	–
CAMP-SH-06	5.5	≤0.3	0.2	–	–	–	44.6	–	≤0.02	0.10	9.8	72
CAMP-SH-07	0.9	–	0.1	–	–	–	42.9	–	–	0.04	7.3	37.9
CAMP-SH-08	14.0	–	0.8	–	0.10	–	173	–	≤0.02	0.30	13.8	–



**Table 10.** Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project—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 90 grid wells were analyzed. Information about the analytes given in [table 4E](#): **GAMA well identification number**: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; \*, value above benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

GAMA well identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Silver (µg/L) (01075)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
Benchmark type	na	SMCL-CA	HAL-US	MCL-CA	MCL-US	SMCL-CA	HAL-US	MCL-US	na	MCL-US	NL-CA	SMCL-CA
Benchmark level [LT-MDL] or [SRL]	na [0.22]	50 [0.7]	40 [0.014]	100 [0.36]	50 [0.03]	100 [0.005]	4,000 [0.2]	2 [0.010]	na [0.11]	30 [0.004]	50 [0.10]	5,000 [4.8]
CAMP Shasta Valley and Mount Shasta Volcanic Area study area—Continued												
CAMP-SH-09	1.8	—	0.3	≤0.31	0.09	—	296	—	—	1.29	1.1	≤4.7
CAMP-SH-10	50.5	≤0.2	1.0	≤0.32	0.04	—	121	—	≤0.02	0.21	21.1	8.9
CAMP-SH-11	54.5	≤0.2	1.4	0.55	—	—	104	—	≤0.03	0.14	20.4	≤2.9
CAMP-SH-12	11.6	—	1.0	0.91	0.16	—	523	—	≤0.07	4.70	36.3	5.4
CAMP-SH-13	12.1	—	0.6	0.41	0.09	—	132	—	≤0.03	0.46	20.5	—
CAMP-SH-14	0.7	1.4	0.02	≤0.13	—	—	307	—	—	0.03	3.0	≤2.6
CAMP-SH-15	23.7	* 186	0.9	0.62	0.05	—	2,430	—	0.99	1.96	0.76	≤3.4
CAMP Tertiary Volcanic Areas study area												
CAMP-TV-01	95.2	4.8	* 41.0	0.55	0.18	—	207	—	0.44	0.21	7.4	5.5
CAMP-TV-02	4.3	≤0.2	0.9	≤0.15	0.15	—	62.6	—	≤0.07	0.23	11.0	15.8
CAMP-TV-03 <sup>5</sup>	6.6	—	1.3	0.37	0.03	—	82.5	—	≤0.03	0.28	11.3	5.9
CAMP-TV-04	—	—	1.0	—	0.05	—	161	—	0.12	0.09	16.0	6.5
CAMP-TV-05	0.8	—	0.5	≤0.13	0.06	—	93.4	—	≤0.08	0.6	10.9	14.4
CAMP-TV-06	0.6	≤0.2	0.2	—	—	—	56.6	—	≤0.02	0.37	3.1	61
CAMP-TV-07	0.3	≤0.2	0.1	—	—	—	163	—	≤0.02	0.33	4.7	5.6
CAMP-TV-08	1.6	—	1.0	—	0.08	—	47.7	—	0.17	0.42	17.4	7.8
CAMP-TV-09	1.3	—	0.3	—	0.04	—	219	—	≤0.01	1.62	7.2	≤2.1
CAMP-TV-10	0.5	1.0	—	≤0.17	—	—	92.4	—	—	0.01	0.29	15.1
CAMP-TV-11	—	—	—	—	—	—	35.9	—	—	—	1.9	≤4.5
CAMP-TV-12	1.1	≤0.2	0.04	—	—	—	72.4	—	—	0.07	4.9	32.7
CAMP-TV-13	0.8	≤0.2	0.02	≤0.14	—	—	93.5	—	—	0.08	2.0	5.0
CAMP-TV-14	—	1.0	—	≤0.13	—	—	11.5	—	—	—	0.74	21.2
CAMP-TV-15	2.0	3.2	9.0	—	—	—	12.3	—	1.3	0.02	0.46	—

**Table 10.** Trace elements detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project—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 90 grid wells were analyzed. Information about the analytes given in [table 4E](#); **GAMA well identification number**: ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; -, not detected; ≤, less than or equal to; \*, value above benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

#### Footnotes:

- <sup>1</sup> Results from the USGS Branch of Quality Systems Quality Assurance project during the time period that the CAMP study unit samples were analyzed at the NWQL (mid-August through November 2010) indicate that boron results with concentrations less than approximately 60 µg/L may have analytical bias, see the appendix for more information.
- <sup>2</sup> SRL defined based on examination of GAMA quality-control samples collected from May 2004 through January 2008 (Olsen and others, 2010). Values below the SRL are reported as ≤ the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is < or = reported value, based on QC data (may include: field blanks, source-solution blanks, trip blanks, NWQL set blanks, NWQL blank water certificates, and USGS BQS Blind Blank Program data).
- <sup>3</sup> SRL defined as the highest concentration detected in field blanks collected for the CAMP study unit. Values below the SRL are reported as less than or equal to (≤) the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is ≤ reported value, based on quality-control data collected for this study.
- <sup>4</sup> MDL raised by the laboratory (aluminum had a raised MDL of 3.4 for HL-03; chromium had a raised MDL of 0.09 for TV-15).
- <sup>5</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

**Table 11.** Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 90 wells were analyzed. Information about the analytes given in [table 4F](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** LT-MDL, long-term method detection level; MRL, method reporting level; mg/L, milligrams per liter;  $\text{SiO}_2$ , silicon dioxide; na, not available; –, not detected; \*, value above benchmark level; \*\*, value above upper benchmark level]

GAMA well identification number	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Silica (as $\text{SiO}_2$ ) (mg/L) (00955)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)
Benchmark type	na	na	SMCL-CA	MCL-CA	na	na	na	na	na	SMCL-CA	SMCL-CA
Benchmark level	na	na	1 250 (500)	2	na	na	na	na	na	1 250 (500)	1 500 (1,000)
[LT-MDL]	[0.010]	[0.022]	[0.06]	[0.04]	[0.0010]	[0.008]	[0.032]	[0.029]	[0.06]	[0.09]	[12]
CAMP Sacramento Valley Eastside study area											
CAMP-ES-01	0.02	20.2	2.92	–	–	11.9	1.27	55.1	5.9	1.40	165
CAMP-ES-02	0.02	15.6	2.46	–	–	9.68	1.77	69.3	5.8	0.23	168
CAMP-ES-03	0.01	17.8	0.96	0.07	–	13.0	1.63	64.9	11.3	1.05	173
CAMP-ES-04	0.03	27.0	7.79	0.10	0.009	19.1	2.30	44.8	22.9	10.8	232
CAMP-ES-05	–	15.3	0.93	–	–	9.35	1.64	63.9	5.0	0.36	147
CAMP-ES-06	–	20.5	0.96	–	–	9.44	1.83	61.6	6.2	0.39	171
CAMP-ES-07	–	20.6	1.03	0.06	–	10.4	1.93	63.2	7.4	1.28	171
CAMP-ES-08	–	17.2	1.03	–	–	10.7	1.84	64.0	7.9	0.57	152
CAMP-ES-09	–	20.4	1.49	0.06	–	17.4	1.66	64.4	11.2	0.64	221
CAMP-ES-10	–	21.7	1.23	0.06	–	11.2	1.25	72.6	7.5	0.38	188
CAMP-ES-11	–	20.2	1.09	–	–	8.41	1.53	63.7	6.2	0.37	185
CAMP-ES-12	–	14.4	3.11	–	–	6.87	1.39	47.2	5.5	0.19	141
CAMP-ES-13	0.02	20.0	4.68	–	–	10.2	1.10	64.7	6.8	0.56	182
CAMP-ES-14	–	20.2	2.05	0.09	–	13.5	2.45	63.9	7.8	0.87	184
CAMP-ES-15	–	17.7	3.26	0.13	–	10.3	1.13	64.0	9.3	3.40	173
CAMP Honey Lake Valley study area											
CAMP-HL-01	0.10	2.66	18.5	0.29	–	0.935	3.44	39.0	75.9	28.8	252
CAMP-HL-02	0.02	16.5	1.44	0.24	0.002	2.96	2.13	19.9	20.9	19.8	129
CAMP-HL-03	0.11	27.0	41.1	0.28	0.008	10.1	4.31	52.8	71.9	119	393
CAMP-HL-04	0.05	24.6	4.32	0.21	0.001	10.3	2.14	58.1	63.2	81.0	351
CAMP-HL-05	0.04	23.8	8.34	0.28	0.004	8.97	1.91	47.1	21.2	14.3	217
CAMP-HL-06	0.02	27.3	18.9	0.07	0.001	6.60	2.95	36.8	19.0	7.64	219
CAMP-HL-07	0.46	16.5	162	0.51	0.020	9.96	5.43	34.5	213	74.5	* 733
CAMP-HL-08	0.06	1.11	19.0	1.08	0.016	0.529	1.60	32.7	252	22.8	* 710

**Table 11.** Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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 90 wells were analyzed. Information about the analytes given in [table 4F](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** LT-MDL, long-term method detection level; MRL, method reporting level; mg/L, milligrams per liter;  $\text{SiO}_2$ , silicon dioxide; na, not available; –, not detected; \*, value above benchmark level; \*\*, value above upper benchmark level]

GAMA well identification number	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Silica (as $\text{SiO}_2$ ) (mg/L) (00955)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)	
											SMCL-CA	SMCL-CA
Benchmark type	na	na	SMCL-CA	MCL-CA	na	na	na	na	na	na	<sup>1</sup> 250 (500)	<sup>1</sup> 500 (1,000)
Benchmark level	na	na	<sup>1</sup> 250 (500)	2	na	na	na	na	na	na	<sup>1</sup> 250 (500)	<sup>1</sup> 500 (1,000)
[LT-MDL]	[0.010]	[0.022]	[0.06]	[0.04]	[0.0010]	[0.008]	[0.032]	[0.029]	[0.06]	[0.09]	[12]	[12]
CAMP Honey Lake Valley study area—Continued												
CAMP-HL-09	0.09	30.3	15.0	0.35	0.001	9.56	5.39	56.1	50.5	62.2	323	323
CAMP-HL-10	0.12	46.1	25.9	0.46	–	18.4	8.42	53.1	70.9	143	490	490
CAMP-HL-11	0.22	32.7	58.0	0.65	0.028	14.7	9.42	50.5	193	166	* 771	* 771
CAMP-HL-12	0.07	65.4	17.5	0.27	0.002	28.9	2.98	34.9	60.1	216	* 545	* 545
CAMP-HL-13	0.02	17.6	3.33	0.23	–	4.46	0.84	49.4	17.9	2.62	149	149
CAMP-HL-14	0.30	52.3	34.4	0.24	0.010	22.9	13.0	58.1	107	181	* 776	* 776
CAMP-HL-15	0.20	7.70	29.8	1.51	0.018	3.17	3.79	51.5	256	77.3	* 622	* 622
CAMP Cascade Range and Modoc Plateau Low Use Basins study area												
CAMP-LU-01	0.04	6.05	7.38	0.20	0.005	2.53	14.2	31.4	58.2	1.30	217	217
CAMP-LU-02	0.21	11.9	45.5	0.23	0.011	18.7	7.13	45.9	121	5.96	472	472
CAMP-LU-03	0.07	20.1	5.96	0.21	0.002	3.26	9.51	76.7	41.5	20.1	266	266
CAMP-LU-04	0.01	33.8	5.24	0.04	–	8.72	0.89	22.9	13.4	9.49	188	188
CAMP-LU-05	0.06	30.4	6.05	0.19	–	6.56	8.41	65.7	30.6	20.4	274	274
CAMP-LU-06	0.04	0.52	9.43	0.53	0.005	0.200	6.20	75.8	77.8	19.3	286	286
CAMP-LU-07	0.08	22.7	2.23	0.11	0.001	14.2	2.27	38.5	8.9	13.1	165	165
CAMP-LU-08	–	4.61	0.21	0.05	–	1.40	1.63	47.4	4.3	0.34	82	82
CAMP-LU-09	0.10	7.88	8.26	0.17	0.002	1.17	8.59	67.3	57.2	15.3	254	254
CAMP-LU-10	0.08	67.0	12.4	0.30	0.017	70.8	12.9	23.3	91.9	33.2	* 676	* 676
CAMP-LU-11	0.03	15.0	3.35	0.23	–	8.92	4.96	65.1	12.1	4.23	170	170
CAMP-LU-12	–	10.4	0.68	0.06	–	7.00	2.54	42.4	7.0	2.31	110	110
CAMP-LU-13	0.03	21.8	9.31	0.27	0.005	12.9	3.32	59.4	32.5	14.9	244	244
CAMP-LU-14	–	7.70	0.49	–	–	6.12	2.64	36.2	6.2	0.46	77	77
CAMP-LU-15	0.01	16.4	1.44	–	–	6.72	2.12	32.7	5.6	0.57	108	108

**Table 11.** Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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 90 wells were analyzed. Information about the analytes given in [table 4F](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** LT-MDL, long-term method detection level; MRL, method reporting level; mg/L, milligrams per liter;  $\text{SiO}_2$ , silicon dioxide; na, not available; —, not detected; \*, value above benchmark level; \*\*, value above upper benchmark level]

GAMA well identification number	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Silica (as $\text{SiO}_2$ ) (mg/L) (00955)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)
Benchmark type	na	na	SMCL-CA	MCL-CA	na	na	na	na	na	SMCL-CA	SMCL-CA
Benchmark level	na	na	<sup>1</sup> 250 (500)	2	na	na	na	na	na	<sup>1</sup> 250 (500)	<sup>1</sup> 500 (1,000)
[LT-MDL]	[0.010]	[0.022]	[0.06]	[0.04]	[0.0010]	[0.008]	[0.032]	[0.029]	[0.06]	[0.09]	[12]
CAMP Quaternary Volcanic Areas study area											
CAMP-QV-01	—	3.52	0.18	—	—	1.14	0.65	23.8	1.9	0.22	54
CAMP-QV-02	—	3.58	0.21	0.07	—	0.930	1.40	33.4	2.9	0.18	64
CAMP-QV-03	0.05	15.5	5.42	0.18	0.006	4.89	9.14	69.8	39.1	17.6	240
CAMP-QV-04	0.10	36.1	20.6	0.37	0.009	44.9	11.4	23.7	95.1	98.8	* 563
CAMP-QV-05	—	10.1	0.55	—	—	5.88	1.74	31.0	5.4	0.36	84
CAMP-QV-06	0.02	9.62	1.41	0.13	—	1.10	3.36	51.2	21.5	3.62	138
CAMP-QV-07	—	9.08	0.25	—	—	4.80	1.44	28.4	3.9	—	71
CAMP-QV-08	—	11.7	1.28	0.06	—	7.75	2.56	39.2	7.9	2.10	121
CAMP-QV-09	—	13.6	0.96	—	—	7.73	1.75	26.8	5.0	0.81	109
CAMP-QV-10	—	21.1	0.89	—	—	16.1	0.67	56.9	6.5	0.31	183
CAMP-QV-11	—	22.2	1.14	—	—	10.4	0.66	52.2	5.7	0.43	166
CAMP-QV-12	—	15.8	1.05	—	—	11.0	0.33	58.0	4.4	0.32	149
CAMP-QV-13	—	12.1	1.00	0.04	—	10.4	3.02	54.1	10.3	2.48	150
CAMP-QV-14	—	1.79	0.68	0.22	—	1.24	1.99	45.4	14.8	0.45	95
CAMP-QV-15	—	11.6	0.80	—	—	7.56	2.28	39.8	8.6	2.13	117
CAMP Shasta Valley and Mount Shasta Volcanic Area study area											
CAMP-SH-01	0.02	72.5	3.83	0.14	—	9.26	0.63	25.5	9.0	8.44	269
CAMP-SH-02	0.07	19.4	26.7	0.20	0.004	45.3	1.34	65.3	30.5	15.7	336
CAMP-SH-03	0.02	67.5	5.41	0.10	—	24.3	1.56	29.4	11.7	21.4	323
CAMP-SH-04	0.04	7.03	8.75	0.33	—	6.38	1.19	56.8	18.3	1.36	141
CAMP-SH-05	—	5.21	0.62	0.27	—	4.14	1.30	53.7	10.1	1.28	109
CAMP-SH-06	—	6.36	1.13	0.07	—	4.08	1.81	51.7	7.4	0.28	104
CAMP-SH-07	—	5.48	0.14	—	—	1.02	1.37	33.2	2.9	0.16	62
CAMP-SH-08	0.02	15.8	6.80	0.23	0.001	13.5	1.83	64.1	19.2	9.49	166
CAMP-SH-09	0.06	56.6	15.0	0.14	0.001	21.7	1.34	29.2	18.7	12.8	306



**Table 11.** Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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 90 wells were analyzed. Information about the analytes given in [table 4F](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** LT-MDL, long-term method detection level; MRL, method reporting level; mg/L, milligrams per liter; SiO<sub>2</sub>, silicon dioxide; na, not available; –, not detected; \*, value above benchmark level; \*\*, value above upper benchmark level]

GAMA well identification number	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Silica (as SiO <sub>2</sub> ) (mg/L) (00955)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)	
											SMCL-CA	SMCL-CA
Benchmark type	na	na	SMCL-CA	MCL-CA	na	na	na	na	na	na	<sup>1</sup> 250 (500)	SMCL-CA
Benchmark level	na	na	<sup>1</sup> 250 (500)	2	na	na	na	na	na	na	<sup>1</sup> 250 (500)	<sup>1</sup> 500 (1,000)
[LT-MDL]	[0.010]	[0.022]	[0.06]	[0.04]	[0.0010]	[0.008]	[0.032]	[0.029]	[0.06]	[0.09]	[12]	[12]
CAMP Shasta Valley and Mount Shasta Volcanic Area study area—Continued												
CAMP-SH-10	0.03	17.5	9.70	0.40	0.003	22.8	1.83	60.6	21.8	7.08	251	251
CAMP-SH-11	0.02	15.2	6.56	0.41	0.007	21.2	1.50	63.2	20.0	6.45	219	219
CAMP-SH-12	0.09	61.0	23.2	0.26	0.010	46.8	5.78	56.9	59.4	45.3	* 570	* 570
CAMP-SH-13	0.04	16.1	9.88	0.22	0.001	14.6	2.09	48.6	18.4	5.46	179	179
CAMP-SH-14	–	10.4	0.48	–	–	5.30	1.62	59.7	6.8	0.10	125	125
CAMP-SH-15	0.17	79.2	94.1	0.45	0.022	36.7	2.23	15.1	115	54.0	* 626	* 626
CAMP Tertiary Volcanic Areas study area												
CAMP-TV-01	1.03	58.5	** 687	0.60	0.092	1.08	0.93	18.9	445	91.5	** 1,380	** 1,380
CAMP-TV-02	0.01	10.6	2.95	0.08	–	6.83	2.42	34.9	11.8	2.33	114	114
CAMP-TV-03 <sup>2</sup>	–	12.6	1.04	0.06	–	10.8	2.98	55.8	9.1	2.40	151	151
CAMP-TV-04	0.01	7.69	3.14	0.11	–	5.85	2.52	44.5	9.9	1.08	112	112
CAMP-TV-05	0.01	12.7	2.21	0.07	–	10.0	4.47	57.9	12.5	0.60	164	164
CAMP-TV-06	–	10.7	0.57	–	–	6.06	1.76	22.2	4.2	0.18	85	85
CAMP-TV-07	–	17.3	0.48	0.04	–	8.02	3.89	33.6	6.9	0.22	132	132
CAMP-TV-08	0.01	9.94	1.41	0.09	–	4.27	3.92	35.6	18.1	0.96	126	126
CAMP-TV-09	0.02	24.3	6.32	–	–	22.1	1.97	31.3	7.7	2.01	191	191
CAMP-TV-10	–	10.2	0.73	–	–	7.07	0.88	23.6	2.4	–	80	80
CAMP-TV-11	–	11.7	0.29	–	–	6.98	0.35	25.9	2.3	–	94	94
CAMP-TV-12	–	12.6	0.66	–	–	7.12	1.16	37.6	4.0	0.22	98	98
CAMP-TV-13	–	14.0	0.50	–	–	9.46	1.15	38.0	3.6	0.14	118	118
CAMP-TV-14	–	3.78	0.42	–	–	4.73	0.15	20.7	1.0	0.14	54	54
CAMP-TV-15	0.04	2.01	14.4	0.60	0.008	0.083	0.27	11.7	65.9	10.3	170	170

<sup>1</sup> The SMCL-CAs for chloride, sulfate, and total dissolved solids (TDS) have recommended and upper benchmark levels. The benchmark level is shown in parentheses.

<sup>2</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

**Table 12.** Uranium isotopes detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 20 grid wells were analyzed, and all results are reported. Values less than the sample-specific critical level ( $ssl_c$ ) are reported as non-detections (–). [Table 4C](#) contains additional information about the constituents. **GAMA well identification number:** HL, Honey Lake Valley study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter;  $\pm$ , plus or minus; \*, value above benchmark level]

GAMA well identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)	
Benchmark type <sup>1</sup>	MCL-CA		MCL-CA		MCL-CA	
Benchmark level	<sup>2</sup> 20		<sup>2</sup> 20		<sup>2</sup> 20	
Reporting level method	result $\pm$ CSU	$ssl_c$	result $\pm$ CSU	$ssl_c$	result $\pm$ CSU	$ssl_c$
<b>CAMP Honey Lake Valley study area</b>						
CAMP-HL-05	0.239 $\pm$ 0.033	0.020	0.019 $\pm$ 0.015	0.016	0.152 $\pm$ 0.025	0.013
CAMP-HL-06	0.455 $\pm$ 0.063	0.026	–	0.023	0.306 $\pm$ 0.052	0.022
CAMP-HL-07	0.143 $\pm$ 0.034	0.028	–	0.025	0.198 $\pm$ 0.042	0.019
CAMP-HL-08	0.056 $\pm$ 0.028	0.025	0.026 $\pm$ 0.017	0.008	0.056 $\pm$ 0.021	0.017
CAMP-HL-11	* 16.20 $\pm$ 0.73	0.031	* 0.618 $\pm$ 0.055	0.011	* 10.40 $\pm$ 0.48	0.028
CAMP-HL-12	* 14.30 $\pm$ 0.67	0.033	* 0.58 $\pm$ 0.060	0.014	* 10.00 $\pm$ 0.48	0.030
CAMP-HL-14	2.20 $\pm$ 0.13	0.019	0.088 $\pm$ 0.019	0.016	1.46 $\pm$ 0.095	0.013
CAMP-HL-15	2.76 $\pm$ 0.15	0.020	0.098 $\pm$ 0.021	0.012	1.70 $\pm$ 0.10	0.015
<b>CAMP Quaternary Volcanic Areas study area</b>						
CAMP-QV-07	0.140 $\pm$ 0.027	0.017	–	0.015	0.070 $\pm$ 0.018	0.012
CAMP-QV-08	0.340 $\pm$ 0.043	0.020	0.022 $\pm$ 0.011	0.015	0.201 $\pm$ 0.033	0.012
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area</b>						
CAMP-SH-01	1.260 $\pm$ 0.090	0.020	0.062 $\pm$ 0.019	0.015	0.287 $\pm$ 0.037	0.016
CAMP-SH-02	0.828 $\pm$ 0.064	0.018	0.053 $\pm$ 0.017	0.015	0.512 $\pm$ 0.046	0.013
CAMP-SH-03	1.090 $\pm$ 0.082	0.017	0.020 $\pm$ 0.010	0.015	0.398 $\pm$ 0.045	0.013
CAMP-SH-04	0.070 $\pm$ 0.020	0.020	–	0.019	–	0.015
CAMP-SH-05	0.054 $\pm$ 0.027	0.032	–	0.024	0.045 $\pm$ 0.027	0.027
CAMP-SH-06	0.079 $\pm$ 0.029	0.032	–	0.020	0.100 $\pm$ 0.029	0.019
CAMP-SH-07	–	0.025	–	0.020	–	0.014
<b>CAMP Tertiary Volcanic Areas study area</b>						
CAMP-TV-01	0.170 $\pm$ 0.027	0.017	–	0.014	0.073 $\pm$ 0.017	0.010
CAMP-TV-04	0.089 $\pm$ 0.025	0.019	–	0.017	0.040 $\pm$ 0.015	0.015
CAMP-TV-05	0.358 $\pm$ 0.047	0.018	–	0.019	0.219 $\pm$ 0.036	0.016

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

<sup>2</sup>The MCL-US benchmark for uranium is the sum of uranium-234, uranium-235, and uranium-238.

**Table 13.** Radon-222 detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 90 grid wells were analyzed. Values less than the sample-specific critical level ( $ssL_c$ ) are reported as non-detections (–). Information about the analytes given in [table 4G](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter;  $\pm$ , plus or minus; nc, not collected; \*, value above benchmark level]

GAMA well identification number	Radon-222 (pCi/L) (82303)		GAMA well identification number	Radon-222 (pCi/L) (82303)	
Benchmark type	Proposed MCL-US		Benchmark type	Proposed MCL-US	
Benchmark level	4,000		Benchmark level	4,000	
Reporting level method	Result $\pm$ CSU	$ssL_c$	Reporting level method	Result $\pm$ CSU	$ssL_c$
CAMP Sacramento Valley Eastside study area			CAMP Cascade Range and Modoc Plateau Low Use Basins study area		
CAMP-ES-01	149 $\pm$ 13	12.26	CAMP-LU-01	420 $\pm$ 27	11.89
CAMP-ES-02	124 $\pm$ 12	12.59	CAMP-LU-02	46.0 $\pm$ 8.4	11.30
CAMP-ES-03	109 $\pm$ 12	13.61	CAMP-LU-03	430 $\pm$ 28	12.49
CAMP-ES-04	350 $\pm$ 23	11.56	CAMP-LU-04	930 $\pm$ 54	12.15
CAMP-ES-05	104 $\pm$ 11	11.15	CAMP-LU-05	600 $\pm$ 39	18.93
CAMP-ES-06	141 $\pm$ 13	11.53	CAMP-LU-06	610 $\pm$ 40	18.41
CAMP-ES-07	173 $\pm$ 15	13.37	CAMP-LU-07	15.0 $\pm$ 8.8	13.75
CAMP-ES-08	70.0 $\pm$ 9.4	11.32	CAMP-LU-08	230 $\pm$ 20	17.99
CAMP-ES-09	98 $\pm$ 10	11.08	CAMP-LU-09	470 $\pm$ 30	13.77
CAMP-ES-10	20.0 $\pm$ 8.1	12.48	CAMP-LU-10	66.0 $\pm$ 9.8	12.19
CAMP-ES-11	103 $\pm$ 11	12.39	CAMP-LU-11	870 $\pm$ 51	13.33
CAMP-ES-12	370 $\pm$ 24	11.83	CAMP-LU-12	740 $\pm$ 46	18.15
CAMP-ES-13	163 $\pm$ 14	11.78	CAMP-LU-13	192 $\pm$ 16	13.55
CAMP-ES-14	108 $\pm$ 11	10.54	CAMP-LU-14	520 $\pm$ 33	13.92
CAMP-ES-15	101 $\pm$ 12	13.45	CAMP-LU-15	390 $\pm$ 26	13.95
CAMP Honey Lake Valley study area			CAMP Quaternary Volcanic Areas study area		
CAMP-HL-01	420 $\pm$ 27	12.60	CAMP-QV-01	138 $\pm$ 13	12.96
CAMP-HL-02	1,520 $\pm$ 89	25.32	CAMP-QV-02	220 $\pm$ 20	18.26
CAMP-HL-03	410 $\pm$ 32	24.86	CAMP-QV-03	640 $\pm$ 39	13.25
CAMP-HL-04	390 $\pm$ 29	21.56	CAMP-QV-04	111 $\pm$ 12	12.10
CAMP-HL-05	380 $\pm$ 25	13.10	CAMP-QV-05	61 $\pm$ 10	13.48
CAMP-HL-06	1,080 $\pm$ 62	12.79	CAMP-QV-06	600 $\pm$ 40	21.08
CAMP-HL-07	460 $\pm$ 29	11.31	CAMP-QV-07	440 $\pm$ 28	12.86
CAMP-HL-08	410 $\pm$ 26	12.21	CAMP-QV-08	430 $\pm$ 28	12.89
CAMP-HL-09	280 $\pm$ 21	13.78	CAMP-QV-09	460 $\pm$ 29	13.30
CAMP-HL-10	970 $\pm$ 56	13.58	CAMP-QV-10	214 $\pm$ 16	12.06
CAMP-HL-11	800 $\pm$ 47	12.59	CAMP-QV-11	225 $\pm$ 17	12.32
CAMP-HL-12	1,040 $\pm$ 60	12.25	CAMP-QV-12	480 $\pm$ 31	13.72
CAMP-HL-13	* 5,100 $\pm$ 280	31.26	CAMP-QV-13	380 $\pm$ 25	13.40
CAMP-HL-14	370 $\pm$ 33	30.94	CAMP-QV-14	970 $\pm$ 56	12.12
CAMP-HL-15	258 $\pm$ 19	12.91	CAMP-QV-15	1,540 $\pm$ 85	11.47

**Table 13.** Radon-222 detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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 90 grid wells were analyzed. Values less than the sample-specific critical level ( $ssL_c$ ) are reported as non-detections (–). Information about the analytes given in [table 4G](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; ±, plus or minus; nc, not collected; \*, value above benchmark level]

GAMA well identification number			Radon-222 (pCi/L) (82303)		
Benchmark type			Proposed MCL-US		
Benchmark level			4,000		
Reporting level method			Result ± CSU	$ssL_c$	
CAMP Shasta Valley and Mount Shasta Volcanic Area study area					
CAMP-SH-01			1,410 ± 79	12.31	
CAMP-SH-02			51.0 ± 9.6	13.05	
CAMP-SH-03			830 ± 49	12.84	
CAMP-SH-04			121 ± 12	12.45	
CAMP-SH-05			219 ± 17	12.48	
CAMP-SH-06			560 ± 34	10.90	
CAMP-SH-07			220 ± 16	10.86	
CAMP-SH-08			790 ± 46	12.06	
CAMP-SH-09			940 ± 55	13.85	
CAMP-SH-10			134 ± 13	13.03	
CAMP-SH-11			75 ± 10	12.88	
CAMP-SH-12			213 ± 17	13.02	
CAMP-SH-13			112 ± 11	11.14	
CAMP-SH-14			320 ± 22	11.96	
CAMP-SH-15			480 ± 30	10.66	
GAMA well identification number			Radon-222 (pCi/L) (82303)		
Benchmark type			Proposed MCL-US		
Benchmark level			4,000		
Reporting level method			Result ± CSU	$ssL_c$	
CAMP Tertiary Volcanic Areas study area					
CAMP-TV-01			126 ± 12	11.98	
CAMP-TV-02			103 ± 11	12.62	
CAMP-TV-03 <sup>1</sup>			230 ± 20	18.45	
CAMP-TV-04			280 ± 20	13.58	
CAMP-TV-05			270 ± 20	13.54	
CAMP-TV-06			620 ± 38	13.38	
CAMP-TV-07			320 ± 21	11.58	
CAMP-TV-08			70 ± 10	13.31	
CAMP-TV-09			930 ± 53	11.54	
CAMP-TV-10			350 ± 23	11.40	
CAMP-TV-11			450 ± 28	12.14	
CAMP-TV-12			360 ± 24	12.30	
CAMP-TV-13			770 ± 45	11.38	
CAMP-TV-14			300 ± 21	12.96	
CAMP-TV-15			1,610 ± 90	12.61	

<sup>1</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

**Table 14.** Gross alpha and gross beta particle activities detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 90 grid wells were analyzed. Information about the analytes given in [table 4G](#). The reference nuclide for measurement of gross alpha is thorium-230, and the reference nuclide for measurement of gross beta is cesium-137. Measured values less than the sample-specific critical level ( $ssL_c$ ) are reported as non-detections (–). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocurie per liter; ±, plus or minus; \*, value above benchmark level]

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)	
Benchmark type	MCL-US		MCL-US		MCL-CA		MCL-CA	
Benchmark level	15		15		50		50	
Reporting level method	Result ± CSU	$ssL_c$	Result ± CSU	$ssL_c$	Result ± CSU	$ssL_c$	Result ± CSU	$ssL_c$
<b>CAMP Sacramento Valley Eastside study area</b>								
CAMP-ES-01	–	0.57	0.70 ± 0.41	0.47	–	0.62	–	0.98
CAMP-ES-02	–	0.48	–	0.42	1.30 ± 0.41	0.63	2.04 ± 0.61	0.96
CAMP-ES-03	–	0.67	–	1.0	2.22 ± 0.66	1.1	1.20 ± 0.60	0.92
CAMP-ES-04	–	1.1	–	1.1	3.62 ± 0.63	0.79	2.38 ± 0.71	1.0
CAMP-ES-05	–	0.71	–	0.61	1.40 ± 0.50	0.67	–	0.87
CAMP-ES-06	–	0.46	1.03 ± 0.61	0.65	0.90 ± 0.40	0.63	–	0.88
CAMP-ES-07	–	0.62	0.50 ± 0.37	0.46	1.72 ± 0.45	0.66	1.53 ± 0.43	0.62
CAMP-ES-08	–	0.36	–	0.59	1.30 ± 0.30	0.44	1.21 ± 0.41	0.61
CAMP-ES-09	–	0.35	–	0.46	1.15 ± 0.36	0.55	1.14 ± 0.42	0.63
CAMP-ES-10	1.08 ± 0.39	0.26	–	0.76	1.89 ± 0.61	0.96	1.30 ± 0.60	0.85
CAMP-ES-11	0.41 ± 0.28	0.30	0.50 ± 0.20	0.17	1.20 ± 0.60	0.96	1.08 ± 0.29	0.44
CAMP-ES-12	–	0.54	–	0.68	0.92 ± 0.38	0.58	1.15 ± 0.55	0.84
CAMP-ES-13	–	0.47	–	0.86	–	0.77	–	0.87
CAMP-ES-14	1.12 ± 0.49	0.52	–	0.76	2.40 ± 0.46	0.62	2.13 ± 0.71	1.1
CAMP-ES-15	1.07 ± 0.51	0.59	–	0.76	0.92 ± 0.41	0.62	1.60 ± 0.70	1.1
<b>CAMP Honey Lake Valley study area</b>								
CAMP-HL-01	1.49 ± 0.77	0.89	0.87 ± 0.56	0.67	3.32 ± 0.53	0.69	3.00 ± 0.50	0.65
CAMP-HL-02	3.61 ± 0.62	0.39	3.63 ± 0.62	0.44	1.31 ± 0.31	0.45	2.95 ± 0.36	0.44
CAMP-HL-03	1.07 ± 0.51	0.64	1.54 ± 0.62	0.70	4.32 ± 0.55	0.74	3.04 ± 0.53	0.75
CAMP-HL-04	2.70 ± 0.80	0.84	1.74 ± 0.58	0.61	1.63 ± 0.44	0.66	1.86 ± 0.56	0.86
CAMP-HL-05	1.14 ± 0.44	0.52	–	0.50	1.82 ± 0.33	0.46	1.64 ± 0.32	0.45
CAMP-HL-06	1.96 ± 0.46	0.38	–	0.42	2.86 ± 0.41	0.55	3.43 ± 0.43	0.55
CAMP-HL-07	–	2.2	2.1 ± 1.1	1.5	<sup>1</sup> 4.63 ± 0.61	0.78	4.30 ± 0.60	0.89
CAMP-HL-08	–	1.5	–	1.5	<sup>1</sup> 1.29 ± 0.39	0.58	–	0.86
CAMP-HL-09	–	0.76	<sup>2</sup> 0.87 ± 0.61	0.69	5.25 ± 0.52	0.57	<sup>2</sup> 4.25 ± 0.64	0.85
CAMP-HL-10	5.0 ± 1.1	0.85	1.64 ± 0.77	1.00	8.27 ± 0.88	1.0	8.04 ± 0.75	0.78
CAMP-HL-11	* 46.0 ± 5.7	1.7	* <sup>3</sup> 38.0 ± 5.0	1.4	<sup>1</sup> 12.00 ± 0.86	0.6	20.2 ± 1.3	0.59
CAMP-HL-12	* <sup>3</sup> 27.4 ± 3.5	1.1	* <sup>3</sup> 26.0 ± 3.3	0.83	5.24 ± 0.76	0.94	15.4 ± 1.3	1.4
CAMP-HL-13	<sup>3</sup> 98 ± 0.69	0.42	1.64 ± 0.53	0.48	1.07 ± 0.35	0.54	1.89 ± 0.66	0.98
CAMP-HL-14	4.7 ± 1.2	1.3	3.8 ± 1.6	1.6	13.6 ± 1.1	0.85	15.7 ± 1.4	1.2
CAMP-HL-15	<sup>1</sup> 10.0 ± 2.0	1.4	6.2 ± 1.7	1.6	<sup>1</sup> 3.90 ± 0.73	1.0	3.85 ± 0.73	1.1



**Table 14.** Gross alpha and gross beta particle activities detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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 90 grid wells were analyzed. Information about the analytes given in [table 4G](#). The reference nuclide for measurement of gross alpha is thorium-230, and the reference nuclide for measurement of gross beta is cesium-137. Measured values less than the sample-specific critical level ( $ssL_c$ ) are reported as non-detections (–). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocurie per liter; ±, plus or minus; \*, value above benchmark level]

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)	
Benchmark type	MCL-US		MCL-US		MCL-CA		MCL-CA	
Benchmark level	15		15		50		50	
Reporting level method	Result ± CSU	$ssL_c$	Result ± CSU	$ssL_c$	Result ± CSU	$ssL_c$	Result ± CSU	$ssL_c$
<b>CAMP Cascade Range and Modoc Plateau Low Use Basins study area</b>								
CAMP-LU-01	–	0.68	–	0.68	13.20 ± 0.97	0.66	13.30 ± 0.98	0.62
CAMP-LU-02	1.98 ± 0.78	0.90	–	1.3	4.85 ± 0.84	1.2	7.22 ± 0.94	1.2
CAMP-LU-03	2.30 ± 0.60	0.54	3.03 ± 0.91	0.81	9.12 ± 0.68	0.53	9.61 ± 0.84	0.78
CAMP-LU-04	2.60 ± 0.57	0.53	1.06 ± 0.56	0.66	0.73 ± 0.31	0.47	3.51 ± 0.77	1.1
CAMP-LU-05	4.24 ± 0.78	0.44	2.67 ± 0.71	0.63	7.78 ± 0.64	0.57	8.12 ± 0.66	0.59
CAMP-LU-06	1.47 ± 0.47	0.39	–	0.58	6.23 ± 0.55	0.56	5.88 ± 0.55	0.56
CAMP-LU-07	1.51 ± 0.57	0.56	1.10 ± 0.50	0.53	1.62 ± 0.45	0.65	1.91 ± 0.45	0.64
CAMP-LU-08	–	0.47	–	0.35	1.42 ± 0.51	0.80	0.80 ± 0.38	0.59
CAMP-LU-09	1.40 ± 0.67	0.75	0.70 ± 0.50	0.62	7.15 ± 0.68	0.67	7.02 ± 0.67	0.66
CAMP-LU-10	–	1.3	–	1.6	<sup>1</sup> 11.30 ± 0.83	0.64	9.95 ± 0.78	0.69
CAMP-LU-11	–	0.49	1.00 ± 0.50	0.57	4.28 ± 0.53	0.60	4.70 ± 0.56	0.63
CAMP-LU-12	<sup>1</sup> 1.74 ± 0.58	0.52	0.99 ± 0.46	0.51	<sup>1</sup> 2.30 ± 0.52	0.73	0.96 ± 0.47	0.72
CAMP-LU-13	0.81 ± 0.39	0.47	–	0.56	2.25 ± 0.35	0.46	2.86 ± 0.49	0.64
CAMP-LU-14	0.49 ± 0.31	0.38	0.68 ± 0.34	0.36	1.32 ± 0.41	0.60	1.96 ± 0.43	0.6
CAMP-LU-15	0.98 ± 0.47	0.56	1.31 ± 0.46	0.41	1.50 ± 0.40	0.57	1.91 ± 0.51	0.75
<b>CAMP Quaternary Volcanic Areas study area</b>								
CAMP-QV-01	–	0.22	0.59 ± 0.31	0.37	–	0.42	1.20 ± 0.50	0.79
CAMP-QV-02	–	0.32	0.46 ± 0.28	0.35	0.84 ± 0.38	0.59	1.30 ± 0.40	0.58
CAMP-QV-03	–	0.69	–	0.58	7.16 ± 0.72	0.79	7.19 ± 0.63	0.56
CAMP-QV-04	–	1.4	–	1.3	<sup>1</sup> 10.00 ± 0.72	0.52	10.10 ± 0.73	0.55
CAMP-QV-05	0.64 ± 0.25	0.28	0.66 ± 0.36	0.42	0.98 ± 0.34	0.52	1.71 ± 0.42	0.60
CAMP-QV-06	–	0.44	0.50 ± 0.30	0.41	3.11 ± 0.35	0.41	3.00 ± 0.35	0.41
CAMP-QV-07	0.62 ± 0.24	0.27	–	0.44	1.32 ± 0.31	0.45	1.40 ± 0.60	0.93
CAMP-QV-08	0.78 ± 0.26	0.25	–	0.52	2.41 ± 0.33	0.41	2.48 ± 0.43	0.57
CAMP-QV-09 <sup>4</sup>	0.58 ± 0.29	0.38	–	0.39	1.33 ± 0.27	0.40	1.57 ± 0.42	0.60
CAMP-QV-10	–	0.49	–	0.50	–	0.61	–	0.63
CAMP-QV-11	–	0.61	0.24 ± 0.19	0.18	–	0.62	–	0.63
CAMP-QV-12	–	0.45	–	0.67	–	0.63	–	0.89
CAMP-QV-13	–	0.59	–	0.86	2.44 ± 0.46	0.62	2.16 ± 0.61	0.87
CAMP-QV-14	–	0.46	–	0.71	2.33 ± 0.52	0.75	1.20 ± 0.70	1.0
CAMP-QV-15	–	0.52	–	0.67	1.90 ± 0.66	0.96	2.22 ± 0.61	0.87
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area</b>								
CAMP-SH-01	1.78 ± 0.43	0.38	1.11 ± 0.56	0.66	–	0.45	6.26 ± 0.69	0.85
CAMP-SH-02	2.30 ± 0.60	0.55	1.06 ± 0.66	0.84	0.86 ± 0.35	0.54	1.29 ± 0.49	0.74
CAMP-SH-03	1.51 ± 0.62	0.75	1.04 ± 0.56	0.69	–	0.92	0.90 ± 0.48	0.75

**Table 14.** Gross alpha and gross beta particle activities detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—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 90 grid wells were analyzed. Information about the analytes given in [table 4G](#). The reference nuclide for measurement of gross alpha is thorium-230, and the reference nuclide for measurement of gross beta is cesium-137. Measured values less than the sample-specific critical level ( $ssL_c$ ) are reported as non-detections (–). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocurie per liter; ±, plus or minus; \*, value above benchmark level]

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)	
Benchmark type	MCL-US		MCL-US		MCL-CA		MCL-CA	
Benchmark level	15		15		50		50	
Reporting level method	Result ± CSU	$ssL_c$	Result ± CSU	$ssL_c$	Result ± CSU	$ssL_c$	Result ± CSU	$ssL_c$
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area—Continued</b>								
CAMP-SH-04	–	0.34	–	0.55	–	0.44	–	0.62
CAMP-SH-05	–	0.39	–	0.48	1.42 ± 0.28	0.39	0.96 ± 0.39	0.6
CAMP-SH-06	–	0.36	–	0.40	1.82 ± 0.33	0.45	1.84 ± 0.42	0.6
CAMP-SH-07	0.27 ± 0.18	0.24	–	0.45	1.57 ± 0.43	0.66	0.85 ± 0.36	0.55
CAMP-SH-08	–	0.50	–	0.45	1.10 ± 0.50	0.78	1.59 ± 0.42	0.64
CAMP-SH-09	2.94 ± 0.67	0.49	–	1.1	1.32 ± 0.46	0.72	1.67 ± 0.66	1.0
CAMP-SH-10	0.75 ± 0.44	0.46	–	0.64	2.24 ± 0.48	0.66	1.10 ± 0.70	1.1
CAMP-SH-11	0.65 ± 0.37	0.38	1.47 ± 0.57	0.58	0.80 ± 0.40	0.62	0.90 ± 0.40	0.61
CAMP-SH-12	<sup>1</sup> 2.97 ± 0.95	0.99	3.10 ± 0.96	0.99	4.68 ± 0.79	1.1	7.16 ± 0.72	0.74
CAMP-SH-13	0.83 ± 0.56	0.69	4.84 ± 0.94	0.54	2.44 ± 0.49	0.67	6.00 ± 0.60	0.60
CAMP-SH-14	–	0.39	–	0.51	0.95 ± 0.27	0.40	1.60 ± 0.39	0.56
CAMP-SH-15	8.8 ± 1.7	0.93	3.1 ± 1.2	1.4	<sup>1</sup> 3.03 ± 0.67	0.96	2.96 ± 0.62	0.89
<b>CAMP Tertiary Volcanic Areas study area</b>								
CAMP-TV-01	–	4.2	–	2.8	<sup>1</sup> –	1.2	–	1.1
CAMP-TV-02	–	0.50	–	0.54	1.68 ± 0.42	0.60	1.87 ± 0.51	0.76
CAMP-TV-03 <sup>5</sup>	<sup>1</sup> 1.36 ± 0.48	0.45	–	0.48	<sup>1</sup> 2.16 ± 0.51	0.75	1.86 ± 0.42	0.61
CAMP-TV-04	–	0.44	–	0.28	3.61 ± 0.52	0.65	1.89 ± 0.31	0.42
CAMP-TV-05	–	0.51	0.50 ± 0.32	0.41	3.70 ± 0.53	0.67	4.41 ± 0.42	0.44
CAMP-TV-06	–	0.34	0.38 ± 0.29	0.37	1.08 ± 0.29	0.42	1.95 ± 0.42	0.59
CAMP-TV-07	0.63 ± 0.28	0.32	0.56 ± 0.27	0.22	3.09 ± 0.35	0.41	3.02 ± 0.47	0.62
CAMP-TV-08	0.45 ± 0.35	0.43	–	0.52	3.15 ± 0.48	0.61	3.91 ± 0.51	0.61
CAMP-TV-09	1.92 ± 0.63	0.64	0.84 ± 0.46	0.51	2.18 ± 0.56	0.85	2.52 ± 0.57	0.85
CAMP-TV-10	–	0.45	–	0.34	–	0.55	0.77 ± 0.46	0.72
CAMP-TV-11	–	0.46	–	0.71	–	0.56	–	0.80
CAMP-TV-12	–	0.46	–	0.65	0.66 ± 0.38	0.60	–	1.3
CAMP-TV-13	–	0.54	–	0.78	1.17 ± 0.55	0.95	0.96 ± 0.55	0.85
CAMP-TV-14	–	0.33	–	0.48	–	0.93	1.24 ± 0.55	0.81
CAMP-TV-15	1.06 ± 0.37	0.39	0.99 ± 0.48	0.47	–	0.55	0.70 ± 0.40	0.62

<sup>1</sup> 72-hour holding time exceeded by 1 to 4 days. Activity in sample may be greater than reported activity. Note replicate results for gross beta, 72-hour from QV-04, were within acceptable ranges.

<sup>2</sup> 30-day holding time exceeded by 35 days. Activity in sample may be greater than reported activity.

<sup>3</sup> The MCL-US for gross alpha activity applies to adjusted gross alpha, which is measured gross alpha activity minus uranium activity. Adjusted gross alpha activities for HL-11, 30-day count, and HL-12, 72-hour and 30-day counts, were lower than the MCL-US.

<sup>4</sup> Data for QV-09 are stored in the USGS NWIS database under the following parameter codes: 63014, gross alpha, 72-hour; 63016, gross alpha, 30-day; 63015, gross beta, 72-hour; 63017, gross beta, 30-day.

<sup>5</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

**Table 15.** Results for analyses of species of inorganic arsenic and iron in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, July through October 2010, California GAMA Priority Basin Project.

[Data in this table were analyzed at U.S. Geological Survey (USGS) Trace Metals Laboratory for the purpose of determining ratios of oxidized and reduced species of arsenic and iron. Information about the analytes given in [table 4H](#). Absolute concentrations may be less accurate than those in [table 10](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** MDL, method detection limit; na, not available; µg/L, micrograms per liter; na, not available; nc, not collected; –, not detected; ≤, less than or equal to; \*, value above benchmark level]

GAMA well identification number	Arsenic (total) (µg/L)	Arsenic (III) (µg/L)	Iron (total) (µg/L)	Iron (II) (µg/L)
<b>Benchmark type</b>	<b>MCL-US</b>	<b>na</b>	<b>SMCL-CA</b>	<b>na</b>
<b>Benchmark level</b>	<b>10</b>	<b>na</b>	<b>300</b>	<b>na</b>
<b>[MDL]</b>	<b>[0.15]</b>	<b>[0.5]</b>	<b><sup>1</sup>[6]</b>	<b>[2]</b>
<b>CAMP Sacramento Valley Eastside study area</b>				
CAMP-ES-01	0.62	–	–	– (2)
CAMP-ES-02	0.24	–	–	– (2)
CAMP-ES-03	1.2	–	–	– (2)
CAMP-ES-04	3.2	–	≤2.7	2.7
CAMP-ES-05	0.32	–	–	–
CAMP-ES-06	0.43	–	–	– (2)
CAMP-ES-07	0.79	–	≤2.5	–
CAMP-ES-08	0.46	–	≤2.2	–
CAMP-ES-09	0.79	–	–	– (2)
CAMP-ES-10	nc	nc	nc	nc
CAMP-ES-11	0.22	–	–	– (2)
CAMP-ES-12	–	–	* 489	44
CAMP-ES-13	–	–	–	– (2)
CAMP-ES-14	0.81	–	–	– (2)
CAMP-ES-15	0.73	–	–	–
<b>CAMP Honey Lake Valley study area</b>				
CAMP-HL-01	9.1	–	≤3.7	–
CAMP-HL-02	2.6	–	≤4.0	4.0
CAMP-HL-03	7.7	–	≤3.8	3.4
CAMP-HL-04	1.2	–	–	– (2)
CAMP-HL-05	2.1	–	–	– (2)
CAMP-HL-06	1.5	–	6.7	5.6
CAMP-HL-07	8.5	6.3	98	95
CAMP-HL-08	0.70	0.7	14.0	14
CAMP-HL-09	3.9	2.2	81	–
CAMP-HL-10	3.4	–	* 405	360
CAMP-HL-11	* 63	1.2	26	24
CAMP-HL-12	3.9	–	≤2.5	2.4
CAMP-HL-13	0.29	–	–	– (2)
CAMP-HL-14	6.32	–	–	– (2)
CAMP-HL-15	* 187	2.9	≤2.5	–
<b>CAMP Cascade Range and Modoc Plateau Low Use Basins study area</b>				
CAMP-LU-01	–	–	≤5.4	5.0
CAMP-LU-02	–	–	* 319	319
CAMP-LU-03	3.5	–	≤2.8	2.8

**Table 15.** Results for analyses of species of inorganic arsenic and iron in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—Continued

[Data in this table were analyzed at U.S. Geological Survey (USGS) Trace Metals Laboratory for the purpose of determining ratios of oxidized and reduced species of arsenic and iron. Information about the analytes given in [table 4H](#). Absolute concentrations may be less accurate than those in [table 10](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** MDL, method detection limit; na, not available; µg/L, micrograms per liter; na, not available; nc, not collected; —, not detected; ≤, less than or equal to; \*, value above benchmark level]

GAMA well identification number	Arsenic (total) (µg/L)	Arsenic (III) (µg/L)	Iron (total) (µg/L)	Iron (II) (µg/L)
<b>Benchmark type</b>	<b>MCL-US</b>	<b>na</b>	<b>SMCL-CA</b>	<b>na</b>
<b>Benchmark level</b>	<b>10</b>	<b>na</b>	<b>300</b>	<b>na</b>
<b>[MDL]</b>	<b>[0.15]</b>	<b>[0.5]</b>	<b><sup>1</sup>[6]</b>	<b>[2]</b>
<b>CAMP Cascade Range and Modoc Plateau Low Use Basins study area—Continued</b>				
CAMP-LU-04	1.0	—	—	— (2)
CAMP-LU-05	5.6	—	—	— (2)
CAMP-LU-06	—	—	17	17
CAMP-LU-07	0.23	—	—	— (2)
CAMP-LU-08	0.33	—	—	— (2)
CAMP-LU-09	4.1	—	8.4	3.8
CAMP-LU-10	0.17	—	248	208
CAMP-LU-11	1.1	—	—	— (2)
CAMP-LU-12	0.76	—	—	— (2)
CAMP-LU-13	2.5	—	* 620	2.2
CAMP-LU-14	2.1	—	—	— (2)
CAMP-LU-15	0.75	—	—	— (2)
<b>CAMP Quaternary Volcanic Areas study area</b>				
CAMP-QV-01	—	—	—	— (2)
CAMP-QV-02	0.47	—	—	— (2)
CAMP-QV-03	0.37	—	154	128
CAMP-QV-04	7.5	2.7	75	69
CAMP-QV-05	—	—	≤4.3	—
CAMP-QV-06	4.0	—	≤3.9	—
CAMP-QV-07	—	—	—	— (2)
CAMP-QV-08	0.89	—	—	— (2)
CAMP-QV-09	—	—	—	— (2)
CAMP-QV-10	—	—	—	— (2)
CAMP-QV-11	—	—	—	— (2)
CAMP-QV-12	—	—	≤5.6	—
CAMP-QV-13	3.2	—	—	— (2)
CAMP-QV-14	4.8	—	22	4.0
CAMP-QV-15	0.56	—	≤3.7	2.5
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area</b>				
CAMP-SH-01	— (3)	— (3)	—	— (3)
CAMP-SH-02	* 101	2.0	≤2.5	2.3
CAMP-SH-03	0.55	— (3)	≤4.1	4.1
CAMP-SH-04	3.7	— (3)	—	—
CAMP-SH-05	0.98	— (3)	—	—
CAMP-SH-06	— (3)	— (3)	—	—
CAMP-SH-07	— (3)	— (3)	—	—

**Table 15.** Results for analyses of species of inorganic arsenic and iron in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—Continued

[Data in this table were analyzed at U.S. Geological Survey (USGS) Trace Metals Laboratory for the purpose of determining ratios of oxidized and reduced species of arsenic and iron. Information about the analytes given in [table 4H](#). Absolute concentrations may be less accurate than those in [table 10](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type, and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** MDL, method detection limit; na, not available; µg/L, micrograms per liter; na, not available; nc, not collected; —, not detected; ≤, less than or equal to; \*, value above benchmark level]

GAMA well identification number	Arsenic (total) (µg/L)	Arsenic (III) (µg/L)	Iron (total) (µg/L)	Iron (II) (µg/L)
<b>Benchmark type</b>	<b>MCL-US</b>	<b>na</b>	<b>SMCL-CA</b>	<b>na</b>
<b>Benchmark level</b>	<b>10</b>	<b>na</b>	<b>300</b>	<b>na</b>
<b>[MDL]</b>	<b>[0.15]</b>	<b>[0.5]</b>	<b><sup>1</sup>[6]</b>	<b>[2]</b>
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area—Continued</b>				
CAMP-SH-08	2.5	—	—	— <sup>(2)</sup>
CAMP-SH-09	0.23	—	—	— <sup>(2)</sup>
CAMP-SH-10	2.5	—	≤2.8	—
CAMP-SH-11	2.5	—	—	— <sup>(2)</sup>
CAMP-SH-12	5.3	—	—	— <sup>(2)</sup>
CAMP-SH-13	4.8	—	—	— <sup>(2)</sup>
CAMP-SH-14	—	—	25	19
CAMP-SH-15	0.25	—	22	18
<b>CAMP Tertiary Volcanic Areas study area</b>				
CAMP-TV-01	2.5	— <sup>(3)</sup>	≤2.7	2.7
CAMP-TV-02	2.9	—	9.8	9.8
CAMP-TV-03 <sup>4</sup>	2.4	—	≤4.4	3.8
CAMP-TV-04	1.8	—	—	— <sup>(2)</sup>
CAMP-TV-05	0.40	—	—	— <sup>(2)</sup>
CAMP-TV-06	0.19	—	—	— <sup>(2)</sup>
CAMP-TV-07	—	—	—	— <sup>(2)</sup>
CAMP-TV-08	0.90	—	—	— <sup>(2)</sup>
CAMP-TV-09	0.98	—	—	— <sup>(2)</sup>
CAMP-TV-10	—	—	≤2.2	—
CAMP-TV-11	—	—	—	— <sup>(2)</sup>
CAMP-TV-12	—	—	7.5	6.5
CAMP-TV-13	—	—	—	— <sup>(2)</sup>
CAMP-TV-14	—	—	9.6	3.9
CAMP-TV-15	3.0	2.3	—	—

<sup>1</sup> Iron (total) was detected in one of the 10 field blanks at a concentration of 20 µg/L; however, the SRL used for iron data from the USGS NWQL was applied to the iron data from the USGS Trace Metal Laboratory (TML) on the basis of comparison between the two datasets (see [appendix](#) for further discussion).

<sup>2</sup> Iron (II) is not measured if iron (total) is a non-detection.

<sup>3</sup> Result is a non-detection less than a raised MDL. The raised MDLs are: 0.5 µg/L for arsenic (total), 1 µg/L for arsenic (III), and 3 µg/L for iron (II).

<sup>4</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.



**Table 16.** Results for analyses of stable isotope ratios, tritium activity, and carbon-14 abundance detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 [tables 4G](#) and [4I](#). Samples from all 90 grid wells were analyzed for stable isotopes of hydrogen and oxygen in water and tritium activities. Samples from 87 grid wells were analyzed for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance. Stable isotope ratios are reported in the standard delta notation ( $\delta$ ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Tritium values less than the sample-specific critical level ( $ssL_c$ ) are reported as non-detections (–). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; H, hydrogen; O, oxygen; C, carbon; pCi/L, picocuries per liter;  $\pm$ , plus or minus; na, not available; nc, not collected]

GAMA well identification number	$\delta^2\text{H}$ (per mil) (82082)	$\delta^{18}\text{O}$ (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{13}\text{C}$ (per mil) (82081)	Carbon-14 (percent modern) (49933)
Benchmark type	na	na	MCL-CA	na	na
Benchmark level	na	na	20,000	na	na
			Result $\pm$ CSU	$ssL_c$	
CAMP Sacramento Valley Eastside study area					
CAMP-ES-01	–65.7	–9.81	$6.50 \pm 0.45$	0.22	106
CAMP-ES-02	–61.9	–9.26	$6.80 \pm 0.43$	0.22	111
CAMP-ES-03	–77.2	–10.72	$0.50 \pm 0.30$	0.15	78
CAMP-ES-04	–60.0	–8.54	$5.00 \pm 0.36$	0.18	87
CAMP-ES-05	–65.1	–9.69	$1.20 \pm 0.30$	0.15	91
CAMP-ES-06	–66.4	–10.05	$1.50 \pm 0.30$	0.15	96
CAMP-ES-07	–81.3	–11.32	$3.40 \pm 0.45$	0.22	93
CAMP-ES-08	–81.0	–11.54	$2.70 \pm 0.44$	0.22	93
CAMP-ES-09	–65.8	–9.34	$1.10 \pm 0.43$	0.22	85
CAMP-ES-10	–65.4	–9.34	$0.50 \pm 0.35$	0.18	88
CAMP-ES-11	–67.9	–9.88	$4.60 \pm 0.46$	0.23	100
CAMP-ES-12	–65.8	–9.97	$6.10 \pm 0.45$	0.22	114
CAMP-ES-13	–65.5	–9.68	$8.90 \pm 0.51$	0.25	114
CAMP-ES-14	–61.8	–9.00	$0.40 \pm 0.38$	0.19	94
CAMP-ES-15	–63.6	–9.15	$2.80 \pm 0.43$	0.22	96
CAMP Honey Lake Valley study area					
CAMP-HL-01	–112	–14.51	$– \pm 0.41$	0.41	25
CAMP-HL-02	–103	–13.32	$1.60 \pm 0.45$	0.45	54
CAMP-HL-03	–112	–14.64	$1.50 \pm 0.41$	0.41	66
CAMP-HL-04	–108	–14.04	$0.70 \pm 0.35$	0.32	63
CAMP-HL-05	–103	–13.36	$5.70 \pm 0.44$	0.22	80
CAMP-HL-06	–99.1	–12.93	$8.40 \pm 0.47$	0.24	101
CAMP-HL-07	–106	–13.59	$– \pm 0.31$	0.16	33
CAMP-HL-08	–102	–13.32	$0.40 \pm 0.30$	0.15	55
CAMP-HL-09	–110	–13.78	$– \pm 0.30$	0.15	57
CAMP-HL-10	–108	–13.53	$1.00 \pm 0.30$	0.15	68
CAMP-HL-11	–105	–13.17	$4.80 \pm 0.32$	0.16	81
CAMP-HL-12	–108	–13.70	$1.70 \pm 0.30$	0.15	90
CAMP-HL-13	–109	–14.30	$1.90 \pm 0.33$	0.16	99
CAMP-HL-14	–112	–14.40	$– \pm 0.36$	0.18	50
CAMP-HL-15	–108	–13.31	$1.40 \pm 0.36$	0.18	84

**Table 16.** Results for analyses of stable isotope ratios, tritium activity, and carbon-14 abundance detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, July through October 2010, California GAMA Priority Basin Project.—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. Information about the analytes given in [tables 4G](#) and [4I](#). Samples from all 90 grid wells were analyzed for stable isotopes of hydrogen and oxygen in water and tritium activities. Samples from 87 grid wells were analyzed for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance. Stable isotope ratios are reported in the standard delta notation ( $\delta$ ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Tritium values less than the sample-specific critical level ( $ssL_c$ ) are reported as non-detections (–). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; H, hydrogen; O, oxygen; C, carbon; pCi/L, picocuries per liter;  $\pm$ , plus or minus; na, not available; nc, not collected]

GAMA well identification number	$\delta^2\text{H}$ (per mil) (82082)	$\delta^{18}\text{O}$ (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{13}\text{C}$ (per mil) (82081)	Carbon-14 (percent modern) (49933)
<b>Benchmark type</b>	na	na	MCL-CA	na	na
<b>Benchmark level</b>	na	na	20,000	na	na
			Result $\pm$ CSU	$ssL_c$	
<b>CAMP Cascade Range and Modoc Plateau Low Use Basins study area</b>					
CAMP-LU-01	–108	–13.72	– $\pm$ 0.31	0.31	24
CAMP-LU-02	–108	–13.54	– $\pm$ 0.32	0.32	9
CAMP-LU-03	–110	–13.74	1.60 $\pm$ 0.35	0.32	58
CAMP-LU-04	–106	–13.72	10.20 $\pm$ 0.51	0.35	93
CAMP-LU-05	–111	–13.70	1.20 $\pm$ 0.32	0.32	57
CAMP-LU-06	–109	–13.59	– $\pm$ 0.35	0.35	32
CAMP-LU-07	–104	–13.72	3.00 $\pm$ 0.32	0.32	98
CAMP-LU-08	–92.9	–13.21	13.10 $\pm$ 0.64	0.35	110
CAMP-LU-09	–110	–13.72	– $\pm$ 0.32	0.32	70
CAMP-LU-10	–59.3	–4.60	– $\pm$ 0.41	0.42	82
CAMP-LU-11	–102	–13.15	2.20 $\pm$ 0.35	0.32	88
CAMP-LU-12	–90.8	–12.80	10.60 $\pm$ 0.41	0.35	nc
CAMP-LU-13	–92.9	–11.39	6.30 $\pm$ 0.48	0.38	91
CAMP-LU-14	–97.1	–13.48	7.50 $\pm$ 0.37	0.18	83
CAMP-LU-15	–99.7	–13.62	7.90 $\pm$ 0.40	0.20	96
<b>CAMP Quaternary Volcanic Areas study area</b>					
CAMP-QV-01	–96.2	–13.49	9.10 $\pm$ 0.48	0.32	111
CAMP-QV-02	–92.9	–13.17	8.70 $\pm$ 0.51	0.32	112
CAMP-QV-03	–115	–14.58	– $\pm$ 0.32	0.32	6
CAMP-QV-04	–77.8	–8.10	5.90 $\pm$ 0.54	0.45	83
CAMP-QV-05	–91.6	–12.76	2.00 $\pm$ 0.45	0.42	nc
CAMP-QV-06	–113	–14.78	10.20 $\pm$ 0.48	0.31	50
CAMP-QV-07	–89.7	–12.64	6.00 $\pm$ 0.46	0.23	90
CAMP-QV-08	–99.8	–13.81	2.90 $\pm$ 0.35	0.18	88
CAMP-QV-09	–102	–14.36	3.30 $\pm$ 0.30	0.15	91
CAMP-QV-10	–80.4	–10.98	1.50 $\pm$ 0.34	0.17	94
CAMP-QV-11	–78.4	–11.36	3.80 $\pm$ 0.42	0.21	95
CAMP-QV-12	–77.6	–10.95	8.20 $\pm$ 0.42	0.21	109
CAMP-QV-13	–93.5	–13.00	4.00 $\pm$ 0.34	0.17	47
CAMP-QV-14	–99.2	–13.65	0.20 $\pm$ 0.30	0.15	58
CAMP-QV-15	–88.0	–12.41	11.60 $\pm$ 0.53	0.26	77

**Table 16.** Results for analyses of stable isotope ratios, tritium activity, and carbon-14 abundance detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) Groundwater Ambient Monitoring and Assessment (GAMA) study unit, July through October 2010, California GAMA Priority Basin Project.—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. Information about the analytes given in [tables 4G](#) and [4I](#). Samples from all 90 grid wells were analyzed for stable isotopes of hydrogen and oxygen in water and tritium activities. Samples from 87 grid wells were analyzed for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance. Stable isotope ratios are reported in the standard delta notation ( $\delta$ ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Tritium values less than the sample-specific critical level ( $ssL_c$ ) are reported as non-detections (–). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; H, hydrogen; O, oxygen; C, carbon; pCi/L, picocuries per liter;  $\pm$ , plus or minus; na, not available; nc, not collected]

GAMA well identification number	$\delta^2\text{H}$ (per mil) (82082)	$\delta^{18}\text{O}$ (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{13}\text{C}$ (per mil) (82081)	Carbon-14 (percent modern) (49933)	
Benchmark type	na	na	MCL-CA	na	na	
Benchmark level	na	na	20,000	na	na	
			Result $\pm$ CSU	ssL <sub>c</sub>		
CAMP Shasta Valley and Mount Shasta Volcanic Area study area						
CAMP-SH-01	−98.0	−12.56	9.80 $\pm$ 0.47	0.31	−13.52	82
CAMP-SH-02	−94.2	−12.10	2.80 $\pm$ 0.34	0.30	−12.68	59
CAMP-SH-03	−99.4	−12.86	8.50 $\pm$ 0.47	0.33	−13.15	99
CAMP-SH-04	−105	−14.42	0.40 $\pm$ 0.31	0.31	−14.09	48
CAMP-SH-05	−105	−14.56	2.40 $\pm$ 0.34	0.31	−12.56	48
CAMP-SH-06	−101	−14.15	4.80 $\pm$ 0.41	0.34	−14.76	71
CAMP-SH-07	−98.0	−13.70	8.10 $\pm$ 0.45	0.31	−19.40	109
CAMP-SH-08	−98.8	−13.62	3.60 $\pm$ 0.41	0.35	−14.71	67
CAMP-SH-09	−95.3	−12.46	6.80 $\pm$ 0.48	0.35	−14.57	96
CAMP-SH-10	−95.3	−12.50	6.40 $\pm$ 0.48	0.35	−11.06	74
CAMP-SH-11	−92.2	−12.05	8.40 $\pm$ 0.45	0.32	−11.15	92
CAMP-SH-12	−99.3	−12.67	5.40 $\pm$ 0.45	0.22	−14.93	92
CAMP-SH-13	−107	−14.11	5.60 $\pm$ 0.44	0.22	−9.55	47
CAMP-SH-14	−93.0	−13.16	11.40 $\pm$ 0.61	0.30	−20.14	100
CAMP-SH-15	−98.5	−12.69	6.00 $\pm$ 0.32	0.16	−15.60	98
CAMP Tertiary Volcanic Areas study area						
CAMP-TV-01	−100	−12.32	45.7 $\pm$ 1.3	0.31	−14.40	42
CAMP-TV-02	−97.6	−13.11	3.50 $\pm$ 0.38	0.35	−13.41	87
CAMP-TV-03 <sup>1</sup>	−91.9	−12.79	5.40 $\pm$ 0.48	0.38	−12.99	55
CAMP-TV-04	−94.6	−13.49	0.50 $\pm$ 0.39	0.20	−13.48	71
CAMP-TV-05	−109	−14.23	0.10 $\pm$ 0.36	0.18	−14.46	77
CAMP-TV-06	−101	−14.01	6.80 $\pm$ 0.36	0.18	−16.62	79
CAMP-TV-07	−114	−15.26	− $\pm$ 0.30	0.15	−16.54	86
CAMP-TV-08	−115	−15.07	0.90 $\pm$ 0.36	0.18	−14.96	52
CAMP-TV-09	−100	−13.79	0.30 $\pm$ 0.32	0.16	−15.59	51
CAMP-TV-10	−97.3	−13.42	3.70 $\pm$ 0.40	0.20	−20.94	97
CAMP-TV-11	−80.0	−11.43	9.20 $\pm$ 0.30	0.15	−19.73	93
CAMP-TV-12	−79.3	−11.35	8.70 $\pm$ 0.45	0.22	nc	nc
CAMP-TV-13	−78.9	−11.24	7.40 $\pm$ 0.39	0.20	−21.35	104
CAMP-TV-14	−75.0	−10.86	7.40 $\pm$ 0.50	0.25	−20.59	108
CAMP-TV-15	−93.8	−11.09	0.80 $\pm$ 0.43	0.22	−16.07	53

<sup>1</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

**Table 17.** Microbial indicator constituents detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[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 83 grid wells were analyzed (samples were not collected at wells CAMP-HL-06, -LU-09, -LU-10, -LU-11, -QV-03, -QV-04, and TV-02). Information about the analytes given in [table 4J](#). **GAMA well identification number:** ES, Sacramento Valley Eastside study area grid well; HL, Honey Lake Valley study area grid well; LU, Cascade Range and Modoc Plateau Low Use Basins study area grid well; QV, Quaternary Volcanic Areas study area grid well; SH, Shasta Valley and Mount Shasta Volcanic Area study area grid well; TV, Tertiary Volcanic Areas study area grid well. Benchmark type and benchmark level as of January 10, 2012. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. TT-US, U.S. Environmental Protection Agency (USEPA) treatment technique, a required process intended to reduce the level of contamination in drinking water; MCL-US, USEPA maximum contaminant level. **Other abbreviations:** –, not detected; D, detected]

GAMA well identification number	<i>Escherichia coli</i> ( <i>E. coli</i> ) (99596)	Total coliform (including fecal coliform and <i>E. coli</i> ) (99595)
Benchmark type	TT-US	MCL-US
Benchmark level	No fecal coliforms are allowed	5 percent of samples per month
<b>CAMP Sacramento Valley Eastside study area (15 grid wells sampled)</b>		
CAMP-ES-15	–	D
<b>CAMP Honey Lake Valley study area (14 grid wells sampled)</b>		
CAMP-HL-01	–	D
<b>CAMP Cascade Range and Modoc Plateau Low Use Basins study area (12 grid wells sampled)</b>		
CAMP-LU-02	–	D
CAMP-LU-12	–	D
<b>CAMP Quaternary Volcanic Areas study area (13 grid wells sampled)</b>		
CAMP-QV-09	–	D
<b>CAMP Shasta Valley and Mount Shasta Volcanic Area study area (15 grid wells sampled)</b>		
CAMP-SH-03	–	D
CAMP-SH-12	–	D
CAMP-SH-13	–	D
<b>CAMP Tertiary Volcanic Areas study area (14 grid wells sampled)</b>		
CAMP-TV-03 <sup>1</sup>	D	D

<sup>1</sup> Conveyance from the TV-03 spring source to the point of use is an open channel.

## Appendix

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## 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 QC data, and the results of the QC assessments also are discussed.

In the CAMP study unit, groundwater samples were collected, and QA/QC procedures were implemented using standard and modified USGS protocols from the USGS NAWQA Program (Koterba and others, 1995), the USGS National Field Manual (U.S. Geological Survey, variously dated), and protocols described by Shelton and others (2001) and Wright and others (2005). The QA plan followed by the NWQL, the primary laboratory used to analyze samples for this study, is described in Maloney (2005) and Pirkey and Glodt (1998).

### Sample Collection and Analysis

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

In most cases, wells were pumped continuously to purge at least three casing volumes of water from the well prior to sampling (Wilde and others, 1999). Drought conditions during the period of sampling for the CAMP study unit (July through October 2010) resulted in limitations on the amount of groundwater that could be pumped from some of the wells. In some cases, continuous pumping was limited to 2 hours, either because of limited space in storage tanks for the pumped water or because of drawdown of the water table. A minimum of one casing volume of groundwater was pumped from each well before sampling. The limitation on pumping did not allow sufficient time to complete the sampling of a few wells, and some constituent groups were not collected from these wells. Wells were sampled using Teflon® tubing with brass and stainless-steel fittings attached to a sampling point (usually a hose-bib fitting) on the well discharge pipe as close to the wellhead as possible. The sampling point was located upstream from water-storage tanks and upstream from a wellhead treatment system (if any). If a chlorinating system was attached to the well, the chlorinator was shut off when possible before the well or spring was purged and sampled in

order to clear all chlorine out of the system. The absence of free chlorine was verified using Hach field kits. The mobile laboratory could not be parked within 50 feet of the sampling point at most of the sampling sites; therefore, all samples were collected outdoors by connecting a 1- to 3-foot length of Teflon® tubing to the sampling point (Lane and others, 2003). All fittings and lengths of tubing were cleaned between samples (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, 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). The flow-through chamber was attached to the same sampling point used for sample collection. All sensors on the multi-probe meter were calibrated daily. Measured temperature, dissolved oxygen, pH, and specific conductance values were recorded at 5-minute intervals for approximately 30 minutes, and when these values remained stable for 20 minutes, samples for laboratory analyses then were collected.

Most of the springs were plumbed and had sampling points on the discharge pipes similar to the sampling points found on discharge pipes from wells. Field water-quality indicators were measured and samples were collected using the same protocols as used for wells.

A few springs were not plumbed, and they discharged into pools from which the water was then pumped into the distribution system. For these springs, field water-quality parameters were measured by dipping the multi-probe meter directly into the water as close to the spring discharge point as possible. Groundwater samples were collected by dipping bottles into the water as close to the spring discharge point as possible. Turbidity was measured in the mobile laboratory with a calibrated turbidity meter (Anderson, 2005). In all cases, turbidity was less than 0.5 nephelometric turbidity units (NTU), and the samples were collected unfiltered, but were marked as filtered for analysis. This method was used because the alternative—pumping water from the pool with a portable peristaltic pump through the filtration apparatus—was not logistically possible at most of the unplumbed spring sites.

Field measurements and instrument calibrations were recorded by hand on field record sheets and electronically in the Personal Computer Field Form (PCFF) program. Analytical service requests also were managed by PCFF. Information from PCFF was uploaded directly into NWIS at the end of every week of sample collection.

Prior to sample collection, polyethylene sample bottles were pre-rinsed two times using deionized water and then once with sample water before sample collection. Samples requiring acidification were acidified to a pH of between 2 and 1 with the appropriate acids using ampoules of certified, traceable concentrated acids obtained from the NWQL.

Temperature-sensitive samples were stored on ice prior to and during daily shipping to the various laboratories. The non-temperature-sensitive samples for tritium, stable isotopes of hydrogen and oxygen in water, and dissolved noble gases were shipped monthly. Temperature- or time-sensitive samples for VOCs, pesticides and pesticide degradates, perchlorate, trace elements, nutrients, major and minor ions, silica, TDS, laboratory alkalinity, radon-222, and gross alpha and gross beta radioactivity were shipped within 2 days of sample collection (samples were shipped daily whenever possible). Samples to be analyzed for species of arsenic and iron were shipped weekly. The temperature-sensitive samples for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance were stored on ice, archived in a laboratory refrigerator, and shipped after all of the alkalinity measurements were collected. Boron, strontium, and uranium isotope samples were stored at room temperature in the office until results from the trace element analyses for all 90 samples were received. A subset of samples were selected for isotope analyses on the basis of the trace element results.

Detailed sampling protocols for individual analyses and groups of analytes are described in Koterba and others (1995), the USGS National Field Manual (Wilde and others, 1999, 2004), and the references for analytical methods listed in [table A1](#); only brief descriptions are given here. VOC samples were collected in three 40-mL sample vials that were purged with three vial volumes of groundwater before bottom filling to eliminate atmospheric contamination. Hydrochloric acid in a one-to-one (1:1) hydrochloric acid to water (HCl/H<sub>2</sub>O) solution was added as a preservative to the VOC samples. Each sample to be analyzed for perchlorate was collected in a 125-mL polystyrene bottle and then filtered in two or three 20-mL aliquots of groundwater through a 0.20- $\mu$ m pore-size Corning® syringe-tip disk filter into a sterilized 125-mL bottle. Tritium samples were collected by bottom filling one 1-L polyethylene bottle and one 1-L glass bottle with unfiltered groundwater after first overfilling the bottles with three volumes of water. Samples for analysis of stable isotopes of hydrogen and oxygen in water were collected in a 60-mL clear glass bottle filled with unfiltered groundwater, sealed with a conical cap, and secured with electrical tape to prevent leakage and evaporation.

Pesticide and pesticide degradate samples were collected in 1-L baked amber glass bottles. Samples were filtered through a 0.7- $\mu$ m nominal pore-size glass fiber filter during collection.

Groundwater samples for trace elements, major and minor ions, silica, and TDS analyses required filling one 250-mL polyethylene bottle with unfiltered groundwater, and one 500-mL and one 250-mL polyethylene bottle with filtered groundwater (Wilde and others, 2004). Filtration was done using either a 0.45- $\mu$ m pore-size Whatman® vented capsule filter or a 0.45- $\mu$ m pore-size PALL® unvented capsule filter that was pre-rinsed with 2 L of deionized water, then rinsed with 1 L of groundwater prior to sampling. The 250-mL

filtered sample then was preserved with 7.5-normal (7.5-N) nitric acid. Samples to be analyzed for species of arsenic and iron were filtered into 250-mL polyethylene bottles that were covered with tape to prevent light exposure, and preserved with 6-N hydrochloric acid. Nutrient samples were collected by filtering groundwater into a 125-mL brown polyethylene bottle. Samples to be analyzed for strontium isotopes were filtered into 250-mL polyethylene bottles after bottles were rinsed with filtered groundwater and secured with electrical tape to prevent leakage and evaporation. Samples to be analyzed for uranium isotopes and gross alpha and gross beta particle activities were filtered into 1-L polyethylene bottles and acidified with nitric acid. Stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance samples were filtered and bottom filled into 500-mL glass bottles that first were overfilled with three bottle volumes of groundwater. These samples had no headspace and were sealed with conical caps to avoid atmospheric contamination. Samples for laboratory or field alkalinity titrations were collected by filtering groundwater into a 500-mL polyethylene bottle.

For the collection of radon-222, a stainless-steel and Teflon® valve assembly was attached to the sampling port at the wellhead (Wilde and others, 2004). The valve was closed partially to create back pressure, and a 10-mL groundwater sample was taken 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 a scintillation mixture and shaken. The vial then was placed in an insulated cardboard tube to protect the sample during shipping.

Dissolved noble gases were collected in 3/8-inch-diameter copper tubes using reinforced nylon tubing connected to the hose bib at the wellhead. Groundwater was flushed through the tubing to dislodge bubbles before the flow was restricted with a back pressure valve. Clamps on either side of the copper tube then were tightened, trapping a sample of groundwater for analyses of dissolved noble gases (Weiss, 1968).

Samples for analysis of the presence or absence of microbial indicators also were collected at the wellhead using the IDEXX Colilert® test kit following standard methods (American Public Health Association, 1998). Prior to the collection of samples, the sampling port was sterilized using isopropyl alcohol, and then was flamed or let air dry. Groundwater was run through the sampling port for at least 2 minutes to remove any traces of the sterilizing agent. A 100-mL Colilert® sterile sample bottle containing sodium thiosulfate (to neutralize chlorine when present) was filled directly from the sampling. After a reagent was added, the sample bottle was inverted gently to mix the reagent with the sample. The sample was incubated for 24 hours at 35°C  $\pm$  0.5°C. Sample results were viewed against a comparator and interpreted as follows: if the sample was (1) less yellow than the comparator, then the presence of total coliform and *E. coli* were not detected; (2) yellow equal to or greater than the comparator, then the presence of total coliform was detected;

(3) yellow and fluorescence equal to or greater than the comparator, then the presence of *E. coli* was detected. Some samples were not analyzed because the incubator temperature sensors fluctuated outside of the required temperature range during the incubation time period.

Field alkalinity was measured in the mobile laboratory at the well site. Alkalinity was measured on filtered samples by Gran's titration method (Gran, 1952). Titration data were entered directly into PCFF, and the concentrations of bicarbonate ( $\text{HCO}_3^-$ ) and carbonate ( $\text{CO}_3^{2-}$ ) were automatically calculated from the titration data using the advanced speciation method (<http://or.water.usgs.gov/alk/methods.html>), with  $\text{pK}_1 = 6.35$ ,  $\text{pK}_2 = 10.33$ , and  $\text{pK}_w = 14$ . Concentrations of  $\text{HCO}_3^-$  and  $\text{CO}_3^{2-}$  also were calculated from the laboratory alkalinity and laboratory pH measurements.

Nine laboratories performed chemical and microbial analyses for this study (table A1), although most of the analyses were performed at the NWQL or by laboratories contracted by the NWQL. The NWQL maintains a rigorous QA program (Pirkey and Glodt, 1998; Maloney, 2005). Laboratory QC samples, including method blanks, continuing calibration verification standards, standard reference samples, reagent spikes, external certified reference materials, and external blind proficiency samples, are analyzed regularly. Method detection limits are tested continuously, and laboratory reporting levels are updated accordingly. NWQL maintains National Environmental Laboratory Accreditation Program (NELAP) and other certifications (<http://www.nelac-institute.org/accred-labs.php>). In addition, the USGS Branch of Quality Systems (BQS) maintains independent oversight of QA at the NWQL and laboratories contracted by the NWQL. The BQS also runs the National Field Quality Assurance program that includes annual testing of all USGS field personnel for proficiency in making field water-quality measurements (<http://bqs.usgs.gov/nfqa/>). Results for analyses made at the NWQL or by laboratories contracted by the NWQL are uploaded directly into NWIS. Results of analyses made at other laboratories are compiled in a project database and uploaded from there into NWIS. Some laboratory QC data are stored in NWIS also.

## Data Reporting

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

## Reporting Limits

The USGS NWQL uses different conventions for reporting results for organic and inorganic constituents. For organic constituents (VOCs and pesticides), a laboratory reporting level (LRL) and a long-term method detection level (LT-MDL) are used as thresholds for reporting analytical

results. The LRL is set to minimize the reporting of false negatives (not detecting a compound when it actually is present in a sample) to less than 1 percent (Childress and others, 1999). The LRL usually is set at two times the LT-MDL. The LT-MDL is derived from the standard deviation of at least 24 method detection level (MDL) determinations made over an extended period of time. The MDL is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the concentration is greater than zero (at the MDL there is less than a 1-percent chance of a false positive) (Childress and others, 1999; U.S. Environmental Protection Agency, 2002).

The USGS NWQL updates LRL and LT-MDL values regularly, and the values listed in this report were in effect during the period that analyses were made for groundwater samples from the CAMP study unit (July 12 through October 14, 2010). The LRLs for some organic constituents changed on October 1, 2010; both values are reported in tables 4A–B, and the higher of the two values is reported with the groundwater-quality data in tables 6 and 7. Non-detections are reported as less than the LRL (<LRL).

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

Prior to September 30, 2010, the USGS NWQL reported inorganic constituents (trace elements, nutrients, major and minor ions, and TDS) using the same reporting conventions as used for organic constituents: non-detections were reported as <LRL, and detections with concentrations between the LT-MDL and LRL were reported as E-coded values (methods used for inorganic constituents are not information-rich methods; thus, no detections with concentrations <LT-MDL were reported). The reporting conventions changed on October 1, 2010 (U.S. Geological Survey Office of Water Quality, 2010), and this report uses the new reporting conventions for samples collected both before and after October 1, 2010. For the new reporting conventions, non-detections of inorganic constituents are reported as <LT-MDL, and E-coding is not applied to any detections. As in the old reporting convention, methods used for inorganic constituents are not information-rich methods; thus, no detections with



concentrations <LT-MDL are reported. The LT-MDLs for some inorganic constituents changed on October 1, 2010; both values are reported in [tables 4D–F](#), and the higher of the two values is reported with the groundwater-quality data in [tables 9–11](#). Detections with concentrations between the lower and higher LT-MDLs are reported as non-detections relative to the higher LT-MDL.

Some constituents in this study are reported using minimum reporting levels (MRLs) or method uncertainties (MU). The MRL is the smallest measurable concentration of a constituent that may be reliably reported using a given analytical method (Timme, 1995). The MU 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, LT-MDL, MDL, MRL, or MU values provided by the analyzing laboratories. Results for some organic and inorganic constituents are presented using study reporting levels (SRLs) derived from assessment of data from QC samples associated with groundwater samples collected as part of the GAMA PBP (see the appendix section titled “[Detections in Field Blanks and Application of SRLs](#)”).

The methods used for analysis of radiochemical constituents (tritium, uranium isotopes, radon-222, and gross alpha and gross beta radioactivity) measure activities by using counting techniques ([table A1](#)). The reporting limits for radiochemical constituents are based on sample-specific critical levels ( $ssL_C$ ) (McCurdy and others, 2008). The critical level is analogous to the LT-MDL used for reporting analytical results for organic and non-radioactive inorganic constituents. Here, 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 is dependent on instrument background, on counting times for the sample and background, and on 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 non-detections.

The analytical uncertainties associated with measurement of activities also are sensitive to sample-specific parameters, including sample size, sample yield during analytical processing, and time elapsed between sample collection and various steps in the analytical procedure, as well as parameters associated with the instrumentation. Therefore, measured activities of radioactive constituents are reported with sample-specific combined standard uncertainties (CSU). The CSU is reported at the 68-percent confidence level (1-sigma). The  $ssL_C$  was not reported for some tritium results, and one-half of the CSU was used as an estimate.

## Notation

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

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

where

$i$  is the atomic mass of the heavier isotope of the element;

$E$  is the element (H for hydrogen, O for oxygen, B for boron, C for carbon);

$R_{\text{sample}}$  is the ratio of the abundance of the heavier isotope of the element ( $^2\text{H}$ ,  $^{18}\text{O}$ ,  $^{11}\text{B}$ ,  $^{13}\text{C}$ ) to the lighter isotope of the element ( $^1\text{H}$ ,  $^{16}\text{O}$ ,  $^{10}\text{B}$ ,  $^{12}\text{C}$ ) 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 in the reference material.

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  values of 0 per mil (note that  $\delta^2\text{H}$  is sometimes written as  $\delta\text{D}$  because the common name of the heavier isotope of hydrogen, hydrogen-2, is deuterium) (Coplen and others, 2002). The reference material for boron is the National Institute of Standards and Technology (NIST) reference material SRM 951 boric acid, which is assigned a  $\delta^{11}\text{B}$  value of 0 per mil (Coplen and others, 2002). The reference material for carbon is Vienna Pee Dee Belemnite (VPDB), which is assigned a  $\delta^{13}\text{C}$  value of 0 per mil (Coplen and others, 2002). 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. The isotopic composition of strontium is reported as the ratio of the abundance of the heavier isotope to the abundance of the lighter isotope,  $^{87}\text{Sr}/^{86}\text{Sr}$  (for example, Faure, 1986).

## Constituents on Multiple Analytical Schedules

Five constituents targeted in this study were measured by more than one analytical method or by more than one laboratory ([table A2](#)). The preferred methods for these constituents were selected on the basis of the procedure recommended by the NWQL ([http://www.nwql.cr.usgs.gov/dyn.shtml?Preferred\\_method\\_selection\\_procedure](http://www.nwql.cr.usgs.gov/dyn.shtml?Preferred_method_selection_procedure)).

The field water-quality indicators—pH, specific conductance, and alkalinity—were measured in the field and at the NWQL. The field measurements are the preferred method

for all three constituents; however, both measurements are reported. Field values are generally preferred because field conditions are considered more representative of groundwater conditions (Hem, 1985).

For arsenic and iron concentrations, the approved method, Schedule 1948, used by the NWQL (table 4E) is preferred over the research methods used by the USGS Trace Metal Laboratory (table 4H). The concentrations measured by the Trace Metal Laboratory are used only to calculate ratios of the abundance of the oxidized species to the abundance of the reduced species for each element,  $\frac{\text{As(V)}}{\text{As(III)}}$  for arsenic and  $\frac{\text{Fe(III)}}{\text{Fe(II)}}$  for iron. For example,

$$\frac{\text{Fe(III)}}{\text{Fe(II)}} = \frac{\text{Fe(T)} - \text{Fe(II)}}{\text{Fe(II)}} \quad (2)$$

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-Control Methods and Results

The purpose of QC is to identify which data best represent environmental conditions and which data may have been affected by contamination or bias during sample collection, processing, storage, transportation, and (or) laboratory analysis. Four types of QC tests were used in this study: (1) blank samples were collected to assess positive bias as a result of contamination during sample handling or analysis, (2) replicate samples were collected to assess variability, (3) matrix-spike tests were done to assess positive or negative bias, and (4) surrogate compounds were added to samples analyzed for organic constituents to assess bias of laboratory analytical methods.

## Blanks

The primary purposes of collecting blanks are to evaluate the magnitude of potential contamination of samples with compounds of interest during sample collection, processing, transport, and (or) analysis and to identify and mitigate these sources of sample contamination. Results from blanks collected for the CAMP study unit and for previous GAMA study units were used to establish study reporting levels (SRLs) for some constituents detected in blanks. SRLs have higher concentrations than the reporting levels used by the laboratory. Detections reported by the laboratory with concentrations less than SRLs may have significant contamination bias. These data were flagged with an appropriate remark code (described in subsequent sections).

## Blank Collection and Analysis

Field blanks were collected using blank water certified by the NWQL to contain less than the LRL, LT-MDL, MDL, or MRL of the analytes investigated in the study (<http://www.nwql.cr.usgs.gov/USGS/OBW/obw.html>). Nitrogen-purged, organic-free blank water was used for field blanks of organic constituents, and inorganic-free blank water was used for field blanks of other constituents.

Field blanks were analyzed for VOCs, pesticides and pesticide degradates, perchlorate, trace elements, nutrients, major ions and TDS, species of arsenic and iron, and microbial indicators. Field blanks were not collected for uranium isotopes, gross alpha and gross beta particle activities, or radon because the laboratory determines a sample-specific critical level ( $ssL_C$ ) value for each sample. The  $ssL_C$  is the minimum measured value that indicates a non-zero amount of the radionuclide in the sample. Field blanks were not collected for tritium and dissolved noble gases because these constituents are present in the atmosphere and would dissolve into any solution used in collecting a blank, making it impractical to collect a blank for these analytes. Isotopic ratios of carbon, boron, hydrogen, oxygen, and strontium are an intrinsic property of any of these elements; therefore, the concept of a blank does not apply to these ratios.

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

## Study Reporting Levels (SRLs)

SRLs for trace elements detected in field blanks collected in the first 20 GAMA PBP study units (May 2004 through January 2008) were defined by Olsen and others (2010) on the basis of statistical assessment of results from the field blanks. The assessment used order statistics and binomial probabilities to construct an upper confidence limit (Hahn and Meeker, 1991) for the maximum concentration of constituents possibly introduced while groundwater samples were collected, handled, transported, and analyzed. Detections of trace elements having concentrations less than the SRLs are marked with a  $\leq$  symbol preceding the reported value in tables 10 and 15 to indicate that the true value may be less than or equal to the reported value (including the possibility of being a non-detection).

SRLs for VOCs detected in field blanks collected for the first 32 GAMA PBP study units (May 2004 through September 2010) were defined by Fram and others (2012) on the basis of assessment of results from field blanks, source-solution blanks, laboratory instrument blanks, and groundwater samples. Detections of VOCs having concentrations less than the SRLs are reported as non-detections in table 6.



SRLs for other classes of constituents detected in field blanks collected for the CAMP study unit were defined as equal to the highest concentration measured in the field blanks. In addition, the highest concentration measured in field blanks was used as the SRL for some trace elements that were not assigned an SRL by Olsen and others (2010).

### Detections in Field Blanks and Application of SRLs

[Table A3](#) presents a summary of detections in the field blanks and the SRLs applied for the CAMP study unit. Field blanks were collected at approximately 10 percent of the sites sampled in the CAMP study unit; not all analyte classes were tested at every well.

Of the nine VOCs with SRLs, five were detected in field blanks or groundwater samples from the CAMP study unit. 1,2,4-Trimethylbenzene was detected in 3 of 10 field blanks at concentrations ranging from 0.028 µg/L to 0.079 µg/L ([table A3](#)), and in 55 of 90 groundwater samples at concentrations ranging from E0.02 µg/L to 0.50 µg/L (median 0.06 µg/L). All detections had concentrations less than the SRL of 0.56 µg/L. All detections in groundwater samples were reclassified as non-detections. For the GAMA PBP, detections of 1,2,4-trimethylbenzene in blanks and groundwater samples are correlated with the presence of equipment in field vehicles used for collecting radon samples (Fram and others, 2012). The vials used to collect radon samples contain a scintillation cocktail made of mineral oil and 1,2,4-trimethylbenzene. Samples for radon analysis were collected at all sites in the CAMP study unit.

Toluene was detected in two groundwater samples at concentrations of E0.02 µg/L and 0.03 µg/L and was not detected in field blanks. Both detections had concentrations less than the SRL of 0.69 µg/L and were reclassified as non-detections. The source of the toluene contamination is uncertain.

Acetone and tetrahydrofuran each were detected in one groundwater sample at concentrations of E0.6 µg/L and 3 µg/L, respectively. Neither was detected in field blanks ([table A3](#)). Contamination of groundwater samples and field blanks by acetone, tetrahydrofuran, and (or) 2-butanone is associated with presence of PVC-cement at sample collection sites (some wells are plumbed with PVC piping) or with contamination of sample collection equipment with the methanol used for cleaning equipment (Fram and others, 2012). Field blanks with contamination from either of these two sources were not considered representative of groundwater conditions; therefore, no quality-control assessment could be made for these three solvents, and no concentration threshold could be established for the SRL. The SRL consists of reclassifying detections of these three solvents in groundwater samples as “not analyzed.” This is implemented in the USGS NWIS database by setting the data quality indicator code to “reviewed and rejected.”

Carbon disulfide was detected in 4 of 10 field blanks at concentrations ranging from E0.02 µg/L to 0.09 µg/L ([table A3](#)), and in 3 of 90 groundwater samples at concentrations ranging from 0.05 µg/L to E0.31 µg/L ([table 5](#)). All of the detections of carbon disulfide in groundwater samples have concentrations greater than the SRL of 0.04 µg/L, therefore, no data were flagged. Two of the field blanks had detections with concentrations greater than the SRL and greater than the lowest concentration detected in groundwater samples ([table A3](#)). If the highest concentration measured in CAMP field blanks had been used as the SRL, the detection of carbon disulfide in groundwater sample QV-04 would have been flagged with a “≤” and considered a non-detection. However, the detection of carbon disulfide in QV-04 (0.05 µg/L) was confirmed by detection of carbon disulfide in the replicate sample collected at the same site (0.06 µg/L), and the oxidation-reduction state of QV-04 was consistent with the presence of naturally occurring carbon disulfide. Carbon disulfide forms naturally under sulfate-reducing conditions, and hydrogen sulfide odor was noted during sample collection ([table 5](#)). The likely source of carbon disulfide contamination is the gloves worn by field and laboratory personnel (Worthington and others, 2007).

Perchlorate was detected in 3 of 10 field blanks collected for the CAMP study unit ([table A3](#)). The need for an SRL was evaluated using the entire population of field and source solution blanks collected in GAMA study units and analyzed by Weck Laboratory. Between August 2007 and November 2011, 88 field blanks and 58 source-solution blanks were analyzed for perchlorate. The method used by Olsen and others (2010) for determining SRLs for trace elements was applied to this population of field blanks to determine an SRL for perchlorate. The 90 percent confidence limit for the 90<sup>th</sup> percentile of 88 field blanks corresponds to the 84<sup>th</sup>-ranked field blank. Because only 4 of the 88 field blanks had detections of perchlorate, the 84<sup>th</sup>-ranked field blank had a result of non-detection for perchlorate. Therefore, no SRL is defined for perchlorate. The reason that three of the four detections of perchlorate in field blanks occurred during the same time that samples were being collected for the CAMP study unit is still under investigation.

Ten field blanks were collected for analysis of trace elements. Six trace elements were detected in at least one field blank: cobalt, copper, iron, lead, manganese, and zinc ([table A3](#)). The detections of copper, iron, and zinc were at concentrations less than the SRL assigned by Olsen and others (2010). SRLs for cobalt (0.38 µg/L), lead (1.04 µg/L), and manganese (0.7 µg/L) were established on the basis of the highest detected concentration in the field blanks. Measured concentrations that were less than the SRLs were flagged with a “≤” symbol ([table 10](#)). There were no other trace elements detected in any of the field blanks in the CAMP study unit. GAMA SRLs from Olsen and others (2010) were used for barium, chromium, copper, iron, nickel, tungsten, and zinc.

Ten field blanks were collected for analysis of the species of arsenic and iron. Iron (total) was detected in one field blank at a concentration of 20 µg/L. However, an SRL was not defined for iron (total) on the basis of this field blank because comparison between results for iron analyzed by the USGS Trace Metal Laboratory (TML) (table 15) and iron analyzed by the USGS NWQL (table 10) indicated that the USGS TML samples were unlikely to have experienced greater amounts of contamination than the USGS NWQL samples.

The results from the two laboratories were evaluated using methods used to evaluate replicates. The reporting limits for iron were 2 µg/L (MRL) at the USGS TML and 3 µg/L (LT-MDL) at the USGS NWQL. Of the 89 groundwater samples analyzed by both laboratories, 41 samples had reported concentrations of  $\geq 3$  µg/L from one or both laboratories and were therefore used in the evaluation. The Wilcoxon ranked-pairs test indicated that the difference between the two datasets was significant ( $p=0.49$ ; the null hypothesis for the test is that the median of the paired differences between the two datasets is zero, thus a  $p$ -value greater than  $\alpha = 0.05$  indicates that the paired datasets are significantly different). Concentrations reported by the USGS TML were significantly lower than those reported by the USGS NWQL for the set of 41 data pairs. Twenty-eight samples had concentrations of iron less than 20 µg/L (the concentration detected in the field blank). Of these 28 samples, 21 had lower concentrations reported by the USGS TML than by the USGS NWQL. These results suggest that the USGS TML samples did not have greater amounts of contamination; thus, application of an SRL with a higher concentration than that applied to the USGS NWQL data may not be warranted.

The hypothesized source of contamination by iron is the metal fittings used in sample collection equipment (Olsen and others, 2010). This source of contamination would affect samples sent to both the USGS NWQL and the USGS TML. Therefore, the SRL that was applied to the USGS NWQL iron data (table 10) was also applied to the USGS TML iron data. Measured concentrations less than the SRL of 6 µg/L were flagged with a " $\leq$ " symbol (table 15). The data from the USGS TML were used to calculate ratios of oxidized to reduced species, not for reporting absolute concentrations.

Constituents were not detected in the field blanks for the following analyte groups: pesticides and pesticide degradates (9 field blanks); nutrients (10 field blanks); major ions and TDS (10 field blanks); and the microbiological indicators *E. coli* and total coliform (6 field blanks).

## Replicates

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

## Assessment of Replicate Samples

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

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

- If both values were reported as detections, the SD was calculated if the mean concentration was  $< 5$  RL for the constituent, or the RSD was calculated if the mean concentration was  $\geq 5$  RL for the constituent. Acceptable precision is defined as an SD of less than  $\frac{1}{2}$  RL or an RSD of less than 10 percent. For comparison, an RSD of 10 percent is equivalent to a relative percent difference (RPD) of 14 percent.
- If both values were reported as non-detections, the variability was set to zero by definition.
- If one value was reported as a non-detection, and the other value was reported as a detection less than the RL, then a value of zero was substituted for the non-detection and the SD was calculated. Substituting zero for the non-detection yielded the maximum estimate of variability for the replicate pair.
- If one value for a sample pair was reported as a non-detection and the other value was reported as a  $\leq$ -coded value (less than or equal to the SRL), or if both values were reported as  $\leq$ -coded values (less than or equal to the SRL), the SD was not calculated because the values may be analytically identical. The  $\leq$ -code indicates that the value is a maximum potential concentration, and that concentration may be low enough to be reported as a non-detection.
- If one value was reported as a non-detection and the other value was reported as a detection greater than the RL, the variability for the pair was considered unacceptable.

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

$$z = \frac{|R_1 - R_2|}{\sqrt{(CSU_1^2 + CSU_2^2)}} \quad (3)$$

where

$z$  is the test statistic,

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

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

Values of  $z < 1.65$  correspond to significant levels ( $p$ )  $< \alpha = 0.05$ , and thus indicate replicate pairs with acceptable precision. Replicate pairs with values that are statistically indistinguishable at a confidence level ( $\alpha$ ) of  $\alpha = 0.05$  are defined as acceptable.

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

### Variability in Replicate Samples

[Tables A4A–C](#) summarize the results of replicate analyses for constituents detected in groundwater samples collected in the CAMP study unit. Replicate analyses were made on approximately 10 percent of the samples collected.

Of the 2,017 replicate pairs of constituents analyzed, 811 were for constituents detected in at least one groundwater sample. Of these 811 pairs, 14 pairs [aluminum (3 pairs), cadmium, silver, thallium, nitrite (as nitrogen), total nitrogen, bromide, iron (II), uranium-238, radon-222, gross alpha particle activity (72-hour count), and gross beta particle activity (30-day count)] were outside the limits for acceptable precision. Of these 14 pairs, 9 were for a replicate pair containing a non-detection and a low-level detection. Results for replicate analyses for constituents that were not detected in groundwater samples are not reported in [tables A4A–C](#).

Ten replicate pairs of samples were analyzed for the 85 VOCs, and all pairs were composed of two values reported as non-detections with the exception of one replicate pair of carbon disulfide and one replicate pair of chloroform

([table A4A](#)). These replicate pairs both yielded two values reported as detections, and both resulted in SDs within acceptable precision.

Ten replicate pairs of samples were analyzed for the 63 pesticide and pesticide degradate compounds, and all pairs were composed of two values reported as non-detections with the exception of two replicate pairs of deethylatrazine and one replicate pair of hexazinone ([table A4A](#)). These replicate pairs both yielded two values reported as detections, and both resulted in SDs within acceptable precision.

Ten replicate pairs of samples were analyzed for the perchlorate, and seven pairs were composed of two values reported as non-detections ([table A4A](#)). The three replicate pairs that yielded two values reported as detections all resulted in SDs within acceptable precision.

Ten replicate pairs of samples were analyzed for the 24 trace elements, and 116 of the 240 total pairs were composed of either two values reported as non-detections, a value reported as a non-detection and a value reported as  $\leq$  SRL, or two values reported as  $\leq$  SRL. Of the remaining 124 pairs of samples with at least one value reported as a detection, the SD value was greater than half of the LT-MDL for six pairs (aluminum, 3 pairs, cadmium, silver, and thallium), and the RSD value was greater than 10 percent for one pair (zinc) ([table A4B](#)).

Ten replicate pairs of samples analyzed for nutrients, major ions, TDS, and isotope tracers resulted in SDs within acceptable precision with the following exceptions: nitrite (1 pair), total nitrogen (1 pair), bromide (1 pair), and TDS (2 pairs). Ten replicate pairs of samples analyzed for species of arsenic and iron resulted in SD or RSD values within acceptable precision, with the exception of one one replicate pair for iron (III).

Eight replicate pairs for tritium were analyzed for variability, and all pairs yielded statistically similar results ( $p \leq 0.05$ ); therefore, they were considered acceptable ([table A4C](#)).

Two replicate pairs for uranium isotopes (uranium-234, uranium-235, and uranium-238) were analyzed for variability ([table A4C](#)). One replicate pair for uranium-238 consisting of a non-detection and a detection was statistically unacceptable; the  $p$ -value for the normalized absolute difference is less than the significance level of  $\alpha$  equal to 0.05 (equivalent to the test statistic  $z > 1.65$ ) ([table A4C](#)).

Ten replicate pair samples of radon-222 and gross alpha and gross beta particle activities were analyzed for variability ([table A4C](#)). One replicate pair out of 10 for radon-222, gross alpha particle activity (72-hour count), and gross beta particle activity (30-day count) was considered unacceptable ( $p > 0.05$ ) ([table A4C](#)).



Six replicate pair samples of microbial indicators (*E. coli* and total coliform) were analyzed for variability (table A4D). *E. coli* was not detected in any of these samples. Two of the six replicate pairs yielded a detection and a non-detection for the presence of total coliform (table A4D). Total coliform was not detected in the other four replicate pairs. The detection of the presence of microbial indicators must be verified with re-testing resulting in 5 percent of samples testing positive per month; one detection is not an violation of the MCL-US.

Environmental detections were not modified on the basis of the replicate analyses.

## Matrix Spikes

The addition of a known concentration of a constituent (spike) to a replicate environmental sample enables the analyzing laboratory to determine the effect of the matrix, in this case groundwater, on the analytical technique used to measure the constituent. The known compounds added in matrix spikes are the same as those being analyzed in the method. This enables an analysis of matrix interferences on a compound-by-compound basis. For this study, matrix spikes were added by the laboratory performing 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 potential concern if the concentration of a compound in a groundwater sample is close to the health-based benchmark; a low recovery could result in a falsely measured concentration less than the health-based benchmark, whereas a high recovery could result in a falsely measured concentration greater than the health-based benchmark.

The GAMA PBP defined the data-quality objective range for acceptable median matrix-spike recoveries as 70 to 130 percent. Only constituents with median matrix-spike recoveries outside of this range were flagged (with a footnote in table 4B) as having unacceptable recoveries. For many constituents, an acceptable range of 70 to 130 percent for median matrix-spike recovery was more restrictive than the acceptable control limits for laboratory-set spike recoveries. Laboratory-set spikes are aliquots of laboratory blank water to which the same spike solution used for the matrix-spikes has been added. One set spike is analyzed with each set of samples. Acceptable control limits for set spikes are defined relative to the long-term variability in recovery. For example, for many NWQL schedules, acceptable set spike recovery is within  $\pm 3$  F-pseudosigma of the median recovery for at least 30 set spikes (Connor and others, 1998). The F-pseudosigma is calculated by dividing the fourth-spread (analogous to interquartile range) by 1.349; therefore, the smaller the F-pseudosigma, the more precise the determinations (Hoaglin, 1983).

Matrix-spike tests were performed for VOCs and pesticides and pesticide degradates because the analytical methods for these constituents may be susceptible to matrix interferences.

## Matrix-Spike Recoveries

Tables A5A–C present a summary of matrix-spike recoveries for the CAMP study unit. Replicate samples for spike additions were collected at approximately 10 percent of the wells sampled, and not all analyte classes were tested at every well.

Nine groundwater samples were spiked with VOCs to calculate matrix-spike recoveries (table A5A). Median matrix-spike recoveries for all 85 VOC spike compounds were between 70 and 130 percent. Six VOC spike compounds had one matrix-spike recovery greater than 130 percent. Of these VOC spike compounds, PCE was detected in groundwater samples (tables 4A, 6, and A5A). Four VOC spike compounds had one matrix-spike recovery less than 70 percent. Of these VOC spike compounds, carbon disulfide was detected in groundwater samples (tables 4A, 6, and A5A). Low recoveries may indicate that the compound might be present at very low concentrations but not detected in some samples.

Nine groundwater samples were spiked with pesticide and pesticide degradate compounds to calculate matrix-spike recoveries (table A5B). Median matrix-spike recoveries for 40 of the 63 spike compounds were between 70 and 130 percent.

At least one matrix-spike recovery for 26 pesticide and pesticide degradate spike compounds was less than 70 percent. Of these pesticide and pesticide degradate spike compounds, only hexazinone was detected in a groundwater sample (tables 4B, 7, and A5B). At least one matrix-spike recovery for sixteen pesticide and pesticide degradate spike compounds was greater than 130 percent, and four of these were detected in groundwater samples (carbaryl, deethylatrazine, metalaxyl, and tebuthiuron) (tables 4B, 7, and A5B).

Environmental detections were not modified on the basis of the matrix-spike recovery analysis.

## Surrogates

Surrogate compounds are added to environmental samples in the laboratory prior to analysis to evaluate the recovery of similar constituents. Surrogate compounds were added in the laboratory to all groundwater and QC samples that were analyzed for VOCs and pesticides and pesticide degradates by the NWQL. Surrogates are used to identify general problems that may arise during laboratory 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 because of improper maintenance and calibration of analytical equipment) that produces a negative bias. A 70 to 130 percent recovery of surrogates, in general, is considered acceptable; values outside this range indicate possible problems with the processing and analysis of samples (Connor and others, 1998; Sandstrom and others, 2001).

## Surrogate Compound Recoveries

[Table A6](#) lists the surrogate, the analytical schedule on which it was applied, the number of analyses for blank and environmental samples, the number of surrogate recoveries less than 70 percent, and the number of surrogate recoveries greater than 130 percent for the blank and environmental samples. Blank and environmental samples were considered separately to assess whether the matrices present in groundwater samples affect surrogate recoveries.

In the CAMP study unit, most surrogate recoveries for the blank and environmental samples were within the acceptable range of 70 to 130 percent. In total, 93 percent of the blank and 91 percent of the environmental sample surrogate recoveries for VOC analyses were within the acceptable range ([table A6](#)). In addition, 94 percent of the blank and 88 percent of the environmental sample surrogate recoveries for pesticide and pesticide degradate analyses were within the acceptable range ([table A6](#)). There were no significant differences between VOC and pesticide and pesticide degradate surrogate recoveries in blank and environmental samples (Wilcoxon rank sum test,  $p < 0.05$ ). Environmental detections were not modified on the basis of the surrogate recovery analysis.

## Other Quality-Control Results

Three other laboratory quality-control issues arose during the analysis of samples collected for CAMP: (1) the effect of holding-time violations on the results of radioactive constituent data, (2) the effect of failure to maintain cold sample temperatures during shipping of samples to the laboratory, and (3) the effect of internal laboratory QC tests indicating bias on the results of trace element data.

### Holding-Time Violations for Radioactive Constituents

Holding time refers to the time in calendar days from sample collection to the analysis of the sample. A holding-time violation is when a sample is analyzed past the given holding time for a particular analysis. The remote sampling areas within the CAMP study unit did not allow for immediate shipment of a few samples for the analysis of radon and gross alpha and gross beta particle activities. This resulted in the later arrival times at the laboratory, and thus the analysis was completed after the holding time. This may be important because a delay in the analysis at the laboratory may result in different measured activities than what may have been present in the groundwater.

The gross alpha or gross beta particle activity reported result is the amount measured in the sample at the time of analysis. Radioactive decay occurs between the time of sample collection and measurement, and therefore gross alpha and gross beta particle activities change with time. For 11 samples, the gross alpha and (or) gross beta particle activity (72-hour

count) analyses were made after expiration of the holding time; for one sample, the gross alpha and gross beta particle activity (30-day count) analyses were made after expiration of the holding time ([table 14](#)).

The dominant sources of beta particles in most groundwater samples are radioactive decay of potassium-40 and radium-228 present in the sample at the time of collection and radioactive decay of beta-particle emitting progeny of uranium-238 that formed from radioactive decay of uranium-238 present in the sample at the time of collection (Welch and others, 1995). These progeny have relatively short half-lives, thus, in samples with elevated uranium contents, gross beta particle activity would likely increase as sample holding time increased. Potassium-40 and radium-228 have relatively long half-lives, thus, gross beta particle activity due to decay of these species does not decrease much over timescales relevant to this project. Of the samples with gross beta particle activity (72-hour count) analyses made after expiration of the holding time, one sample had high uranium abundance (CAMP-HL-11, [tables 12](#) and [14](#)). The gross beta particle activity measured in the sample was 12 pCi/L, which is less than  $\frac{1}{4}$  of the benchmark value of 50 pCi/L. GAMA PBP assessments of the status of groundwater quality are based on proportions of the primary aquifer system having groundwater with activities or concentrations of constituents that are high, moderate, or low relative to the value of the benchmark. For inorganic constituents, the boundary between moderate and low is defined as  $\frac{1}{2}$  of the benchmark value. Thus, the delayed analysis times will not affect results of the assessment of status of groundwater quality in the CAMP study unit.

The dominant sources of alpha particles in most groundwater samples are radioactive decay of alpha-particle emitting isotopes of uranium, radium, and radon present in the sample at the time of collection (note that radon is removed from the sample during sample preparation), and radioactive decay of alpha-particle emitting progeny of species present in the sample at the time of sample collection. Gross alpha particle activity commonly decreases during the first 3 weeks after sample collection due to decay of radium-224 and its alpha-particle emitting progeny, all of which have relatively short half-lives (Arndt, 2010). For samples collected by the GAMA PBP, gross alpha particle activity generally is well-correlated with uranium activity (for example, Fram and Belitz, 2012); thus, the presence of elevated uranium may be a proxy for elevated gross alpha particle activity. Of the four samples for which gross alpha particle activity measurements were made after expiration of the holding time, two had uranium concentrations less than 0.30  $\mu\text{g/L}$  (CAMP-LU-12 and -TV-03), thus the reported gross alpha particle activities (1.72 pCi/L and 1.36 pCi/L, respectively) likely are not far from the values had the measurements been made on time. Two samples had uranium concentrations of approximately 5  $\mu\text{g/L}$  (CAMP-HL-15 and -SH-12), suggesting



that the reported gross alpha particle activities (10 pCi/L and 3.0 pCi/L, respectively) may be noticeably lower than they would have been had the measurements been made on time. The benchmark for gross alpha particle activity is 15 pCi/L (MCL-US). For CAMP-HL-15, it is possible that the delayed analysis resulted in decreasing the gross alpha particle activity from a high value to a moderate value relative to the benchmark. This would affect the results of the status assessment.

The radon-222 reported result is corrected back to the time of collection. Late analysis results in a higher  $ssL_C$  and a higher CSU. The higher CSU means the result is less precise; however, it is not necessary to qualify the data because the CSU is reported with the data. If radon was very low in the sample, then late analysis might result in an  $ssL_C$  higher than the measured value, resulting in a reported non-detection. The same 12 groundwater samples that were analyzed past the holding time for gross alpha and gross beta particle activities were analyzed past the holding time for radon-222. Holding-time violations did not affect whether or not the reported results were above or below the benchmark. The only situation where late analysis would affect data interpretation is for samples with an activity close to the benchmark—the lower precision of the analysis (bigger CSU) may cause a sample to be counted as above benchmark when it is really below, or to be counted as below when it is really above. None of the CAMP late samples have radon activities close enough to benchmark (or  $\frac{1}{2}$  benchmark) for this to be an issue.

### Temperature Violations During Shipping of Samples

Samples collected for analysis of VOCs, pesticides, nutrients, trace elements, and major ions are shipped to the USGS NWQL in coolers packed with ice. Samples collected at the following eight sites were received after all of the ice had melted and the samples warmed to room temperature: CAMP-HL-05, -06, -07, and -08; CAMP-QV-07 and -08; and CAMP-TV-04 and -05. Quality-control samples collected at sites CAMP-HL-05 and CAMP-QV-07 were included in the same shipment. The question is whether or not the failure to keep the samples chilled affected the quality of the resulting data. Cool temperatures commonly are used as a means of sample preservation because they may decrease biotic and (or) abiotic degradation of some constituents and may slow the rate of sample degassing.

The trace elements and most of the major ions do not undergo changes that alter their total concentrations, thus, results for those constituents were not affected by the warm temperatures. Comparisons of field and laboratory measurements of pH and alkalinity suggest that the warm samples did not experience different amounts of degassing of carbon dioxide than the rest of the samples: laboratory pH values generally were higher than field pH values when field pH values were less than 8.0, and the offsets between field and laboratory pH values in the warm samples were similar to the offsets for other samples of the same field pH.

Conversion among the nitrogen species ammonia, nitrite, and nitrate is biologically mediated. However, the primary means of preservation of nutrient samples is filtration because it removes the most of the bacteria. The nitrogen species measured in the eight samples are consistent with the dissolved oxygen (DO) measurements made at the time of sample collection, suggesting that interconversion was negligible: samples with DO > 1 mg/L have nitrate (the most oxidized of the three nitrogen species), and samples with DO < 1 mg/L have ammonia (the most reduced of the three nitrogen species) and no nitrate. The primary means of preservation for the pesticides also is filtration.

The warm temperatures were unlikely to have adversely affected the VOCs because the primary means of sample preservation is acidification. Maskarinec and others (1990) measured degradation rates of VOCs as a function of sample acidification and temperature and found that acidification effectively prevented degradation. Even in unacidified samples, they found that for most VOCs, the amount of degradation during the first 10 days was essentially the same in chilled and unchilled samples. The few VOCs that showed differences in degradation rates with temperature in unacidified samples were all VOCs that have GAMA SRLs that result in censoring of all or nearly all of the data, or are rarely detected by the GAMA PBP, occurring only in groundwater that has detections of many other related VOCs.

### Laboratory Bias in Trace Element Analyses

Laboratory bias as indicated from internal laboratory QC tests is another issue that must be investigated to determine whether or not there is any effect on the data. The BQS operates an independent, external quality-assurance project called the Inorganic Blind Sample Project (IBSP) to monitor and evaluate the quality of results for analyses of trace elements, nutrients, and major ions by the NWQL. The IBSP submits standard reference samples consisting of natural matrix water samples spiked with reagent chemicals to contain known concentrations of the inorganic constituents (Farrar and Long, 1997). The IBSP samples are disguised as regular environmental samples for submission to the NWQL. The BQS uses results from the IBSP samples to evaluate potential bias, positive or negative, in the results reported by the NWQL on a continuous basis. The BQS IBSP data are readily available on the BQS website, and the BQS issues monthly summaries of the results, reporting the amount of bias (if any) observed in the results (<http://bqs.usgs.gov/ibsp/>).

The BQS monthly summaries were examined for July 2010 through November 2010, the period during which samples were analyzed for the CAMP study unit. The BQS reported that two inorganic constituents showed evidence of bias during this period: a negative bias for boron and a positive bias for cadmium. Examination of the results for the IBSP samples for these two constituents indicated that the analytical biases reported by the BQS were not significant for the data collected for the CAMP study unit.

The IBSP samples for boron had concentrations ranging from 16 to 45  $\mu\text{g/L}$ . The average difference between the measured and expected concentrations was  $-3 \mu\text{g/L}$  (standard deviation =  $3 \mu\text{g/L}$ ), and the average relative percent difference between the measured and expected concentrations was  $-10$  percent (standard deviation =  $8$  percent). The NL-CA for boron is  $1,000 \mu\text{g/L}$ , a concentration much higher than the maximum concentration in the IBSP samples. A negative bias of  $10$  percent, or  $3 \mu\text{g/L}$ , for groundwater samples with measured concentrations of less than  $45 \mu\text{g/L}$  does not affect assessment of whether groundwater samples in the CAMP study unit have boron concentrations greater than or less than the NL-CA concentration or greater than or less than  $\frac{1}{2}$  of the NL-CA concentration. Moreover, a determination of bias at low concentrations does not imply that there is equivalent bias at higher concentrations.

The IBSP samples for cadmium had concentrations ranging from  $0.2 \mu\text{g/L}$  to  $2.5 \mu\text{g/L}$ . The average difference between the measured and expected concentrations was  $0.06 \mu\text{g/L}$  (standard deviation =  $0.07 \mu\text{g/L}$ ), and the average relative percent difference between the measured and expected concentrations was  $9$  percent (standard deviation =  $25$  percent). The MCL-US for cadmium is  $5 \mu\text{g/L}$ ; thus the estimate of bias from the IBSP samples would be relevant for assessment of whether groundwater samples have cadmium concentrations greater than or less than the MCL-US concentration or greater than or less than  $\frac{1}{2}$  of the MCL-US concentration. However, the maximum concentration of cadmium in samples from the CAMP study unit was  $0.12 \mu\text{g/L}$  ([table 10](#)); thus, a potential positive bias of  $0.06 \mu\text{g/L}$ , or  $8$  percent, would not result in a measured concentration above either threshold when the true concentration would have been below the threshold.

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

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the NWQL are given in parentheses after the laboratory names. **Abbreviation:** VOC, volatile organic compound; USEPA, U.S. Environmental Protection Agency]

Analyte	Analytical Method	Water-quality indicators	Laboratory and analytical schedule	Citation(s)
Field water-quality indicators	Calibrated field meters and test kits	USGS field measurement	U.S. Geological Survey, variously dated	
<b>Organic constituents</b>				
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 2003	Zaugg and others, 1995; Lindley and others, 1996; Sandstrom and others, 2001; Madsen and others, 2003	
<b>Constituents of special interest</b>				
Perchlorate	Liquid chromatography with mass spectrometry/mass spectrometry (USEPA Method 331.0)	Week Laboratories, Inc., standard operating procedure ORG099.R01	U.S. Environmental Protection Agency, 2005	
<b>Inorganic constituents</b>				
Nutrients	Alkaline persulfate digestion, Kjeldahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003	
Major and minor ions, trace elements	Atomic absorption spectrometry, colorimetry, ion-exchange chromatography, inductively-coupled plasma atomic emission spectrometry and mass spectrometry	NWQL, Schedule 1948	Fishman and Friedman, 1989; Fishman, 1993; Faires, 1993; McLain, 1993; Garbarino, 1999; American Public Health Association, 1998; Garbarino and others, 2006	
Arsenic and iron speciation	Various techniques of ultraviolet visible (UV-VIS) spectrophotometry and atomic absorbance spectroscopy	USGS Trace Metal Laboratory, Boulder, Colorado (USGSTMCO)	Stookey, 1970; To and others, 1998; McCleskey and others, 2003	
<b>Isotope ratios</b>				
Stable isotopes of hydrogen ( $\delta^2\text{H}$ ) and oxygen ( $\delta^{18}\text{O}$ ) of 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	
$\delta^{13}\text{C}$ of inorganic carbon dissolved in water and carbon-14 abundance	Accelerator mass spectrometry	Woods Hole Oceanographic Institution, National Ocean Sciences Accelerator Mass Spectrometry Facility (NOSAMS), NWQL Schedule 2255	Vogel and others, 1987; Donahue and others, 1990; McNichol and others, 1992; Gagnon and Jones, 1993; McNichol and others, 1994; Schneider and others, 1994	

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

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names. **Abbreviation:** VOC, volatile organic compound]

Analyte	Analytical Method	Laboratory and analytical schedule		Citation(s)
		Isotope ratios—Continued		
$\delta^{11}\text{B}$ of boron dissolved in water	Negative thermal-ionization mass spectrometry	USGS NRP Metals Isotope Research Lab, Menlo Park, California (USGSMICA)		Vengosh and others, 1989; Dwyer and Vengosh, 2008
	Chemical separations and thermal-ionization mass spectrometry	USGS NRP Metals Isotope Research Lab, Menlo Park, California (USGSMICA)		Bullen and others, 1996
Radioactivity and gases				
Tritium	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA)		Thatcher and others, 1977
Dissolved noble gases and tritium	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
Uranium isotopes	Chemical separations and alpha-particle spectrometry	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1130		American Society for Testing and Materials, 2002 (ASTM D3972)
Gross alpha and gross beta particle activity	Alpha and beta activity counting (USEPA Method 900.0)	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1792		Kreiger and Whittaker, 1980
Microbial constituents				
<i>Escherichia coli</i> ( <i>E. coli</i> ) and total coliform	IDEXX Colilert® test kit (Standard Methods 9223)	USGS field measurement		American Public Health Association, 1998

**Table A2.** Preferred analytical schedules for selected constituents collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[Preferred analytical schedules/methods are selected on the basis of the procedure recommended by the NWQL ([http://www.nwql.cr.usgs.gov/dyn.shtml?Preferred\\_method\\_selection\\_procedure](http://www.nwql.cr.usgs.gov/dyn.shtml?Preferred_method_selection_procedure)). **Abbreviations:** TML, U.S. Geological Survey Trace Metal Laboratory, Boulder, Colorado; LLNL, Lawrence Livermore National Laboratory; SITL, U.S. Geological Survey Stable Isotope and Tritium Laboratory]

Constituent	Primary constituent classification	Analytical schedules	Preferred analytical schedule
<b>Results from both methods reported</b>			
Alkalinity	Water-quality indicator	Field, 1948	Field
Arsenic, 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

**Table A3.** Constituents detected in field blanks and the study reporting level (SRL) analysis for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[Study reporting levels (SRLs) defined on the basis of CAMP field blanks are equal to the highest concentration measured in the field blanks. **Abbreviations:** LRL, laboratory reporting level; LT-MDL, long term-method detection level; MDL, method detection level; ≤, less than or equal to; E, estimated or having a higher degree of uncertainty; µg/L, micrograms per liter; –, not detected]

Constituent	Number of field blank detections/ total number of field blanks	LRL, LT-MDL, MDL, or MRL <sup>1</sup>	Concentrations detected in field blanks	SRL concentration	Source of SRL	Number of groundwater samples ≤-coded
<b>Volatile organic compounds (VOC) (µg/L)</b>						
Carbon disulfide	4/10	0.08	0.09, 0.06, E0.02, E0.02	0.04	Fram and others, 2012	<sup>2</sup> 0
Toluene	0/10	0.018	–	0.69	Fram and others, 2012	<sup>3</sup> 3
1,2,4-Trimethylbenzene	3/10	0.032	0.069, 0.079, 0.028	0.56	Fram and others, 2012	<sup>3</sup> 55
<b>Special-interest constituents (µg/L)</b>						
Perchlorate	3/10	0.10	0.31, 0.13, 2.72	none	none	0
<b>Trace elements (µg/L)</b>						
Barium	0/10	0.07	–	0.4	Olsen and others, 2010	1
Chromium	0/10	0.06	–	0.4	Olsen and others, 2010	17
Cobalt	10/10	0.02	0.38, 0.19, 0.05, 0.08, 0.06, 0.13, 0.17, 0.06, 0.10, 0.13	0.38	CAMP field blanks	41
Copper	1/10	0.5	0.91	1.7	Olsen and others, 2010	39
Iron	1/10	3.2	4	6	Olsen and others, 2010	16
Lead	5/10	0.02	0.02, 1.04, 0.05, 0.02, 0.03	1.04	CAMP field blanks	75
Manganese	6/10	0.2	0.7, 0.3, 0.2, 0.3, 0.2, 0.3	0.7	CAMP field blanks	28
Nickel	1/10	0.09	0.06	0.36	Olsen and others, 2010	35
Tungsten	0/10	0.01	–	0.11	Olsen and others, 2010	44
Zinc	2/10	1.4	2.5, 1.4	4.8	Olsen and others, 2010	26
<b>Arsenic and iron species (µg/L)</b>						
Iron (total)	1/10	2	20	6	Olsen and others, 2010	20

<sup>1</sup> LRL is listed for VOCs, LT-MDL is listed for trace elements, and MDL is listed for arsenic and iron species.

<sup>2</sup> Carbon disulfide detections in samples from the CAMP study unit had concentrations greater than the SRL.

<sup>3</sup> Laboratory results for toluene and 1,2,4-trimethylbenzene in samples from the CAMP study unit had concentrations less than the SRLs—toluene (HL-01, E0.02 µg/L and TV-15, 0.03 µg/L) and 1,2,4-trimethylbenzene (55 samples at concentrations ranging from E0.02 µg/L to 0.5 µg/L; median = 0.06 µg/L).



**Table A4A.** Quality-control summary for replicate analyses of organic constituents and perchlorate detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[Abbreviations: SD, percent standard deviation; RSD, percent relative standard deviation; ≤, less than or equal to; LRL, laboratory reporting level; SRL, study reporting level; nv, no value in category]

Constituent	Number of non-detect replicates/ number of replicates	Number of SDs greater than ½ LRL / number of replicates with concentration less than 5 times the LRL	Concentrations of replicates with SDs greater than ½ LRL (environmental, replicate)	Number of RSDs greater than 10 percent/ number of replicates with concentration greater than 5 times the LRL	Concentrations of replicates with RSDs greater than 10 percent (environmental, replicate)
<b>Volatile organic compounds (VOC) (Schedule 2020)</b>					
Benzene	10/10	nv	nv	nv	nv
Carbon disulfide	9/10	0/1	nv	nv	nv
Chloroform (Trichloromethane)	9/10	0/1	nv	nv	nv
1,4-Dichlorobenzene	10/10	nv	nv	nv	nv
1,1-Dichloroethene (1,1-DCE)	10/10	nv	nv	nv	nv
<i>o</i> -Ethyl toluene (1-Ethyl-2-methyl benzene)	10/10	nv	nv	nv	nv
Isopropylbenzene	10/10	nv	nv	nv	nv
4-Isopropyl-1-methyl benzene	10/10	nv	nv	nv	nv
Methyl <i>tert</i> -butyl ether (MTBE)	10/10	nv	nv	nv	nv
Methylene chloride (Dichloromethane)	10/10	nv	nv	nv	nv
Perchloroethene (PCE, Tetrachloroethene)	10/10	nv	nv	nv	nv
<i>n</i> -Propylbenzene	10/10	nv	nv	nv	nv
1,2,3,4-Tetramethylbenzene	10/10	nv	nv	nv	nv
1,2,3,5-Tetramethylbenzene	10/10	nv	nv	nv	nv
1,1,1-Trichloroethane (1,1,1-TCA)	10/10	nv	nv	nv	nv
Trichlorotrifluoroethane (CFC-113)	10/10	nv	nv	nv	nv
1,2,3-Trimethylbenzene	10/10	nv	nv	nv	nv
1,3,5-Trimethylbenzene	10/10	nv	nv	nv	nv
<b>Pesticides and pesticide degradates (Schedule 2003)</b>					
Atrazine	10/10	nv	nv	nv	nv
Carbaryl	10/10	nv	nv	nv	nv
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino- <i>s</i> -triazine)	8/10	0/2	nv	nv	nv
3,4-Dichloroaniline	10/10	nv	nv	nv	nv
Hexazinone	9/10	0/1	nv	nv	nv
Metalaxyl	10/10	nv	nv	nv	nv
Prometon	10/10	nv	nv	nv	nv
Simazine	10/10	nv	nv	nv	nv
Tebuthiuron	10/10	nv	nv	nv	nv
<b>Constituent of special interest - Perchlorate</b>					
Perchlorate	7/10	0/3	nv	nv	nv

**Table A4B.** Quality-control summary for replicate analyses of inorganic constituents and isotope tracers detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[Types of reporting levels (RL): LT-MDL or SRL are used for trace elements (table 10); LT-MDL or MDL are used for nutrients (table 9); LT-MDL or MRL are used for major ions (table 11); MDL is used for oxidation-reduction species (table 15); MU is used for isotope tracers (table 16). **Abbreviations:** SD, percent standard deviation; RSD, percent relative standard deviation; LT-MDL, long-term method detection level; SRL, study reporting level; MDL, method detection limit; MRL, minimum reporting level; MU, method uncertainty; µg/L, micrograms per liter; H, hydrogen; O, oxygen; C, carbon; mg/L, milligrams per liter; <, less than; ≤, less than or equal to; nv, no value in category]

Constituent	Number of non-detect or ≤-coded replicates/total number of replicates	Replicates with concentrations less than or equal to 5 times the RL		Replicates with concentrations greater than 5 times the RL	
		Number of SDs greater than ½ the RL/number of replicates	Concentrations of replicates with SDs greater than ½ the RL (environmental, replicate)	Number of RSDs greater than 10 percent/number of replicates	Concentrations of replicates with RSDs greater than 10 percent (environmental, replicate)
Trace elements (µg/L)					
Aluminum	0/10	3/9	(5.4, 3.9; 5.6, 4.2; 1.8, <1.7)	0/1	nv
Antimony	6/10	0/4	nv	nv	nv
Arsenic	0/10	0/2	nv	0/8	nv
Barium	0/10	0/1	nv	0/9	nv
Beryllium	9/10	0/1	nv	nv	nv
Boron	0/10	0/4	nv	0/6	nv
Cadmium	8/10	1/2	(0.02, <0.02)	nv	nv
Chromium	2/10	0/6	nv	0/2	nv
Cobalt	8/10	0/2	nv	nv	nv
Copper	8/10	0/2	nv	nv	nv
Iron	9/10	0/1	nv	nv	nv
Lead	9/10	0/1	nv	nv	nv
Lithium	0/10	0/4	nv	0/6	nv
Manganese	8/10	nv	nv	0/2	nv
Molybdenum	0/10	0/3	nv	0/7	nv
Nickel	9/10	0/1	nv	nv	nv
Selenium	6/10	0/3	nv	0/1	nv
Silver	9/10	1/1	(0.01, <0.01)	nv	nv
Strontium	0/10	nv	nv	0/10	nv
Thallium	9/10	1/1	(0.01, <0.01)	nv	nv
Tungsten	7/10	0/2	nv	0/1	nv
Uranium	1/10	0/1	nv	0/8	nv
Vanadium	1/10	nv	nv	0/9	nv
Zinc	7/10	1/1	(5.0, ≤4.7)	1/2	(24.3, 20.0)
Nutrients (mg/L)					
Ammonia (as nitrogen)	8/10	nv	nv	0/2	nv
Nitrate plus nitrite (as nitrogen)	1/10	0/5	nv	0/4	nv
Nitrite (as nitrogen)	8/10	1/1	(0.001, <0.001)	0/1	nv
Total nitrogen	4/10	1/2	(<0.05, 0.05)	0/4	nv
Orthophosphate (as phosphorus)	0/10	nv	nv	0/10	nv

**Table A4B.** Quality-control summary for replicate analyses of inorganic constituents and isotope tracers detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—Continued

[Types of reporting levels (RL): LT-MDL or SRL are used for trace elements (table 10); LT-MDL or MDL are used for nutrients (table 9); LT-MDL or MRL are used for major ions (table 11); MDL is used for oxidation-reduction species (table 15); MU is used for isotope tracers (table 16). **Abbreviations:** SD, percent standard deviation; RSD, percent relative standard deviation; LT-MDL, long-term method detection level; SRL, study reporting level; MDL, method detection limit; MRL, minimum reporting level; MU, method uncertainty; µg/L, micrograms per liter; H, hydrogen; O, oxygen; C, carbon; , mg/L, milligrams per liter; <, less than; ≤, less than or equal to; nv, no value in category]

Constituent	Number of non-detect or ≤-coded replicates/total number of replicates	Replicates with concentrations less than or equal to 5 times the RL		Replicates with concentrations greater than 5 times the RL	
		Number of SDs greater than ½ the RL/number of replicates	Concentrations of replicates with SDs greater than ½ the RL (environmental, replicate)	Number of RSDs greater than 10 percent/number of replicates	Concentrations of replicates with RSDs greater than 10 percent (environmental, replicate)
Major and minor ions, silica, and total dissolved solids (TDS) (mg/L)					
Bromide	5/10	1/3	(0.02, 0.03)	0/2	nv
Calcium	0/10	nv	nv	0/10	nv
Chloride	0/10	0/1	nv	0/9	nv
Fluoride	5/10	0/1	nv	0/4	nv
Iodide	7/10	0/2	nv	0/1	nv
Magnesium	0/10	nv	nv	0/10	nv
Potassium	0/10	nv	nv	0/10	nv
Sodium	0/10	nv	nv	0/10	nv
Sulfate	1/10	0/3	nv	0/6	nv
Silica (as SiO <sub>2</sub> )	0/10	nv	nv	0/10	nv
TDS	0/10	nv	nv	2/10	(141, 116; 77, 104)
Arsenic and iron species (µg/L)					
Arsenic (total)	3/10	nv	nv	0/7	nv
Arsenic (III)	9/10	nv	nv	0/1	nv
Iron (total)	9/10	0/1	nv	nv	nv
Iron (II)	8/10	1/1	(5.0, 3.3)	0/1	nv
Isotope tracers					
δ <sup>2</sup> H in water	0/10	nv	nv	0/10	nv
δ <sup>18</sup> O in water	0/10	nv	nv	0/10	nv
δ <sup>13</sup> C in dissolved inorganic carbon	0/10	nv	nv	0/10	nv
Carbon-14	0/10	nv	nv	0/10	nv

**Table A4C.** Quality-control summary for replicate analyses of radioactive constituents detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[For activities of radiochemical constituents, a replicate pair of analyses is defined as acceptable if the p-value for the normalized absolute difference is less than the significance level,  $\alpha = 0.05$ . **Abbreviations:** >, greater than; pCi/L, picocuries per liter;  $\pm$ , plus or minus; nv, no value in category; –, not detected (value is below  $ssL_C$ );  $ssL_C$ , sample-specific critical level]

Constituent	Number of pairs with $p > 0.05$ / total number of replicate pairs	Activities in pCi/L for replicate pairs with $p > 0.05$ (environmental, replicate)
		result $\pm$ CSU
Tritium	1/8	$(7.40 \pm 0.39, 8.70 \pm 0.47)$
Uranium-234	0/2	nv
Uranium-235	0/2	nv
Uranium-238	1/2	$(-, 0.042 \pm 0.013)$
Radon-222	1/10	$(420 \pm 27, 360 \pm 23)$
Gross alpha radioactivity, 72-hour count	1/10	$(-, 1.50 \pm 0.62)$
Gross alpha radioactivity, 30-day count	0/10	nv
Gross beta radioactivity, 72-hour count	0/10	<sup>1</sup> nv
Gross beta radioactivity, 30-day count	1/10	$(-, 1.63 \pm 0.41)$

<sup>1</sup> Includes an acceptable replicate pair collected from QV-04 counted 6 days after collection.

**Table A4D.** Quality-control summary for replicate analyses of microbial constituents detected in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

[**Abbreviations:** –, not detected; D, detected]

Constituent	Total number of replicates	Number of (–, –) replicates	Number of (D, D) replicates	Number of (D, –) or (–, D) replicates
<b>Microbial constituents</b>				
<i>E. coli</i>	6	6	0	0
Total coliform	6	4	0	<sup>1</sup> 2

<sup>1</sup> Potential change in sample collection line may have affected replicate sample.

**Table A5A.** Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.[Acceptable recovery range is between 70 and 130 percent. **Abbreviation:** D, detected in groundwater samples ([table 6](#)); –, not detected]

Constituent	Number of spike samples	Minimum recovery (percent)	Median recovery (percent)	Maximum recovery (percent)	Detected in groundwater samples
Acetone	9	88	100	141	– <sup>(1)</sup>
Acrylonitrile	9	80	98	112	–
<i>tert</i> -Amyl methyl ether (TAME)	9	83	95	104	–
Benzene	9	95	100	107	D
Bromobenzene	9	91	95	112	–
Bromochloromethane	9	92	100	110	–
Bromodichloromethane	9	79	86	101	–
Bromoform (Tribromomethane)	9	79	89	107	–
Bromomethane (Methyl bromide)	9	79	106	122	–
<i>n</i> -Butylbenzene	9	71	92	102	–
<i>sec</i> -Butylbenzene	9	87	99	108	–
<i>tert</i> -Butylbenzene	9	91	103	107	–
Carbon disulfide	9	68	85	99	D
Carbon tetrachloride (Tetrachloromethane)	9	83	95	105	–
Chlorobenzene	9	91	94	102	–
Chloroethane	9	70	100	124	–
Chloroform (Trichloromethane)	9	93	103	120	D
Chloromethane	9	80	110	136	–
3-Chloropropene	9	79	94	103	–
2-Chlorotoluene	9	92	103	114	–
4-Chlorotoluene	9	91	99	114	–
Dibromochloromethane	9	82	90	99	–
1,2-Dibromo-3-chloropropane (DBCP)	9	76	93	106	–
1,2-Dibromoethane (EDB)	9	91	101	108	–
Dibromomethane	9	90	97	106	–
1,2-Dichlorobenzene	9	96	102	123	–
1,3-Dichlorobenzene	9	96	101	114	–
1,4-Dichlorobenzene	9	99	102	117	D
<i>trans</i> -1,4-Dichloro-2-butene	9	62	86	102	–
Dichlorodifluoromethane (CFC-12)	9	70	87	126	–
1,1-Dichloroethane (1,1-DCA)	9	84	98	114	–
1,2-Dichloroethane (1,2-DCA)	9	97	103	115	–
1,1-Dichloroethene (1,1-DCE)	9	84	99	108	D
<i>cis</i> -1,2-Dichloroethene ( <i>cis</i> -1,2-DCE)	9	94	98	104	–
<i>trans</i> -1,2-Dichloroethene ( <i>trans</i> -1,2-DCE)	9	87	99	106	–
1,2-Dichloropropane	9	89	96	100	–
1,3-Dichloropropane	9	94	101	106	–
2,2-Dichloropropane	9	72	85	92	–
1,1-Dichloropropene	9	87	92	97	–
<i>cis</i> -1,3-Dichloropropene	9	82	87	96	–
<i>trans</i> -1,3-Dichloropropene	9	76	88	97	–
Diethyl ether	9	82	103	109	–
Diisopropyl ether (DIPE)	9	84	100	105	–
Ethylbenzene	9	88	92	100	–
Ethyl <i>tert</i> -butyl ether (ETBE)	9	86	95	101	–
Ethyl methacrylate	9	83	86	93	–
<i>o</i> -Ethyl toluene (1-Ethyl-2-methyl benzene)	9	91	99	109	D



**Table A5A.** Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—Continued[Acceptable recovery range is between 70 and 130 percent. **Abbreviation:** D, detected in groundwater samples ([table 6](#)); –, not detected]

Constituent	Number of spike samples	Minimum recovery (percent)	Median recovery (percent)	Maximum recovery (percent)	Detected in groundwater samples
Hexachlorobutadiene	9	80	87	111	–
Hexachloroethane	9	78	92	113	–
2-Hexanone ( <i>n</i> -Butyl methyl ketone)	9	82	96	108	–
Iodomethane (Methyl iodide)	9	93	108	117	–
Isopropylbenzene	9	86	92	99	D
4-Isopropyl-1-methyl benzene	9	78	95	103	D
Methyl acrylate	9	91	95	105	–
Methyl acrylonitrile	9	95	105	113	–
Methyl <i>tert</i> -butyl ether (MTBE)	9	85	106	119	D
Methyl <i>iso</i> -butyl ketone (MIBK)	9	84	90	102	–
Methylene chloride (Dichloromethane)	9	83	103	118	D
Methyl ethyl ketone (2-butanone, MEK)	9	87	96	111	–
Methyl methacrylate	9	82	90	92	–
Naphthalene	9	79	91	101	–
Perchloroethene (PCE, Tetrachloroethene)	9	93	125	159	D
<i>n</i> -Propylbenzene	9	83	93	102	D
Styrene	9	79	93	103	–
1,1,1,2-Tetrachloroethane	9	84	94	110	–
1,1,2,2-Tetrachloroethane	9	90	93	109	–
Tetrahydrofuran	9	94	105	119	– <sup>(1)</sup>
1,2,3,4-Tetramethylbenzene	9	78	94	111	D
1,2,3,5-Tetramethylbenzene	9	77	96	116	D
Toluene	9	97	104	111	– <sup>(1)</sup>
1,2,3-Trichlorobenzene	9	89	97	114	–
1,2,4-Trichlorobenzene	9	84	95	106	–
1,1,1-Trichloroethane (1,1,1-TCA)	9	94	101	116	D
1,1,2-Trichloroethane (1,1,2-TCA)	9	92	97	109	–
Trichloroethene (TCE)	9	85	94	103	–
Trichlorofluoromethane (CFC-11)	9	93	110	131	–
1,2,3-Trichloropropane (1,2,3-TCP)	9	92	97	117	–
Trichlorotrifluoroethane (CFC-113)	9	87	99	127	D
1,2,3-Trimethylbenzene	9	87	102	118	D
1,2,4-Trimethylbenzene	9	84	91	145	– <sup>(1)</sup>
1,3,5-Trimethylbenzene	9	91	100	109	D
Vinyl bromide (Bromoethene)	9	95	99	113	–
Vinyl chloride (Chloroethene)	9	69	97	130	–
<i>m</i> - and <i>p</i> -Xylene	9	89	99	105	–
<i>o</i> -Xylene	9	87	95	105	–

<sup>1</sup> These constituents had concentrations less than the study reporting levels defined on the basis of examination of quality-control samples collected between May 2004 and September 2010 for the first 32 study units of the California GAMA Priority Basin Project (Fram and others, 2012).

**Table A5B.** Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.[Acceptable recovery range is between 70 and 130 percent. **Abbreviation:** D, detected in groundwater samples ([table 7](#)); –, not detected]

Constituent	Number of spike samples	Minimum recovery (percent)	Median recovery (percent)	Maximum recovery (percent)	Detected in groundwater samples
Acetochlor	9	84	97	184	— <sup>(1)</sup>
Alachlor	9	80	95	136	—
Atrazine	9	79	101	114	D
Azinphos-methyl	9	86	98	121	—
Azinphos-methyl oxon	9	45	75	100	—
Benfluralin	9	67	77	94	—
Carbaryl	9	95	114	164	D
2-Chloro-2,6-diethylacetanilide	9	87	104	118	—
4-Chloro-2-methylphenol	9	65	73	94	—
Chlorpyrifos	9	75	87	104	—
Chlorpyrifos oxon	9	16	34	50	—
Cyfluthrin	9	46	62	112	—
Cypermethrin	9	45	58	100	—
Dacthal (DCPA)	9	97	109	111	—
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino- <i>s</i> -triazine)	9	92	109	138	D
Desulfinylfipronil	9	79	101	135	—
Desulfinylfipronil amide	9	69	90	130	—
Diazinon	9	85	100	109	—
3,4-Dichloroaniline	9	76	84	99	D
Dichlorvos	9	12	22	51	—
Dicrotophos	9	24	35	48	—
Dieldrin	9	69	93	108	—
2,6-Diethylaniline	9	93	97	110	—
Dimethoate	9	51	64	87	—
Ethion	9	65	79	117	—
Ethion monoxon	9	76	98	119	—
2-Ethyl-6-methylaniline	9	74	92	106	—
Fenamiphos	9	71	95	136	—
Fenamiphos sulfone	9	74	95	113	—
Fenamiphos sulfoxide	9	7	17	33	—
Fipronil	9	82	108	136	—
Fipronil sulfide	9	85	101	142	—
Fipronil sulfone	9	67	79	101	—
Fonofos	9	72	93	97	—
Hexazinone	9	52	69	98	D
Iprodione	9	68	79	128	—
Isofenphos	9	81	97	137	—
Malaoxon	9	71	91	111	—
Malathion	9	74	97	121	—
Metalaxyl	9	87	109	157	D
Methidathion	9	87	95	111	—
Metolachlor	9	78	92	131	—
Metribuzin	9	76	94	152	—
Myclobutanil	9	78	81	125	—
1-Naphthol	9	39	61	86	—

**Table A5B.** Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.—Continued[Acceptable recovery range is between 70 and 130 percent. **Abbreviation:** D, detected in groundwater samples ([table 7](#)); –, not detected]

Constituent	Number of spike samples	Minimum recovery (percent)	Median recovery (percent)	Maximum recovery (percent)	Detected in groundwater samples
Paraoxon-methyl	9	54	73	101	–
Parathion-methyl	9	81	104	149	–
Pendimethalin	9	85	102	133	–
<i>cis</i> -Permethrin	9	51	67	146	–
Phorate	9	66	76	91	–
Phorate oxon	9	74	112	130	–
Phosmet	9	33	41	72	–
Phosmet oxon	9	23	37	57	–
Prometon	9	75	97	116	D
Prometryn	9	82	102	130	–
Pronamide (Propyzamide)	9	90	103	120	–
Simazine	9	82	97	117	D
Tebuthiuron	9	95	143	179	D
Terbufos	9	70	85	100	–
Terbufos oxon sulfone	9	58	83	116	–
Terbuthylazine	9	83	103	117	–
Tribufos	9	51	61	105	–
Trifluralin	9	70	84	103	–

<sup>1</sup> These constituents had concentrations less than the study reporting levels defined on the basis of examination of quality-control samples collected between May 2004 and September 2010 for the first 32 study units of the California GAMA Priority Basin Project (Fram and others, 2012).

**Table A6.** Quality-control summary for surrogate recoveries of volatile organic compounds (VOCs) and pesticides and pesticide degradates in samples collected for the Cascade Range and Modoc Plateau (CAMP) study unit, July through October 2010, California GAMA Priority Basin Project.

Surrogate	Analytical schedule	Constituent or constituent class analyzed	Number of blank analyses	Median recovery in blanks (percent)	Number of surrogate recoveries less than 70 percent in blanks	Number of surrogate recoveries greater than 130 percent in blanks	Number of sample analyses	Median recovery in samples (percent)	Number of surrogate recoveries less than 70 percent in samples	Number of surrogate recoveries greater than 130 percent in samples
1-Bromo-4-fluorobenzene	2020	VOC	10	84	0	0	90	83	1	0
1,2-Dichloroethane-d4	2020	VOC	10	119	0	2	90	125	0	24
Toluene-d8	2020	VOC	10	93	0	0	90	93	0	0
Diazinon-d10	2003	Pesticide	9	82	1	0	90	78	21	0
$\alpha$ -HCH-d6	2003	Pesticide	9	91	0	0	90	90	1	0

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<http://ca.water.usgs.gov>

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