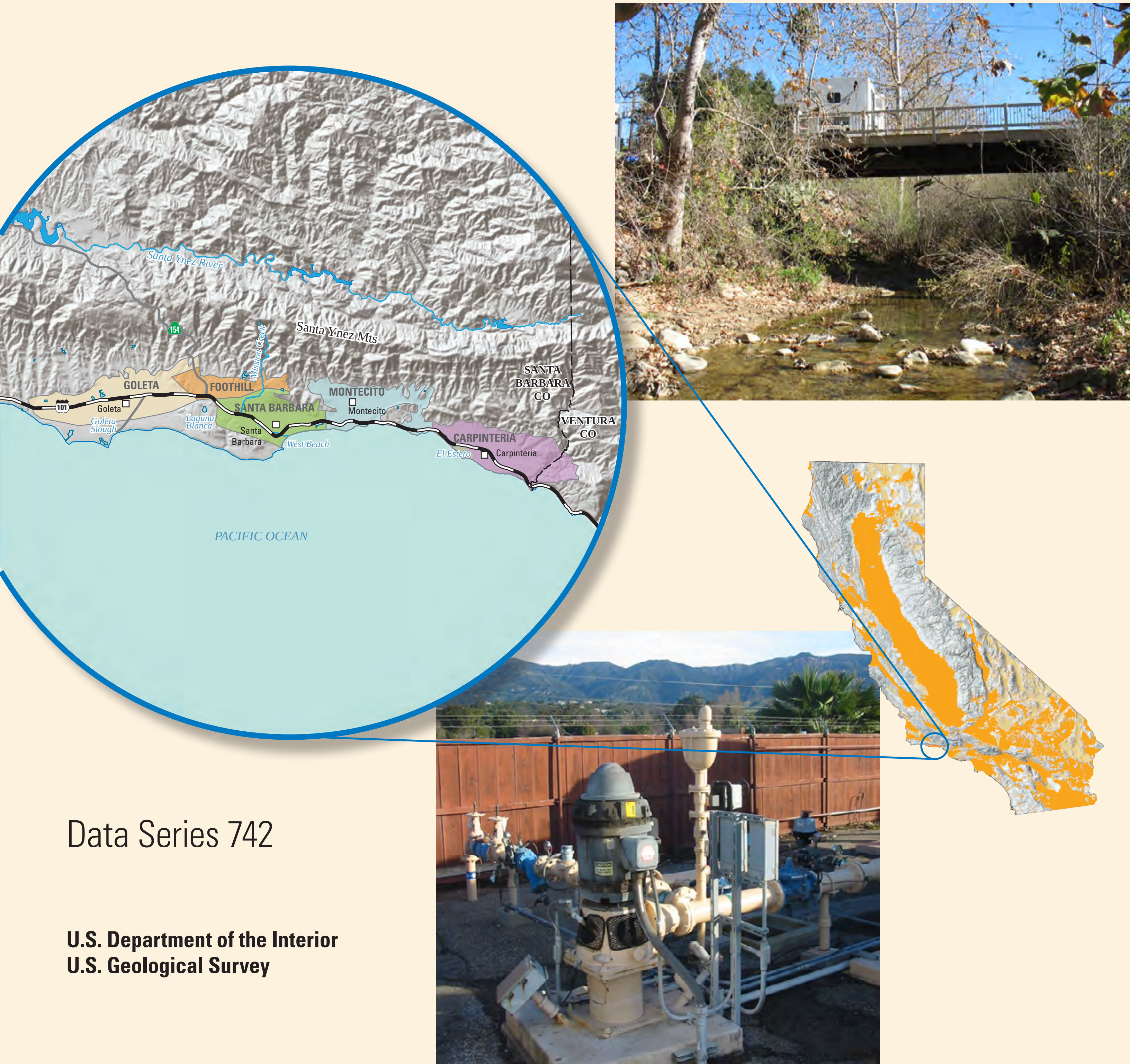
Prepared in cooperation with the California State Water Resources Control Board

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

Groundwater-Quality Data in the Santa Barbara Study Unit, 2011: Results from the California GAMA Program



Data Series 742

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

Cover photographs:

Top right: Bridge over Rincon Creek in Carpinteria, California. (Photograph taken by Tracy Davis, U.S. Geological Survey.)

Bottom right: Well facing Santa Ynez Mountains, California. (Photograph taken by Carmen Burton, U.S. Geological Survey.)

Groundwater-Quality Data in the Santa Barbara Study Unit, 2011: Results from the California GAMA Program

By Tracy A. Davis, Justin T. Kulongoski, and Kenneth Belitz

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

Prepared in cooperation with the California State Water Resources Control Board

Data Series 742

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

U.S. Department of the Interior
SALLY JEWELL, Secretary

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

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

Suggested citation:
Davis, T.A., Kulongoski, J.T., and Belitz, Kenneth, 2013, Groundwater-quality data in the Santa Barbara study unit, 2011—Results from the California GAMA Program: U.S. Geological Survey Data Series 742, 72 p.

Contents

Figures

Tables

Tables—Continued

Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
ounce, avoirdupois (oz)	28.35	gram (g)
	Mass	
pound, avoirdupois (lb)	0.4536	kilogram (kg)

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.28	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
liter (L)	1.057	quart (qt)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)
	Radioactivity	
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32

Temperature in degrees Fahrenheit (°F) may be converted to Celsius (°C) as follows:
°C=(°F – 32)/1.8

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

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

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

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

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

Abbreviations and Acronyms

AL-US	action level (USEPA)
APE	Alternate Place Entry Form program designed for USGS sampling
BBP	Blind Blank Program
CAS	Chemical Abstract Service (American Chemical Society)
CASRN	Chemical Abstract Service (American Chemical Society) Registry Number®
CSU	combined standard uncertainty
DWP	Domestic Well Project (SWRCB)
E	estimated or having a higher degree of uncertainty
GAMA	Groundwater Ambient Monitoring and Assessment Program
GPS	Global Positioning System
HAL-US	lifetime health advisory level (USEPA)
IBSP	Inorganic Blind Sample Program (USGS)
HPLC	high-performance liquid chromatography
LRL	laboratory reporting level
LSD	land surface datum
LT-MDL	long-term method detection level
MCL-CA	maximum contaminant level (CDPH)
MCL-US	maximum contaminant level (USEPA)
MDL	method detection limit
MRL	minimum reporting level
MU	method uncertainty
na	not available
NAD	normalized absolute difference
nc	not collected
NFM	National Field Manual (USGS)
NFQA	National Field Quality Assurance Program (USGS)
NL-CA	notification level (CDPH)
np	no preference
nv	no measured value or no value in category
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

Abbreviations and Acronyms—Continued

RL	reporting level
RPD	relative percent difference
RSD	relative standard deviation
RSD5-US	risk-specific dose at a risk factor of 10^{-5} (USEPA)
SBFFB	Santa Barbara fold and fault belt
SD	standard deviation
SMCL-CA	secondary maximum contaminant level (CDPH)
SMCL-US	secondary maximum contaminant level (USEPA)
SRL	study reporting level (concentration cutoff for applying the ≤ symbol in reporting results)
ssL_C	sample-specific critical level
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)

Selected Terms and Symbols

α	confidence level
cm^3 STP/g	cubic centimeters of gas at standard temperature and pressure (0 degrees Celsius and 1 atmosphere of pressure) per gram of water
$\delta^{i}E$	delta notation, the ratio of a heavier isotope of an element (^{i}E) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil
=	equal to
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
N	Normal (1-gram-equivalent per liter of solution)
—	not detected
p	significant level
pH	a measure of the acidity or basicity of a solution
$pK_{1,2}$	negative logarithms of the acid dissociation constants for carbonic acid
pK_w	negative logarithm of the acid dissociation constant of water
R	result
±	plus or minus

Selected Terms and Symbols—Continued

*	value is at a concentration greater than benchmark level
**	value is at a concentration greater than upper benchmark level

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, Livermore, California
NAWQA	National Water-Quality Assessment Program (USGS)
NELAP	National Environmental Laboratory Accreditation Program
NWQL	National Water Quality Laboratory (USGS)
SITL	Stable Isotope and Tritium Laboratory, Menlo Park, California (USGS)
SWRCB	California State Water Resources Control Board
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Selected Chemical Names

$CaCO_3$	calcium carbonate
CO_3^{2-}	carbonate
CFC	chlorofluorocarbon
H_2O	water
HCl	hydrochloric acid
HCO_3^-	bicarbonate
MTBE	methyl *tert*-butyl ether
PCE	perchloroethene (tetrachloroethene)
PVC	polyvinyl chloride
SiO_2	silicon dioxide
TDS	total dissolved solids
THM	trihalomethane
VOC	volatile organic compound

Groundwater-Quality Data in the Santa Barbara Study Unit, 2011: Results from the California GAMA Program

By Tracy A. Davis, Justin T. Kulongoski, and Kenneth Belitz

Abstract

Groundwater quality in the 48-square-mile Santa Barbara study unit was investigated by the U.S. Geological Survey (USGS) from January to February 2011, 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 Santa Barbara study unit was the thirty-fourth study unit to be sampled as part of the GAMA-PBP.

The GAMA Santa Barbara 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 those parts of the aquifers corresponding to the perforation intervals of wells listed in the California Department of Public Health (CDPH) database for the Santa Barbara study unit. Groundwater quality in the primary aquifer system may differ from the quality in the shallower or deeper water-bearing zones; shallow groundwater may be more vulnerable to surficial contamination.

In the Santa Barbara study unit located in Santa Barbara and Ventura Counties, groundwater samples were collected from 24 wells. Eighteen of the wells were selected by using a spatially distributed, randomized grid-based method to provide statistical representation of the study unit (grid wells), and six wells were selected to aid in evaluation of water-quality issues (understanding wells).

The groundwater samples were analyzed for organic constituents (volatile organic compounds [VOCs], pesticides and pesticide degradates, and pharmaceutical compounds); constituents of special interest (perchlorate and *N*-nitrosodimethylamine [NDMA]); naturally occurring inorganic constituents (trace elements, nutrients, major and minor ions, silica, total dissolved solids [TDS], alkalinity, and arsenic, chromium, and iron species); and radioactive constituents (radon-222 and gross alpha and gross beta radioactivity). Naturally occurring isotopes (stable isotopes of hydrogen and oxygen in water, stables isotopes of inorganic carbon and boron dissolved in water, isotope ratios of dissolved strontium, tritium activities, and carbon-14 abundances) and dissolved noble gases also were measured to help identify the sources and ages of the sampled groundwater. In total, 281 constituents and water-quality indicators were measured.

Three types of quality-control samples (blanks, replicates, and matrix spikes) were collected at up to 12 percent of the wells in the Santa Barbara 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 82 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 18 grid wells in the Santa Barbara study unit were detected at concentrations less than drinking-water benchmarks.

Of the 220 organic and special-interest constituents sampled for at the 18 grid wells, 13 were detected in groundwater samples; concentrations of all detected constituents were less than regulatory and non-regulatory health-based benchmarks. In total, VOCs were detected in 61 percent of the 18 grid wells sampled, pesticides and pesticide degradates were detected in 11 percent, and perchlorate was detected in 67 percent. Polar pesticides and their degradates, pharmaceutical compounds, and NDMA were not detected in any of the grid wells sampled in the Santa Barbara study unit.

Eighteen grid wells were sampled for trace elements, major and minor ions, nutrients, and radioactive constituents; most detected concentrations were less than health-based benchmarks. Exceptions are one detection of boron greater than the CDPH notification level (NL-CA) of 1,000 micrograms per liter (μg/L) and one detection of fluoride greater than the CDPH maximum contaminant level (MCL-CA) of 2 milligrams per liter (mg/L).

Results for constituents with non-regulatory benchmarks set for aesthetic concerns from the grid wells showed that iron concentrations greater than the CDPH secondary maximum contaminant level (SMCL-CA) of 300 μg/L were detected in three grid wells. Manganese concentrations greater than the SMCL-CA of 50 μg/L were detected in seven grid wells. Chloride was detected at a concentration greater than the SMCL-CA recommended benchmark of 250 mg/L in four grid wells. Sulfate concentrations greater than the SMCL-CA recommended benchmark of 250 mg/L were measured in eight grid wells, and the concentration in one of these wells was also greater than the SMCL-CA upper benchmark of 500 mg/L. TDS concentrations greater than the SMCL-CA recommended benchmark of 500 mg/L were measured in 17 grid wells, and concentrations in six of these wells were also greater than the SMCL-CA upper benchmark of 1,000 mg/L.

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 (California Environmental Protection Agency, 2011, website at 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 (U.S. Geological Survey, 2011a, California Water Science Center website at http://ca.water.usgs.gov/gama/); (2) the GAMA Domestic Well Project (DWP) conducted by the SWRCB; (3) the GAMA Special Studies 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 DWP 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. GeoTracker GAMA is an online interface serving all published and quality-assurance/quality-control (QA/QC) approved analytical data from the GAMA Program (California State Water Resources Control Board, 2009, website at http://geotracker.waterboards.ca.gov/gama/). GeoTracker GAMA 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 groundwater monitoring wells at contaminated 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, Sections 10780–10782.3 of the California Water Code, Assembly Bill 599). The GAMA-PBP assesses groundwater quality in key groundwater basins that account for more than 90 percent of all groundwater used for public 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 range of hydrologic, geologic, and climatic conditions in California should be considered in an assessment of groundwater quality. Belitz and others (2003) partitioned the State into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics: Cascades 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 and subbasins designated by the CDWR (California Department of Water Resources, 2003). Groundwater basins and subbasins 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 and subbasins within the 10 hydrogeologic provinces. Groundwater basins and subbasins were prioritized for sampling on the basis of the number of CDPH wells in the basin, with secondary consideration given to municipal groundwater use, agricultural pumping, the number of formerly leaking underground fuel tanks, and the number of registered pesticide applications (Belitz and others, 2003). Of the 472 basins and subbasins designated by the CDWR, 116 were identified as priority basins that include approximately 95 percent of the CDPH wells in California. In addition, some areas outside of the defined groundwater basins were included to achieve representation of the 20 percent of the CDPH wells

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

Provinces from Belitz and others, 2003

Figure 1. Hydrogeologic provinces of California and the location of the Santa Barbara study unit, California GAMA Priority Basin Project.

not located in the groundwater basins. The priority basins, selected other basins, and selected areas outside of basins were grouped into 35 study units for sampling. The Santa Barbara study unit is composed of five groundwater subbasins in the Transverse Ranges and selected Peninsular Ranges hydrogeologic province (fig. 1).

Three types of water-quality assessments are being conducted with the data collected in each study unit: (1) Status—assessment of the current quality of the groundwater resource; (2) Understanding—identification of the natural and human factors affecting groundwater quality; and (3) Trends—detection of changes in groundwater quality over time (Kulongoski and Belitz, 2004). The assessments are intended to characterize the quality of groundwater in the primary aquifer system of the study units, not the treated drinking water delivered to consumers by water purveyors. The primary aquifer system is defined as parts of the aquifers corresponding to the perforation intervals of wells listed in the CDPH databases for the study units. The CDPH database lists wells used for public drinking-water supplies and includes wells from systems classified as community (such as those in cities, towns, and mobile-home parks), non-transient and non-community (such as those in schools, workplaces, and restaurants), and transient and non-community (such as those in campgrounds and parks). Collectively, the CDPH refers to these wells as “public-supply” wells. Groundwater quality in the primary aquifer system may differ from the quality in the shallow or deep parts of the aquifer systems. 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 (such as volatile organic compounds [VOCs] and nitrate) from anthropogenic sources than samples from wells screened in the underlying primary aquifer system (Landon and others, 2010).

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 GAMA-PBP are typically analyzed for approximately 300 chemical constituents by using 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 isotope 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.

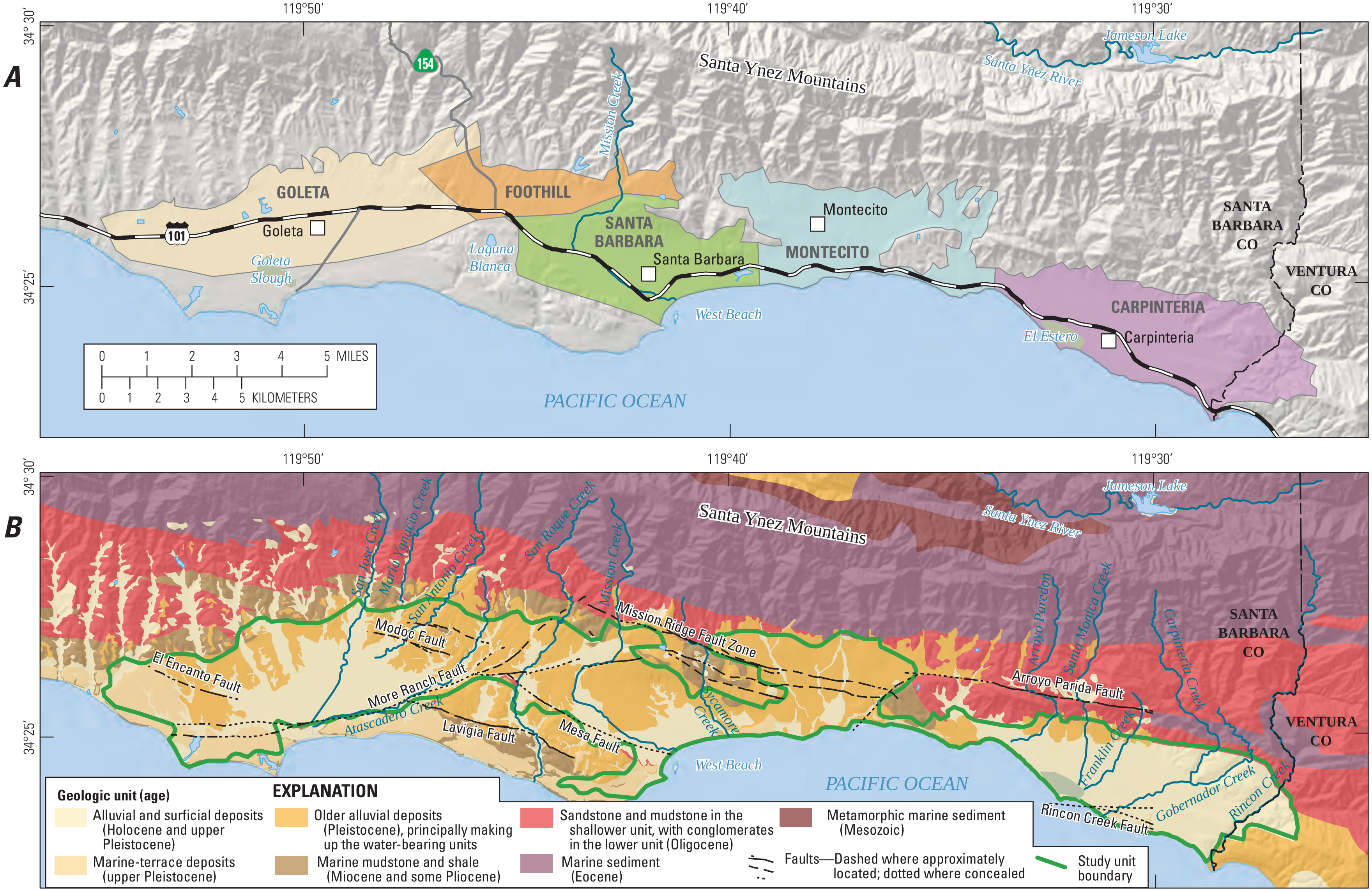
This USGS Data Series Report is similar to other USGS Data Series Reports written for the GAMA-PBP study units sampled to date and is the first in a series of reports (i.e., Data Series Report, Scientific Investigations Report, and Fact Sheet) presenting the water-quality data collected in the Santa Barbara study unit. 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.

Purpose and Scope

The purposes of this report are to describe (1) the hydrogeologic setting of the Santa Barbara study unit, the study design, and the study methods; (2) the analytical results for groundwater samples collected in the Santa Barbara study unit, and (3) the results of quality-control (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 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.

Hydrogeologic Setting

The Santa Barbara study unit lies within the Transverse Ranges and selected Peninsular Ranges hydrogeologic province described by Belitz and others (2003). The study area covers 48 square miles (mi^2), primarily in Santa Barbara County, and extends into Ventura County to the east. The Santa Barbara study unit is a narrow coastal strip flanked by the Santa Ynez Mountains in the north with summit elevations over 4,000 feet (ft) and bounded by the Pacific Ocean in the south. The study unit includes five CDWR-defined groundwater basins and sub-basins: (from west to east) Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria (California Department of Water Resources, 2003) (fig. 2*A*).



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

Figure 2. (*A*) Boundaries of California Department of Water Resources (CDWR) groundwater basins in the Santa Barbara study unit and the locations of counties, major cities, major roads, topographic features, and hydrologic features. (*B*) Geologic map of the Santa Barbara Coastal Plain showing major faults and hydrologic features, Santa Barbara study unit, California GAMA Priority Basin Project.

The Santa Barbara fold and fault belt (SBFFB) and the overlapping Santa Ynez Mountains uplift dominate the structural geology of the Santa Barbara coastal plain. The east-west trending SBFFB is defined by three major fault systems: the west-northwest-trending Mission Ridge fault zone and Arroyo Parida fault, and the east-northeast-trending More Ranch fault (fig. 2*B*) (Minor and others, 2009). These systems and other individual faults define some subbasin boundaries as they impede water flow within and along the perimeter of the Santa Barbara study unit. Along the southern boundary of the study unit, seawater intrusion is partially restricted by uplift along the More Ranch fault in the southwest, Mesa and Lavigia faults in the central part of the coastal plain, and Rincon Creek fault in the southeast (California Department of Water Resources, 2004a–e).

Deformed Eocene marine sediments along the southern flank of the Santa Ynez Mountains form the backdrop to the Santa Barbara coastal plain and give way to Oligocene through Pleistocene sedimentary rocks of the lower foothills (fig. 2*B*). Moderately warped Pleistocene marine and terrestrial sediments underlie many of the hills and mesas, with much of the low-lying, urbanized area underlain by Pleistocene and Holocene surficial deposits (Minor and others, 2009). The Santa Barbara study unit boundary encompasses water-bearing formations which are made up of these Quaternary deposits.

The principal aquifer formations of the Santa Barbara study unit are the older alluvial deposits and the underlying Santa Barbara and Casitas Formations. Located in the western part of the Santa Barbara coastal plain, the middle and lower Pleistocene Santa Barbara Formation consists of fine- to medium-grained marine sandstone. In the central region of the study unit, the oldest alluvial deposits interstratify the Santa Barbara Formation below and may be correlative with the Casitas Formation. The consolidated nonmarine deposits of the Casitas Formation are of upper and middle Pleistocene age. The thickness varies from less than 164 ft found in outcrops to much thicker in the subsurface of Carpinteria, Montecito, and possibly Santa Barbara cities. The Casitas Formation is overlain with marine terrace deposits and was previously mapped as the Carpinteria Formation by Lian (1954). Alluvial deposits typically present in the upper part of marine terrace sequences may also be correlative with the intermediate and older alluvial deposits (Minor and others, 2009).

The sources of surface discharge for the study unit are several creeks flowing from the mountains out to the Pacific Ocean. The study unit is primarily drained by Mission Creek and its tributaries (fig. 2*B*). The creek originates in the Santa Ynez Mountains and flows southeasterly to where it enters the Pacific Ocean just east of West Beach (Izbicki and others, 2009). Other surface-drainage features are San Jose, Maria Ygnacio, San Antonio, Atascadero, San Roque, Sycamore, Arroyo Paredon, Santa Monica, Rincon, Carpinteria, and Gobernador Creeks. Sources of recharge in the groundwater basins are infiltration of precipitation and irrigation waters, seepage from creeks and streams, imported water from Lake Cachuma and Gibraltar Reservoir, and subsurface inflow (California Department of Water Resources, 2004a–e).

The climate in the Santa Barbara study unit is characterized as Mediterranean, with warm, dry summers and cool, wet winters. The National Climatic Data Center located at the Santa Barbara Municipal Airport reported an average annual temperature of 58 degrees Fahrenheit (°F) (14.5 degrees Celsius [°C]) for 2010; total annual precipitation was higher than normal (about 17 inches) at more than 27 inches, occurring as rain during the winter and early spring (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 2010).

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 by 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 quality-assurance (QA) methods, and the results of analyses of QC samples.

Study Design

The wells selected for sampling in this study reflect the combination of two well-selection strategies. Eighteen wells were selected to provide a statistically unbiased, spatially distributed assessment of the quality of groundwater resources used for public drinking-water supply. Hereinafter, wells sampled as part of the spatially distributed, randomized grid-cell network are referred to as “grid wells.” Six additional, non-randomized wells (hereinafter referred to as “understanding wells”) were selected to aid in the understanding of specific issues associated with vertical changes in groundwater quality and age in different parts of the Santa Barbara study unit.

The grid wells were selected using a randomized grid-based method (Scott, 1990). The randomized grid-based method divides the study unit 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 part of a grid cell may be located on either side of a mountain range, but the grid cell is still considered one grid cell. The Santa Barbara study unit was divided into 20 equal-area grid cells, each approximately 2.4 mi^2 in area.

The objective was to sample one CDPH well in each grid cell (fig. 3*A*). If a grid cell contained more than one CDPH well, each well randomly was assigned a rank. The highest ranking well that met basic sampling criteria (for example, sampling point located prior to treatment or capability to pump for several hours) was sampled. If a grid cell contained no accessible CDPH wells, then other types of wells, such as irrigation wells, domestic wells, or commercial wells, 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. For the six cells that contained no active wells, wells in adjacent cells near the cell boundaries were considered for sampling. In this fashion, 1 well was selected for sampling in 18 of the 20 grid cells to provide a spatially distributed, randomized monitoring network. The remaining two cells contained no accessible wells.

The 18 grid wells sampled in the Santa Barbara study unit were named by using the prefix "SB" and by using a suffix numbered by location within the study unit, from west to east (fig. 3*B*). The six understanding wells sampled as part of the study were not included in the statistical characterization of water quality in the Santa Barbara study unit because inclusion of these wells would have lead to the overrepresentation of some cells. These additional wells were named by using the prefix "SBU" ("U" indicating "understanding") and by using a suffix numbered from west to east within the study unit. Of the understanding wells, four were short-screened monitoring (observation) wells at a single location with openings at different depths in the aquifer system.

The GAMA alphanumeric identification number for each well, along with the date sampled, well altitude, well type, and available well-construction information are shown in table 1. Groundwater samples were collected during January and February 2011. Grid wells included 11 CDPH wells, 5 irrigation wells, and 2 domestic wells. Understanding wells included four monitoring (observation) wells, one public-supply well, and one unused well.

Well locations were verified by using a global positioning system (GPS), 1:24,000-scale USGS topographic maps, comparison with existing well information in USGS and CDPH databases, and information provided by well owners, drillers' logs, or other sources of construction information. Well locations and information were recorded by hand on field sheets and electronically on field laptop computers using the Alternate Place Entry (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.

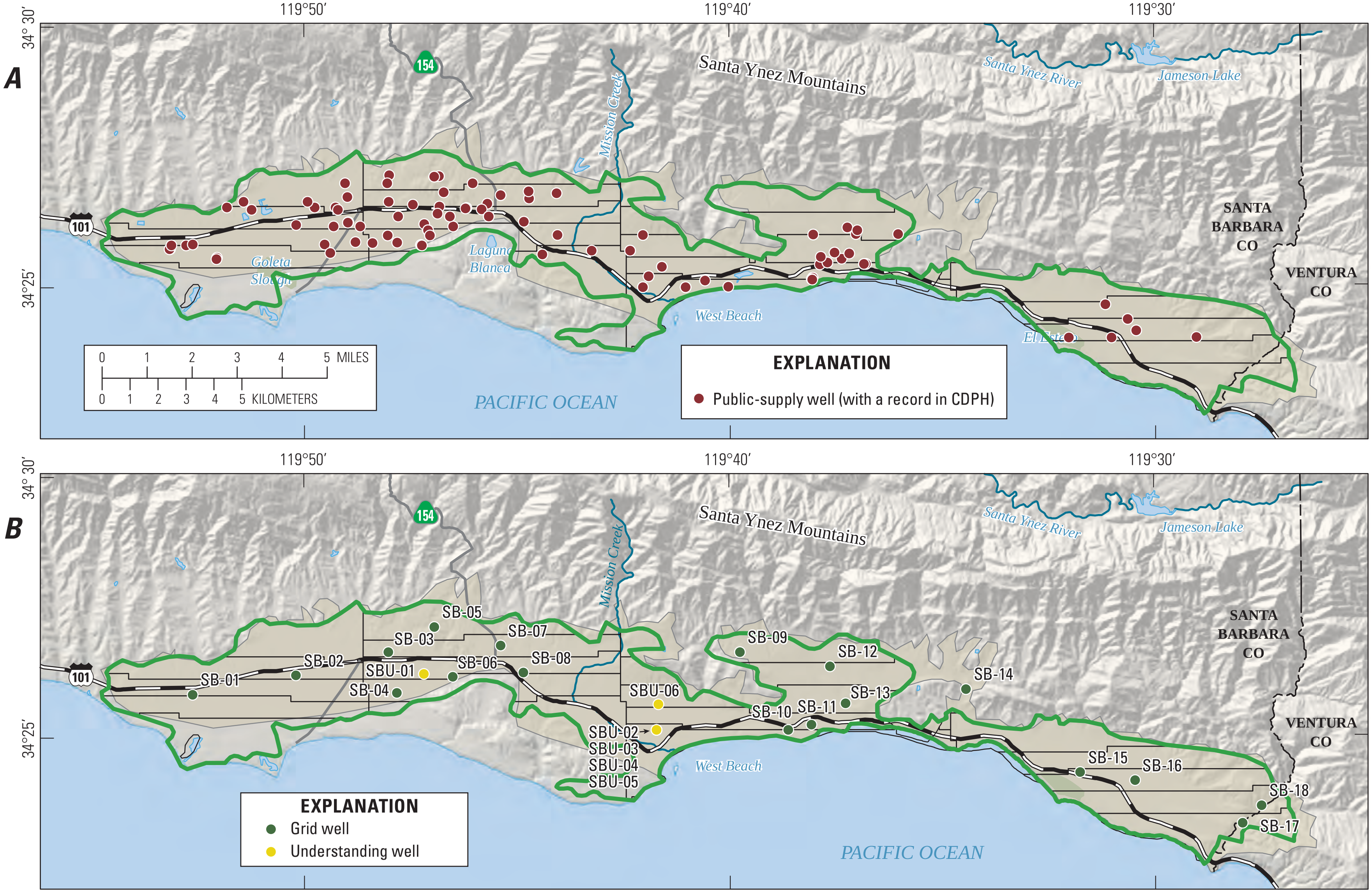
Sample Collection and Analysis

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 (NFM) (U.S. Geological Survey, variously dated). These sampling protocols were followed so that representative samples of groundwater were collected at each site and so that the samples were collected and handled in ways that minimized the potential for contamination.

All 24 wells in the Santa Barbara study unit were sampled for a standard set of constituents (table 2). Tables 3A–K list the compounds analyzed in each constituent class. Groundwater samples were analyzed for 85 VOCs (table 3A); 63 pesticides and pesticide degradates (table 3B); 60 polar pesticides and degradates (table 3C); 13 pharmaceutical compounds (table 3D); 2 constituents of special interest (table 3E); 24 trace elements (table 3F); 5 nutrients (table 3G); 9 major and minor ions, silica, and total dissolved solids (table 3H); arsenic, chromium, and iron species (table 3I); stable isotopes of hydrogen and oxygen in water, dissolved inorganic carbon, and dissolved boron, and isotope ratios of dissolved strontium, and 5 radioactive constituents, including tritium and carbon-14 abundance (table 3J); stable isotope ratios of helium, 5 dissolved noble gases, and tritium (table 3K). 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." Six constituents analyzed in this study were measured by more than one method at the USGS National Water Quality Laboratory (NWQL), four of which only have results reported from the preferred method (see the appendix section titled "Constituents on Multiple Analytical Schedules" for the preferred method selection procedure). Three field water-quality indicators—alkalinity, pH, and specific conductance (table 4)—were measured in the field and at the NWQL, and three other constituents—total arsenic, chromium, and iron—were measured by two different laboratories; both sets of results are reported for each of these constituents. Tritium activities were measured by two different laboratories, but only one set of results was available at the time this report was published.



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

Figure 3. (*A*) The distribution of the grid cells and the location of public-supply wells from the California Department of Public Health (CDPH) database, and (*B*) the distribution of grid cells, the location of sampled grid and understanding wells, Santa Barbara study unit, California GAMA Priority Basin Project.

Quality-Assurance Methods

The QA procedures used for this study followed the protocols used by the NAWQA Program (Koterba and others, 1995) and described in the NFM (U.S. Geological Survey, variously dated). The QA plan followed by the 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 Santa Barbara study unit are blanks, replicates, and matrix and surrogate spikes. 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 procedures and QC results are described in the appendix section titled "Quality-Assurance Methods and Results."

Water-Quality Results

Quality-Control Results

Results of QC analyses (blanks, replicates, and matrix and surrogate spikes) 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, raised "study reporting levels" (SRLs) for 1 volatile organic compound (1,2,4-trimethylbenzene), 11 trace elements, and 1 nutrient (ammonia) were applied (see table A3 and additional discussion in the appendix section titled "Detections in Field Blanks and Application of SRLs"). Detections of these 13 constituents with concentrations less than their SRLs were flagged with a less than or equal to symbol (≤) in this report and in the NWIS database (tables 5, 8, and 9).

Results from the replicate analyses confirm that the procedures used to collect and analyze the samples were consistent. Variability for nearly 100 percent of the replicate pairs for constituents detected in samples was within the acceptable limits (tables A4A–C). The criteria for acceptable replication is described in the appendix section titled "Quality Assurance Methods and Results." Median matrix-spike recoveries for 31 of the 205 organic constituents analyzed were lower than the acceptable limit of 70 percent, and 6 were greater than the acceptable limit of 130 percent (tables 3A–D and A5A–D). The constituents 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). Constituents with high recoveries may indicate that reported values could be greater than what is in the sample. The QC results are described in the appendix section titled "Quality-Control Methods and Results."

Comparative Benchmarks

Concentrations of constituents detected in groundwater samples were compared with CDPH and USEPA regulatory and non-regulatory drinking-water health-based benchmarks and benchmarks established for aesthetic purposes (California Department of Public Health, 2008a, b; U.S. Environmental Protection Agency, 2008a–c). The chemical data presented in this report are meant to characterize the quality of the untreated groundwater within the primary aquifer system of the Santa Barbara 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 non-compliance with drinking-water regulations. The following benchmarks were used for comparisons:

- **MCL–Maximum Contaminant Level.** Legally enforceable standards that apply to public-water systems and are designed to protect public health by limiting the levels of contaminants in drinking water. MCLs established by the USEPA are the minimum standards with which States are required to comply, and individual States may choose to set more stringent standards. CDPH has established MCLs for additional constituents not regulated by the USEPA, as well as lowered the benchmark concentrations for a number of constituents with MCLs established by the USEPA. In this report, a benchmark set by the USEPA and adopted by CDPH is labeled "MCL-US," and one set by CDPH that is more stringent than the MCL-US is labeled "MCL-CA." Well owners are notified when constituents are detected at concentrations greater than an MCL-US or an MCL-CA benchmark 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, these benchmarks are labeled "AL-US" in this report.

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

- **NL–Notification Level.** Health-based notification levels established by CDPH for some of the constituents in drinking water that lack MCLs (NL-CA). If a constituent is detected in drinking water 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 the 10^{-5} risk level (10^{-5} equals 1/100,000). RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10 (RSD5-US).

For constituents with regulatory benchmarks (MCLs or ALs), detections in groundwater samples were compared to the MCL-US, MCL-CA, or AL-US. Constituents with SMCLs were compared with the SMCL-CA. For chloride, sulfate, specific conductance, and total dissolved solids, CDPH defines a “recommended” and an “upper” SMCL-CA; detections of these constituents in groundwater samples were compared with both levels. The SMCL-US levels for these constituents correspond to their recommended SMCL-CAs. Detected concentrations of constituents without an MCL, AL, or SMCL were compared to the NL-CA. For constituents without an MCL, AL, SMCL, or NL-CA, detected concentrations were compared with the HAL-US. For constituents without an MCL, AL, SMCL, NL-CA, or HAL-US, detected concentrations were compared with the RSD5-US. Note that using this hierarchy to select the comparative 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 (µg/L) and the HAL-US is 2,000 µg/L, but the comparative benchmark selected by this hierarchy is the SMCL-CA. The comparative benchmarks used in this report are listed in tables 3A–K for all constituents and in tables 4–13 for constituents detected in groundwater samples from the Santa Barbara study unit. Established benchmarks are not available for all constituents analyzed for this study. Detections of constituents at concentrations greater than the selected comparative benchmarks are marked with an asterisk (*) in tables 4, 8, 10, and 11.

Groundwater-Quality Data

Results from analyses of untreated groundwater samples from the Santa Barbara study unit are presented in tables 4–13. Groundwater samples collected in the Santa Barbara study unit were analyzed for 281 constituents. Of those constituents, 207 were not detected in any of the samples, and 66 constituents were detected. The results for stable isotopes of dissolved boron, isotope ratios of dissolved strontium, and the LLNL results for dissolved noble gases, tritium, and helium isotope ratios have not been received and are not presented in this report; they will be included in a subsequent publication.

For organic and special-interest constituents, the results tables include only those constituents that were detected, and the following summary statistics are presented for all of the grid wells: the number of wells at which each analyte was detected, the frequency at which it was detected (in relation to the number of grid wells in the study unit), and the total number of constituents detected at each well (except for special-interest constituents because only one constituent was analyzed). For the inorganic, isotopic, and radioactive constituents, the tables include all of the constituents and wells that were analyzed.

Water-quality indicators measured in the field and at the NWQL are included in table 4. The results of groundwater analyses, organized by constituent class, are presented in tables 5–13:

- Organic constituents
  - Volatile organic compounds (table 5)
  - Pesticides and pesticide degradates (table 6)
- Perchlorate (table 7)
- Inorganic constituents
  - Trace elements (table 8)
  - Nutrients (table 9)
  - Major and minor ions, silica, and total dissolved solids (table 10)
- Arsenic, chromium, and iron species (table 11)

- Isotope tracers (table 12)
- Radioactive constituents
  - Radon-222 (table 13A)
  - Gross alpha and gross beta radioactivity (table 13B)

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 4. Bicarbonate and carbonate concentrations were calculated from the pH and alkalinity results. Dissolved oxygen and alkalinity are used as indicators of natural processes that affect water chemistry. The pH value indicates the acidity or basicity of the water. Specific conductance is the measure of electrical conductivity of the water and is proportional to the amount of total dissolved solids (TDS) in the water.

Field pH values were outside of the SMCL-US range for 17 percent of the Santa Barbara study unit grid wells: three well samples had field pH values less than 6.5 (table 4). 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 at 25 degrees Celsius (µS/cm at 25°C) for 15 of the 18 grid-well samples, 5 of which were also greater than the upper benchmark of 1,600 µS/cm at 25°C. Five Santa Barbara understanding-well samples had field specific-conductance values that were greater than the recommended SMCL-CA, one of which was also greater than the upper SMCL-CA (table 4).

Organic Constituents

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 for the Santa Barbara study unit, 11 were detected in groundwater samples; 9 of these 11 VOCs were detected in grid wells. All concentrations were less than health-based benchmarks (table 5). One or more VOCs were detected in 11 of the 18 grid-well samples (about 61 percent detection frequency). The trihalomethane chloroform was the most frequently detected VOC in the study unit. Chloroform is among the most commonly detected VOCs in groundwater nationally, and its source is attributed, in part, to the recycling of chlorinated waters to aquifers (Zogorski and others, 2006). Five other VOCs also had detection frequencies greater than 10 percent in the grid wells: bromodichloromethane; 1,1,1-trichloroethane; 1,1-dichloroethane; perchloroethene (PCE, tetrachloroethene); and the gasoline oxygenate, methyl *tert*-butyl ether (MTBE). Four VOCs were detected in one of the understanding-well samples in the Santa Barbara study unit (SBU-05).

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 120 pesticides and pesticide degradates analyzed at 18 grid wells in the Santa Barbara study unit, one was detected in groundwater samples: simazine. All concentrations were less than health-based benchmarks (table 6). No pesticide or pesticide degradate was detected in any of the six understanding wells.

Pharmaceutical compounds may enter the environment in many ways, including septic systems, discharge of treated wastewater, sewer lines, seepage from landfills, land application of manure fertilizers, and runoff from animal wastes (Fram and Belitz, 2011). Pharmaceutical compounds were not detected at concentrations greater than or equal to the method detection limits (MDLs) in any of the 24 wells sampled for the Santa Barbara study unit.

Constituents of Special Interest

Perchlorate and NDMA are constituents of special interest in California because they may adversely affect water quality and recently have been detected in water supplies (California Department of Public Health, 2008b). Perchlorate was detected in 12 of 18 grid-well samples (about 67 percent detection frequency) and in 2 of the understanding-well samples (table 7). Perchlorate was not detected at concentrations greater than the MCL-CA of 6 µg/L in any of the grid- or understanding-well samples in the Santa Barbara study unit. NDMA was not detected in any of the grid or understanding wells and therefore was not included in table 7.

Inorganic Constituents

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

Seventeen of the 24 trace elements and 1 of the major and minor ions analyzed and detected in the Santa Barbara study unit have regulatory or non-regulatory health-based benchmarks (tables 3F, 3H). Of these 18 constituents with health-based benchmarks, 4 constituents were detected at concentrations greater than benchmarks; all detections of 14 constituents had concentrations less than their respective benchmarks. One grid-well sample (SB-14) contained boron and fluoride at concentrations greater than benchmark levels: CDPH notification level (NL-CA) of 1,000 µg/L and MCL-CA of 2 milligrams per liter (mg/L), respectively (tables 8 and 10). One understanding-well sample had detections of barium, boron, and strontium greater than the benchmark levels: MCL-CA of 1,000 µg/L, NL-CA of 1,000 µg/L, and HAL-US of 4,000 µg/L, respectively.

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 can adversely affect human health, particularly the health of infants. All concentrations of ammonia, nitrite, and nitrate measured in the 24 Santa Barbara study unit wells were less than health-based benchmarks (table 9).

The levels of certain trace elements, major-ion composition, and 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 three grid-well samples. Manganese concentrations greater than the SMCL-CA of 50 µg/L were detected in seven grid-well samples. Iron was detected at a concentration greater than the benchmark level in one understanding-well sample, and manganese was detected at concentrations greater than the benchmark level in three understanding-well samples (table 8).

Chloride concentrations were greater than the recommended SMCL-CA of 250 mg/L in four grid-well samples. Chloride was detected at a concentration greater than the upper SMCL-CA of 500 mg/L in one understanding-well sample. Sulfate concentrations were greater than the recommended SMCL-CA of 250 mg/L in eight grid-well samples, one of which was also above the upper SMCL-CA of 500 mg/L. Sulfate was detected at a concentration greater than the recommended SMCL-CA in one understanding well. TDS concentrations were greater than the recommended SMCL-CA of 500 mg/L for 17 grid-well samples, 6 of which were also greater than the upper SMCL-CA of 1,000 mg/L. TDS concentrations were greater than the recommended SMCL-CA for five of the six understanding-well samples, one of which was also greater than the upper SMCL-CA (table 10).

Arsenic, chromium, 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 arsenic, chromium, and iron and the dissolved concentration of either the reduced or the oxidized species of these elements are reported in table 11.

Isotopic Tracers

The isotopic delta values, activities, and abundances of many elements and the concentrations of dissolved gases (including noble gases) may be used as tracers of hydrologic processes (Clark and Fritz, 1997).

Stable isotopes of hydrogen and oxygen in water (table 12) aid in the interpretation of the sources of groundwater recharge (see appendix section titled “Notation” for how the isotope delta values are calculated). These stable-isotope delta values 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 (table 12) and helium isotope ratios 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 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. Of the isotope-tracer constituents analyzed for this study, tritium is the only one with a health-based benchmark. All measured tritium activities in samples from the Santa Barbara study unit were less than 1/1,000 of the MCL-CA benchmark (table 12).

Carbon-14 (table 12), a radioactive isotope of carbon, is also an age-dating tracer. Low levels of carbon-14 are produced continuously by interaction of cosmic radiation with the Earth’s atmosphere and 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 thousand years old or more.

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). In each step in the decay series, one radioactive element turns into a different radioactive element by emitting an alpha or a beta particle from its nucleus. The alpha and beta particles emitted during radioactive decay may be 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.

Radon-222 was sampled for at 22 of the 24 wells in the Santa Barbara study unit. Radon-222 activity was less than the proposed MCL-US of 4,000 pCi/L in all sampled wells (table 13A). The proposed MCL-US will apply 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). Activities in all grid- and understanding-well samples for gross alpha and gross beta radioactivity were less than established health-based benchmarks (table 13B).

Future Work

Subsequent reports for the Santa Barbara study unit 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 Santa Barbara 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 results for the analysis of stable isotopes of dissolved boron and strontium in water and the LLNL results (dissolved noble gas, tritium, and helium isotope ratios) for the Santa Barbara study unit.

Summary

Groundwater quality in the 48-square-mile Santa Barbara study unit was investigated by the U.S. Geological Survey (USGS) from January to February 2011, 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 Program was created to provide a comprehensive baseline of groundwater quality in the State. The GAMA-PBP was created as a result of the Groundwater Quality Monitoring Act of 2001 (Sections 10780–10782.3 of the California Water Code, Assembly Bill 599) to assess and monitor the quality of groundwater. The GAMA-PBP is being conducted by the USGS in cooperation with the SWRCB and Lawrence Livermore National Laboratory (LLNL).

The GAMA Santa Barbara study 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 intervals of the wells listed in the California Department of Public Health (CDPH) database for the Santa Barbara study unit. The quality of groundwater in shallow or deeper 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 non-regulatory health-based benchmarks established by the U.S. Environmental Protection Agency (USEPA) and CDPH and non-regulatory benchmarks established for aesthetic concerns by the CDPH.

The Santa Barbara study unit is located within the Transverse and selected Peninsular Ranges hydrologic province and includes five groundwater basins defined by the California Department of Water Resources. The Santa Barbara study included assessment of the groundwater quality from 24 wells in Santa Barbara County. Eighteen wells were selected by using a randomized grid approach to achieve a statistically unbiased representation of groundwater used for public drinking-water supplies (grid wells), and six additional wells were selected to aid in the evaluation of water-quality issues (understanding wells).

Groundwater samples were analyzed for field water-quality indicators, organic constituents, special-interest constituents, inorganic constituents, and radioactive constituents. Naturally occurring isotopes and dissolved noble gases also were measured to provide a dataset that will be used to interpret the sources and ages of the sampled groundwater. In total, 281 constituents and water-quality indicators were measured for this study. This report describes the sampling, analytical, and quality-assurance methods used in the study, and presents the results of the chemical analyses of the groundwater samples.

Three types of quality-control samples (blanks, replicates, and matrix spikes) were collected at up to 12 percent of the wells in the Santa Barbara 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 87 percent of the compounds.

All constituents were sampled for at all 24 wells in the Santa Barbara study unit, and most detections had concentrations less than drinking-water benchmarks.

In the grid-well samples, one detection of boron was greater than the CDPH notification level (NL-CA), and one detection of fluoride was greater than the CDPH maximum contaminant level (MCL-CA). The following constituents had concentrations in grid-well samples greater than their CDPH secondary maximum contaminant levels (SMCL-CA): 3 detections of iron, 7 detections of manganese, 4 detections of chloride, 8 detections of sulfate (1 of which was also greater than the SMCL-CA upper benchmark), and 17 detections of TDS (6 of which were also greater than the SMCL-CA upper benchmark).

In the understanding-well samples, one detection of barium was greater than the MCL-CA, one detection of boron was greater than the NL-CA, and one detection of strontium was greater than the USEPA lifetime health advisory level (HAL-US). Three detections of manganese were greater than the SMCL-CA. One detection of chloride was greater than the recommended and upper SMCL-CA, one detection of sulfate was greater than the SMCL-CA, and five detections of TDS were greater than the recommended SMCL-CA (one detection was also greater than the upper SMCL-CA).

Acknowledgments

The authors thank the following cooperators for their support: the California State Water Resources Control Board, California Department of Public Health, California Department of Water Resources, and Lawrence Livermore National Laboratory. We especially thank the well owners and water purveyors for allowing the U.S. Geological Survey to collect samples from their wells.

References Cited

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

American Society for Testing and Materials, 1998, Water and Environmental Technology, *in* Annual Book of ASTM Standards: Philadelphia, Pa., American Society for Testing and Materials, section 11.02 (Water II), p. 664–666.

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

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

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

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

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

California Department of Public Health, 2008a, California drinking water-related laws—Drinking water-related regulations, Title 22: California Department of Public Health, accessed October 27, 2011, at http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Lawbook.aspx.

California Department of Public Health, 2008b, Drinking water notification levels—Notification levels: California Department of Public Health, accessed October 27, 2011, at http://www.cdph.ca.gov/certlic/drinkingwater/Pages/NotificationLevels.aspx.

California Department of Water Resources, 2003, California's groundwater update 2003: California Department of Water Resources Bulletin 118, 246 p., accessed October 27, 2011, at http://www.water.ca.gov/groundwater/bulletin118/update2003.cfm.

California Department of Water Resources, 2004a, California's groundwater—Individual basin descriptions, Carpinteria: California Department of Water Resources Bulletin 118, accessed April 6, 2011, at http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/3-18.pdf.

California Department of Water Resources, 2004b, California's groundwater—Individual basin descriptions, Foothill: California Department of Water Resources Bulletin 118, accessed April 6, 2011, at http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/3-53.pdf.

California Department of Water Resources, 2004c, California's groundwater—Individual basin descriptions, Goleta: California Department of Water Resources Bulletin 118, accessed April 6, 2011, at http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/3-16.pdf.

California Department of Water Resources, 2004d, California's groundwater—Individual basin descriptions, Montecito: California Department of Water Resources Bulletin 118, accessed April 6, 2011, at http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/3-49.pdf.

California Department of Water Resources, 2004e, California's groundwater—Individual basin descriptions, Santa Barbara: California Department of Water Resources Bulletin 118, accessed April 6, 2011, at http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/3-17.pdf.

California State Water Resources Control Board, 2003, Report to the Governor and Legislature, A comprehensive groundwater quality monitoring program for California: Assembly Bill 599 March 2003, 121 p., accessed October 27, 2011, at http://www.waterboards.ca.gov/gama/docs/final_ab_599_rpt_to_legis_7_31_03.pdf.

California State Water Resources Control Board, 2009, Geotracker GAMA: State Water Resources Control Board database, accessed October 27, 2011, at https://geotracker.waterboards.ca.gov/gama/.

California State Water Resources Control Board, 2011, GAMA—Groundwater Ambient Monitoring and Assessment Program: State Water Resources Control Board website, accessed April 6, 2011, at http://www.waterboards.ca.gov/water_issues/programs/gama/.

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

Clark, I.D., and Fritz, P., 1997, Environmental isotopes in hydrogeology: Boca Raton, Florida, CRC Press LLC, 328 p.

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

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

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

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

Donahue, D.J., Linick, T.W., and Jull, A.J.T., 1990, Isotope-ratio and background corrections for accelerator mass spectrometry radiocarbon measurements: Radiocarbon, v. 32, book 2, p. 135–142.

Dwyer, G.S., and Vengosh, A., 2008, Alternative filament loading solution for accurate analysis of boron isotopes by negative thermal ionization mass spectrometry: Eos Transactions AGU, v. 89, no. 53, Abstract H51C-0824.

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

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

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

Farrar, J.W., and Long, H.K., 1997, Report on the U.S. Geological Survey's evaluation program for standard reference samples distributed in September 1996—T-143 (trace constituents), T-145 (trace constituents), M-140 (major constituents), N-51 (nutrient constituents), P-27 (low ionic strength constituents), and Hg-23 (mercury): U.S. Geological Survey Open-File Report 97–20, 145 p.

Faure, Gunter, and Mensing, T.M., 2005, Isotopes—Principles and Applications (3d ed.): Hoboken, New Jersey, John Wiley & Sons, Inc., 897 p.

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

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

Fram, M.S., and Belitz, Kenneth, 2011, Occurrence and concentrations of pharmaceutical compounds in groundwater used for public drinking-water supply in California: Science of the Total Environment, v. 409, no. 18, p. 3409–3417. (Also available at http://www.sciencedirect.com/science/article/pii/S0048969711005778.)

Fram, M.S., Olsen, L.D., and Belitz, Kenneth, 2012, Evaluation of volatile organic compound (VOC) blank data and application of study reporting levels to groundwater data collected for the California GAMA Priority Basin Project, May 2004 through September 2010: U.S. Geological Survey Scientific Investigations Report 2012–5139, 94 p.

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

Furlong, E.T., Werner, S.L., Anderson, B.D., and Cahill, J.D., 2008, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of human-health pharmaceuticals in filtered water by chemically modified styrene-divinylbenzene resin-based solid-phase extraction and high-performance liquid chromatography/mass spectrometry: U.S. Geological Survey Techniques and Methods, book 5, chap. B5, 56 p.

Gagnon, A.R., and Jones, G.A., 1993, AMS-graphite target production methods at the Woods Hole Oceanographic Institution during 1986–1991: Radiocarbon, v. 35, book 2, p. 301–310.

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

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

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

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

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

Hoaglin, D.C., 1983, Letter values—A set of selected order statistics, *in* Hoaglin, D.C., Mosteller, F., and Tukey, J.W., eds., Understanding robust and exploratory data analysis: New York, John Wiley & Sons, p. 33–54.

Izbicki, J.A., Swarzenski, P.W., Reich, C.D., Rollins, C., and Holden, P.A., 2009, Sources of fecal indicator bacteria in urban streams and ocean beaches, Santa Barbara, California: Annals of Environmental Science, v. 3, p. 139–178, accessed March 27, 2013, at http://iris.lib.neu.edu/cgi/viewcontent.cgi?article=1034&context=aes.

Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A., 2009, Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, 52 p.

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

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

Krieger, H.L., and Whittaker, E.L., 1980, Prescribed procedures for measurement of radioactivity in drinking water: U.S. Environmental Protection Agency EPA-600-4-80-032, 142 p. (Also available as PB80-224744 at http://www.ntis.gov.)

Kulongoski, J.T., and Belitz, Kenneth, 2004, Groundwater Ambient Monitoring and Assessment Program: U.S. Geological Survey Fact Sheet 2004–3088, 2 p.

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

Lane, S.L., Flanagan, Sarah, and Wilde, F.D., 2003, Selection of equipment for water sampling (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A2, accessed October 27, 2011, at http://pubs.water.usgs.gov/twri9A2/.

Lewis, M.E., 2006, Dissolved oxygen (ver. 2.1): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.2, accessed October 27, 2011, at http://pubs.water.usgs.gov/twri9A6.2/.

Lian, H.M., 1954, Geology of the Carpinteria district, Santa Barbara County, *in* Geology of southern California: California Division of Mines and Geology Bulletin 170, map sheet 25.

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

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

Maloney, T.J., ed., 2005, Quality management system, U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 2005–1263, accessed October 27, 2011, at http://pubs.usgs.gov/of/2005/1263/.

McCleskey, R.B., Nordstrom, D.K., and Ball, J.W., 2003, Metal interferences and their removal prior to the determination of As(T) and As(III) in acid mine waters by hydride generation atomic absorption spectrometry: U.S. Geological Survey Water-Resources Investigations Report 03–4117, 14 p.

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

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

McNichol, A.P., Gagnon, A.R., Jones, G.A., and Osborne, E.A., 1992, Illumination of a black box—Analysis of gas composition during graphite target preparation, *in* Long, A., and Kra, R.S., eds., Proceedings of the 14th International ^{14}C Conference: Radiocarbon, v. 34, book 3, p. 321–329.

McNichol, A.P., Jones, G.A., Hutton, D.L., and Gagnon, A.R., 1994, The rapid preparation of seawater $\sum CO_2$ for radiocarbon analysis at the National Ocean Sciences AMS Facility: Radiocarbon, v. 36, book 2, p. 237–246.

Minor, S.A., Kellogg, K.S., Stanley, R.G., Gurrola, L.D., Keller, E.A., and Brandt, T.R., 2009, Geologic map of the Santa Barbara Coastal Plain area, Santa Barbara County, California: U.S. Geological Survey Scientific Investigations Map 3001, scale 1:25,000, 1 sheet, pamphlet, 38 p.

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

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

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

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

Pirkey, K.D., and Glodt, S.R., 1998, Quality control at the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Fact Sheet 026–98, 4 p., accessed October 27, 2011, at http://pubs.er.usgs.gov/usgspubs/fs/fs02698.

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

Radtke, D.B., Davis, J.V., and Wilde, F.D., 2005, Specific electrical conductance (ver. 1.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.3, accessed October 27, 2011, at http://pubs.water.usgs.gov/twri9A6.3/.

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

Schneider, R.J., Jones, G.A., McNichol, A.P., von Reden, K.F., Elder, K.A., Huang, K., and Kessel, E.D., 1994, Methods for data screening, flagging, and error analysis at the National Ocean Sciences AMS Facility: Nuclear Instruments and Methods in Physics Research, book 92, p. 172–175.

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

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

Soddy, F., 1913, Radioactivity: Annual Reports on the Progress of Chemistry, v. 10, p. 262–288.

State of California, 2001a, Assembly Bill No. 599, Chapter 522, accessed October 27, 2011, at http://www.swrcb.ca.gov/gama/docs/ab_599_bill_20011005_chaptered.pdf.

State of California, 2001b, Groundwater Monitoring Act of 2001: California Water Code, part 2.76, Sections 10780–10782.3, accessed October 27, 2011, at http://www.leginfo.ca.gov/cgi-bin/displaycode?section=wat&group=10001-11000&file=10780-10782.3.

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

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

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

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

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 2010, National Climatic Data Center, accessed October 27, 2011, at http://www1.ncdc.noaa.gov/pub/orders/IPS-FC06BF11-2768-478F-B77B-771EEE910A2B.pdf.

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

U.S. Environmental Protection Agency, 1999, National primary drinking water regulations, Radon-222: Federal Register, v. 64, no. 211, p. 59, 245–259, and 294.

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

U.S. Environmental Protection Agency, 2005, Method 331.0—Determination of perchlorate in drinking water by liquid chromatography electrospray ionization mass spectrometry (Revision 1.0, January 2005): Office of Groundwater and Drinking Water, EPA Document # 815-R-05-007, 34 p., accessed October 27, 2011, at http://www.epa.gov/safewater/methods/pdfs/methods/met331_0.pdf.

U.S. Environmental Protection Agency, 2008a, Drinking water contaminants, accessed July 12, 2010, at http://www.epa.gov/safewater/contaminants/index.html.

U.S. Environmental Protection Agency, 2008b, Drinking water health advisories—2006 Drinking water standards and health advisory tables, accessed October 27, 2011, at http://www.epa.gov/waterscience/criteria/drinking/.

U.S. Environmental Protection Agency, 2008c, Proposed radon in drinking water rule, accessed October 27, 2011, at http://www.epa.gov/ogwdw/radon/proposal.html.

U.S. Geological Survey, 2011a, What is the Priority Basin Project?: California Water Science Center website, accessed October 27, 2011, at http://ca.water.usgs.gov/gama/.

U.S. Geological Survey, 2011b, Publications: California Water Science Center website, accessed October 27, 2011, at http://ca.water.usgs.gov/gama/includes/GAMA_publications.html.

U.S. Geological Survey, 2011c, Branch of Quality Systems, Inorganic Blind Sample Project (IBSP) QADATA summaries, accessed October 27, 2011, at http://bqs.usgs.gov/ibsp/qadata.shtml.

U.S. Geological Survey, 2011d, Branch of Quality Systems, Inorganic Blind Sample Project (IBSP) NWQL control charts for fiscal year 2011 analytes, accessed October 27, 2011, at http://bqs.usgs.gov/ibsp/FY11charts.shtml.

U.S. Geological Survey, [variously dated], National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A1–A9, accessed October 27, 2011, at http://water.usgs.gov/owq/FieldManual/.

U.S. Geological Survey Office of Water Quality, 2010, Changes to the reporting convention and to data qualification approaches for selected analyte results reported by the National Water Quality Laboratory (NWQL): U.S. Geological Survey Office of Water Quality Technical Memorandum 2010.07.

Vengosh A., Chivas, A.R., and McCulloch M.T., 1989, Direct determination of boron and chlorine isotopes in geological materials by negative thermal ionization mass spectrometry: Chemical Geology, v. 79, p. 333–343.

Vogel, J.S., Nelson, D.E., and Southon, J.R., 1987, ^{14}C background levels in an accelerator mass spectrometry system: Radiocarbon, v. 29, book 3, p. 323–333.

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

Wilde, F.D., ed., 2004, Cleaning of equipment for water sampling (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, accessed October 27, 2011, at http://pubs.water.usgs.gov/twri9A3/.

Wilde, F.D., 2006, Temperature (ver. 2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.1, accessed October 27, 2011, at http://pubs.water.usgs.gov/twri9A6.1/.

Wilde, F.D., Busenberg, E., and Radtke, D.B., 2006, pH (ver. 1.3): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.4, accessed October 27, 2011, at http://pubs.water.usgs.gov/twri9A6.4/.

Wilde, F.D., and Radtke, D.B., 2005, General information and guidelines (ver. 1.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.0, accessed October 27, 2011, at http://pubs.water.usgs.gov/twri9A6.0/.

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1999, Collection of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, accessed October 27, 2011, at http://pubs.water.usgs.gov/twri9A4/.

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 2004, Processing of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5, accessed October 27, 2011, at http://pubs.water.usgs.gov/twri9A5/.

Wright, M.T., Belitz, Kenneth, and Burton, C.A., 2005, California GAMA Program—Ground-water quality data in the San Diego Drainages hydrogeologic province, California, 2004: U.S. Geological Survey Data Series 129, 91 p. (Also available at http://pubs.usgs.gov/ds/2005/129.)

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

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

Table 1. Identification, sampling, and construction information for wells sampled for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[**GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. **Other abbreviations**: ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum of 1988; na, not available]

GAMA well identification number	Date Sampled (m/dd/ yyyy)	Altitude of LSD (ft above NAVD 88)[1]	Well type	Construction information		
				Well depth (ft below LSD)	Depth to top perforation (ft below LSD)	Depth to bottom perforation (ft below LSD)
Santa Barbara grid wells						
SB-01	2/3/2011	47	Production	150	110	150
SB-02	2/1/2011	21	Production	840	210	820
SB-03	2/1/2011	108	Production	450	250	450
SB-04	1/31/2011	45	Production	700	180	680
SB-05	2/14/2011	363	Production	420	255	410
SB-06	2/2/2011	83	Production	630	350	630
SB-07	1/26/2011	191	Production	427	215	427
SB-08	1/26/2011	177	Production	588	203	583
SB-09	2/8/2011	545	Production	350	140	350
SB-10	2/8/2011	30	Production	145	55	145
SB-11	2/9/2011	26	Production	206	100	206
SB-12	2/7/2011	267	Production	140	na	na
SB-13	2/7/2011	81	Production	460	170	460
SB-14	2/9/2011	358	Production	975	195	975
SB-15	2/2/2011	43	Production	958	317	938
SB-16	2/3/2011	66	Production	1,245	310	1,230
SB-17	2/16/2011	153	Production	250	na	na
SB-18	2/10/2011	198	Production	295	85	295
Santa Barbara understanding wells						
SBU-01	1/31/2011	46	Production	1,110	549	1,065
SBU-02	1/24/2011	35	Monitoring	780	760	780
SBU-03	1/24/2011	35	Monitoring	670	650	670
SBU-04	1/25/2011	35	Monitoring	441	420	440
SBU-05	1/25/2011	35	Monitoring	221	200	220
SBU-06	2/15/2011	22	Unused	464	280	464

[1] 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.

Table 2. Classes of chemical constituents and field water-quality indicators collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

Constituent classes	Constituent list table	Results table
Field water-quality indicators		
Dissolved oxygen, temperature, pH, and specific conductance	—	4
Field alkalinity, bicarbonate, and carbonate	—	4
Organic constituents		
Volatile organic compounds (VOC)	3A	5
Pesticides and pesticide degradates	3B	6
Polar pesticides and degradates	3C	none [1]
Pharmaceutical compounds	3D	none [1]
Constituents of special interest		
Perchlorate	3E	7
N-Nitrosodimethylamine (NDMA)	3E	none [1]
Inorganic constituents		
Trace elements	3F	8
Nutrients	3G	9
Major and minor ions, silica, and total dissolved solids (TDS)	3H	10
Laboratory alkalinity, bicarbonate, and carbonate	3H	4
Arsenic, chromium, and iron species	3I	11
Isotopic tracers, dissolved noble gases, and radioactive constituents		
Stable isotopes of hydrogen and oxygen in water	3J	12
Stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance	3J	12
Stable isotopes of dissolved boron in water	3J	none [2]
Isotope ratio of dissolved strontium in water	3J	none [2]
Tritium	3J	12
Stable isotope ratio of helium, dissolved nobles gases, and tritium	3K	none [2]
Radon-222	3J	13A
Gross alpha and gross beta radioactivity (72-hour and 30-day counts)	3J	13B

[1] Constituent(s) not detected in groundwater samples.

[2] Results were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

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

[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 February 4, 2011. **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**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LRL, laboratory reporting level; SRL, study reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS Registry Number® [1]	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Acetone	Solvent	81552	67-64-1	3.4	na	na	—
Acrylonitrile	Organic synthesis	34215	107-13-1	0.8	RSD5-US	0.6	—
tert-Amyl methyl ether (TAME)	Gasoline oxygenate	50005	994-05-8	0.06	na	na	—
Benzene	Gasoline hydrocarbon	34030	71-43-2	0.026	MCL-CA	1	—
Bromobenzene	Solvent	81555	108-86-1	0.022	HAL-US	70	—
Bromochloromethane	Fire retardant	77297	74-97-5	0.06	HAL-US	90	—
Bromodichloromethane	Disinfection byproduct (THM)	32101	75-27-4	0.034	MCL-US	[2] 80	D
Bromoform (Tribromomethane)	Disinfection byproduct (THM)	32104	75-25-2	0.1	MCL-US	[2] 80	—
Bromomethane (Methyl bromide)	Fumigant	34413	74-83-9	0.20	HAL-US	10	—
n-Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	0.08	NL-CA	260	—
sec-Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	0.034	NL-CA	260	—
tert-Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	0.060	NL-CA	260	—
Carbon disulfide	Organic synthesis	77041	75-15-0	0.08	NL-CA	160	—
Carbon tetrachloride (Tetrachloromethane)	Solvent	32102	56-23-5	0.06	MCL-CA	0.5	D
Chlorobenzene	Solvent	34301	108-90-7	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	[2] 80	D
Chloromethane	Solvent	34418	74-87-3	0.14	na	na	—
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	[2] 80	—
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	0.40	MCL-US	0.2	—
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.028	MCL-US	0.05	—
Dibromomethane	Solvent	30217	74-95-3	0.050	na	na	D
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	—

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Laboratory reporting level, benchmark type, and benchmark level as of February 4, 2011. **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**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LRL, laboratory reporting level; SRL, study reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS Registry Number® [1]	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	0.026	MCL-CA	5	—
trans-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	D [3]
1,1-Dichloroethane (1,1-DCA)	Solvent	34496	75-34-3	0.044	MCL-CA	5	D
1,2-Dichloroethane (1,2-DCA)	Solvent	32103	107-06-2	0.08	MCL-CA	0.5	D
1,1-Dichloroethene (1,1-DCE)	Organic synthesis	34501	75-35-4	0.022	MCL-CA	6	—
cis-1,2-Dichloroethene (*cis*-1,2-DCE)	Solvent	77093	156-59-2	0.022	MCL-CA	6	—
trans-1,2-Dichloroethene (*trans*-1,2-DCE)	Solvent	34546	156-60-5	0.018	MCL-CA	10	—
1,2-Dichloropropane	Fumigant	34541	78-87-5	0.026	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	0.040	na	na	—
cis-1,3-Dichloropropene	Fumigant	34704	10061-01-5	0.1	RSD5-US	[4] 4	—
trans-1,3-Dichloropropene	Fumigant	34699	10061-02-6	0.14	RSD5-US	[4] 4	—
Diethyl ether	Solvent	81576	60-29-7	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 *tert*-butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.032	na	na	—
Ethyl methacrylate	Organic synthesis	73570	97-63-2	0.20	na	na	—
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	Gasoline hydrocarbon	77220	611-14-3	0.032	na	na	—
Hexachlorobutadiene	Organic synthesis	39702	87-68-3	0.08	RSD5-US	9	—
Hexachloroethane	Solvent	34396	67-72-1	0.22	HAL-US	1	—
2-Hexanone (n-Butyl methyl ketone)	Solvent	77103	591-78-6	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	—
4-Isopropyl-1-methyl benzene	Gasoline hydrocarbon	77356	99-87-6	0.06	na	na	—
Methyl acrylate	Organic synthesis	49991	96-33-3	0.8	na	na	—

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Laboratory reporting level, benchmark type, and benchmark level as of February 4, 2011. **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**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LRL, laboratory reporting level; SRL, study reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS Registry Number® [1]	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	0.26	na	na	—
Methyl *tert*-butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.1	MCL-CA	13	D
Methyl *iso*-butyl ketone (MIBK)	Solvent	78133	108-10-1	0.32	NL-CA	120	—
Methylene chloride (Dichloromethane)	Solvent	34423	75-09-2	0.04	MCL-US	5	—
Methyl ethyl ketone (2-butanone, MEK)	Solvent	81595	78-93-3	1.6	HAL-US	4,000	—
Methyl methacrylate	Organic synthesis	81597	80-62-6	0.22	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
n-Propylbenzene	Solvent	77224	103-65-1	0.036	NL-CA	260	—
Styrene	Gasoline hydrocarbon	77128	100-42-5	0.042	MCL-US	100	—
1,1,1,2-Tetrachloroethane	Solvent	77562	630-20-6	0.040	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	—
1,2,3,4-Tetramethylbenzene	Gasoline hydrocarbon	49999	488-23-3	0.1	na	na	—
1,2,3,5-Tetramethylbenzene	Gasoline hydrocarbon	50000	527-53-7	0.08	na	na	—
Toluene	Gasoline hydrocarbon	34010	108-88-3	0.018	MCL-CA	150	—
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	0.030	MCL-US	200	D
1,1,2-Trichloroethane (1,1,2-TCA)	Solvent	34511	79-00-5	0.028	MCL-US	5	—
Trichloroethene (TCE)	Solvent	39180	79-01-6	0.022	MCL-US	5	—
Trichlorofluoromethane (CFC-11)	Refrigerant	34488	75-69-4	0.06	MCL-CA	150	—
1,2,3-Trichloropropane (1,2,3-TCP)	Solvent/organic synthesis	77443	96-18-4	0.12	HAL-US [5]	40	—
Trichlorotrifluoroethane (CFC-113)	Refrigerant	77652	76-13-1	0.034	MCL-CA	1,200	D
1,2,3-Trimethylbenzene	Gasoline hydrocarbon	77221	526-73-8	0.06	na	na	—
1,2,4-Trimethylbenzene	Gasoline hydrocarbon	77222	95-63-6	0.032	NL-CA	330	— [6]
1,3,5-Trimethylbenzene	Organic synthesis	77226	108-67-8	0.032	NL-CA	330	—

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Laboratory reporting level, benchmark type, and benchmark level as of February 4, 2011. **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**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LRL, laboratory reporting level; SRL, study reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS Registry Number® [1]	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Vinyl bromide (Bromoethene)	Fire retardant	50002	593-60-2	0.12	na	na	—
Vinyl chloride (Chloroethene)	Organic synthesis	39175	75-01-4	0.06	MCL-CA	0.5	—
m- and *p*-Xylene	Gasoline hydrocarbon	85795	108-38-3 / 106-42-3	0.08	MCL-CA	[7] 1,750	—
o-Xylene	Gasoline hydrocarbon	77135	95-47-6	0.032	MCL-CA	[7] 1,750	—

---

[1] 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℠.

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

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

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

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

[6] All results for 1,2,4-trimethylbenzene were less than the SRL (0.56 µg/L) that was defined on the basis of the examination of quality-control samples collected for the first 32 GAMA study units (May 2004 through September 2010) and in laboratory instrument and preparation blanks analyzed during the same time period as the samples (Fram and others, 2012).

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

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparative benchmarks, and reporting information for the 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 February 4, 2011. **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**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS Registry Number®	LRL (µg/L)	Benchmark type	Benchmark level (µg/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	0.008	MCL-CA	1	—
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	—[1]
Carbaryl	Insecticide	82680	63-25-2	0.06	RSD5-US	400	—
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	0.0046	na	na	—
Chlorpyrifos	Insecticide	38933	2921-88-2	0.0036	HAL-US	2	—
Chlorpyrifos oxon	Insecticide degradate	61636	5598-15-2	0.06	na	na	—[1]
Cyfluthrin	Insecticide	61585	68359-37-5	0.016	na	na	—[1]
Cypermethrin	Insecticide	61586	52315-07-8	0.020	na	na	—[1]
Dacthal (DCPA)	Herbicide	82682	1861-32-1	0.0076	HAL-US	70	—
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	Herbicide degradate	04040	6190-65-4	0.006	na	na	—
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	0.0060	HAL-US	1	—
3,4-Dichloroaniline	Herbicide degradate	61625	95-76-1	0.0042	na	na	—
Dichlorvos	Insecticide	38775	62-73-7	0.04	na	na	—[1]
Dicrotophos	Insecticide	38454	141-66-2	0.08	na	na	—[1]
Dieldrin	Insecticide	39381	60-57-1	0.008	RSD5-US	0.02	—
2,6-Diethylaniline	Herbicide degradate	82660	579-66-8	0.0060	na	na	—
Dimethoate	Insecticide	82662	60-51-5	0.006	na	na	—[1]
Ethion	Insecticide	82346	563-12-2	0.008	na	na	—[1]
Ethion monoxon	Insecticide degradate	61644	17356-42-2	0.021	na	na	—
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	0.010	na	na	—
Fenamiphos	Insecticide	61591	22224-92-6	0.030	HAL-US	0.7	—
Fenamiphos sulfone	Insecticide degradate	61645	31972-44-8	0.054	na	na	—
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	0.08	na	na	—[1]
Fipronil	Insecticide	62166	120068-37-3	0.018	na	na	—
Fipronil sulfide	Insecticide degradate	62167	120067-83-6	0.012	na	na	—
Fipronil sulfone	Insecticide degradate	62168	120068-36-2	0.024	na	na	—[1]
Fonofos	Insecticide	04095	944-22-9	0.0048	HAL-US	10	—
Hexazinone	Herbicide	04025	51235-04-2	0.008	HAL-US	400	—[1]
Iprodione	Fungicide	61593	36734-19-7	0.014	na	na	—[1]
Isofenphos	Insecticide	61594	25311-71-1	0.006	na	na	—
Malaoxon	Insecticide degradate	61652	1634-78-2	0.022	na	na	—
Malathion	Insecticide	39532	121-75-5	0.016	HAL-US	500	—

Table 3B. Pesticides and pesticide degradates, primary uses or sources, comparative benchmarks, and reporting information for the 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 February 4, 2011. **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**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS Registry Number®	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Metalaxyl	Fungicide	61596	57837-19-1	0.014	na	na	—
Methidathion	Insecticide	61598	950-37-8	0.012	na	na	—
Metolachlor	Herbicide	39415	51218-45-2	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	—[1]
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	0.014	na	na	—[1]
Parathion-methyl	Insecticide	82667	298-00-0	0.008	HAL-US	1	—
Pendimethalin	Herbicide	82683	40487-42-1	0.012	na	na	—
cis-Permethrin	Insecticide	82687	54774-45-7	0.010	na	na	—[1]
Phorate	Insecticide	82664	298-02-2	0.020	na	na	—[1]
Phorate oxon	Insecticide degradate	61666	2600-69-3	0.027	na	na	—
Phosmet	Insecticide	61601	732-11-6	0.14	na	na	—[1]
Phosmet oxon	Insecticide degradate	61668	3735-33-9	0.0511	na	na	—[1]
Prometon	Herbicide	04037	1610-18-0	0.012	HAL-US	400	—
Prometryn	Herbicide	04036	7287-19-6	0.006	na	na	—
Pronamide (Propyzamide)	Herbicide	82676	23950-58-5	0.0036	RSD5-US	10	—
Simazine	Herbicide	04035	122-34-9	0.006	MCL-US	4	D
Tebuthiuron	Herbicide	82670	34014-18-1	0.028	HAL-US	500	—
Terbufos	Insecticide	82675	13071-79-9	0.018	HAL-US	0.4	—[1]
Terbufos oxon sulfone	Insecticide degradate	61674	56070-15-6	0.045	na	na	—
Terbuthylazine	Herbicide	04022	5915-41-3	0.0060	na	na	—
Tribufos	Defoliant	61610	78-48-8	0.018	na	na	—[1]
Trifluralin	Herbicide	82661	1582-09-8	0.018	HAL-US	10	—

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

Table 3C. Polar pesticides and degradates, primary uses or sources, comparative thresholds, and reporting information for the USGS National Water Quality Laboratory Schedule 2060.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Laboratory reporting level, benchmark type, and benchmark level as of February 4, 2011. 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. **Benchmark type**: HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk-specific dose at a risk factor of 10^{-5}. **Other abbreviations**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LRL, laboratory reporting level; na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS Registry Number®	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Acifluorfen	Herbicide	49315	50594-66-6	0.04	na	na	—[1]
Aldicarb	Insecticide	49312	116-06-3	0.12	HAL-US	[2] 7	—[1]
Aldicarb sulfone	Degradate	49313	1646-88-4	0.08	HAL-US	[2] 7	—
Aldicarb sulfoxide	Degradate	49314	1646-87-3	0.06	HAL-US	[2] 7	—
Atrazine	Herbicide	39632	1912-24-9	0.04	MCL-CA	1	—[3]
Bendiocarb	Insecticide	50299	22781-23-3	0.04	na	na	—
Benomyl	Fungicide	50300	17804-35-2	0.06	na	na	—
Bensulfuron-methyl	Herbicide	61693	83055-99-6	0.06	na	na	—
Bentazon	Herbicide	38711	25057-89-0	0.06	MCL-CA	18	—[1]
Bromacil	Herbicide	04029	314-40-9	0.06	HAL-US	70	—
Bromoxynil	Herbicide	49311	1689-84-5	0.12	na	na	—[1]
Caffeine	Beverages	50305	58-08-2	[4] 0.10	na	na	—
Carbaryl	Herbicide	49310	63-25-2	0.04	RSD5-US	400	—
Carbofuran	Herbicide	49309	1563-66-2	0.04	MCL-CA	18	—
Chloramben methyl ester	Herbicide	61188	7286-84-2	0.10	na	na	—
Chlorimuron-ethyl	Herbicide	50306	90982-32-4	0.08	na	na	—[5]
3-(4-Chlorophenyl)-1-methyl urea	Degradate	61692	5352-88-5	0.06	na	na	—
Clopyralid	Herbicide	49305	1702-17-6	0.06	na	na	—[1]
Cycloate	Herbicide	04031	1134-23-2	0.04	na	na	—
2,4-D	Herbicide	39732	298-00-0	0.06	HAL-US	70	—
2,4-D methyl ester	Herbicide	50470	na	0.2	na	na	—
2,4-D plus 2,4-D methyl ester	Herbicides	66496	na	0.06	na	na	—
2,4-DB (4-(2,4-Dichlorophenoxy)butyric acid)	Herbicide	38746	94-82-6	0.02	na	na	—[1]
DCPA (Dacthal) monoacid	Degradate	49304	887-54-7	0.04	na	na	—
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	Degradate	04040	6190-65-4	0.06	na	na	—[3]
Deisopropyl atrazine (2-Chloro-6-ethylamino-4-amino-*s*-triazine)	Degradate	04038	1007-28-9	0.06	na	na	—
Dicamba	Herbicide	38442	1918-00-9	0.04	HAL-US	4,000	—[1]
Dichlorprop	Herbicide	49302	120-36-5	0.04	na	na	—
Dinoseb (Dinitrobutyl phenol)	Herbicide	49301	88-85-7	0.04	MCL-CA	7	—[1]
Diphenamid	Herbicide	04033	957-51-7	0.04	HAL-US	200	—
Diuron	Herbicide	49300	330-54-1	0.04	RSD5-US	20	—
Fenuron	Herbicide	49297	101-42-8	0.06	na	na	—
Flumetsulam	Herbicide	61694	98967-40-9	0.06	na	na	—
Fluometuron	Herbicide	38811	2164-17-2	0.04	HAL-US	90	—
Hydroxyatrazine (2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine)	Degradate	50355	2163-68-0	0.06	na	na	—
3-Hydroxycarbofuran	Degradate	49308	16655-82-6	0.04	na	na	—
Imazaquin	Herbicide	50356	81335-37-7	0.06	na	na	—[5]
Imazethapyr	Herbicide	50407	81335-77-5	0.06	na	na	—[5]
Imidacloprid	Insecticide	61695	138261-41-3	0.06	na	na	—

Table 3C. Polar pesticides and degradates, primary uses or sources, comparative thresholds, and reporting information for the USGS National Water Quality Laboratory Schedule 2060.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Laboratory reporting level, benchmark type, and benchmark level as of February 4, 2011. 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. **Benchmark type**: HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk-specific dose at a risk factor of 10^{-5}. **Other abbreviations**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LRL, laboratory reporting level; na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS Registry Number®	LRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Linuron	Herbicide	38478	330-55-2	0.04	na	na	—
MCPA (2-Methyl-4-chlorophenoxyacetic acid)	Herbicide	38482	94-74-6	0.04	HAL-US	30	—
MCPB (4-(2-Methyl-4-chlorophenoxy)butyric acid)	Herbicide	38487	94-81-5	0.2	na	na	— [1]
Metalaxyl	Fungicide	50359	57837-19-1	0.04	na	na	—
Methiocarb	Insecticide	38501	2032-65-7	0.04	na	na	—
Methomyl	Insecticide	49296	16752-77-5	0.12	HAL-US	200	—
Metsulfuron methyl	Herbicide	61697	74223-64-6	0.14	na	na	—
Neburon	Herbicide	49294	555-37-3	0.02	na	na	—
Nicosulfuron	Herbicide	50364	111991-09-4	0.10	na	na	— [5]
Norflurazon	Herbicide	49293	27314-13-2	0.04	na	na	—
Oryzalin	Herbicide	49292	19044-88-3	0.04	na	na	—
Oxamyl	Insecticide	38866	23135-22-0	0.12	MCL-CA	50	—
Picloram	Herbicide	49291	1918-02-01	0.12	MCL-US	500	— [1]
Propham	Herbicide	49236	122-42-9	0.04	HAL-US	100	—
Propiconazole	Fungicide	50471	60207-90-1	0.04	na	na	—
Propoxur	Insecticide	38538	114-26-1	0.06	HAL-US	3	—
Siduron	Herbicide	38548	1982-49-6	0.04	na	na	— [5]
Sulfometuron-methyl	Herbicide	50337	74222-97-2	0.06	na	na	— [5]
Tebuthiuron	Herbicide	82670	34014-18-1	0.06	HAL-US	500	— [3]
Terbacil	Herbicide	04032	5902-51-2	0.04	HAL-US	90	—
Triclopyr	Herbicide	49235	55335-06-3	0.08	na	na	—

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

[2] The HAL-US benchmark is the sum of aldicarb, aldicarb sulfone, and aldicarb sulfoxide.

[3] Constituent was measured on more than one schedule. See table 3B for results with preferred method.

[4] The California Groundwater Ambient Monitoring and Assessment (GAMA) Program uses more conservative reporting limits for the pharmaceutical compounds than are used by the USGS National Water Quality Laboratory (NWQL) (Fram and Belitz, 2011). The method detection limit (MDL) corresponds to the highest long-term method detection limit (LT-MDL) or interim method detection limit (I-MDL) used by the NWQL during the period GAMA samples were analyzed (May 2004 through June 2010). Results reported by the NWQL with concentrations less than the MDLs are reported as non-detections by GAMA. Data are stored in the USGS National Water Information System (NWIS) database as reported by GAMA: results initially reported as detections with concentrations below the MDLs or as non-detections less than LT-MDLs are re-coded as non-detections less than MDLs.

[5] The median matrix-spike recovery was greater than 130 percent.

Table 3D. Pharmaceutical compounds, primary uses or sources, comparative benchmarks, and reporting information for the USGS National Water Quality Laboratory Schedule 2080.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Abbreviations**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; MDL, method detection level; na, not available; µg/L, micrograms per liter]

Constituent	Primary use or source	USGS parameter code	CAS Registry Number®	MDL[1] (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Acetaminophen	Analgesic	62000	103-90-2	0.06	na	na	—
Albuterol	Bronchodilator	62020	18559-94-9	0.04	na	na	— [2]
Caffeine	Stimulant	50305	58-08-2	0.10	na	na	— [3]
Carbamazapine	Anticonvulsant; mood stabilizer	62793	298-46-4	0.03	na	na	—
Codeine	Opiod narcotic	62003	76-57-3	0.023	na	na	—
Cotinine	Nicotine metabolite	62005	486-56-6	0.019	na	na	—
Dehydronifedipine	Antianginal metabolite	62004	67035-22-7	0.04	na	na	—
Diltiazem	Antianginal; antihypertensive	62008	42399-41-7	0.04	na	na	— [2]
1,7-Dimethylxanthine	Caffeine metabolite	62030	611-59-6	0.06	na	na	—
Diphenydramine	Antihistime	62796	147-25-0	0.02	na	na	—
Sulfamethoxazole	Antibacterial	62021	723-46-6	0.08	na	na	— [2]
Thiabendazole	Anthelmintic	62801	148-79-8	0.03	na	na	—
Trimethoprim	Antibacterial	62023	738-70-5	0.017	na	na	—
Warfarin	Anticoagulant	62024	81-81-2	0.05	na	na	— [2]

[1] The California Groundwater Ambient Monitoring and Assessment (GAMA) Program uses more conservative reporting limits for the pharmaceutical compounds than are used by the USGS National Water Quality Laboratory (NWQL) (Fram and Belitz, 2011). The method detection limit (MDL) corresponds to the highest long-term method detection limit (LT-MDL) or interim method detection limit (I-MDL) used by the NWQL during the period GAMA samples were analyzed (May 2004 through June 2010). Results reported by the NWQL with concentrations less than their MDLs are reported as non-detections by GAMA. Results for the Santa Barbara study unit for all pharmaceutical compounds on schedule 2080 were less than their respective MDL.

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

[3] Constituent was measured on more than one schedule. See table 3C for results with preferred method.

Table 3E. Constituents of special interest, primary uses or sources, comparative benchmarks, and reporting information for Weck Laboratories, Inc., City of Industry, California, analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Minimum reporting level, benchmark type, and benchmark level as of February 4, 2011. **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; NL-CA, CDPH notification level. **Other abbreviations**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; MRL, minimum reporting level; D, detected in groundwater samples (table 7); µg/L, micrograms per liter; —, not detected; SB, Santa Barbara grid well]

Constituent	Primary use or source	USGS parameter code	CAS Registry Number®	MRL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Perchlorate	Rocket fuel, fireworks, flares	63790	14797-73-0	0.10	MCL-CA	6	D
N-Nitrosodimethylamine (NDMA)	Disinfection by-product	34438	62-75-9	0.0020	NL-CA	0.010	— [1]

[1] Sample holding time exceeded for SB-05 and the associated field blank. NDMA might not have been detected in samples if it was present at very low concentrations.

Table 3F. Trace elements, comparative benchmarks, and reporting information for the USGS National Water Quality Laboratory Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Method detection level, benchmark type, and benchmark level as of February 4, 2011. **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. Secondary maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as the SMCL-US when no SMCL-CA 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**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LT-MDL, long-term method detection level; D, detected in groundwater samples (table 8); na, not available; µg/L, micrograms per liter; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

Constituent	USGS parameter code	CAS Registry Number®	LT-MDL (µg/L)	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	3	NL-CA	1,000	D
Cadmium	01025	7440-43-9	0.016	MCL-US	5	D
Chromium	01030	7440-47-3	0.06	MCL-CA	50	D
Cobalt	01035	7440-48-4	0.02	na	na	D
Copper	01040	7440-50-8	0.5	AL-US	1,300	D
Iron	01046	7439-89-6	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	0.09	MCL-CA	100	D
Selenium	01145	7782-49-2	0.03	MCL-US	50	D
Silver	01075	7440-22-4	0.005	SMCL-CA	100	D
Strontium	01080	7440-24-6	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	5,000	D

Table 3G. Nutrients, comparative benchmarks, and reporting information for the USGS National Water Quality Laboratory Schedule 2755.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Method detection level, benchmark type, and benchmark level as of February 4, 2011. **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 Registry Number®	LT-MDL (mg/L)	Benchmark type	Benchmark level (mg/L)	Detection
Ammonia (as nitrogen)	00608	7664-41-7	0.010	HAL-US	[1] 24.7	D
Nitrate plus nitrite (as nitrogen)	00631	na	0.02	MCL-US	10	D
Nitrite (as nitrogen)	00613	14797-65-0	0.0010	MCL-US	1	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

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

Table 3H. Major and minor ions, silica, total dissolved solids (TDS), and alkalinity, comparative benchmarks, and reporting information for the USGS National Water Quality Laboratory Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Method detection level, benchmark type, and benchmark level as of February 4, 2011. **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. Secondary maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as the SMCL-US when no SMCL-CA exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; LT-MDL, long-term method detection level; MRL, minimum reporting level; D, detected in groundwater samples (table 10); na, not available; mg/L, milligrams per liter]

Constituent	USGS parameter code	CAS Registry Number®	LT-MDL, MDL, or MRL (mg/L)	Benchmark type	Benchmark level (mg/L)	Detection
Bromide	71870	24959-67-9	0.010	na	na	D
Calcium	00915	7440-70-2	0.022	na	na	D
Chloride	00940	16887-00-6	0.06	SMCL-CA	[1] 250 (500)	D
Fluoride	00950	16984-48-8	0.04	MCL-CA	2	D
Iodide	71865	7553-56-2	0.0010	na	na	D
Magnesium	00925	7439-95-4	0.008	na	na	D
Potassium	00935	7440-09-7	0.022	na	na	D
Silica (as SiO_2)	00955	7631-86-9	0.029	na	na	D
Sodium	00930	7440-23-5	0.06	na	na	D
Sulfate	00945	14808-79-8	0.09	SMCL-CA	[1] 250 (500)	D
Residue on evaporation (total dissolved solids, TDS)	70300	na	12	SMCL-CA	[1] 500 (1,000)	D
Laboratory alkalinity (as $CaCO_3$)[2]	29801	na	4.0	na	na	D

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

[2] Laboratory alkalinity results are presented in table 4.

Table 3I. Arsenic, chromium, and iron species, comparative benchmarks, and reporting information for the USGS Trace Metal Laboratory, Boulder, Colorado, analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Method detection level, benchmark type, and benchmark level as of February 4, 2011. **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. Secondary maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as the SMCL-US when no SMCL-CA exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; MDL, method detection limit; na, not available; µg/L, micrograms per liter; D, detected in groundwater samples (table 11)]

Constituent	USGS parameter code	CAS Registry Number®	MDL (µg/L)	Benchmark type	Benchmark level (µg/L)	Detection
Arsenic (total)	99033	7440-38-2	0.2	MCL-US	10	D
Arsenic (III)	99034	22569-72-8	0.5	na	na	D
Chromium (total)	01030	7440-47-3	0.1	MCL-CA	50	D
Chromium (VI)	01032	18540-29-9	0.1	na	na	D
Iron (total)	01046	7439-89-6	2	SMCL-CA	300	D
Iron (II)	01047	7439-89-6	2	na	na	D

Table 3J. Isotope tracers and 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. 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. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Method uncertainties for the isotope tracers are 2-sigmas; method uncertainties for radioactive constituents are 1-sigma. Benchmark type and benchmark value as of February 4, 2011. **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, USEPA maximum contaminant level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level. **Elements**: H, hydrogen; O, oxygen; B, boron; Sr, strontium; C, carbon. **Reporting units**: pCi/L, picocuries per liter; pmc, percent modern carbon. **Other abbreviations**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; na, not available; D, detected in groundwater samples (tables 12, 13A, and 13B); CSU, combined standard uncertainty]

Constituent	USGS parameter code	CAS number	Method uncertainty	Reporting units	Benchmark type	Benchmark level (pCi/L)	Detection
Isotope tracers							
δ^{2}H in water [1]	82082	na	2	per mil	na	na	D
δ^{18}O in water [1]	82085	na	0.20	per mil	na	na	D
δ^{11}B in water [2]	62648	na	2	per mil	na	na	na
Strontium isotope ratio (^{87}Sr/^{86}Sr) [2]	75978	na	0.0000	atom ratio	na	na	na
δ^{13}C in dissolved inorganic carbon [3]	82081	na	0.05	per mil	na	na	D
Radioactive constituents							
Carbon-14 [3]	49933	14762-75-5	CSU	pmc	na	na	D
Tritium [4]	07000	10028-17-8	CSU	pCi/L	MCL-CA	20,000	D
Radon-222 [5]	82303	14859-67-7	CSU	pCi/L	Proposed MCL-US	4,000	D
Gross alpha radioactivity, 72-hour and 30-day counts [6]	62636, 62639	12587-46-1	CSU	pCi/L	MCL-US	15	D
Gross beta radioactivity, 72-hour and 30-day counts [6]	62642, 62645	12587-47-2	CSU	pCi/L	MCL-CA	50	D

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

[2] USGS NRP Metals Isotope Research Laboratory, Menlo Park, California (USGSMICA).

[3] Woods Hole Oceanographic Institution, National Ocean Sciences Accelerator Mass Spectrometry Facility (NOSAMS), Woods Hole, Massachusetts (MA-WHAMS).

[4] USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA).

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

[6] Eberline Analytical Services, Richmond, California (CA-EBERL).

Table 3K. Dissolved gases and isotope tracers, comparison benchmarks, and reporting information for Lawrence Livermore National Laboratory.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark values as of February 4, 2011. **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, USEPA maximum contaminant level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant Level. **Reporting units**: cm^{3} STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water; pCi/L, picocuries per liter. **Other abbreviations**: USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; na, not available]

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

Table 4. Water-quality indicators in samples collected for the Santa Barbara study unit, January to February 2011, 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**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Reporting level, benchmark type, and benchmark level as of February 4, 2011. **Benchmark type**: Maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as the SMCL-US when no SMCL-CA exists. SMCL-US, U.S. Environmental Protection Agency (USEPA) secondary maximum contaminant level; SMCL-CA, California Department of Public Health (CDPH) secondary maximum contaminant level. **Other abbreviations**: °C, degree Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, not collected; na, not available; µS/cm, microsiemens per centimeter; <, less than; >, greater than; $CaCO_3$, calcium carbonate; HCO_3^-, bicarbonate; CO_3^{2-}, carbonate; *, value greater than benchmark level; **, value greater than upper benchmark level; —, not detected]

GAMA well identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, laboratory (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, laboratory (µS/cm at 25°C) (90095)	Specific conductance, field (µS/cm at 25°C) (00095)	Alkalinity, laboratory (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)	Bicarbonate, field (mg/L as HCO_3^-) (63786)	Bicarbonate, calculated from laboratory data (mg/L as HCO_3^-)	Carbonate, field (mg/L as CO_3^{2-}) (63788)	Carbonate, calculated from laboratory data (mg/L as CO_3^{2-})
Benchmark type	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**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**
[Reporting level or range]	**[0.2]**	**[0.0–38.5]**	**[0–14]**	**[0–14]**	**[5]**	**[5]**	**[4.0]**	**[1]**	**[1]**	**[1]**	**[0.1]**	**[0.1]**
Santa Barbara grid wells (18 wells sampled)												
SB-01	0.2	20.0	7.1	7.0	** 2,540	** 2,510	373	nc	na	454	na	0.3
SB-02	0.2	19.5	7.3	7.1	*1,250	*1,240	348	328	398	424	0.4	0.4
SB-03	0.3	18.5	7.3	7.1	*1,330	*1,320	281	nc	na	342	na	0.3
SB-04	0.7	18.0	7.2	6.9	*925	*925	232	nc	na	282	na	0.2
SB-05	5.1	19.5	7.2	7.0	**1,800	** 1,800	183	nc	na	223	na	0.2
SB-06	0.2	22.0	7.4	7.2	*1,310	*1,300	322	nc	na	392	na	0.4
SB-07	3.3	21.0	7.2	6.8	** 2,080	** 2,090	324	nc	na	394	na	0.3
SB-08	0.2	22.0	7.0	6.6	789	794	232	nc	na	283	na	0.1
SB-09	3.3	21.0	6.5	*6.4	593	619	97	nc	na	119	na	—
SB-10	0.3	19.0	6.5	*6.3	**1,640	** 1,660	218	nc	na	265	na	—
SB-11	3.1	17.0	7.0	6.9	*1,080	*1,080	268	nc	na	326	na	0.2
SB-12	3.8	17.5	6.6	*6.4	*1,400	*1,400	276	nc	na	336	na	0.1
SB-13	3.2	21.0	6.8	6.7	** 2,170	** 2,140	209	nc	na	255	na	0.1
SB-14	0.2	21.0	7.7	7.5	*1,110	*1,080	357	331	402	434	1.1	1.0
SB-15	0.4	20.5	7.5	7.2	827	817	289	nc	na	351	na	0.5
SB-16	0.6	18.0	7.4	7.2	* 973	* 943	283	nc	na	345	na	0.4
SB-17	4.7	16.0	7.2	7.0	*1,490	*1,490	356	nc	na	433	na	0.3
SB-18	2.3	17.5	7.4	7.1	*1,280	*1,240	358	nc	na	435	na	0.5

Table 4. Water-quality indicators in samples collected for the Santa Barbara study unit, January to February 2011, 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**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Reporting level, benchmark type, and benchmark level as of February 4, 2011. **Benchmark type**: Maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as the SMCL-US when no SMCL-CA exists. SMCL-US, U.S. Environmental Protection Agency (USEPA) secondary maximum contaminant level; SMCL-CA, California Department of Public Health (CDPH) secondary maximum contaminant level. **Other abbreviations**: °C, degree Celsius; E, estimated or having a higher degree of uncertainty; mg/L, milligrams per liter; nc, not collected; na, not available; µS/cm, microsiemens per centimeter; <, less than; >, greater than; $CaCO_3$, calcium carbonate; HCO_3^-, bicarbonate; CO_3^{2-}, carbonate; *, value greater than benchmark level; **, value greater than upper benchmark level; —, not detected]

GAMA well identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, laboratory (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, laboratory (µS/cm at 25°C) (90095)	Specific conductance, field (µS/cm at 25°C) (00095)	Alkalinity, laboratory (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)	Bicarbonate, field (mg/L as HCO_3^-) (63786)	Bicarbonate, calculated from laboratory data (mg/L as HCO_3^-)	Carbonate, field (mg/L as CO_3^{2-}) (63788)	Carbonate, calculated from laboratory data (mg/L as CO_3^{2-})
Benchmark type	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**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**
[Reporting level or range]	**[0.2]**	**[0.0–38.5]**	**[0–14]**	**[0–14]**	**[5]**	**[5]**	**[4.0]**	**[1]**	**[1]**	**[1]**	**[0.1]**	**[0.1]**
Santa Barbara understanding wells (6 wells sampled)												
SBU-01	0.2	23.5	7.3	7.2	*1,090	*1,080	298	nc	na	362	na	0.4
SBU-02	0.2	23.0	7.6	7.6	** 4,810	** 4,810	246	nc	na	299	na	0.6
SBU-03	< 0.2	23.0	7.8	7.4	* 917	* 935	335	nc	na	406	na	1.2
SBU-04	0.7	21.5	7.2	6.9	645	653	229	nc	na	279	na	0.2
SBU-05	1.8	21.0	7.0	6.7	897	* 905	194	176	214	236	—	0.1
SBU-06	0.4	21.0	7.3	7.0	* 994	* 999	195	nc	na	238	na	0.2

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

Table 5. Volatile organic compounds (VOCs) detected in samples collected for the Santa Barbara study unit, January to February 2011, 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. Samples from all 24 wells were analyzed, but only samples with detections are listed. Constituents are listed in order of decreasing detection frequency in the 18 grid wells. All analytes are listed in table 3A. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Reporting level, benchmark type, and benchmark level as of February 4, 2011. **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 (CDPH) maximum contaminant level; NL-CA, CDPH notification level. **Other abbreviations**: E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, microgram per liter; na, not available; —, not detected; NWIS, USGS National Water Information System]

Primary use or source	**Disinfection byproducts**		**Solvents**			**Gasoline oxygenate**	**Refrigerant**
GAMA well identification number	**Chloroform (Trichloromethane) (µg/L) (32106)**	**Bromodichloromethane (µg/L) (32101)**	**1,1,1-Trichloroethane (µg/L) (34506)**	**1,1-Dichloroethane (µg/L) (34496)**	**Perchloroethene (µg/L) (34475)**	**Methyl *tert*-butyl ether (µg/L) (78032)**	**Trichlorotrifluoroethane (CFC-113) (µg/L) (77652)**
Benchmark type	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**MCL-CA**
Benchmark level	**[2] 80**	**[2] 80**	**200**	**5**	**5**	**13**	**1,200**
[LRL]	**[0.03]**	**[0.034]**	**[0.03]**	**[0.044]**	**[0.026]**	**[0.1]**	**[0.034]**
Santa Barbara grid wells (18 wells sampled)							
SB-03	0.30	—	—	—	—	—	—
SB-04	21.8	—	—	—	—	—	—
SB-05	0.09	—	—	—	—	—	—
SB-07	0.06	—	—	0.044	0.022	—	1.7
SB-08	—	—	—	—	—	9.1	—
SB-09	0.09	—	—	—	—	—	—
SB-10	—	—	—	0.021	—	1.9	—
SB-12	1.78	0.27	0.01	—	0.012	—	—
SB-15	0.02	—	—	—	—	—	—
SB-17	0.13	—	0.05	—	—	—	—
SB-18	0.51	0.067	—	—	—	—	—
Number of wells with detections	9	2	2	2	2	2	1
Detection frequency (percent)	50	11	11	11	11	11	5.6
Total number of detections							
Santa Barbara understanding wells (6 wells sampled) [3]							
SBU-05	0.04	—	—	—	0.78	—	—

Table 5. Volatile organic compounds (VOCs) detected in samples collected for the Santa Barbara study unit, January to February 2011, 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 all 24 wells were analyzed, but only samples with detections are listed. Constituents are listed in order of decreasing detection frequency in the 18 grid wells. All analytes are listed in table 3A. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Reporting level, benchmark type, and benchmark level as of February 4, 2011. **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 (CDPH) maximum contaminant level; NL-CA, CDPH notification level. **Other abbreviations**: E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, microgram per liter; na, not available; —, not detected; NWIS, USGS National Water Information System]

Primary use or source	**Solvents**			**Refrigerant**		
GAMA well identification number	**1,2-Dichloroethane (µg/L) (32103)**	**Dibromomethane (µg/L) (30217)**	**Carbon tetrachloride (tetrachloromethane) (µg/L) (32102)**	**Dichlorodifluoromethane (CFC-12) (µg/L) (34668)**	**Detections per well**	**VOC detection summary [1]**
Benchmark type	**MCL-CA**	**na**	**MCL-CA**	**NL-CA**		
Benchmark level	**0.5**	**na**	**0.5**	**1,000**		
[LRL]	**[0.08]**	**[0.05]**	**[0.06]**	**[0.1]**		
Santa Barbara grid wells (18 wells sampled)						
SB-03	—	—	—	—	1	
SB-04	—	—	—	—	1	
SB-05	—	—	—	—	1	
SB-07	—	—	—	—	4	
SB-08	—	—	—	—	1	
SB-09	—	—	—	—	1	
SB-10	0.07	—	—	—	3	
SB-12	—	0.03	—	—	5	
SB-15	—	—	—	—	1	
SB-17	—	—	—	—	2	
SB-18	—	—	—	—	2	
Number of wells with detections	1	1	0	0		11
Detection frequency (percent)	5.6	5.6	0	0		61
Total number of detections						22
Santa Barbara understanding wells (6 wells sampled) [3]						
SBU-05	—	—	0.16	E0.07	3	

[1] Raw results for VOCs included four detections for 1,2,4-trimethylbenzene that were less than the study reporting level (SRL) of 0.56 µg/L. The SRL was determined on the basis of the quality-control data collected between May 2004 and September 2010 for the first 32 study units of the California GAMA Priority Basin Project (Fram and others, 2012). 1,2,4-trimethylbenzene was detected at concentrations (in micrograms per liter) less than the SRL for SB-02 (0.038), SB-03 (0.071), SB-04 (0.027), and SB-16 (0.032). In the USGS NWIS database, the results are accompanied with the following comment: Result is < or = reported value, based on quality-control data.

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

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

Table 6. Pesticides and pesticide degradates detected in samples collected for the Santa Barbara study unit, January to February 2011, 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 24 wells were analyzed, but only samples with detections are listed. All analytes are listed in table 3B. **GAMA well identification number**: SB, Santa Barbara study unit grid well. Laboratory reporting level, benchmark type, and benchmark level as of February 4, 2011. **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; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations**: E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter]

Primary use or source	Herbicide		
GAMA well identification number	**Simazine (µg/L) (04035)**	**Pesticide detections per well**	**Pesticide detection summary**
Benchmark type	**MCL-US**		
Benchmark level	**4**		
[LRL]	**[0.006]**		
Santa Barbara grid wells (18 wells sampled)			
SB-04	E0.005	1	
SB-17	E0.004	1	
Number of wells with detections	2		2
Detection frequency (percent)	11		11
Total number of detections			2

Table 7. Perchlorate detected in the samples collected for the Santa Barbara study unit, January to February 2011, 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 constituent is given in table 3E. Samples from all 24 wells were analyzed for perchlorate, but only samples with detections are listed. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Minimum reporting level, benchmark type, and benchmark level as of February 4, 2011. **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**: MRL, minimum reporting level; µg/L, microgram per liter]

GAMA well identification number	Perchlorate (µg/L) (63790)
Benchmark type	**MCL-CA**
Benchmark level	**6**
[MRL]	**[0.10]**
Santa Barbara grid wells (18 wells sampled)	
SB-05	3.90
SB-07	1.65
SB-08	0.34
SB-09	1.09
SB-10	1.03
SB-11	0.54
SB-12	0.88
SB-13	2.18
SB-15	1.32
SB-16	2.54
SB-17	0.57
SB-18	0.90
Number of wells with detections	12
Detection frequency (percent)	67
Santa Barbara understanding wells (6 wells sampled)	
SBU-05	1.43
SBU-06	0.24

Table 8. Trace elements detected in the samples collected for the Santa Barbara study unit, January to February 2011, 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. Information about the analytes given in table 3F. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Method detection level, benchmark type, and benchmark level as of February 4, 2011. **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. Secondary maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as MCL-US when the SMCL-CA does not exist. 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**: USGS, U.S. Geological Survey; LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; —, not detected; ≤, less than or equal to; *, value above benchmark level; NWIS, USGS National Water Information System]

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 (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]**	**[1] [0.36]**	**[0.006]**	**[3]**	**[0.016]**	**[1] [0.42]**	**[2] [0.22]**	**[1] [1.7]**	**[1] [6.0]**	**[1] [0.65]**
Santa Barbara grid wells (18 wells sampled)												
SB-01[3]	—	—	0.26	21	—	399	—	—	≤0.14	—	* 1,220	—
SB-02	5.2	0.08	1.1	50	—	131	0.02	—	0.23	≤0.56	* 1,240	≤0.45
SB-03	3.1	0.40	2.3	157	—	115	0.03	≤0.18	0.76	—	265	≤0.07
SB-04	2.3	0.17	0.64	77	—	158	0.05	≤0.10	≤0.08	≤0.92	90.9	≤0.41
SB-05	—	—	0.40	92	—	44	0.03	1.1	≤0.07	5.3	6.1	0.80
SB-06	1.9	0.10	0.46	50	—	147	—	≤0.06	0.42	≤0.56	168	—
SB-07	—	—	0.38	40	0.007	181	0.04	0.63	≤0.08	3.7	66.0	≤0.29
SB-08	—	—	0.37	42	—	44	0.02	≤0.11	≤0.06	6.0	≤5.3	≤0.23
SB-09	3.7	—	0.15	146	0.009	28	—	≤0.36	≤0.04	13.0	—	5.3
SB-10	2.3	—	0.35	193	0.009	151	0.13	≤0.10	0.95	5.1	≤5.1	≤0.62
SB-11	—	—	0.11	103	0.007	271	—	≤0.15	≤0.07	≤1.1	≤5.7	≤0.64
SB-12	—	—	0.09	91	0.007	186	0.02	≤0.14	≤0.09	5.1	—	≤0.32
SB-13	—	—	0.19	94	—	98	0.07	≤0.09	≤0.12	5.3	170	1.0
SB-14	4.0	—	0.09	360	0.034	* 1,110	—	—	≤0.02	—	* 369	—
SB-15	—	—	0.79	74	—	104	0.02	≤0.24	≤0.05	—	21.4	≤0.36
SB-16	—	0.04	0.75	59	—	75	0.02	0.45	≤0.07	≤0.75	73.4	≤0.64
SB-17	—	0.03	0.05	17	—	96	—	≤0.10	≤0.13	—	≤3.6	—
SB-18	—	—	0.42	55	0.006	269	—	≤0.33	≤0.08	4.4	9.6	1.1

Table 8. Trace elements detected in the samples collected for the Santa Barbara study unit, January to February 2011, 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. Information about the analytes given in table 3F. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Method detection level, benchmark type, and benchmark level as of February 4, 2011. **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. Secondary maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as MCL-US when the SMCL-CA does not exist. 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**: USGS, U.S. Geological Survey; LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; —, not detected; ≤, less than or equal to; *, value above benchmark level; NWIS, USGS National Water Information System]

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 (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]**	**[1] [0.36]**	**[0.006]**	**[3]**	**[0.016]**	**[1] [0.42]**	**[2] [0.22]**	**[1] [1.7]**	**[1] [6.0]**	**[1] [0.65]**
Santa Barbara understanding wells (6 wells sampled)												
SBU-01	—	—	0.39	33	—	58	—	—	≤0.05	—	* 413	≤0.19
SBU-02[3]	3.7	—	0.35	* 4,770	0.14	* 7,560	—	≤0.12	≤0.05	—	—	—
SBU-03	2.5	—	0.14	145	—	106	—	—	≤0.04	—	—	—
SBU-04	—	—	0.27	49	—	35	0.02	≤0.13	≤0.04	≤0.69	10.6	0.74
SBU-05	—	—	0.23	68	—	35	—	≤0.38	≤0.07	≤1.6	—	1.11
SBU-06	—	—	2.3	67	—	51	0.02	≤0.10	≤0.06	—	209	≤0.17

Table 8. Trace elements detected in the samples collected for the Santa Barbara study unit, January to February 2011, 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. Information about the analytes given in table 3F. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Method detection level, benchmark type, and benchmark level as of February 4, 2011. **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. Secondary maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as MCL-US when the SMCL-CA does not exist. 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**: USGS, U.S. Geological Survey; LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; —, not detected; ≤, less than or equal to; *, value above benchmark level; NWIS, USGS National Water Information System]

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	**na**	**50**	**40**	**100**	**50**	**100**	**4,000**	**2**	**na**	**30**	**50**	**5,000**
[LT-MDL] or [SRL]	**[0.22]**	**2 [0.47]**	**[0.014]**	**1 [0.36]**	**[0.03]**	**[0.005]**	**[0.2]**	**[0.010]**	**[1] [0.11]**	**[0.004]**	**[1] [0.10]**	**[1] [4.8]**
Santa Barbara grid wells (18 wells sampled)												
SB-01[3]	106	* 182	5.3	0.94	0.32	—	3,440	—	—	0.70	0.24	—
SB-02	25.5	* 245	3.7	2.6	0.08	—	1,410	—	0.11	14.4	0.61	≤3.4
SB-03	40.1	* 59.6	5.6	2.9	4.9	—	1,400	—	1.7	13.5	6.5	73.7
SB-04	18.3	26.2	4.6	1.1	24.5	—	904	—	0.18	3.37	2.0	5.2
SB-05	30.9	≤0.23	0.7	0.6	1.7	0.006	1,290	—	≤0.01	1.01	1.8	17.0
SB-06	70.7	7.6	1.3	1.0	1.5	—	1,300	—	≤0.08	8.13	0.40	—
SB-07	46.8	3.5	5.8	0.7	5.8	0.005	1,670	—	—	7.69	1.3	32.3
SB-08	41.8	43.5	1.4	0.6	3.2	—	574	—	—	0.62	1.1	≤1.6
SB-09	27.0	≤0.16	0.3	1.0	4.4	—	371	—	≤0.01	0.04	0.82	5.5
SB-10	30.1	* 190	0.4	4.4	0.20	—	688	—	≤0.02	0.20	1.2	11.4
SB-11	21.1	—	0.6	0.71	1.1	—	804	—	—	1.92	0.60	7.6
SB-12	21.9	—	0.3	1.1	0.77	0.008	1,410	—	≤0.03	1.32	0.51	≤4.4
SB-13	41.3	13.4	0.6	1.5	6.4	0.006	1,430	—	—	1.42	0.83	146
SB-14	100	* 103	0.4	≤0.22	—	0.005	1,580	—	1.4	0.04	0.23	—
SB-15	17.0	* 96	1.9	≤0.17	0.46	—	700	—	≤0.02	1.56	1.2	≤1.8
SB-16	13.5	* 249	0.9	1.2	2.5	—	733	—	—	2.91	0.85	14.2
SB-17	20.9	17.0	1.0	1.7	0.48	—	311	—	≤0.05	0.27	—	—
SB-18	35.3	18.8	3.0	1.8	4.6	—	1,350	—	≤0.02	12.2	1.7	60.7

Table 8. Trace elements detected in the samples collected for the Santa Barbara study unit, January to February 2011, 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. Information about the analytes given in table 3F. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Method detection level, benchmark type, and benchmark level as of February 4, 2011. **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. Secondary maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as MCL-US when the SMCL-CA does not exist. 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**: USGS, U.S. Geological Survey; LT-MDL, long-term method detection level; SRL, study reporting level; µg/L, micrograms per liter; —, not detected; ≤, less than or equal to; *, value above benchmark level; NWIS, USGS National Water Information System]

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	**na**	**50**	**40**	**100**	**50**	**100**	**4,000**	**2**	**na**	**30**	**50**	**5,000**
[LT-MDL] or [SRL]	**[0.22]**	**2 [0.47]**	**[0.014]**	**1 [0.36]**	**[0.03]**	**[0.005]**	**[0.2]**	**[0.010]**	**[1] [0.11]**	**[0.004]**	**[1] [0.10]**	**[1] [4.8]**
Santa Barbara understanding wells (6 wells sampled)												
SBU-01	16.2	* 63.4	1.0	1.3	0.03	—	1,090	—	≤0.02	0.03	≤0.08	5.8
SBU-02[3]	177	23.5	0.1	≤0.26	0.11	0.011	* 4,460	0.03	0.70	—	1.6	—
SBU-03	33.6	* 50	0.015	≤0.27	—	—	727	—	0.98	0.05	≤0.10	—
SBU-04	20.8	1.2	2.2	≤0.35	0.35	—	505	—	0.17	0.80	1.2	11.0
SBU-05	21.7	—	1.1	0.83	1.2	—	639	—	—	0.74	1.1	15.7
SBU-06	22.9	* 240	2.0	0.42	0.22	—	850	—	—	0.52	0.54	8.8

[1] SRL defined based on examination of GAMA quality-control samples collected from May 2004 through January 2008 (Olsen and others, 2010). Values less than 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.

[2] SRL defined as the highest concentration detected in field blanks collected for the Santa Barbara study unit. Values less than 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.

[3] For samples SB-01 and SBU-02, LT-MDLs reported by the NWQL raised by a factor of two due to dilution during analyses for all trace elements except iron.

Table 9. Nutrients detected in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[The five-digit U.S. Geological Survey parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about the analytes given in table 3G. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Long-term method detection level, benchmark type, and benchmark level as of February 4, 2011. **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; SRL, study unit reporting level; mg/L, milligrams per liter; na, not available; —, not detected]

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) (mg/L) (62854)[1]	Phosphate, orthophosphate (as phosphorus) (mg/L) (00671)
Benchmark type	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Benchmark level	**[2] 24.7**	**1**	**10**	**na**	**na**
[LT-MDL] or [SRL]	**[3] [0.013]**	**[0.0010]**	**[0.02]**	**[0.05]**	**[0.004]**
Santa Barbara grid wells (18 wells sampled)					
SB-01	2.98	0.0011	—	3.24	0.052
SB-02	0.533	—	—	0.57	0.123
SB-03	0.104	—	—	0.14	0.018
SB-04	—	0.0057	0.41	0.44	0.088
SB-05	—	0.0021	4.10	3.97	0.035
SB-06	0.496	—	—	0.51	0.068
SB-07	—	0.0011	4.29	4.42	0.063
SB-08	—	0.0029	1.62	1.61	0.093
SB-09	—	—	3.38	3.55	0.070
SB-10	—	0.0043	7.39	7.63	0.157
SB-11	—	—	1.86	1.84	0.028
SB-12	—	—	3.80	4.03	0.025
SB-13	—	0.0032	6.11	6.17	0.026
SB-14	0.063	—	—	0.06	0.052
SB-15	0.047	0.0017	1.80	1.84	0.050
SB-16	0.018	0.0045	7.10	7.35	0.051
SB-17	—	—	4.32	4.31	0.030
SB-18	—	0.0018	3.22	3.27	0.031
Santa Barbara understanding wells (6 wells sampled)					
SBU-01	0.115	—	—	0.12	0.047
SBU-02	0.746	—	—	0.80	0.027
SBU-03	0.079	—	—	0.08	0.067
SBU-04	—	—	0.18	0.17	0.065
SBU-05	0.019	—	7.75	7.78	0.105
SBU-06	0.083	0.0358	0.26	0.34	0.063

[1] Using the raw results, total nitrogen concentration was compared with the sum of ammonia concentration and nitrite plus nitrate concentration: for total nitrate concentration greater than 0.25 mg/L (5 times LT-MDL), relative standard deviation less than 10 percent indicates acceptable results; for total nitrate concentration less than or equal to 0.25 mg/L, standard deviation less than 0.025 mg/L (½ LT-MDL) indicates acceptable results. All nutrient results for the Santa Barbara study unit met the acceptablility criteria.

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

[3] SRL defined for ammonia as the highest concentration detected in field blanks collected for the Santa Barbara study unit. All detections of ammonia reported by the laboratory were greater than the SRL.

Table 10. Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[The five-digit U.S. Geological Survey parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about the analytes given in table 3H. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Laboratory reporting level, benchmark type, and benchmark level as of February 4, 2011. **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. Secondary maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as SMCL-US when the SMCL-CA does not exist. 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, minimum reporting level; mg/L, milligrams per liter; SiO_2, silicon dioxide; —, 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_2) (mg/L) (00955)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Residue on evaporation (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] or [MRL]	**[0.010]**	**[0.022]**	**[0.06]**	**[0.04]**	**[0.0010]**	**[0.008]**	**[0.022]**	**[0.029]**	**[0.06]**	**[0.09]**	**[12]**
Santa Barbara grid wells (18 wells sampled)											
SB-01	0.97	327	239	0.43	0.088	87.3	14.7	39.9	132	**795	**1,930
SB-02	0.25	128	64.3	0.42	0.029	36.7	4.13	33	89.6	*255	*850
SB-03	0.23	158	69.7	0.40	0.020	51.5	2.68	23.9	60.1	*360	*946
SB-04	0.10	95.9	33.3	0.41	0.021	36.7	3.38	18.4	49.5	231	*620
SB-05	0.92	191	*399	0.31	0.005	40.2	1.60	28.2	101	125	**1,150
SB-06	0.32	127	83.4	0.52	0.066	38.6	3.13	36.8	109	*285	*904
SB-07	0.86	175	*344	0.59	0.007	87.3	1.07	21.8	147	*265	**1,280
SB-08	0.11	78.7	38.3	0.26	0.007	25.3	1.33	41.5	53.1	154	*541
SB-09	0.25	41.6	73.6	0.34	0.004	14.2	0.92	53.7	55.4	64.1	344
SB-10	1.00	101	*314	0.55	0.030	39.1	1.78	36	174	134	**1,070
SB-11	0.22	115	81.9	1.05	0.002	32.8	0.88	28	71.0	196	*716
SB-12	0.16	162	122	0.36	0.003	49.5	0.88	26.9	77.9	*301	*960
SB-13	1.17	198	*453	0.73	0.020	76.9	1.55	32.3	133	*261	**1,390
SB-14	0.32	38.7	134	*2.37	0.057	1.49	1.48	14.6	199	26.9	*640
SB-15	0.11	87.0	31.7	0.36	0.022	24.4	1.37	26.7	58.7	111	*524
SB-16	0.37	110	57.3	0.34	0.015	29.5	1.19	22.3	50.3	139	*619
SB-17	0.25	156	108	0.49	0.003	60.1	1.83	21.9	95.0	*303	**1,020
SB-18	0.23	116	104	0.51	0.007	54.6	1.76	21.6	88.7	225	*853
Santa Barbara understanding wells (6 wells sampled)											
SBU-01	0.11	153	40.2	0.34	0.012	34.2	2.27	41.4	50.4	*265	*782
SBU-02	5.50	97.5	**1,440	1.47	2.82	26.5	7.43	27.5	813	32.2	**2,640
SBU-03	0.22	101	75.0	0.30	0.089	23.9	1.70	35.1	60.3	37.4	*552
SBU-04	0.05	71.4	20.2	0.30	—	20.4	1.31	36.2	40.2	94.8	425
SBU-05	0.29	96.8	92.9	0.47	0.001	29.8	1.34	38.2	42.0	118	*528
SBU-06	0.35	107	118	0.25	0.021	31.8	1.58	33.8	47.4	155	*622

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

Table 11. Arsenic, chromium, and iron species detected in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[Data in this table analyzed at U.S. Geological Survey (USGS) Trace Metals Laboratory using research methods. Information about the analytes given in table 3I. The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Method detection level, benchmark type, and benchmark level as of February 4, 2011. **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. Secondary maximum contaminant level benchmarks are listed as SMCL-CA when the SMCL-CA exists, and as the SMCL-US when the SMCL-CA does not exist. MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations**: MDL, method detection limit; na, not available; µg/L, micrograms per liter; —, not detected; *, greater than the benchmark level]

GAMA well identification number	Arsenic (µg/L) (99033)	Arsenic (III) (µg/L) (99034)	Chromium (µg/L) (01030)	Chromium (VI) (µg/L) (01032)	Iron (µg/L) (01046)	Iron (II) (µg/L) (01047)
Benchmark type	**MCL-US**	**na**	**MCL-CA**	**na**	**SMCL-CA**	**na**
Benchmark level	**10**	**na**	**50**	**na**	**300**	**na**
[MDL]	**[0.2]**	**[0.5]**	**[0.1]**	**[0.1]**	**[2]**	**[2]**
Santa Barbara grid wells (18 wells sampled)						
SB-01	—	—	0.2	—	*1,310	1,280
SB-02	1.8	1.3	0.1	0.1	*1,300	1,280
SB-03	1.3	0.7	0.2	0.2	293	266
SB-04	0.5	—	0.2	0.2	79	42
SB-05	0.3	—	1.7	1.5	6	—
SB-06	0.2	—	0.3	—	174	171
SB-07	0.2	—	0.8	0.7	120	80
SB-08	0.3	—	0.5	0.3	4	2
SB-09	—	—	0.9	0.7	—	—[1]
SB-10	0.2	—	1.6	0.2	4	—
SB-11	—	—	0.3	0.2	4	2
SB-12	—	—	2.0	0.2	2	—
SB-13	—	—	—	—	153	104
SB-14	—	—	—	0.2	*415	360
SB-15	0.8	—	0.7	0.6	22	11
SB-16	0.7	—	0.4	0.4	75	40
SB-17	—	—	0.2	0.2	3	—
SB-18	0.3	—	0.4	0.4	7	—
Santa Barbara understanding wells (6 wells sampled)						
SBU-01	0.3	—	0.3	0.3	*426	411
SBU-02	1.1	na[2]	0.9	0.5	4	4
SBU-03	1.3	na[2]	0.4	0.3	—	—[1]
SBU-04	0.2	—	0.4	0.2	—	—[1]
SBU-05	—	—	1.4	0.8	—	—[1]
SBU-06	1.9	0.7	0.3	—	192	185

[1] Iron (II) is not measured if iron (total) is a non-detection.

[2] Values censored by the laboratory due to suspected positive interference during analysis.

Table 12. Results for analyses of stable isotope ratios, tritium activity, and carbon-14 abundance detected in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[The five-digit U.S. Geological Survey parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about the analytes given in table 3J. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Measured values of tritium less than the sample-specific critical level (ssL$_C$) are reported as non-detections (—). **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Benchmark type and benchmark level as of February 4, 2011. **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. **Elements**: H, hydrogen; O, oxygen; C, carbon. **Other abbreviations**: CSU, 1-sigma combined standard uncertainty; ±, plus or minus; pCi/L, picocuries per liter; na, not available]

GAMA well identification number	δ^{2}H (per mil) (82082)	δ^{18}O (per mil) (82085)	δ^{13}C (per mil) (81081)	Carbon-14 (percent modern carbon) (49933)	Tritium (pCi/L) (07000)	
Benchmark type	**na**	**na**	**na**	**na**	**MCL-CA**	
Benchmark level	**na**	**na**	**na**	**na**	**20,000**	
					Result ± CSU	**ssL$_C$**
Santa Barbara grid wells (18 wells sampled)						
SB-01	–34.0	–5.74	–13.37	46.5	—	0.27
SB-02	–35.2	–5.87	–14.18	77.2	0.4 ± 0.31	0.31
SB-03	–36.4	–5.90	–12.79	82.2	1.64 ± 0.32	0.29
SB-04	–39.0	–6.14	–14.29	69.9	3.38 ± 0.35	0.3
SB-05	–34.9	–5.68	–14.66	82.3	1.37 ± 0.44	0.4
SB-06	–36.3	–5.98	–13.18	43.0	—	0.3
SB-07	–33.9	–5.67	–14.67	83.6	1.26 ± 0.41	na [1]
SB-08	–36.8	–6.10	–13.30	69.2	0.75 ± 0.3	0.3
SB-09	–35.2	–5.86	–18.20	86.3	1.31 ± 0.34	0.32
SB-10	–34.9	–5.55	–16.59	87.3	3.89 ± 0.44	0.39
SB-11	–36.0	–5.99	–14.40	96.2	4.59 ± 0.44	0.38
SB-12	–34.3	–5.59	–17.45	108	5.33 ± 0.43	0.34
SB-13	–34.1	–5.44	–15.11	76.4	1.24 ± 0.35	0.33
SB-14	–39.2	–6.21	–15.58	47.9	—	0.34
SB-15	–39.4	–6.30	–13.64	56.6	—	0.3
SB-16	–38.8	–6.23	–13.35	66.5	0.94 ± 0.28	0.27
SB-17	–34.8	–5.50	–14.60	92.4	5.01 ± 0.41	0.36
SB-18	–35.6	–5.66	–14.01	77.6	1.9 ± 0.39	0.35
Santa Barbara understanding wells (6 wells sampled)						
SBU-01	–36.5	–6.06	–12.78	71.6	—	0.3
SBU-02	–38.2	–5.79	–14.17	85.4	—	na [1]
SBU-03	–36.2	–6.06	–16.60	57.4	—	na [1]
SBU-04	–37.0	–6.25	–15.12	72.7	0.61 ± 0.38	na [1]
SBU-05	–36.8	–6.12	–10.44	33.9	—	na [1]
SBU-06	–37.3	–6.15	–13.81	84.8	1.01 ± 0.35	0.4

[1] Some ssL$_C$s were not reported by the laboratory in time for inclusion in this report. For these results, measured values of tritium less than the 1-sigma combined standard uncertainty (SBU-02: 0.41; SBU-03: 0.41; SBU-05: 0.38) were reported as non-detections.

Table 13A. Radon-222 detected in samples collected for the Santa Barbara study unit, January to February 2011, 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 22 wells were analyzed. Information about the analytes are given in table 3J. The reporting levels for radioactive constituents are given as sample-specific critical levels (ssL_C). **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Benchmark type and benchmark level as of February 4, 2011. **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 (USEPA) maximum contaminant level. **Other abbreviations**: CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; ±, plus or minus]

GAMA well identification number	Radon-222 (pCi/L) (82303)	
Benchmark type	**Proposed MCL-US**	
Benchmark level	**4,000**	
	Result ± CSU	**ssL_C**
Santa Barbara grid wells (16 wells sampled) [1]		
SB-01	139 ± 13	12
SB-03	840 ± 49	13
SB-04	274 ± 19	12
SB-05	1,150 ± 66	14
SB-07	860 ± 50	10
SB-08	1,070 ± 60	10
SB-09	1,500 ± 83	12
SB-10	760 ± 44	12
SB-11	1,080 ± 61	11
SB-12	1,990 ± 110	14
SB-13	1,460 ± 82	14
SB-14	520 ± 32	11
SB-15	390 ± 26	14
SB-16	330 ± 22	12
SB-17	1,180 ± 67	14
SB-18	660 ± 39	12
Santa Barbara understanding wells (6 wells sampled)		
SBU-01	212 ± 16	12
SBU-02	470 ± 30	14
SBU-03	840 ± 50	14
SBU-04	350 ± 23	12
SBU-05	630 ± 38	12
SBU-06	850 ± 49	12

[1] Sample-collection syringe broke before radon samples from SB-02 and SB-06 could be collected.

Table 13B. Gross alpha and gross beta radioactivity detected in samples collected for the Santa Barbara study unit, January to February 2011, 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. Information about the analytes given in table 3J. The reference nuclide for measurement of gross alpha radioactivity is thorium-230, and the reference nuclide for measurement of gross beta radioactivity is cesium-137. The reporting levels for radioactive constituents are given as sample-specific critical levels (ssL$_C$). Measured values less than the ssL$_C$ are reported as non-detections (—). **GAMA well identification number**: SB, Santa Barbara study unit grid well; SBU, Santa Barbara study unit understanding well. Benchmark type and benchmark level as of February 4, 2011. **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 (USEPA) maximum contaminant level. **Other abbreviations**: CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; ±, plus or minus]

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**	
	Result ± CSU	**ssL$_C$**	**Result ± CSU**	**ssL$_C$**	**Result ± CSU**	**ssL$_C$**	**Result ± CSU**	**ssL$_C$**
Santa Barbara grid wells (18 wells sampled)								
SB-01	3.6 ± 2.1	2.6	4 ± 2.4	3.2	15.7 ± 1.6	1.8	14.8 ± 1.2	1.1
SB-02	2.8 ± 1.2	1.4	3.8 ± 1.2	0.95	4.7 ± 0.75	1	4.1 ± 0.5	0.62
SB-03	11.5 ± 2.2	1.3	7.6 ± 1.7	1.2	3.37 ± 0.53	0.75	6.93 ± 0.75	0.86
SB-04	4 ± 1	0.77	1.65 ± 0.82	1	3.64 ± 0.43	0.51	4.52 ± 0.44	0.48
SB-05	[1] 1.9 ± 1.1	1.2	—	2	1.48 ± 0.66	1	1.5 ± 0.7	1.1
SB-06	3.1 ± 1.4	1.8	3.9 ± 1.3	1.2	2.93 ± 0.53	0.75	4.15 ± 0.78	1.1
SB-07	5.4 ± 2.3	2.8	—	2.2	1.0 ± 0.6	0.95	3.18 ± 0.72	1
SB-08	2.65 ± 0.85	0.85	0.86 ± 0.51	0.6	1.49 ± 0.51	0.76	2 ± 0.81	1.2
SB-09	1.12 ± 0.51	0.6	—	0.6	1.05 ± 0.42	0.68	1.06 ± 0.43	0.67
SB-10	—	1.8	—	1.7	2.04 ± 0.56	0.85	1.69 ± 0.81	1.2
SB-11	3.0 ± 1.2	1.4	—	1.1	1.28 ± 0.35	0.52	1.15 ± 0.31	0.46
SB-12	2.9 ± 1.3	1.6	1.6 ± 0.96	1.1	1.92 ± 0.51	0.78	1.81 ± 0.48	0.7
SB-13	6 ± 2	2	1.6 ± 1.2	1.5	3.35 ± 0.68	0.95	1.92 ± 0.56	0.85
SB-14	—	1.3	—	1	1.11 ± 0.43	0.67	2.07 ± 0.42	0.6
SB-15	3.03 ± 0.95	0.89	—	0.89	1.43 ± 0.39	0.59	1.72 ± 0.34	0.48
SB-16	4.9 ± 1.2	0.88	—	1.2	1.92 ± 0.37	0.52	2.2 ± 0.41	0.59
SB-17	7.3 ± 1.8	1.5	8 ± 2.2	2.2	1.91 ± 0.61	0.94	4.5 ± 0.7	0.98
SB-18	[1] 6.8 ± 1.7	1.6	8.4 ± 1.7	1.1	[1] 2.66 ± 0.49	0.69	4.23 ± 0.55	0.7
Santa Barbara understanding wells (6 wells sampled)								
SBU-01	2.6 ± 1.1	1.2	—	1.1	2.4 ± 0.4	0.55	2.13 ± 0.41	0.57
SBU-02	[1] 10.9 ± 4.2	4.72	—	6.39	9.4 ± 1.5	2.1	8.8 ± 1.5	2.1
SBU-03	[1] 3.1 ± 1.2	1.5	—	0.94	2.39 ± 0.36	0.49	1.72 ± 0.34	0.48
SBU-04	2.6 ± 0.7	0.64	—	0.87	1.16 ± 0.49	0.75	2.03 ± 0.51	0.75
SBU-05	1.67 ± 0.97	1.3	1.02 ± 0.71	0.93	1.48 ± 0.56	0.86	1.41 ± 0.56	0.85
SBU-06	—	0.85	—	0.97	1.24 ± 0.41	0.63	1.68 ± 0.56	0.82

[1] 72-hour holding time exceeded by 4 to 5 days from time of sample collection.

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 Santa Barbara study unit, groundwater samples were collected, and QA procedures were implemented by using standard and modified USGS protocols from the NAWQA Program (Koterba and others, 1995), the NFM (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

Wells were pumped continuously to purge at least three casing volumes of water from the well prior to sampling (Wilde and others, 1999). 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 well head as possible. The sampling point was located upstream from water-storage tanks and upstream from the well-head treatment system (if a system existed). If a chlorinating system was attached to the well, the chlorinator was shut off, when possible, before the well was purged and sampled, in order to clear all chlorine out of the system. The absence of free chlorine was verified by using a Hach® field test kit. All monitoring wells sampled for the Santa Barbara study unit were artesian wells, and special monitoring-well sampling equipment was not used. 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 that was attached to the sampling point and 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 NFM (Radtke and others, 2005; Wilde and Radtke, 2005; Lewis, 2006; Wilde, 2006; Wilde and others, 2006). All sensors on the multi-probe meter were calibrated daily. Measured dissolved oxygen, temperature, pH, and specific-conductance values were recorded at 5-minute (min) intervals, and when these values remained stable for a minimum of 30 min, samples for laboratory analyses then were collected.

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, whereas analytical service requests for non-NWQL analysis were entered into laboratory-specific spreadsheets. 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 three times using deionized water, and then once with native 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-sensitive or time-sensitive samples for VOCs, pesticides (including polar pesticides) and pesticide degradates, pharmaceutical compounds, perchlorate, NDMA, trace elements, nutrients, major and minor ions, silica, TDS, laboratory alkalinity, radon-222, and gross alpha and gross beta radioactivity were shipped daily whenever possible. Samples to be analyzed for arsenic, chromium, and iron species 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 laboratory alkalinity measurements were received. Isotopes of dissolved boron and strontium in water samples were stored at room temperature in the office until all groundwater samples were collected and results from the trace element analyses were obtained; a subset of samples was selected for analyses, based on total boron and strontium concentrations.

Detailed sampling protocols for individual analyses and groups of analytes are described in Koterba and others (1995), the NFM (Wilde and others, 1999, 2004), and in the references for analytical methods listed in table A1; only brief descriptions are given here. VOC samples were collected in three 40-milliliter (mL) sample vials that were purged with three vial volumes of unfiltered groundwater before bottom filling to eliminate atmospheric contamination. One to one (1:1) hydrochloric acid to water (HCl/H_2O) 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-micrometer (µm) pore-size Corning® syringe-tip disk filter into a sterilized 125-mL bottle. Tritium samples were collected by bottom filling one 1-liter (L) polyethylene bottle and one 1-L glass bottle with unfiltered groundwater, after first overfilling the bottles with three volumes of unfiltered groundwater. 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.

Samples for analysis of pesticides (including polar pesticides), pesticide degradates, and pharmaceutical compounds were collected in 1-L baked amber glass bottles. These samples were filtered through a 0.7-µm nominal pore-size glass fiber filter during collection. NDMA samples were collected in 500-mL baked amber glass bottles treated with 0.05 gram of sodium thiosulfate ($Na_2S_2O_3$) as a preservative and were filtered at Weck Laboratories, Inc., prior to analysis.

Groundwater samples for trace elements, major and minor ions, silica, laboratory alkalinity, 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 a 0.45-µm 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. Each 250-mL filtered sample then was preserved with 7.5-Normal (N) nitric acid. Nutrient samples were collected by filtering groundwater into 125-mL brown polyethylene bottles. Arsenic and iron species samples were filtered into 250-mL polyethylene bottles that were covered with tape to prevent light exposure, and samples were preserved with 6-N hydrochloric acid. Samples to be analyzed for isotopes of dissolved boron and strontium in water 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 gross alpha and gross beta particle activities were filtered into 1-L polyethylene bottles and acidified with 7.5-N 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 filtered groundwater. These samples had no headspace and were sealed with conical caps to avoid atmospheric contamination.

Chromium species samples were collected at the well head using a 10-mL syringe with an attached 0.45-µm pore-size MILLEX®HA disk filter. After the syringe was rinsed thoroughly and filled with groundwater, the first 4 mL of water were forced through the filter to waste (to condition the filter), and the next 2 mL were filtered slowly into a small centrifuge vial for analysis of total chromium. Hexavalent chromium then was collected by attaching a small cation-exchange column to the syringe filter and, after conditioning the column with 2 mL of sample water, an additional 2 mL of sample water was collected in a second centrifuge vial. Both vials were preserved with 10 microliters (µL) of 7.5-N nitric acid (Ball and McCleskey, 2003a, b).

For the collection of radon-222 samples, a stainless-steel and Teflon® valve assembly was attached to the sampling port at the well head (Wilde and others, 2004). The valve was closed partially to create back pressure, and a 10-mL groundwater sample was taken through a Teflon® septum on the valve assembly by 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 (mineral oil and 1,2,4-trimethylbenzene) and shaken. The vial then was placed in an insulated cardboard tube to protect the sample during shipping.

Dissolved noble gases were collected in ⅜-inch-diameter copper tubes using reinforced nylon tubing connected to the hose bib at the well head. 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).

Field alkalinity was measured in the mobile laboratory at the well site. Samples for field alkalinity titrations were collected by filtering groundwater into a 500-mL polyethylene bottle. 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 (HCO_3^-) and carbonate (CO_3^{2-}) automatically were calculated from the titration data using the advanced speciation method (http://or.water.usgs.gov/alk/methods.html) with $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_W = 14$. Concentrations of HCO_3^- and CO_3^{2-} also were calculated from the laboratory alkalinity and laboratory pH measurements.

Nine laboratories performed chemical 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 updated accordingly. The NWQL maintains National Environmental Laboratory Accreditation Program (NELAP) and other certifications (http://www.nelac-institute.org/accred-labs.php). 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 (NFQA) that includes annual testing of all USGS field personnel for proficiency in making field water-quality measurements (http://qadata.cr.usgs.gov/nfqa/). Results for analyses made at the NWQL or by laboratories contracted by the NWQL are uploaded directly into the USGS NWIS database. Results of analyses made at other laboratories are compiled in a project database and uploaded from there into NWIS.

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, 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 limit (MDL) determinations made over an extended period of time. The MDL is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the concentration is greater than zero (at the MDL there is less than 1 percent chance of a false positive) (Childress and others, 1999; U.S. Environmental Protection Agency, 2002). Concentrations less than the LT-MDL are reported as non-detections with a dash (–) in the data tables.

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 Santa Barbara study unit (January to February 2011).

For organic constituents, concentrations between the LRL and the LT-MDL are reported as having a higher degree of uncertainty (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 presence, 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 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).

For reporting detections of pharmaceutical compounds, GAMA uses more conservative reporting limits than are used by the NWQL. The MDL for each compound was selected as the maximum of up to five LT-MDLs used by the laboratory during the time period May 2004 through March 2010 (table 3D). Detections reported by the NWQL with concentrations less than the selected MDLs are reported as less than the MDL and are not considered detections when calculating detection frequencies (Fram and Belitz, 2011).

For most inorganic constituents, the LT-MDL is the only threshold used by the NWQL for reporting analytical results. All non-detections for inorganics constituents are reported in the NWIS database as less than the LT-MDL (except for non-detections of bromide, which are reported as less than the MDL); E-codes are not used to designate results with concentrations less than LRLs or LT-MDLs.

Total dissolved solids, perchlorate, and NDMA are reported by using minimum reporting levels (MRLs). The MRL is the smallest measurable concentration of a constituent that may be reliably reported using a given analytical method (Timme, 1995).

Isotopes of hydrogen, oxygen, carbon, boron, and strontium are reported using method uncertainties (MUs). 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 reporting limits for radiochemical constituents (carbon-14, tritium, radon-222, and gross alpha and gross beta radioactivity) 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 with a dash (–) in the data tables.

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 (CSUs). The CSU is reported at the 68-percent confidence level (1-sigma). The

ssL_C was not reported by the laboratory for some tritium results, in which case the CSU was used as an estimated reporting level.

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):

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

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_{sample} is the ratio of the abundance of the heavier isotope of the element (^{2}H, ^{18}O, ^{11}B, ^{13}C) to the lighter isotope of the element (^{1}H, ^{16}O, ^{10}B, ^{12}C) in the sample, and

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

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned δ^{18}O and δ^{2}H values of 0 per mil (note that δ^{2}H is sometimes written as δD because the common name of the heavier isotope of hydrogen, hydrogen-2, is deuterium) (Coplen and others, 2002). The reference material for carbon is Vienna Pee Dee Belemnite (VPDB), which is assigned a δ^{13}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 presented as the abundance of atoms of the heavier isotope (^{87}Sr) to the lighter isotope (^{86}Sr) of the element.

Constituents on Multiple Analytical Schedules

Thirteen constituents targeted in this study were measured by more than one analytical method or by more than one laboratory (table A2). Preferred analytical methods generally were selected on the basis of better performance or sensitivity for the constituent, or (in some cases) to provide consistency with historical data from the same method. Six organic constituents (atrazine, deethylatrazine, tebuthiuron, caffeine, metalaxyl, and carbaryl; table 3) each were analyzed by two analytical methods for the Santa Barbara study unit; however, none of the six constituents were detected by either method.

The field water-quality indicators alkalinity, pH, and specific conductance were measured in the field and at the NWQL (table 4). Field measurements are generally preferred because they are considered more representative of groundwater conditions by limiting the amount of time for reactions in the water and exposure to the atmosphere to occur (Hem, 1985). Field values of pH and specific conductance were measured at each Santa Barbara well. Due to time constraints, field alkalinities were measured at 12 percent of the wells in order to confirm that differences between lab and field alkalinity values are negligible for the purpose of this study.

For total arsenic, chromium, and iron concentrations, the approved method used by the NWQL, Schedule 1948 (table 3F), is preferred over the research methods used by the USGS Trace Metal Laboratory (table 3I).The concentrations measured by the USGS Trace Metal Laboratory only are used to calculate ratios of redox species for arsenic, chromium, and iron.

For example,

$$\frac{\text{Cr(III)}}{\text{Cr(VI)}} = \frac{\text{Cr(T) - Cr(VI)}}{\text{Cr(VI)}}, \qquad (2)$$

where

Cr(T) is the total chromium concentration (measured);

Cr(VI) is the concentration of hexavalent chromium (measured); and

Cr(III) is the concentration of trivalent chromium (calculated).

Additionally, tritium was measured at two laboratories: LLNL and USGS Stable Isotope and Tritium Laboratory (SITL), although only tritium data from the SITL were available for reporting at the time of this publication.

Quality-Control Methods and Results

The purpose of QC is to identify which data best represent environmental conditions and which may have been affected by contamination or bias during sample collection, processing, storage, transportation, and (or) laboratory analysis. Four types of QC tests were evaluated 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 potential 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 handling or analysis and to identify and mitigate the sources of sample contamination. Results from blanks collected for the Santa Barbara 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

Blanks were collected using blank water certified by the NWQL to contain less than the reporting levels for selected constituents investigated in the study (James A. Lewis, National Water Quality Laboratory, written commun., 2012). Nitrogen-purged, organic-free blank water was used for blanks of organic constituents, and inorganic-free blank water was used for blanks of other constituents.

Source-solution blanks are collected at the beginning of a study or when using a new lot of blank water to assess potential contamination of samples during transport and analysis and potential contamination of the certified blank water obtained from the NWQL. Source-solution blanks were collected in the USGS San Diego Projects Office laboratory by pouring blank water directly into sample containers that were preserved, stored, shipped, and analyzed in the same manner as the groundwater samples. Source-solution blanks were analyzed for VOCs, perchlorate, pharmaceutical compounds, NDMA, perchlorate, trace elements, major and minor ions, silica, and TDS. Three additional source-solution blanks were collected at sampling sites for perchlorate analysis.

Field blanks were collected to assess potential contamination of samples during collection, processing, transport, and analysis. To collect field blanks at the sampling sites, blank water was either 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. Field blanks were analyzed for VOCs, pesticides (including polar pesticides) and pesticide degradates, pharmaceutical compounds, NDMA, perchlorate, trace elements, nutrients, major and minor ions, silica, TDS, and arsenic, chromium, and iron species.

Field or source-solution blanks were not collected for gross alpha and gross beta radioactivity or radon because the laboratory determines an 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, in other words, an amount of the radionuclide that is statistically significantly greater than the amount in a blank. Blanks were not collected for tritium and dissolved noble gases. Tritium and dissolved noble gases are 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.

Study Reporting Levels (SRLs)

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 5.

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 ≤ symbol preceding the reported value in table 8 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 other classes of constituents detected in field blanks collected for the Santa Barbara study unit were defined as equal to the highest concentration measured in the field blanks.

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 Santa Barbara study unit. Three field blanks (representing approximately 12 percent of the sampled sites) were collected in the Santa Barbara study unit. No constituents were detected in the source-solution blanks collected during the Santa Barbara study.

VOCs were not detected in the field blanks for the Santa Barbara study unit (table A3). Of the 10 VOCs with SRLs defined by Fram and others (2012), only two were detected in groundwater samples from the Santa Barbara study unit: 1,2,4-trimethylbenzene and chloroform. All four detections for 1,2,4-trimethylbenzene had concentrations less than the SRL of 0.56 µg/L and were thus reclassified as non-detections in the Santa Barbara study unit dataset (table 5). For the GAMA-PBP, concentrations of 1,2,4-trimethylbenzene in blanks and groundwater samples less than 0.56 µg/L were found to be correlated with the presence of equipment used for collecting radon samples in field vehicles (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 22 sites in the Santa Barbara study unit.

The SRL of 0.20 µg/L for chloroform was defined by Fram and others (2012) for monitoring wells that require special sampling equipment. The length and complexity of the lines used with the equipment, such as the Grunfos® submersible pump, are much greater than for the long and short lines sampling configurations. However, the monitoring wells sampled for the Santa Barbara study unit were artesian (groundwater under positive pressure) and were sampled with short lines similar to those used for the other 20 wells. Therefore, the SRL was not applied to any chloroform detections in the Santa Barbara study unit dataset.

The application and concentration of an SRL for each trace element were determined primarily by Olsen and others (2010) based on a statistical assessment of quality-control results from 2004 to 2008. GAMA SRLs from Olsen and others (2010) were used for barium, chromium, copper, iron, lead, nickel, tungsten, vanadium, and zinc for the Santa Barbara study unit (table A3). Of these trace elements, four were detected in at least one Santa Barbara field blank: copper, iron, lead, and zinc. Field blank detections were at concentrations below the SRL for each constituent, with the exception of one iron detection (7.2 µg/L) and one lead detection (0.87 µg/L).

For the trace elements cobalt and manganese, the concentrations and detection frequencies in field blanks collected for the Santa Barbara study unit suggest that the dataset of field blanks used by Olsen and others (2010) may not be representative of conditions encountered during collection of samples in the Santa Barbara study unit. Cobalt was detected in all three field blanks at concentrations ranging from 0.05 to 0.22 µg/L; manganese was detected at concentrations ranging from 0.24 to 0.47 µg/L (table A3). SRLs for cobalt and manganese were defined based on these results, at 0.22 µg/L and 0.47 µg/L, respectively. Measured concentrations in groundwater samples that were less than the SRLs were flagged with a ≤ symbol in table 8.

Olsen and others (2010) also assigned an SRL of 1.6 µg/L for aluminum; however, the NWQL has since raised the detection level to 1.7 µg/L based on laboratory performance. (See the appendix section titled "Other Quality-Control Results" for analysis of BQS data for aluminum.) No SRL was defined for aluminum for the Santa Barbara study unit.

Ammonia was detected in one field blank at a concentration of 0.013 mg/L (table A3). This concentration was used as the SRL for ammonia for the Santa Barbara study unit dataset. The SRL resulted in the censoring of no detections because there were no measured concentrations of ammonia less than 0.013 mg/L in the groundwater samples (table 9).

Constituents were not detected in field blanks for the following analyte groups: pesticides (including polar pesticides) and pesticide degradates; pharmaceutical compounds; perchlorate; NDMA; major and minor ions, silica, and TDS; and arsenic, chromium, and iron species.

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, 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 ≥ 5 RL for the constituent. Acceptable precision is defined as an SD of less than ½ 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 ≤-coded value (less than or equal to the SRL), or if both values were reported as ≤-coded values (less than or equal to the SRL), the SD was not calculated because the values may be analytically identical. The ≤ code indicates that the value is a maximum potential concentration, and that concentration may be low enough to be reported as a 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) to calculate the normalized absolute difference, *NAD*:

$$NAD = \frac{|R_1 - R_2|}{\sqrt{(CSU_1^2 + CSU_2^2)}}, \qquad (3)$$

where

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

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

Values of *NAD* < 1.65 correspond to a significance levels (α) of 5 percent ($\alpha = 0.05$), indicating differences that are acceptably small and not statistically significant.

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 Santa Barbara study unit. Replicate analyses were made at three sites, representing approximately 12 percent of all of the samples collected.

Of the 854 replicate pairs of constituents analyzed, 198 pairs had a detection in one or both samples of the pair. Of these 198 pairs, 8 pairs (simazine, iron, total chromium [three pairs], chromium [VI], iron [II], and gross alpha radioactivity [30-day count]) were outside the limits for acceptable precision. Results for replicate analyses for constituents that were not detected in groundwater samples are not reported in tables A4A–C.

All replicate pairs of samples analyzed for VOCs were within limits for acceptable precision. One VOC replicate pair had non-detections with different LRLs for two constituents (carbon disulfide and *trans*-1,4-dichloro-2-butene) due to interference caused by high levels of sulfur in a previous sample set at the NWQL.

Replicate pairs of samples were analyzed for 120 pesticides (including polar pesticides) and pesticide degradates and 13 pharmaceutical compounds. All pairs of samples analyzed were composed of non-detections with the exception of one replicate pair of simazine. The replicate pair consisted of a non-detection (<0.006 µg/L) and a value above the LRL (0.007 µg/L), yielding variability considered unacceptable (table A4A).

Three replicate pairs of samples were analyzed for the 24 trace elements. Of the 72 replicate pairs, 17 were composed of either two values reported as non-detections, a value reported as a non-detection and a value reported as less than or equal to the SRL, or two values reported as less than or equal to the SRL. Of the remaining 55 pairs of constituents, the SD value was greater than half of the LT-MDL for iron (10.6 µg/L and —) for one replicate pair (table A4B).

Replicate pairs analyzed for nutrients, major ions, TDS, and isotope tracers resulted in SD and RSD values within acceptable precision. Three replicate sets of samples were analyzed for arsenic, chromium, and iron species. Twelve pairs were composed of non-detections and (or) were within the acceptable range of precision, and 5 pairs (total chromium [3 pairs], chromium [VI], and iron [II]) had RSD or SD values outside the limits for acceptable precision (table A4B).

Replicate pairs of radioactive constituents were analyzed for variability, including one radon pair with a sample volume discrepancy caused during sample collection. Most pairs yielded statistically similar results ($p \leq 0.05$) and were, therefore, considered acceptable. The exception was one gross alpha radioactivity (30-day count) pair that was considered unacceptable ($p > 0.05$) (table A4C).

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 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 analyzed in the environmental samples. 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 rather than in the field. Low matrix-spike recovery may indicate that the compound might not be detected in some samples if it were 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 as having unacceptable recoveries. For some 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 analyses, acceptable set-spike recovery is within ± 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, pesticides (including polar pesticides), pesticide degradates, pharmaceutical compounds, and NDMA because the analytical methods for these constituents may be susceptible to matrix interferences.

Matrix-Spike Recoveries

Tables A5A–E present a summary of matrix-spike recoveries for the Santa Barbara study unit. Replicate samples for spike additions of organic constituents were collected at three sites, representing approximately 12 percent of all the wells sampled.

Groundwater samples were spiked with 85 VOCs to calculate matrix-spike recoveries. Median matrix-spike recoveries were between 70 and 130 percent for all VOCs, except for one constituent detected in groundwater samples: dichlorodifluoromethane (CFC-12). This compound had two matrix spike recoveries less than 70 percent (table A5A).

Groundwater samples were spiked with 63 pesticides and pesticide degradates to calculate matrix-spike recoveries. Twenty compounds had median matrix-spike recoveries less than 70 percent, none of which were detected in groundwater samples (table A5B).

Groundwater samples were spiked with 56 polar pesticides and degradates to calculate matrix-spike recoveries. Ten compounds had median matrix-spike recoveries less than 70 percent, and 6 had recoveries greater than 130 percent, none of which were detected in groundwater samples (table A5C). Results for the compounds included in spiking solutions for both pesticide schedules are reported for the preferred method only (NWQL Schedule 2003, table A5B) and were omitted from table A5C.

Groundwater samples were spiked with 14 pharmaceutical compounds to calculate matrix-spike recoveries. Four compounds had median matrix-spike recoveries less than 70 percent, none of which were detected in groundwater samples (table A5D). Results for the compounds included in spiking solutions of multiple analytical schedules are reported for the preferred method only (NWQL Schedule 2060, table A5C) and were omitted from table A5D. All three matrix-spike recoveries for NDMA were within the acceptable range of 70 to 130 percent (table A5D).

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 by the NWQL for VOCs, pesticides (including polar pesticides), and pesticide degradates. Surrogates are used to identify general problems that may arise during laboratory sample analysis that could affect the 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 presents a summary of the surrogate recoveries for the Santa Barbara study unit. The table lists the surrogates, the analytical schedule for which each surrogate was used, the number of analyses for field blanks 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. Field blanks and environmental samples were considered separately to assess whether or not the matrixes present in environmental samples affect surrogate recoveries.

Most surrogate recoveries for the field blanks and environmental samples were within the acceptable range of 70 to 130 percent. For VOC analyses, 100 percent of the field blank and 99 percent of the environmental sample surrogate recoveries were within the acceptable range. For pesticides and pesticide degradates, 100 percent of the field blank and

98 percent of the environmental sample surrogate recoveries were within the acceptable range. For polar pesticides and degradates, 89 percent of the blank and 90 percent of the environmental sample surrogate recoveries were within the acceptable range. For pharmaceutical compounds, 100 percent of the blank and 92 percent of the environmental sample surrogate recoveries were within the acceptable range (table A6). There were no significant differences between surrogate recoveries in field blanks 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

Two other laboratory QC issues arose during the analysis of samples collected for the Santa Barbara study unit: the effect of holding-time violations on the results of radioactive constituent data and the effect of internal laboratory QC tests indicating bias on the results of trace element data.

Holding time refers to the time in calendar days from sample collection to the analysis of the sample. A holding-time violation occurs when a sample is analyzed past the given holding time for a particular analysis. Analyses for some samples in the Santa Barbara study unit were completed after the given holding time due to a scheduling error at the laboratory or a shipping error. A delay in the analysis at the laboratory may result in different measured activities or concentrations than what may have been present in the sample.

NDMA has a holding time of 7 days to minimize the risk of the compound degrading prior to analysis. One groundwater sample and the associated field blank for NDMA analysis (table 3E) exceeded this holding time due to a shipping error. NDMA was not detected in this sample, but if the sample had been analyzed on time, NDMA may have been detected at very low concentrations.

The gross alpha and beta radioactivity reported result is the amount measured in the sample. Radioactive decay occurs between the time of sample collection and measurement; therefore, gross alpha and gross beta radioactivity can change with time. At least one result from the analysis of gross alpha and beta radioactivity (72-hour counts) was analyzed past the holding time in each of five groundwater and quality-control samples. The results for these five samples are footnoted in tables 13B or A4C. Gross alpha radioactivity (72-hour) may be lower and gross beta radioactivity (72-hour) may be lower or higher in samples analyzed past the holding time than they would have been if analyzed on time. One of the Santa Barbara study unit samples had a gross alpha radioactivity result near the benchmark and was analyzed 5 days past the collection time.

Laboratory bias as indicated from internal laboratory QC tests is another issue that must be investigated to determine whether or not the data are affected. The BQS operates independent, external quality-assurance projects called the Inorganic Blind Sample Project (IBSP) and Blind Blank Program (BBP) to monitor and evaluate the quality of results for analyses of trace elements, nutrients, major and minor ions, silica, and TDS 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 BBP samples are disguised as regular blank samples. The BQS uses results from the IBSP and BBP samples to evaluate potential bias in the results reported by the NWQL on a continuous basis. The BQS data are readily available on the BQS website, and the BQS issues summaries of the results, reporting the amount of bias (if any) observed in the results (U.S. Geological Survey, 2011c, d, website at http://bqs.usgs.gov/ibsp/).

The April 2011 BQS summary, which includes a review of data for the time period September 1, 2010, through March 31, 2011, was examined. The BQS reported that three inorganic constituents showed evidence of bias during this period: a positive bias for aluminum in blind blanks, a positive bias for zinc in blind non-blanks, and a negative bias for uranium. Examination of the results for the IBSP samples for these three constituents indicated that the analytical biases reported by the BQS were not significant for the data collected for the Santa Barbara study unit.

During the time which samples for the Santa Barbara study unit were analyzed (January through March 2011), 1 of the 15 blind blanks analyzed (6.7 percent) was measured at a concentration greater than the LT-MDL: 2.74 µg/L. Additionally, two of the three replicate pairs for aluminum collected for the Santa Barbara study unit were re-analyzed by the NWQL due to disagreement between the environmental and replicate samples. The samples, which initially had reported values for aluminum ranging from non-detection to 22.1 µg/L, were all adjusted by the lab to non-detections upon re-analysis.

The BBP and replicate data demonstrated variability for aluminum at low concentrations; however, the IBSP data indicate that the variability is not significant for this particular study. The IBSP non-blank samples for aluminum, analyzed January through March 2011, had concentrations ranging from 33.8 µg/L to 144 µg/L. The average difference between the measured and expected concentrations was –0.5 µg/L (standard deviation = 3 µg/L). The maximum concentration of aluminum for the Santa Barbara study unit was 5.2 µg/L (table 8), and a difference of 0.5 µg/L does not affect assessment of whether groundwater samples in the Santa Barbara study unit have aluminum concentrations greater than or less than the MCL-CA concentration (1,000 µg/L) or greater than or less than one-half of the MCL-CA concentration.

The IBSP non-blank blind samples for zinc had concentrations ranging from 9 µg/L to 840 µg/L, with positive bias demonstrated primarily at the high end due to instruments set to achieve lower detection levels. The average difference between the measured and expected concentrations was 37 µg/L (standard deviation = 36 µg/L), and the average relative percent difference between the measured and expected concentrations was 7 percent (standard deviation = 5 percent). The maximum concentration of zinc in samples for the Santa Barbara study unit is 73.7 µg/L, a value less than 1/10 of the concentrations showing most bias (800 µg/L or above), and much lower than the SMCL-CA for zinc (5,000 µg/L). Thus, the estimate of bias from the ISBP samples would not be relevant for assessment of whether groundwater samples have zinc concentrations greater than or less than the SMCL-CA concentration or greater than or less than one-half of the SMCL-CA concentration.

The negative bias for uranium demonstrated by IBSP samples started in December 2010; however, results were within acceptable bias and variability during the time period Santa Barbara study unit samples were analyzed. The IBSP samples for uranium (January through March 2011) had concentrations ranging from 0.28 to 1.4 µg/L. The average difference between measured and expected concentrations was –0.03 µg/L (standard deviation = 0.04 µg/L), and the average relative percent difference between the measured and expected concentrations was –4 percent (standard deviation = 5 percent). However, the maximum concentration of uranium in samples from the Santa Barbara study unit was 14.4 µg/L; thus, a potential negative bias of 0.6 µg/L, or 4 percent, does not affect assessment of whether groundwater samples in the Santa Barbara study unit have uranium concentrations greater than or less than the MCL-US of 30 µg/L. Moreover, the bias observed in the IBSP samples was the highest at concentrations close to the LT-MDL and does not imply that there is equivalent bias at higher concentrations.

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 contract laboratories.

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS NWQL are given in parentheses after the laboratory names.
Abbreviations: UV-VIS, ultraviolet-visible; VOC, volatile organic compound; USEPA, U.S. Environmental Protection Agency; δ, delta notation, the ratio of a heavier isotope of an element (^{i}E) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil; H, hydrogen; O, oxygen; B, boron; Sr, strontium; C, carbon; NRP, National Research Program]

Analyte	Analytical method	Laboratory and analytical schedule	Citation(s)
Water-quality indicators			
Field parameters	Calibrated field meters and test kits	USGS field measurement	U.S. Geological Survey, variously dated
Organic constituents			
VOCs	Purge and trap capillary gas chromatography/mass spectrometry	NWQL, Schedule 2020	Connor and others, 1998
Pesticides and degradates	Solid-phase extraction and gas chromatography/mass spectrometry	NWQL, Schedule 2003	Zaugg and others, 1995; Lindley and others, 1996; Sandstrom and others, 2001; Madsen and others, 2003
Polar pesticides and degradates	Solid-phase extraction and high-performance liquid chromatography (HPLC)/mass spectrometry with selective-ion monitoring	NWQL, Schedule 2060	Furlong and others, 2001
Pharmaceuticals	Solid-phase extraction and HPLC/mass spectrometry	NWQL, Schedule 2080	Kolpin and others, 2002; Furlong and others, 2008
Constituents of special interest			
Perchlorate	Liquid chromatography with mass spectrometry/mass spectrometry (USEPA Method 331.0)	Weck Laboratories, Inc., City of Industry, California, standard operating procedure ORG099.R01	U.S. Environmental Protection Agency, 2005
N-Nitrosodimethylamine (NDMA)	Isotopic dilution with gas chromatography and chemical-ionization mass spectrometry (USEPA Method 1625 *modified*)	Weck Laboratories, Inc., City of Industry, California, standard operating procedure ORG065.R10	U.S. Environmental Protection Agency, 1989; Plomley and others, 1994
Inorganic constituents			
Nutrients	Alkaline persulfate digestion, Kjedahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
Major and minor ions, trace elements	Atomic absorption spectrometry, colorimetry, ion-exchange chromatography, inductively-coupled plasma atomic-emission spectrometry and mass spectrometry	NWQL, Schedule 1948	Fishman and Friedman, 1989; Faires, 1993; Fishman, 1993; McLain, 1993; Garbarino, 1999; American Public Health Association, 1998; Garbarino and others, 2006
Arsenic, chromium, and iron species	Various techniques of ultraviolet visible (UV-VIS) spectrophotometry and atomic-absorbance spectroscopy	USGS Trace Metal Laboratory, Boulder, Colorado (USGSTMCO)	Stookey, 1970; To and others, 1998; Ball and McCleskey, 2003a, b; McCleskey and others, 2003

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

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS NWQL are given in parentheses after the laboratory names.
Abbreviations: UV-VIS, ultraviolet-visible; VOC, volatile organic compound; USEPA, U.S. Environmental Protection Agency; δ, delta notation, the ratio of a heavier isotope of an element (^{i}E) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil; H, hydrogen; O, oxygen; B, boron; Sr, strontium; C, carbon; NRP, National Research Program]

Analyte	Analytical method	Laboratory and analytical schedule	Citation(s)
Isotopes			
Stable isotopes of hydrogen ($\delta^{2}H$) and oxygen ($\delta^{18}O$) 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
$\delta^{13}C$ 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), Woods Hole, Massachusetts (MA-WHAMS), 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
$\delta^{11}B$ of boron dissolved in water	Negative thermal-ionization mass spectrometry	USGS NRP Metals Isotope Research Laboratory, Menlo Park, California (USGSMICA)	Vengosh and others, 1989; Dwyer and Vengosh, 2008
$^{87}Sr/^{86}Sr$ of strontium dissolved in water	Chemical separations of thermal-ionization mass spectrometry	USGS NRP Metals Isotope Research Laboratory, Menlo Park, California (USGSMICA)	Bullen and others, 1996
Radioactive constituents and noble gases			
Tritium	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA)	Thatcher and others, 1977
Tritium and dissolved noble gases	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory, Livermore, California (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
Gross alpha and gross beta radioactivity	Alpha and beta activity counting (USEPA Method 900.0)	Eberline Analytical Services, Richmond, California (CA-EBERL), NWQL Schedule 1792	Krieger and Whittaker, 1980

Table A2. Preferred analytical schedules for selected constituents collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[Preferred analytical schedules/methods are selected on the basis of the procedure recommended by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) (http://wwwnwql.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, Livermore, California; SITL, U.S. Geological Survey Stable Isotope and Tritium Laboratory, Reston, Virginia; np, no preference]

Constituent	Primary constituent classification	Analytical schedules	Preferred analytical schedule
Results from preferred method reported			
Atrazine	Pesticide	2003, 2060	2003
Caffeine	Wastewater indicator	2060, 2080	2060
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	Pesticide degradate	2003, 2060	2003
Tebuthiuron	Pesticide	2003, 2060	2003
Results from both methods reported			
Alkalinity	Water-quality indicator	field, 1948	field
Arsenic, total	Trace element	1948, TML	1948
Carbaryl	Pesticide	2003, 2060	np
Chromium, total	Trace element	1948, TML	1948
Iron, total	Trace element	1948, TML	1948
Metalaxyl	Pesticide	2003, 2060	np
pH	Water-quality indicator	field, 1948	field
Specific conductance	Water-quality indicator	field, 1948	field
Tritium	Inorganic tracer	LLNL, SITL	np

Table A3. Constituents detected in field blanks and study reporting level (SRL) analyses for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[**Sources of study reporting level (SRL)**: Each SRL was selected using one of the three approaches: (1) an analysis of quality-control data from May 2004 through September 2010 for volatile organic compounds (Fram and others, 2012), (2) an analysis of quality-control data from May 2004 through January 2008 for trace elements (Olsen and others, 2010), or (3) the maximum concentration observed in the field blanks collected for the Santa Barbara study unit. **Abbreviations**: ≤, less than or equal to; µg/L, micrograms per liter; mg/L, milligrams per liter; —, not detected]

Constituent	Number of field blank detections/ total number of field blanks	Concentrations detected in field blanks	SRL concentration	Source of SRL	Number of groundwater detections ≤-coded
Volatile organic compounds (VOCs) (µg/L)					
1,2,4-trimethylbenzene	0/3	—	0.56	Fram and others, 2012	4
Trace elements (µg/L)					
Barium	0/3	—	0.36	Olsen and others, 2010	0
Chromium	0/3	—	0.42	Olsen and others, 2010	16
Cobalt	3/3	0.17, 0.05, 0.22	0.22	Santa Barbara field blanks	20
Copper	2/3	1.0, 1.2	1.7	Olsen and others, 2010	7
Iron	1/3	7.2	6.0	Olsen and others, 2010	4
Lead	3/3	0.87, 0.02, 0.06	0.65	Olsen and others, 2010	12
Manganese	3/3	0.31, 0.24, 0.47	0.47	Santa Barbara field blanks	2
Nickel	0/3	—	0.36	Olsen and others, 2010	5
Tungsten	0/3	—	0.11	Olsen and others, 2010	9
Vanadium	0/3	—	0.10	Olsen and others, 2010	2
Zinc	2/5	3.3, 4.2	4.8	Olsen and others, 2010	4
Nutrients (mg/L)					
Ammonia, as nitrogen	1/3	0.013	0.013	Santa Barbara field blanks	0

Table A4A. Quality-control summary for replicate analyses of organic constituents and perchlorate detected in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[**Abbreviations**: SD, percent standard deviation; RSD, percent relative standard deviation; ≤, less than or equal to; RL, reporting level; nv, no value in category; —, not detected]

Constituent	Number of non-detects/ number of replicates	Number of ≤-coded replicates	Number of SDs greater than ½ RL / number of replicates with concentration less than 5 times the RL	Concentrations of replicates with SDs greater than ½ RL (environmental, replicate)	Number of RSDs greater than 10 percent/number of replicates with concentration greater than 5 times the RL	Concentrations of replicates with RSDs greater than 10 percent (environmental, replicate)
Volatile organic compounds (VOCs) (µg/L)						
Chloroform (Trichloromethane)	1/3	nv	0/1	nv	0/1	nv
Bromodichloromethane	2/3	nv	0/1	nv	nv	nv
1,1,1-Trichloroethane	3/3	nv	nv	nv	nv	nv
1,1-Dichloroethane	3/3	nv	nv	nv	nv	nv
Perchloroethene	3/3	nv	nv	nv	nv	nv
Methyl *tert*-butyl ether	3/3	nv	nv	nv	nv	nv
Trichlorotrifluoroethane (CFC-113)	3/3	nv	nv	nv	nv	nv
1,2-Dichloroethane	3/3	nv	nv	nv	nv	nv
Dibromomethane	3/3	nv	nv	nv	nv	nv
Carbon tetrachloride (tetrachloromethane)	3/3	nv	nv	nv	nv	nv
Dichlorodifluoromethane (CFC-12)	3/3	nv	nv	nv	nv	nv
Pesticides and pesticide degradates (µg/L)						
Simazine	2/3	nv	1/1	—, 0.007	nv	nv
Constituent of special interest (µg/L)						
Perchlorate	1/3	nv	nv	nv	0/2	nv

Table A4B. Quality-control summary for replicate analyses of inorganic constituents, isotope tracers, and radioactivity detected in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[**Abbreviations**: SD, percent standard deviation; RSD, percent relative standard deviation; RL, reporting level; µg/L, micrograms per liter; mg/L, milligrams per liter; ≤, less than or equal to; nv, no value in category; — not detected; SiO_2, silicon dioxide]

Constituent	Number of non-detections or ≤-coded replicates/ number of replicates	Number of SDs greater than ½ RL/ number of replicates with concentration less than 5 times the RL	Concentrations of replicates with SDs greater than ½ RL (environmental, replicate)	Number of RSDs greater than 10 percent/number of replicates with concentration greater than 5 times the RL	Concentrations of replicates with RSDs greater than 10 percent (environmental, replicate)
		Trace elements (µg/L)			
Aluminum	3/3	nv	nv	nv	nv
Antimony	3/3	nv	nv	nv	nv
Arsenic	0/3	nv	nv	0/3	nv
Barium	0/3	nv	nv	0/3	nv
Beryllium	2/3	0/1	nv	nv	nv
Boron	0/3	nv	nv	0/3	nv
Cadmium	1/3	0/2	nv	nv	nv
Chromium	0/3	0/3	nv	nv	nv
Cobalt	0/3	0/3	nv	nv	nv
Copper	1/3	0/2	nv	nv	nv
Iron	1/3	1/2	10.6, —	nv	nv
Lead	0/3	0/3	nv	nv	nv
Lithium	0/3	nv	nv	0/3	nv
Manganese	0/3	0/1	nv	0/2	nv
Molybdenum	0/3	nv	nv	0/3	nv
Nickel	0/3	0/3	nv	nv	nv
Selenium	0/3	nv	nv	0/3	nv
Silver	3/3	nv	nv	nv	nv
Strontium	0/3	nv	nv	0/3	nv
Thallium	3/3	nv	nv	nv	nv
Tungsten	0/3	0/3	nv	nv	nv
Uranium	0/3	nv	nv	0/3	nv
Vanadium	0/3	nv	nv	0/3	nv
Zinc	0/3	0/2	nv	0/1	nv
		Nutrients (mg/L)			
Ammonia (as nitrogen)	2/3	0/1	nv	nv	nv
Nitrate plus nitrite (as nitrogen)	0/3	nv	nv	0/3	nv
Nitrite (as nitrogen)	1/3	0/1	nv	0/1	nv
Total nitrogen (ammonia + nitrite + nitrate + organic nitrogen)	0/3	0/1	nv	0/2	nv
Phosphate, orthophosphate (as phosphorus)	0/3	nv	nv	0/3	nv

Table A4B. Quality-control summary for replicate analyses of inorganic constituents, isotope tracers, and radioactivity detected in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.—Continued

[**Abbreviations**: SD, percent standard deviation; RSD, percent relative standard deviation; RL, reporting level; µg/L, micrograms per liter; mg/L, milligrams per liter; ≤, less than or equal to; nv, no value in category; — not detected; SiO_2, silicon dioxide]

Constituent	Number of non-detections or ≤-coded replicates/ number of replicates	Number of SDs greater than ½ RL/ number of replicates with concentration less than 5 times the RL	Concentrations of replicates with SDs greater than ½ RL (environmental, replicate)	Number of RSDs greater than 10 percent/number of replicates with concentration greater than 5 times the RL	Concentrations of replicates with RSDs greater than 10 percent (environmental, replicate)
Major and minor ions, silica, and total dissolved soilds (TDS) (mg/L)					
Bromide	0/3	nv	nv	0/3	nv
Calcium	0/3	nv	nv	0/3	nv
Chloride	0/3	nv	nv	0/3	nv
Fluoride	0/3	nv	nv	0/3	nv
Iodide	1/3	nv	nv	0/2	nv
Magnesium	0/3	nv	nv	0/3	nv
Potassium	0/3	nv	nv	0/3	nv
Sodium	0/3	nv	nv	0/3	nv
Sulfate	0/3	nv	nv	0/3	nv
Silica (as SiO_2)	0/3	nv	nv	0/3	nv
TDS	0/3	nv	nv	0/3	nv
Arsenic, chromium, and iron species (µg/L)					
Arsenic (total)	0/3	0/3	nv	nv	nv
Arsenic (III)	3/3	nv	nv	nv	nv
Chromium (total)	0/3	2/2	0.4, 0.2; 0.4, 0.3	1/1	0.7, 0.4
Chromium (VI)	0/3	1/3	0.6, 0.3	nv	nv
Iron (total)	1/3	0/1	nv	0/2	nv
Iron (II)	[1] 1/2	nv	nv	1/1	11, 13
Isotope tracers					
δ^2H in water (per mil)	0/3	nv	nv	0/3	nv
$\delta^{18}O$ in water (per mil)	0/3	nv	nv	0/3	nv
$\delta^{13}C$ in dissolved inorganic carbon (per mil)	0/3	nv	nv	0/3	nv
Carbon-14 (percent modern)	0/3	nv	nv	0/3	nv

[1] One pair was not analyzed for iron (II) because total iron was not detected.

Table A4C. Quality-control summary for replicate analyses of radioactive constituents detected in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[For activities of radiochemical constituents, a replicate pair of analyses is defined as acceptable if the normalized absolute difference (NAD) is less than 1.65, which corresponds to a significance level of 5 percent (α = 0.05). **Abbreviations**: >, greater than; pCi/L, picocuries per liter; —, not detected; ±, plus or minus; nv, no value in category]

Constituent	Number of pairs with NAD > 1.65/total number of replicate pairs	Activities for replicate pairs with NAD > 1.65 (environmental, replicate) (pCi/L)
Tritium	0/3	nv
Radon-222	[1] 0/3	nv
Gross alpha radioactivity, 72-hour count	[2] 0/3	nv
Gross alpha radioactivity, 30-day count	1/3	— ± 0.55, 1.51 ± 0.57
Gross beta radioactivity, 72-hour count	[2] 0/3	nv
Gross beta radioactivity, 30-day count	0/3	nv

[1] One of the replicate results was affected by a sample volume discrepancy but was within acceptable precision.

[2] Includes a replicate pair counted 4 days after sample collection.

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetone	3	101	113	106
Acrylonitrile	3	104	107	104
tert-Amyl methyl ether (TAME)	3	88	102	88
Benzene	3	101	105	102
Bromobenzene	3	92	100	92
Bromochloromethane	3	100	106	104
Bromodichloromethane [1]	3	92	95	94
Bromoform (Tribromomethane)	3	85	96	91
Bromomethane (Methyl bromide)	3	70	102	84
n-Butylbenzene	3	76	83	77
sec-Butylbenzene	3	88	97	88
tert-Butylbenzene	3	91	105	94
Carbon disulfide	3	62	125	89
Carbon tetrachloride (Tetrachloromethane) [1]	3	82	98	98
Chlorobenzene	3	94	99	95
Chloroethane	3	88	107	89
Chloroform (Trichloromethane) [1]	3	106	114	109
Chloromethane	3	61	109	74
3-Chloropropene	3	81	97	95
2-Chlorotoluene	3	94	96	94
4-Chlorotoluene	3	90	100	95
Dibromochloromethane	3	85	97	96
1,2-Dibromo-3-chloropropane (DBCP)	3	78	89	86
1,2-Dibromoethane (EDB)	3	100	108	101

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Dibromomethane [1]	3	97	104	102
1,2-Dichlorobenzene	3	93	101	94
1,3-Dichlorobenzene	3	88	95	89
1,4-Dichlorobenzene	3	91	97	91
trans-1,4-Dichloro-2-butene	3	[2] 14	107	71
Dichlorodifluoromethane (CFC-12) [1]	3	38	86	41
1,1-Dichloroethane (1,1-DCA) [1]	3	105	107	106
1,2-Dichloroethane (1,2-DCA) [1]	3	103	110	107
1,1-Dichloroethene (1,1-DCE)	3	93	106	97
cis-1,2-Dichloroethene (*cis*-1,2-DCE)	3	92	99	93
trans-1,2-Dichloroethene (*trans*-1,2-DCE)	3	96	100	96
1,2-Dichloropropane	3	98	105	101
1,3-Dichloropropane	3	99	105	103
2,2-Dichloropropane	3	84	87	85
1,1-Dichloropropene	3	87	94	89
cis-1,3-Dichloropropene	3	70	96	92
trans-1,3-Dichloropropene	3	67	89	88
Diethyl ether	3	98	104	102
Diisopropyl ether (DIPE)	3	91	103	92
Ethylbenzene	3	92	99	94
Ethyl *tert*-butyl ether (ETBE)	3	92	97	94
Ethyl methacrylate	3	90	91	91
o-Ethyl toluene (1-Ethyl-2-methyl benzene)	3	92	104	93
Hexachlorobutadiene	3	76	77	76
Hexachloroethane	3	83	86	86
2-Hexanone (*n*-Butyl methyl ketone)	3	100	106	102
Iodomethane (Methyl iodide)	3	100	110	102
Isopropylbenzene	3	90	98	90
4-Isopropyl-1-methyl benzene	3	82	91	83
Methyl acrylate	3	94	104	99
Methyl acrylonitrile	3	100	107	101
Methyl *tert*-butyl ether (MTBE) [1]	3	101	105	104
Methyl *iso*-butyl ketone (MIBK)	3	99	103	102
Methylene chloride (Dichloromethane)	3	104	109	105
Methyl ethyl ketone (2-butanone, MEK)	3	100	108	103
Methyl methacrylate	3	92	93	92
Naphthalene	3	88	96	89
Perchloroethene (PCE, Tetrachloroethene) [1]	3	123	139	130
n-Propylbenzene	3	85	95	86
Styrene	3	88	92	92
1,1,1,2-Tetrachloroethane	3	94	97	94
1,1,2,2-Tetrachloroethane	3	96	100	99
Tetrahydrofuran	3	94	104	96

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
1,2,3,4-Tetramethylbenzene	3	85	99	87
1,2,3,5-Tetramethylbenzene	3	89	100	90
Toluene	3	102	107	104
1,2,3-Trichlorobenzene	3	92	93	92
1,2,4-Trichlorobenzene	3	84	88	86
1,1,1-Trichloroethane (1,1,1-TCA) [1]	3	98	110	104
1,1,2-Trichloroethane (1,1,2-TCA)	3	97	102	97
Trichloroethene (TCE)	3	92	97	94
Trichlorofluoromethane (CFC-11)	3	102	113	105
1,2,3-Trichloropropane (1,2,3-TCP)	3	99	103	102
Trichlorotrifluoroethane (CFC-113) [1]	3	90	98	93
1,2,3-Trimethylbenzene	3	96	105	97
1,2,4-Trimethylbenzene	3	93	101	95
1,3,5-Trimethylbenzene	3	89	97	92
Vinyl bromide (Bromoethene)	3	90	107	94
Vinyl chloride (Chloroethene)	3	81	101	83
m- and *p*-Xylene	3	93	101	95
o-Xylene	3	92	100	95

[1] Constituents detected in groundwater samples.

[2] Laboratory reported that this sample had a very low recovery for *trans*-1,4-dichloro-2-butene due to matrix interference from sulfur in a previous sample set.

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetochlor	3	77	91	87
Alachlor	3	79	93	90
Atrazine	3	89	105	100
Azinphos-methyl	3	70	94	86
Azinphos-methyl oxon	3	66	76	76
Benfluralin	3	54	67	63
Carbaryl	3	96	114	97
2-Chloro-2,6-diethylacetanilide	3	79	95	91
4-Chloro-2-methylphenol	3	66	98	89
Chlorpyrifos	3	76	88	80
Chlorpyrifos oxon	3	16	50	24
Cyfluthrin	3	43	49	48
Cypermethrin	3	38	44	43
Dacthal (DCPA)	3	93	106	106
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	3	93	118	95
Desulfinylfipronil	3	80	99	97
Desulfinylfipronil amide	3	66	84	76
Diazinon	3	87	97	94
3,4-Dichloroaniline	3	79	94	83
Dichlorvos	3	13	52	30
Dicrotophos	3	23	28	27
Dieldrin	3	71	93	77
2,6-Diethylaniline	3	92	97	96
Dimethoate	3	48	73	58
Ethion	3	39	67	62
Ethion monoxon	3	64	88	77
2-Ethyl-6-methylaniline	3	91	94	94
Fenamiphos	3	83	92	87
Fenamiphos sulfone	3	78	88	78
Fenamiphos sulfoxide	3	18	28	21
Fipronil	3	76	99	85
Fipronil sulfide	3	80	82	80
Fipronil sulfone	3	51	72	68
Fonofos	3	68	86	84
Hexazinone	3	45	49	47
Iprodione	3	65	72	67
Isofenphos	3	73	81	81
Malaoxon	3	62	87	83
Malathion	3	74	91	79
Metalaxyl	3	91	103	93
Methidathion	3	63	84	82
Metolachlor	3	78	88	83
Metribuzin	3	72	100	85

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Myclobutanil	3	70	84	72
1-Naphthol	3	33	75	47
Paraoxon-methyl	3	50	76	68
Parathion-methyl	3	84	99	93
Pendimethalin	3	83	108	85
cis-Permethrin	3	37	49	47
Phorate	3	57	70	66
Phorate oxon	3	71	92	73
Phosmet	3	20	33	28
Phosmet oxon	3	15	39	33
Prometon	3	79	96	88
Prometryn	3	76	94	88
Pronamide (Propyzamide)	3	61	96	88
Simazine [1]	3	80	92	87
Tebuthiuron	3	116	148	117
Terbufos	3	53	78	69
Terbufos oxon sulfone	3	48	75	74
Terbuthylazine	3	87	102	100
Tribufos	3	28	44	43
Trifluralin	3	62	75	73

[1] Constituent detected in groundwater samples.

Table A5C. Quality-control summary for matrix-spike recoveries of polar pesticides and degradates in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[Acceptable recovery range is between 70 and 130 percent. Abbreviations: na, not available]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acifluorfen	3	49	125	58
Aldicarb	3	62	105	63
Aldicarb sulfone	3	87	108	98
Aldicarb sulfoxide	3	103	114	103
Atrazine	3	[1] na	[1] na	[1] na
Bendiocarb	3	100	129	104
Benomyl	3	76	119	86
Bensulfuron-methyl	3	119	172	127
Bentazon	3	56	66	63
Bromacil	3	102	200	124
Bromoxynil	3	25	42	36
Caffeine	3	101	147	121
Carbaryl	3	114	161	119
Carbofuran	3	117	158	122
Chloramben, methyl ester	3	77	121	97
Chlorimuron-ethyl	3	120	217	155
3-(4-Chlorophenyl)-1-methyl urea	3	69	148	105
Clopyralid	3	17	82	69
Cycloate	3	73	87	86
2,4-D	3	62	74	70
2,4-D methyl ester	none [2]	na	na	na
2,4-D plus 2,4-D methyl ester	3	62	74	70
2,4-DB (4-(2,4-Dichlorophenoxy) butyric acid)	3	55	62	61
DCPA (Dacthal) monoacid	3	75	88	86
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine)	3	[1] na	[1] na	[1] na
Deisopropyl atrazine (2-Chloro-6-ethylamino-4-amino-*s*-triazine)	3	49	94	84
Dicamba	3	58	76	63
Dichlorprop	3	71	87	81
Dinoseb (Dinitrobutyl phenol)	3	27	55	34
Diphenamid	3	113	139	114
Diuron	3	112	131	119
Fenuron	3	102	129	105
Flumetsulam	3	115	315	124
Fluometuron	3	111	154	114
Hydroxyatrazine (2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine)	3	109	149	120
3-Hydroxycarbofuran	3	108	162	109
Imazaquin	3	147	273	165
Imazethapyr	3	133	277	136
Imidacloprid	3	120	268	123
Linuron	3	112	126	117
MCPA (2-Methyl-4-chlorophenoxyacetic acid)	3	64	73	72
MCPB (4-(2-Methyl-4-chlorophenoxy)butyric acid)	3	54	61	58
Metalaxyl	3	107	135	111
Methiocarb	3	112	146	121
Methomyl	3	108	122	121
Metsulfuron methyl	3	85	192	90
Neburon	3	98	135	114
Nicosulfuron	3	139	204	170
Norflurazon	3	118	161	126
Oryzalin	3	85	101	89
Oxamyl	3	111	122	114
Picloram	3	31	105	53
Propham	3	102	111	108
Propiconazole	3	96	131	112
Propoxur	3	117	147	118
Siduron	3	123	170	142
Sulfometuron-methyl	3	134	194	147
Tebuthiuron	3	[1] na	[1] na	[1] na
Terbacil	3	108	186	125
Triclopyr	3	80	85	85

[1] See table A5B for atrazine, deethylatrazine, and tebuthurion matrix-spike recoveries from the preferred method.

[2] 2,4-D methyl ester was not included in the spiking solution.

Table A5D. Quality-control summary for matrix-spike recoveries of pharmaceutical compounds and *N*-nitrosodimethylamine (NDMA) in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

[Acceptable recovery range is between 70 and 130 percent. **Abbreviations**: na, not available]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetaminophen	3	41	122	109
Albuterol	3	34	82	57
Caffeine	3	[1] na	[1] na	[1] na
Carbamazapine	3	81	107	89
Codeine	3	76	110	94
Cotinine	3	79	94	93
Dehydronifedipine	3	68	97	91
Diltiazem	3	14	32	23
1,7-Dimethylxanthine	3	81	108	94
Diphenydramine	3	47	75	73
Sulfamethoxazole	3	29	44	32
Thiabendazole	3	31	91	86
Trimethoprim	3	78	111	100
Warfarin	3	38	50	46
N-Nitrosodimethylamine (NDMA)	3	92	104	95

[1] See table A5C for caffeine matrix-spike recoveries from the preferred method.

Table A6. Quality-control summary for surrogate recoveries of volatile organic compounds (VOCs), pesticides and pesticide degradates, polar pesticides and degradates, and pharmaceutical compounds in samples collected for the Santa Barbara study unit, January to February 2011, California GAMA Priority Basin Project.

Surrogate	Analytical schedule	Constitutent or constituent class analyzed	Surrogate information for field blanks				Surrogate information for environmental samples			
			Number of analyses	Median recovery (percent)	Number of surrogate recoveries less than 70 percent	Number of surrogate recoveries greater than 130 percent	Number of analyses	Median recovery (percent)	Number of surrogate recoveries less than 70 percent	Number of surrogate recoveries greater than 130 percent
1-Bromo-4-fluorobenzene	2020	VOC	3	89	0	0	24	89	0	0
1,2-Dichloroethane-*d*4	2020	VOC	3	118	0	0	24	123	0	1
Toluene-*d*8	2020	VOC	3	95	0	0	24	94	0	0
Diazinon-*d*10	2003	Pesticide	3	88	0	0	24	80	1	0
α-HCH-*d*6	2003	Pesticide	3	87	0	0	24	84	0	0
2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	2060	Polar Pesticide	3	89	0	0	24	84	0	0
Barban	2060	Polar Pesticide	3	128	0	1	24	110	0	4
Caffeine-^{13}C	2060	Polar Pesticide	3	113	0	0	24	111	1	2
Ethyl nicotinate-*d*4	2080	Pharmaceutical compound	3	94	0	0	24	88	1	0
Carbamazapine-*d*4	2080	Pharmaceutical compound	3	109	0	0	24	100	2	1

Publishing support provided by the U.S. Geological Survey Science Publishing Network, Sacramento, Tacoma, and Raleigh Publishing Service Centers

For more information concerning the research in this report, contact the

Director, California Water Science Center
U.S. Geological Survey
6000 J Street, Placer Hall
Sacramento, California 95819
http://ca.water.usgs.gov

Davis and others—**Groundwater-Quality Data in the Santa Barbara Study Unit, 2011: Results from the California GAMA Program**—Data Series 742

Printed on recycled paper