Prepared in cooperation with the California State Water Resources Control Board

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

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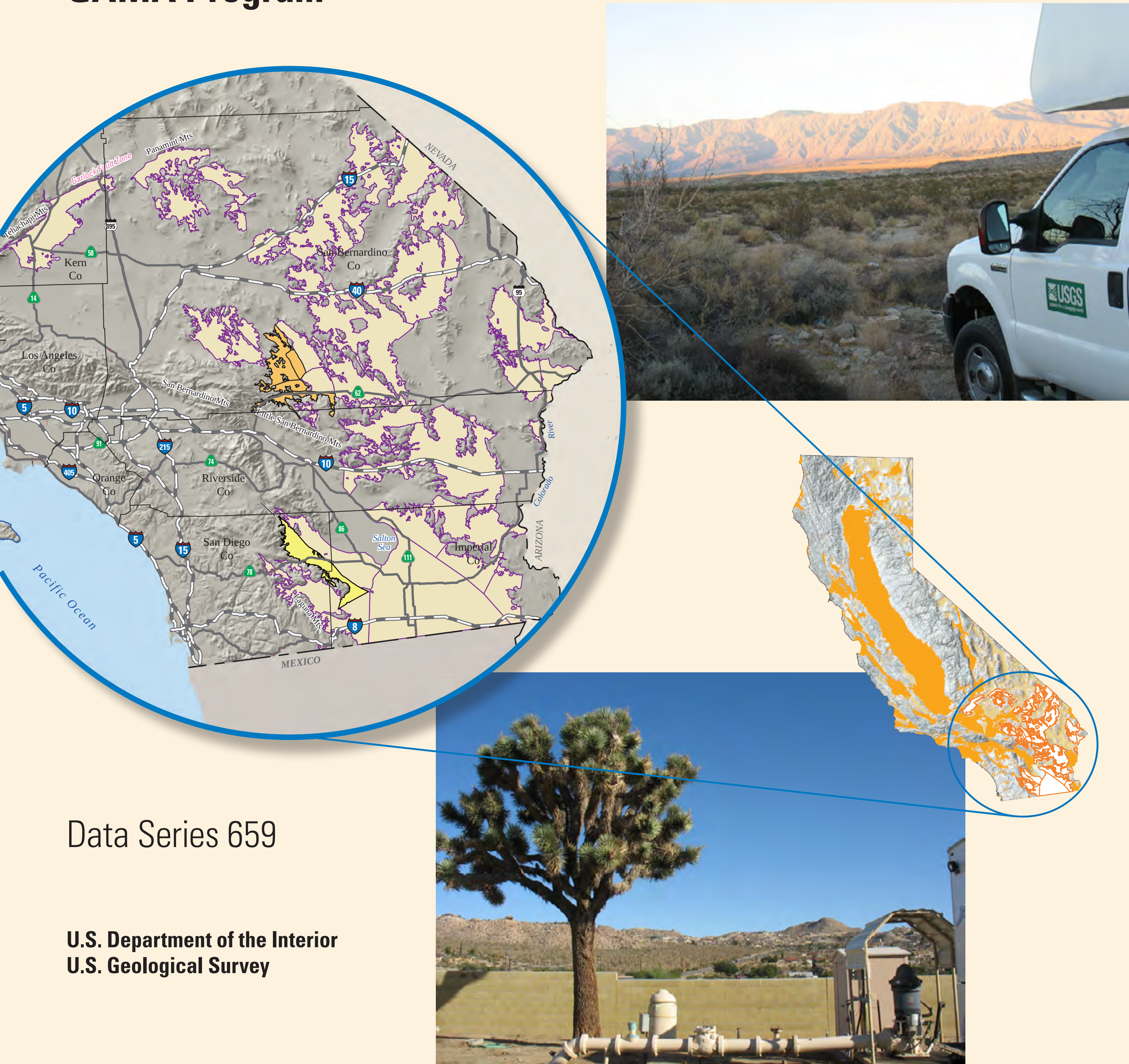

Data Series 659

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

**Top Right**:
Borrego Valley at sunset, California. (Photograph taken by Michael Solt, U.S. Geological Survey)
**Bottom**:
Joshua Tree and public supply well, Yucca Valley, California. (Photograph taken by Dara Goldrath, U.S. Geological Survey)

# Groundwater-Quality Data in the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts Study Unit, 2008–2010: Results from the California GAMA Program

By Timothy M. Mathany, Michael T. Wright, Brandon S. Beuttel, and Kenneth Belitz

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

**U.S. Geological Survey**
Marcia K. McNutt, Director

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## Conversion Factors

### Inch/Pound to SI

| Multiply | By | To obtain |
|---|---|---|
| inch (in.) | 2.54 | centimeter (cm) |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |
| quart (qt) | 0.9464 | liter (L) |
| pound, avoirdupois (lb) | 0.4536 | kilogram (kg) |

### SI to Inch/Pound

| Multiply | By | To obtain |
|---|---|---|
| centimeter (cm) | 0.3937 | inch (in.) |
| micrometer (µm) | $3.3 \times 10^{-6}$ | foot (ft) |
| kilometer (km) | 0.6214 | mile (mi) |
| square kilometer ($km^2$) | 0.3861 | square mile ($mi^2$) |
| liter (L) | 1.0567 | quart (qt) |
| gram (g) | 0.03527 | ounce, avoirdupois (oz) |
| kilogram (kg) | 2.205 | pound, avoirdupois (lb) |

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

$$°F=(1.8\times°C)+32.$$

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).

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

## Datums

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

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

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

# Selected Terms and Symbols

| | |
|---|---|
| $\alpha$ | confidence level |
| $cm^3$ 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 | measure of the acidity of water |
| $pK_{1,2}$ | acid dissociation constants of carbonic acid |
| $pK_w$ | acid dissociation constant of water |
| R | result |
| z | test statistic |
| ± | plus or minus |
| * | value is at a concentration greater than benchmark level |
| ** | value is at a concentration greater than upper benchmark level |

# Abbreviations and Acronyms

| | |
|---|---|
| AL | action level |
| AL-US | action level (USEPA) |
| APE | Alternate Place Entry Form program designed for USGS sampling |
| BV | Borrego Valley study area |
| BVU | Borrego Valley study area understanding (well) |
| CAS | Chemical Abstract Service (American Chemical Society) |
| CASRN | Chemical Abstract Service (American Chemical Society) Registry Number® |
| CD | Central Desert study area |
| CLUB | Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts study unit |
| 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 | lifetime health advisory level |
| HAL-US | lifetime health advisory level (USEPA) |
| HPLC | high-performance liquid chromatography |
| IBSP | Inorganic Blind Sample Project (USGS) |

## Abbreviations and Acronyms—Continued

| | |
|---|---|
| LRL | laboratory reporting level |
| LSD | land surface datum |
| LT-MDL | long-term method detection level |
| LUB | Low-Use Basins of the Mojave and Sonoran Deserts study area |
| LUBU | Low-Use Basins of the Mojave and Sonoran Deserts study area understanding (well) |
| MCL | maximum contaminant level |
| MCL-US | maximum contaminant level (USEPA) |
| MCL-CA | maximum contaminant level (CDPH) |
| MDL | method detection limit |
| MRL | minimum reporting level |
| MU | method uncertainty |
| na | not available |
| nc | not collected |
| NELAP | National Environmental Laboratory Accreditation Program |
| NFM | National Field Manual (USGS) |
| NFQA | National Field Quality Assurance Program (USGS) |
| NL | notification level |
| NL-CA | notification level (CDPH) |
| nv | no measured value or no value in category |
| np | no preference |
| NRP | National Research Program (USGS) |
| NWIS | National Water Information System (USGS) |
| OBSP | Organic Blind Sample Program (USGS) |
| PBP | Priority Basin Project |
| PCFF | Personal Computer Field Form program designed for USGS sampling |
| QA | quality assurance |
| QC | quality control |
| RL | reporting level |
| RPD | relative percent difference |
| RSD | relative standard deviation |
| RSD5 | risk-specific dose at $10^{-5}$ (USEPA) |
| SD | standard deviation |
| SMCL | secondary maximum contaminant level |
| SMCL-CA | secondary maximum contaminant level (CDPH) |
| SMCL-US | secondary maximum contaminant level (USEPA) |
| SRL | study reporting level (concentration cutoff for applying the ≤ symbol) |
| $ssL_C$ | sample-specific critical level |
| U.S. | United States |
| UV | ultraviolet |
| VPDB | Vienna Pee Dee Belemnite (the international reference standard for carbon isotopes) |
| VSMOW | Vienna Standard Mean Ocean Water (an isotopic water standard defined in 1968 by the International Atomic Energy Agency) |

# Abbreviations and Acronyms—Continued

## Organizations

| | |
|---|---|
| BQS | Branch of Quality Systems (USGS) |
| CDPH | California Department of Public Health |
| CDPR | California Department of Pesticide Regulation |
| CDWR | California Department of Water Resources |
| LLNL | Lawrence Livermore National Laboratory |
| NAWQA | National Water-Quality Assessment Program (USGS) |
| NIST | National Institute of Standards and Technology |
| NWQL | National Water Quality Laboratory (USGS) |
| SITL | Stable Isotope and Tritium Laboratory, Menlo Park, California (USGS) |
| SWRCB | California State Water Resources Control Board |
| TALIR | TestAmerica Laboratories, Inc., Irvine, California |
| TML | Trace Metal Laboratory, Boulder, Colorado (USGS) |
| USEPA | U.S. Environmental Protection Agency |
| USGS | U.S. Geological Survey |

## Selected Chemical Names

| | |
|---|---|
| $CaCO_3$ | calcium carbonate |
| $CO_3^{2-}$ | carbonate |
| CFC | chlorofluorocarbon |
| Cr-VI | hexavalent chromium (chromium-VI) |
| DIPE | diisopropyl ether |
| $H_2O$ | water |
| HCl | hydrochloric acid |
| $HCO_3^-$ | bicarbonate |
| MTBE | methyl *tert*-butyl ether |
| NDMA | *N*-nitrosodimethylamine |
| PCE | perchloroethene (tetrachloroethene) |
| PVC | polyvinyl chloride |
| $SiO_2$ | silicon dioxide |
| TCE | trichloroethene |
| TDS | total dissolved solids |
| THM | trihalomethane |
| VOC | volatile organic compound |

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By Timothy M. Mathany, Michael T. Wright, Brandon S. Beuttel, and Kenneth Belitz

## Abstract

Groundwater quality in the 12,103-square-mile Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) study unit was investigated by the U.S. Geological Survey (USGS) from December 2008 to March 2010, as part of the California State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment (GAMA) Program's Priority Basin Project (PBP). The GAMA-PBP was developed in response to the California Groundwater Quality Monitoring Act of 2001 and is being conducted in collaboration with the SWRCB and Lawrence Livermore National Laboratory (LLNL). The CLUB study unit was the twenty-eighth study unit to be sampled as part of the GAMA-PBP.

The GAMA CLUB study was designed to provide a spatially unbiased assessment of untreated-groundwater quality in the primary aquifer systems, and to facilitate statistically consistent comparisons of untreated-groundwater quality throughout California. The primary aquifer systems (hereinafter referred to as primary aquifers) are defined as parts of aquifers corresponding to the perforation intervals of wells listed in the California Department of Public Health (CDPH) database for the CLUB study unit. The quality of groundwater in shallow or deep water-bearing zones may differ from the quality of groundwater in the primary aquifers; shallow groundwater may be more vulnerable to surficial contamination.

In the CLUB study unit, groundwater samples were collected from 52 wells in 3 study areas (Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts) in San Bernardino, Riverside, Kern, San Diego, and Imperial Counties. Forty-nine 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 three 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 species of inorganic chromium), and radioactive constituents (radon-222, radium isotopes, and gross alpha and gross beta radioactivity). Naturally-occurring isotopes (stable isotopes of hydrogen, oxygen, boron, and strontium in water, stable isotopes of carbon in dissolved inorganic carbon, activities of tritium, and carbon-14 abundance) and dissolved noble gases also were measured to help identify the sources and ages of sampled groundwater. In total, 223 constituents and 12 water-quality indicators were investigated.

Three types of quality-control samples (blanks, replicates, and matrix spikes) were collected at up to 10 percent of the wells in the CLUB study unit, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that contamination 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. Median matrix-spike recoveries were within the acceptable range (70 to 130 percent) for approximately 85 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 delivered 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.

Most inorganic constituents detected in groundwater samples from the 49 grid wells were detected at concentrations less than drinking-water benchmarks. In addition, all detections of organic constituents from the CLUB study-unit grid-well samples were less than health-based benchmarks.

In total, VOCs were detected in 17 of the 49 grid wells sampled (approximately 35 percent), pesticides and pesticide degradates were detected in 5 of the 47 grid wells sampled (approximately 11 percent), and perchlorate was detected in 41 of 49 grid wells sampled (approximately 84 percent).

Trace elements, major and minor ions, and nutrients were sampled for at 39 grid wells, and radioactive constituents were sampled for at 23 grid wells; most detected concentrations were less than health-based benchmarks. Exceptions in the grid-well samples include seven detections of arsenic greater than the USEPA maximum contaminant level (MCL-US) of 10 micrograms per liter (µg/L); four detections of boron greater than the CDPH notification level (NL-CA) of 1,000 µg/L; six detections of molybdenum greater than the USEPA lifetime health advisory level (HAL-US) of 40 µg/L; two detections of uranium greater than the MCL-US of 30 µg/L; nine detections of fluoride greater than the CDPH maximum contaminant level (MCL-CA) of 2 milligrams per liter (mg/L); one detection of nitrite plus nitrate ($NO_2^-$+$NO_3^-$), as nitrogen, greater than the MCL-US of 10 mg/L; and four detections of gross alpha radioactivity (72-hour count), and one detection of gross alpha radioactivity (30-day count), greater than the MCL-US of 15 picocuries per liter.

Results for constituents with non-regulatory benchmarks set for aesthetic concerns showed that a manganese concentration greater than the CDPH secondary maximum contaminant level (SMCL-CA) of 50 µg/L was detected in one grid well. Chloride concentrations greater than the recommended SMCL-CA benchmark of 250 mg/L were detected in three grid wells, and one of these wells also had a concentration that was greater than the upper SMCL-CA benchmark of 500 mg/L. Sulfate concentrations greater than the recommended SMCL-CA benchmark of 250 mg/L were measured in six grid wells. TDS concentrations greater than the SMCL-CA recommended benchmark of 500 mg/L were measured in 20 grid wells, and concentrations in 2 of these wells also were 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 three 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; and (3) GAMA Special Studies conducted by LLNL. 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.

All published and quality-assurance/quality-control (QA/QC) approved analytical data collected for the GAMA Program are stored in the web-based Geotracker Database (California State Water Resources Control Board, 2009a, website at https://geotracker.waterboards.ca.gov/gama/). The Geotracker Database also stores groundwater-quality data and related reports collected by other State agencies, such as the California Department of Public Health (CDPH), California Department of Water Resources (CDWR), and California Department of Pesticide Regulation (CDPR), and data collected by the SWRCB and Regional Boards from environmental monitoring wells at contaminated and (or) remediated sites.

The GAMA Program was initiated by the SWRCB in 2000 and later expanded by the Groundwater Quality Monitoring Act of 2001 (State of California, 2001a,b; 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 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 GAMA-PBP is entirely voluntary.

The GAMA-PBP is unique in California because it includes many chemical analyses that are not otherwise available in the statewide water-quality monitoring datasets. Groundwater samples collected for the GAMA-PBP are typically analyzed for approximately 300 chemical constituents using analytical methods with lower detection limits than required by the CDPH for regulatory monitoring of water from 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 required by CDPH and for a suite of chemical and isotopic tracers for understanding hydrologic and geochemical processes. This understanding of groundwater composition is useful for identifying the natural and human factors affecting water quality. Understanding the occurrence and distribution of chemical constituents of significance to water quality is important for the long-term management and protection of groundwater resources.

The range of hydrologic, geologic, and climatic conditions in California must be considered in an assessment of groundwater quality. Belitz and others (2003) partitioned the State into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics: 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, 2003a). 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 priority basins were selected and grouped into 35 GAMA study units, representing approximately 95 percent of the CDPH wells in California. In addition, some areas outside of the defined groundwater basins were included in the nearest respective study unit to achieve representation of the 20 percent of the CDPH wells not located in the groundwater basins.

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

The Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts study unit (hereinafter referred to as the CLUB study unit) lies in the Desert hydrogeologic province as described by Belitz and others (2003) (fig. 1). Groundwater is a major source of public drinking-water supply for many of the cities located in the CLUB study unit (Water Education Foundation, 2006); therefore, the CLUB study unit was considered high priority for sampling to provide adequate representation of the Desert hydrogeologic province. This USGS Data Series Report is the first in a series of reports presenting the water-quality data collected by the USGS in the CLUB study unit for the GAMA-PBP. Other 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/projects/gama/includes/GAMA_publications.html.

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

Provinces from Belitz and others, 2003.

**Figure 1.** The hydrogeologic provinces of California and the location of the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study unit and study areas.

## Purpose and Scope

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

# Hydrogeologic Setting

The CLUB study unit contains 47 groundwater basins and subbasins delineated by CDWR and is located in the South Lahontan and Colorado River hydrogeologic regions (California Department of Water Resources, 2003b,c, 2004a–ss). The three study areas (Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts) of the CLUB study unit cover an area of 12,103 square miles (mi$^2$) in San Bernardino, Riverside, Kern, San Diego, and Imperial Counties, California (fig. 2).

## CLUB Study Unit—Borrego Valley Study Area

The Borrego Valley study area (hereinafter referred to as the BV study area) is 238 mi$^2$ in area and lies in the westernmost part of the Sonoran Desert, about 80 miles (mi) east of San Diego (fig. 2). The BV study area is located within the Borrego Valley groundwater basin (California Department of Water Resources, 2004a) and encompasses a large section of the Anza-Borrego Desert State Park. The study area is bounded on the west by the San Ysidro, Vallecito, Fish Creek, and Coyote Mountains and on the north by the Santa Rosa Mountains. The eastern boundary of the study area is defined by the Coyote Creek and Superstition Mountain faults. The southernmost border of the study area is a large unnamed wash that stretches from the Coyote Mountains northeast to Superstition Mountain (fig. 3).

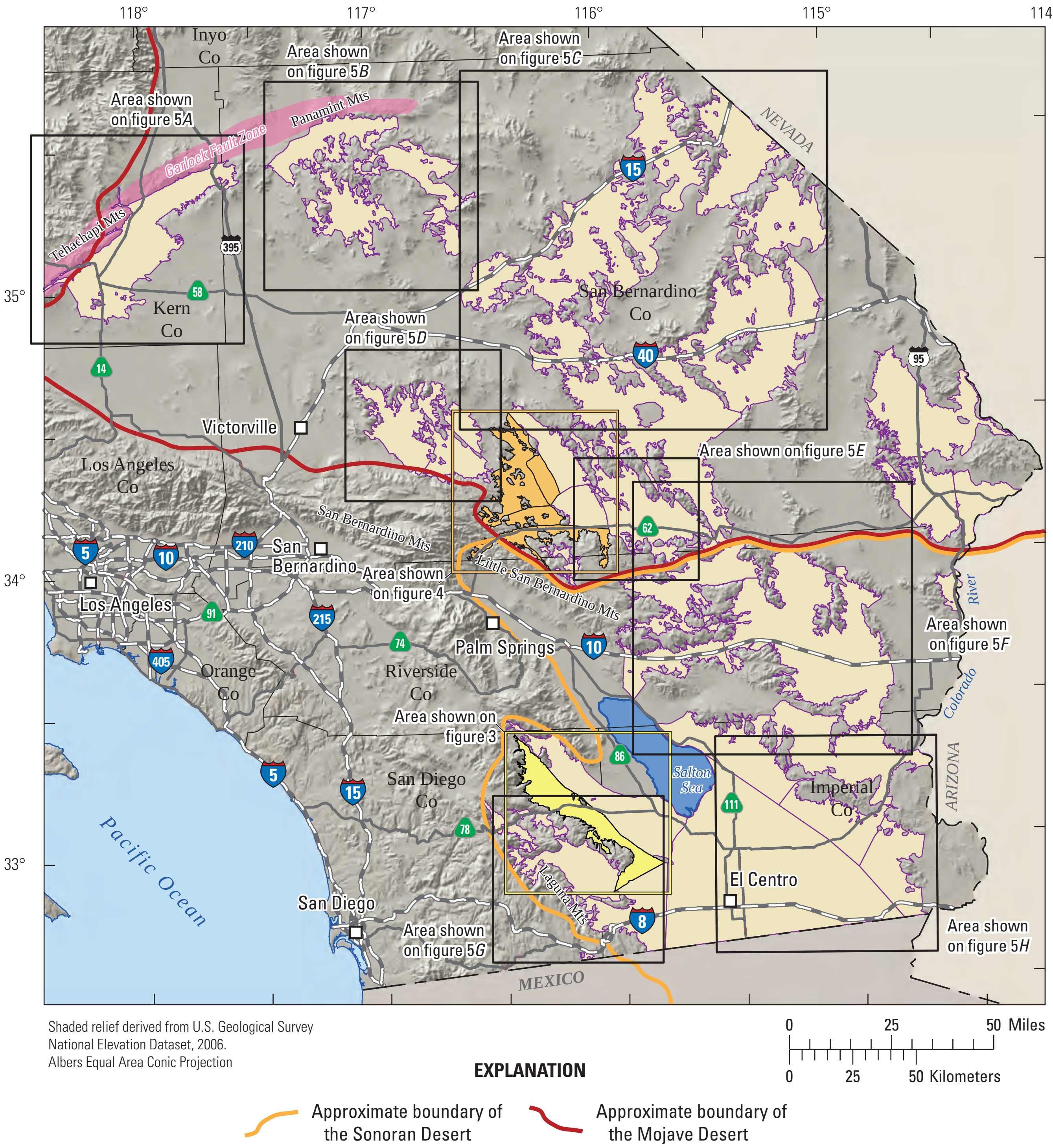
Land-surface altitudes in the study area range from approximately 30 feet below mean sea level (ft below msl) in the Lower Borrego Valley, to over 4,500 feet above mean sea level (ft above msl) in the San Ysidro Mountains, located just west of the village of Borrego Springs. The major surface drainage features of the study area are the Coyote and San Felipe Creeks, both of which have their headwaters in the mountains to the north and west and drain to the Salton Sea. There is also a large surface drainage feature in the northern part of the study area named Borrego Sink, which is a major collection point for surficial runoff from Coyote Creek (fig. 3).

The climate in the study area is classified as subtropical desert (due to the land-surface altitude), with very hot summers and cool winters (PRISM Climate Group, 2010; U.S. Department of Commerce, National Climatic Data Center, 2010). Rainfall is predominantly derived from storms originating in the Pacific Ocean in the winter and to a lesser extent from the North American Monsoon, which is drawn northward through Mexico from the Pacific Ocean and (or) the Gulf of Mexico in the summer (Adams, 1997). Average annual precipitation in the study area is less than 7 inches (in.) (PRISM Climate Group, Oregon State University, 2010; Western Regional Climate Center, 2010).

The primary aquifer in the study area is the upper aquifer of a three-tiered alluvium-filled aquifer system that is underlain by crystalline bedrock. The upper aquifer is composed of alluvial, playa, eolian, and fan deposits of Holocene to Pleistocene age. The middle and lower aquifers consist of continental deposits of moderately consolidated gravel, sand, and boulders of Pleistocene age (California Department of Water Resources, 2004a).

The general groundwater-flow direction in the study area is from the western and northern sides of the study area toward the center, then southward, following the topography of the Borrego and Lower Borrego Valleys. The study area has two major northwest trending faults (Superstition Mountain and Coyote Creek), which act as hydrologic barriers to groundwater movement (California Department of Water Resources, 2004a) (fig. 3).

Groundwater recharge in the study area primarily occurs from the infiltration of runoff from the surrounding mountains into Coyote Creek, San Felipe Creek, and Borrego Sink. To a lesser extent, ambient recharge also occurs from the seepage of small intermittent streams and washes originating from the mountains west and north of the study area (California Department of Water Resources, 2004a).



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

**EXPLANATION**

Approximate boundary of the Sonoran Desert

Approximate boundary of the Mojave Desert

**Figure 2.** The location of the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study units.

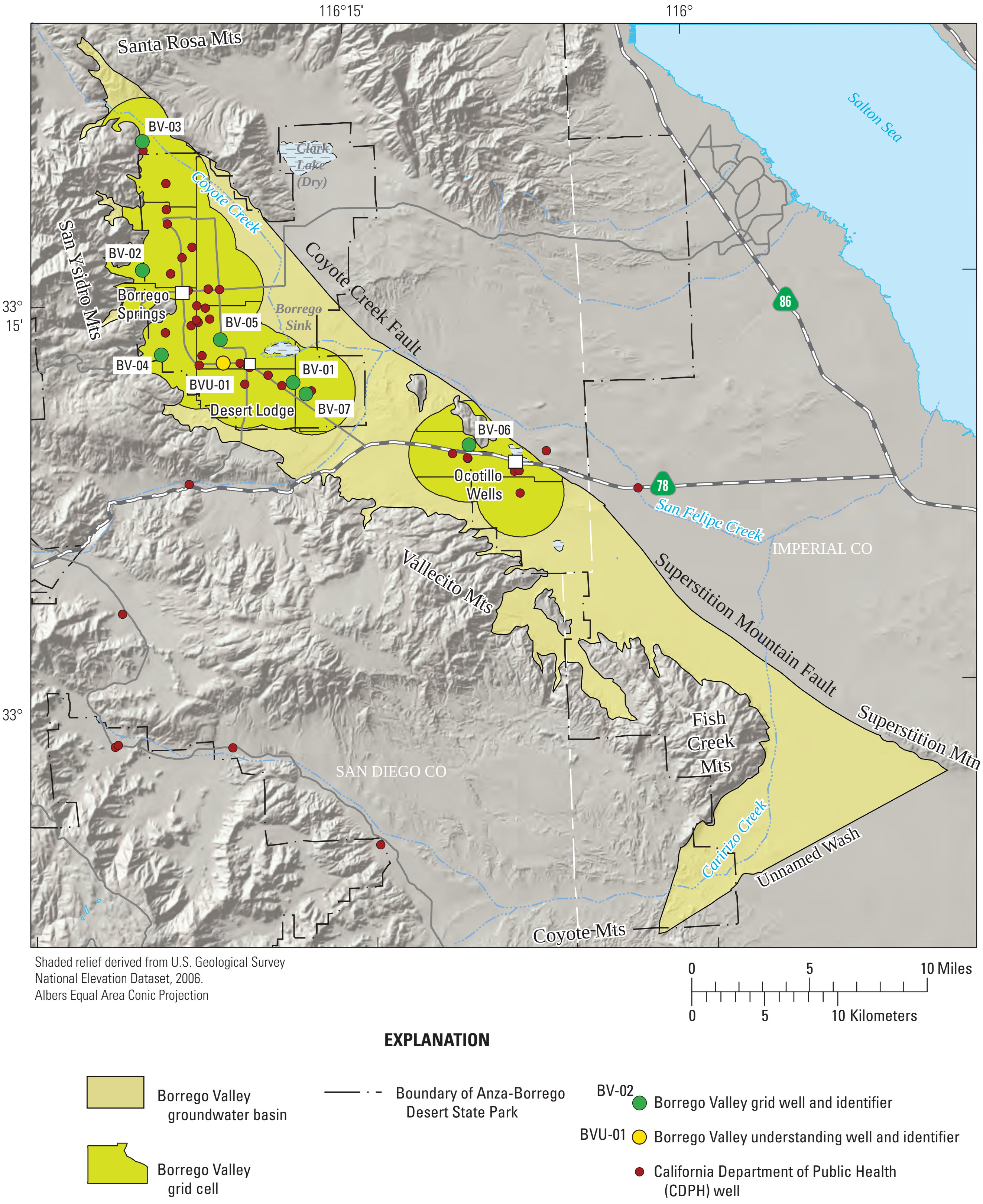


**Figure 3.** The Borrego Valley study area (BV), the boundaries of the California Department of Water Resources (CDWR) defined groundwater basins, the distribution of the Central Desert study area grid cells, the location of California Department of Public Health (CDPH) wells, and the location of sampled grid wells.

## CLUB Study Unit—Central Desert Study Area

The Central Desert study area (hereinafter referred to as the CD study area) is 353 $mi^2$ in area and contains six CDWR-defined basins and subbasins (California Department of Water Resources, 2003b, 2004b–f). The CD study area lies within the southern part of the Mojave Desert about 30 mi north of the city of Palm Springs and includes the northernmost section of the Joshua Tree National Park (fig. 4). The study area is bounded on the west by the uplands of the San Bernardino Mountains and the northern reaches of the Emerson fault. It is bounded to the north by the Johnson Valley fault zone and Iron Ridge. The eastern boundary of the study area is defined by the Surprise Spring fault and the Hidalgo, Copper, and Pinto Mountains. The southernmost borders of the study area are Lower Morongo Canyon, the Little San Bernardino Mountains, and the uplands areas of the Joshua Tree National Park (California Department of Water Resources, 2003b, 2004b–f).

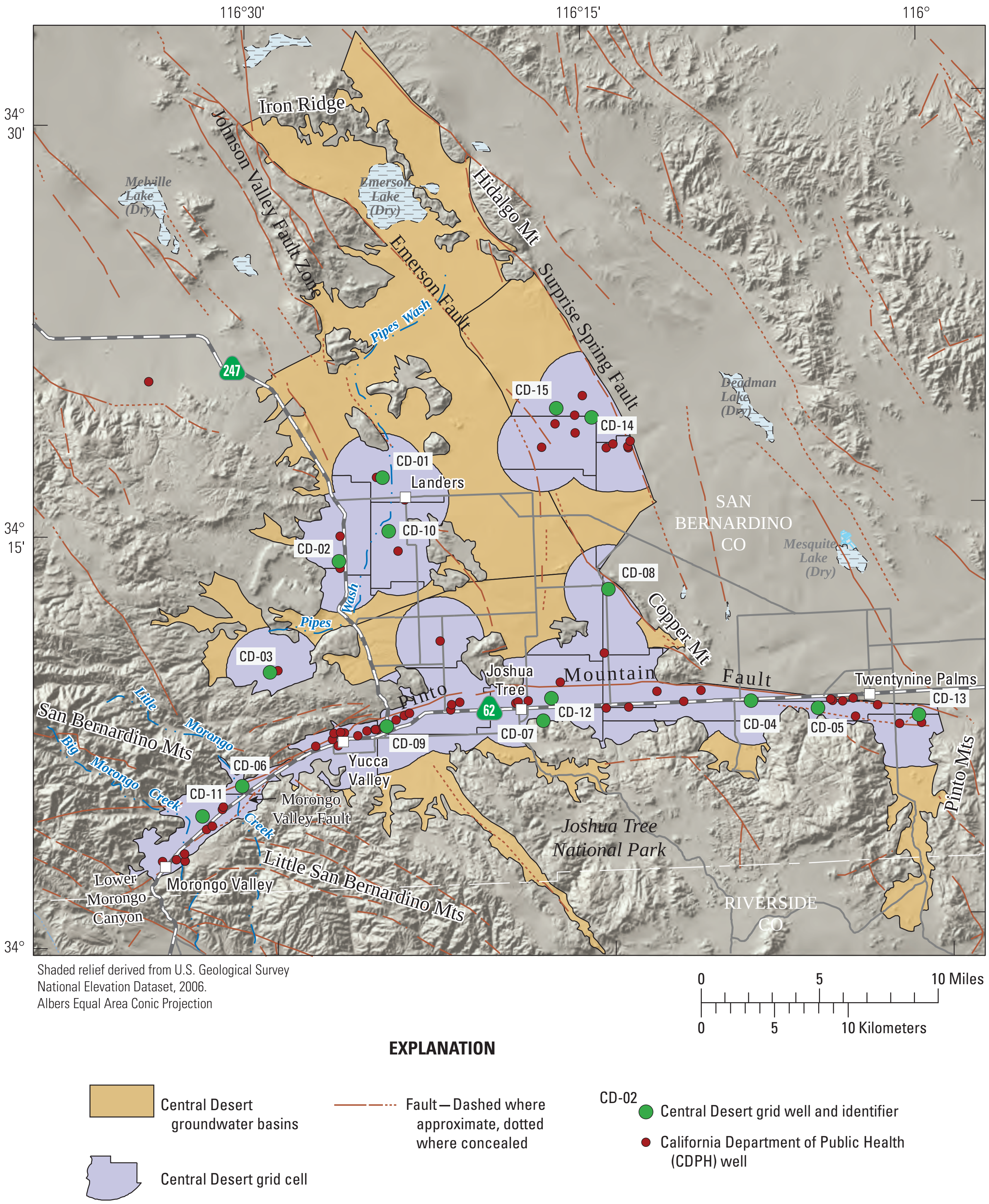
Land-surface altitudes in the study area range from approximately 2,300 ft above msl near Emerson Lake in the northern part of the study area, to over 5,000 ft above msl in the Little San Bernardino Mountains, located south of the town of Yucca Valley. The northern and western portions of the study area are drained by Pipes Wash to Emerson Lake. The southernmost reaches of the study area are drained by the Big and Little Morongo Creeks. Small ephemeral streams drain the eastern parts of the study area towards Emerson and Deadman Lakes (California Department of Water Resources, 2003b, 2004b–f) (fig. 4).

The climate in the study area is classified as high arid desert (due to the land-surface altitude), with hot, dry summers and cold winters (PRISM Climate Group, Oregon State University, 2010; U.S. Department of Commerce, National Climatic Data Center, 2010). Rainfall in the study area primarily stems from storms originating in the Pacific Ocean and is fairly evenly distributed throughout the year. Average annual precipitation in the study area is approximately 6.5 in. (PRISM Climate Group, Oregon State University, 2010; Western Regional Climate Center, 2010).

The primary aquifers in the study area are located in unconsolidated to partly consolidated continental deposits and alluvium of Miocene to Quaternary age. These unconfined water-bearing formations consist of interbedded conglomerates, gravels, sands, and silts deposited into alluvial fan systems. To a lesser extent, groundwater in the study area is found in deposits of clays, sandy-clays, distal silts, and dune sand (California Department of Water Resources, 2003b, 2004b–f).

The general direction of groundwater flow in the study area is from the southern, western, and eastern parts, towards the center, then northward to the Emerson Lake area. In the southwesternmost part of the study area, the direction of groundwater flow follows Morongo Canyon to the southwest then exits the study area by way of Lower Morongo Canyon. The east-west trending Pinto Mountain fault is the most influential hydrologic barrier to groundwater movement in the study area, with water table differences across the fault of more than 125 ft in some locations. Additionally, the Emerson, Surprise Spring, and Morongo Valley faults and the Johnson Valley fault zone act as impediments to groundwater movement (Mendez and Christensen, 1997; California Department of Water Resources, 2003b, 2004b–f; U.S. Geological Survey, 2009) (fig. 4).

Groundwater recharge in the study area occurs from a mixture of ambient recharge (infiltration of runoff from surrounding mountains and hills into Little and Big Morongo Creeks, Pipes Wash, and Emerson Lake, seepage from ephemeral streams, and direct percolation of precipitation), subsurface inflow (from non-alluvial geologic units that bound the alluvial basins), and engineered recharge (percolation ponds and septic tank effluent) (California Department of Water Resources, 2003b, 2004b–f; U.S. Geological Survey, 2009) (fig. 4).



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

**Figure 4.** The Central Desert study area (CD), the boundaries of the California Department of Water Resources (CDWR) defined groundwater basins, the distribution of the CD study area grid cells, the location of California Department of Public Health (CDPH) wells, and the location of sampled grid wells.

## CLUB Study Unit—Low-Use Basins of the Mojave and Sonoran Deserts Study Area

The Low-Use Basins of the Mojave and Sonoran Deserts study area (hereinafter referred to as the LUB study area) is 11,512 mi$^2$ in area and contains a total of 40 CDWR-defined basins and subbasins (California Department of Water Resources, 2003c, 2004g–ss). These basins and subbasins are spread over a large area in southeastern California that encompasses portions of the Mojave and Sonoran Deserts (fig. 2). The LUB study area is bounded on the west by the Laguna, San Bernardino, and Little San Bernardino Mountains. The northern border of the study area is bounded by the Garlock fault zone and the Tehachapi, Chuckwalla, El Paso, Panamint, Soda, and Clark Mountains. The eastern border of the study area is bounded by the state of Nevada and the Colorado River, and the southern boundary is the international border with Mexico (fig. 5*A–H*).

### Low-Use Basins of the Mojave and Sonoran Deserts Study Area—Mojave Desert Region

In the LUB study area, 24 CDWR-defined basins and subbasins are located in the Mojave Desert (hereinafter referred to as the LUB Mojave Desert region). The LUB Mojave Desert region consists of the CDWR-defined basins and subbasins located along and to the north of California State Route 62 (fig. 2). Land-surface altitudes in the region range from approximately 600 ft above msl near Bristol Lake, to over 7,900 ft above msl on the flanks of the Clark Mountains located northeast of the city of Baker (fig. 5*C*). The major surface drainage features in the region are the Los Angeles Aqueduct, Mojave River, and numerous ephemeral streams, creeks, and washes that flow towards dry lake beds located inside or adjacent to the groundwater basins and (or) subbasins (fig. 5*A–E*).

The climate in this region is classified as high arid desert (due to the land-surface altitude), with hot, dry summers and cold winters (PRISM Climate Group, Oregon State University, 2010; U.S. Department of Commerce, National Climatic Data Center, 2010). The region lies in the rain shadow of the Tehachapi and the Sierra Nevada Mountains with rainfall principally occurring in the winter months from storms originating in the Pacific Ocean. Average annual precipitation in the region is approximately 6 inches per year (in/yr). Some basins and subbasins can potentially receive no annual rainfall (PRISM Climate Group, Oregon State University, 2010; Western Regional Climate Center, 2010).

Aquifers in the region are found in alluvial deposits of Miocene to Holocene age. The primary aquifers in the region are located in alluvium of Quaternary age. To a lesser extent, groundwater is found in Tertiary alluvium primarily underlying the alluvial deposits of Quaternary age, which are composed largely of unconsolidated to semi-consolidated clays, silts, sands, and gravels. Water-bearing formations in the region are on average about 2,000-ft thick (California Department of Water Resources, 2003c, 2004g–r, u–bb).

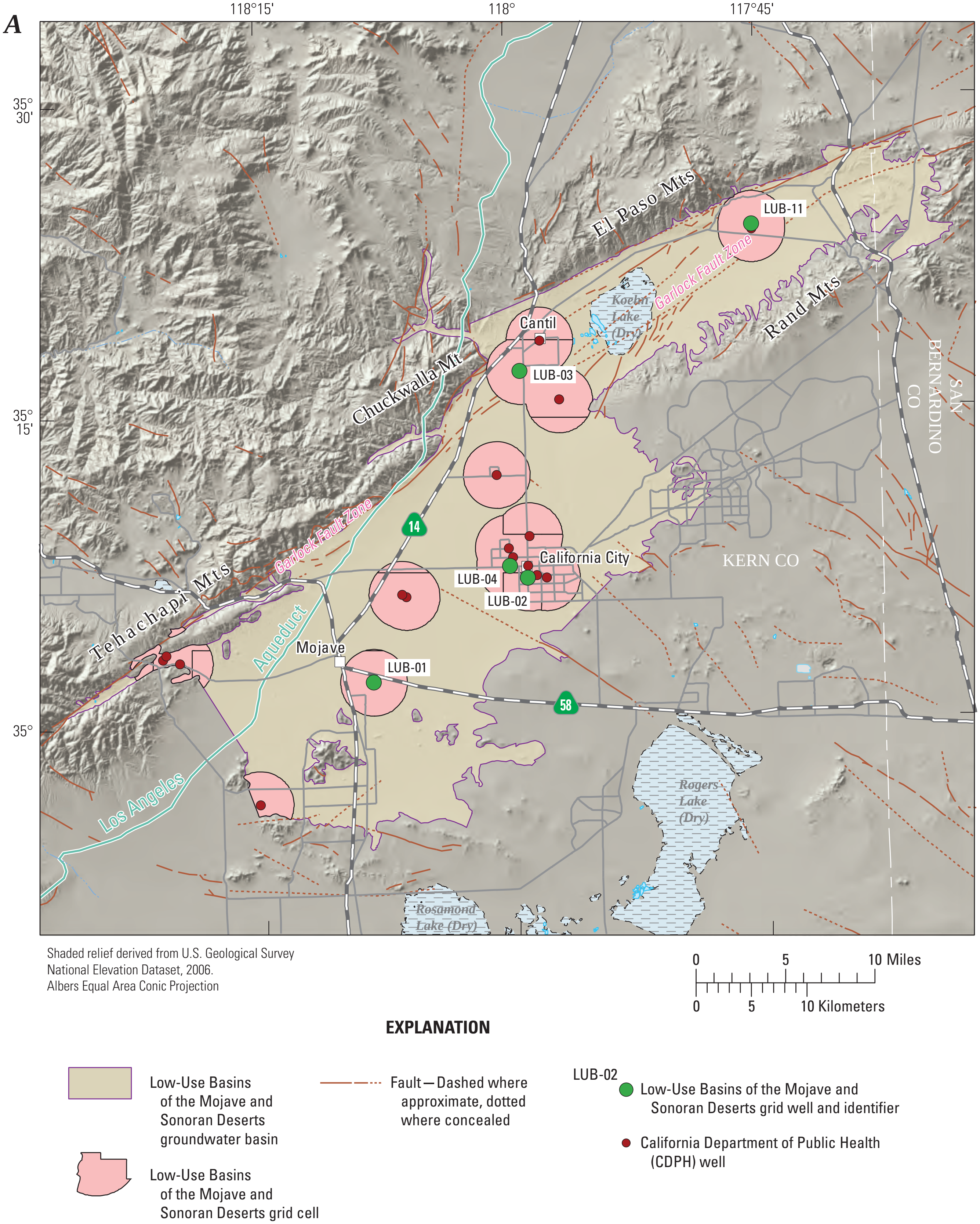
The general direction of groundwater flow in the region is from the surrounding mountains and hills towards dry lake beds located inside or adjacent to the basins and (or) subbasins. Nearly every basin and subbasin that makes up the region has faults present. Some faults act as hydrologic barriers, while the effect of other faults on groundwater flow is unknown (California Department of Water Resources, 2003c, 2004g–r, u–bb). In addition, an anticline is present north and west of the city of Twentynine Palms, limiting groundwater interaction between the LUB Mojave Desert region and the CD study area (California Department of Water Resources, 2004w–y) (fig. 5*C* and 5*E*).

Groundwater recharge in the region occurs from a mixture of ambient recharge (infiltration of runoff from the surrounding mountains into alluvial fan deposits, direct percolation of precipitation, and seepage from ephemeral rivers, streams, and washes) and subsurface inflow (from non-alluvial geologic units that bound the alluvial basins) (California Department of Water Resources, 2003c, 2004g–r, u–bb).

### Low-Use Basins of the Mojave and Sonoran Deserts Study Area—Sonoran Desert Region

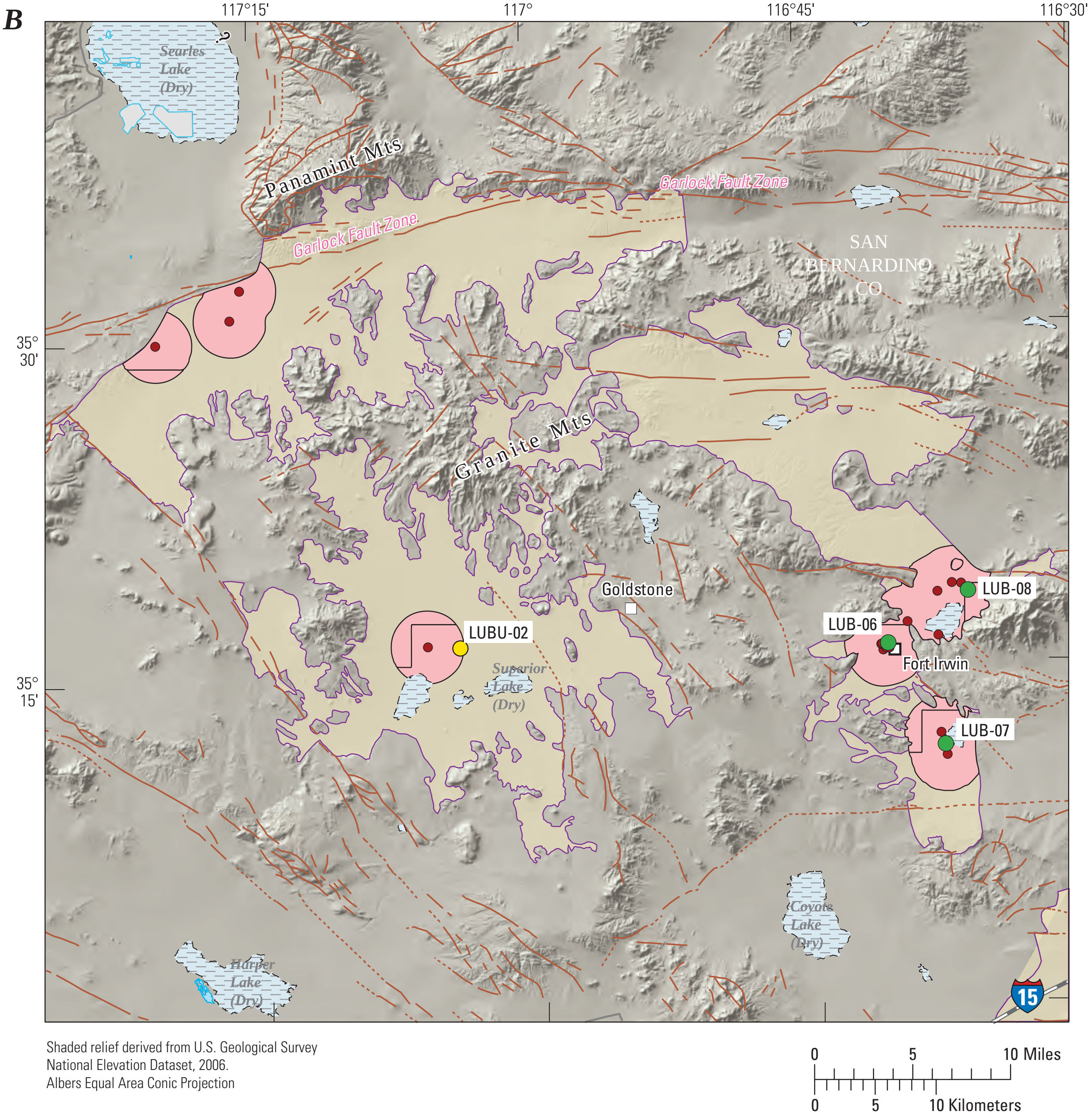
In the LUB study area, 16 CDWR-defined basins are situated in the Sonoran Desert (hereinafter referred to as the LUB Sonoran Desert region). The LUB Sonoran Desert region is composed of CDWR-defined basins located to the south of California State Route 62 (fig. 2). Land-surface altitudes in this region range from approximately 230 ft below msl in the basins surrounding the Salton Sea, to approximately 9,700 ft above msl in the Santa Rosa Mountains just north of the BV study area (figs. 3 and 5*F–H*). The major surface drainage features of the region are the Salton Sea and the Colorado River. The Salton Sea is fed by the New and Alamo Rivers, San Felipe, Vallecitos, and Caririzo Creeks, and unnamed ephemeral streams. The Colorado River supplies water to the Colorado Aqueduct, the All American, Coachella, and East Highline Canals, and the New and Alamo Rivers (fig. 5*F–H*).

The climate in the region is classified as subtropical desert (due to the land-surface altitude), with very hot summers and cool winters (PRISM Climate Group, Oregon State University, 2010; U.S. Department of Commerce, National Climatic Data Center, 2010). Rainfall in these basins follows a bimodal pattern similar to that of the BV study area. The winter storms originating in the Pacific Ocean have a greater influence on precipitation in the western parts of the LUB Sonoran Desert region, and the North American Monsoon accounts for most of the rainfall in the central and eastern parts (Adams, 1997). Annual rainfall in the region is approximately 4 in/yr, while some basins can receive little to no precipitation per year (PRISM Climate Group, Oregon State University, 2010; Western Regional Climate Center, 2010).



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

**Figure 5.** (*A*) The northwestern part, (*B*) the northern part, (*C*) the northeastern part, (*D*) the western part, (*E*) the central part, (*F*) the eastern part, (*G*) the southwestern part, and (*H*) the southeastern part of the Low-Use Basins of the Mojave and Sonoran Deserts study area (LUB), the boundaries of the California Department of Water Resources (CDWR) defined groundwater basins, the distribution of the LUB study-area grid cells, the location of California Department of Public Health (CDPH) wells, and the location of sampled grid and understanding wells.



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

**EXPLANATION**

▭ Low-Use Basins of the Mojave and Sonoran Deserts groundwater basin

▭ Low-Use Basins of the Mojave and Sonoran Deserts grid cell

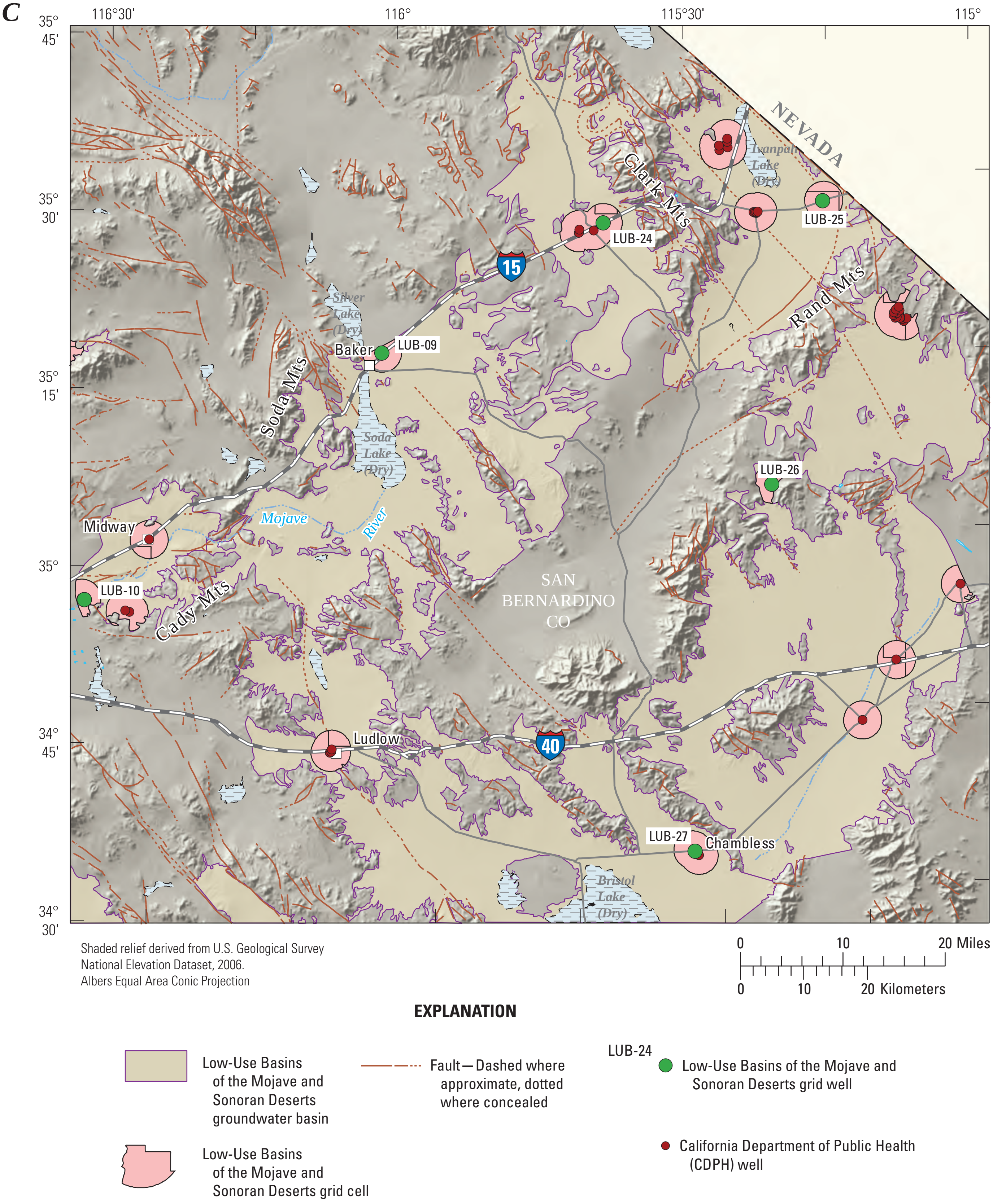
— — ··· Fault—Dashed where approximate, dotted where concealed

LUB-07 ● Low-Use Basins of the Mojave and Sonoran Deserts grid well and identifier

LUBU-02 ● Low-Use Basins of the Mojave and Sonoran Deserts understanding well and identifier

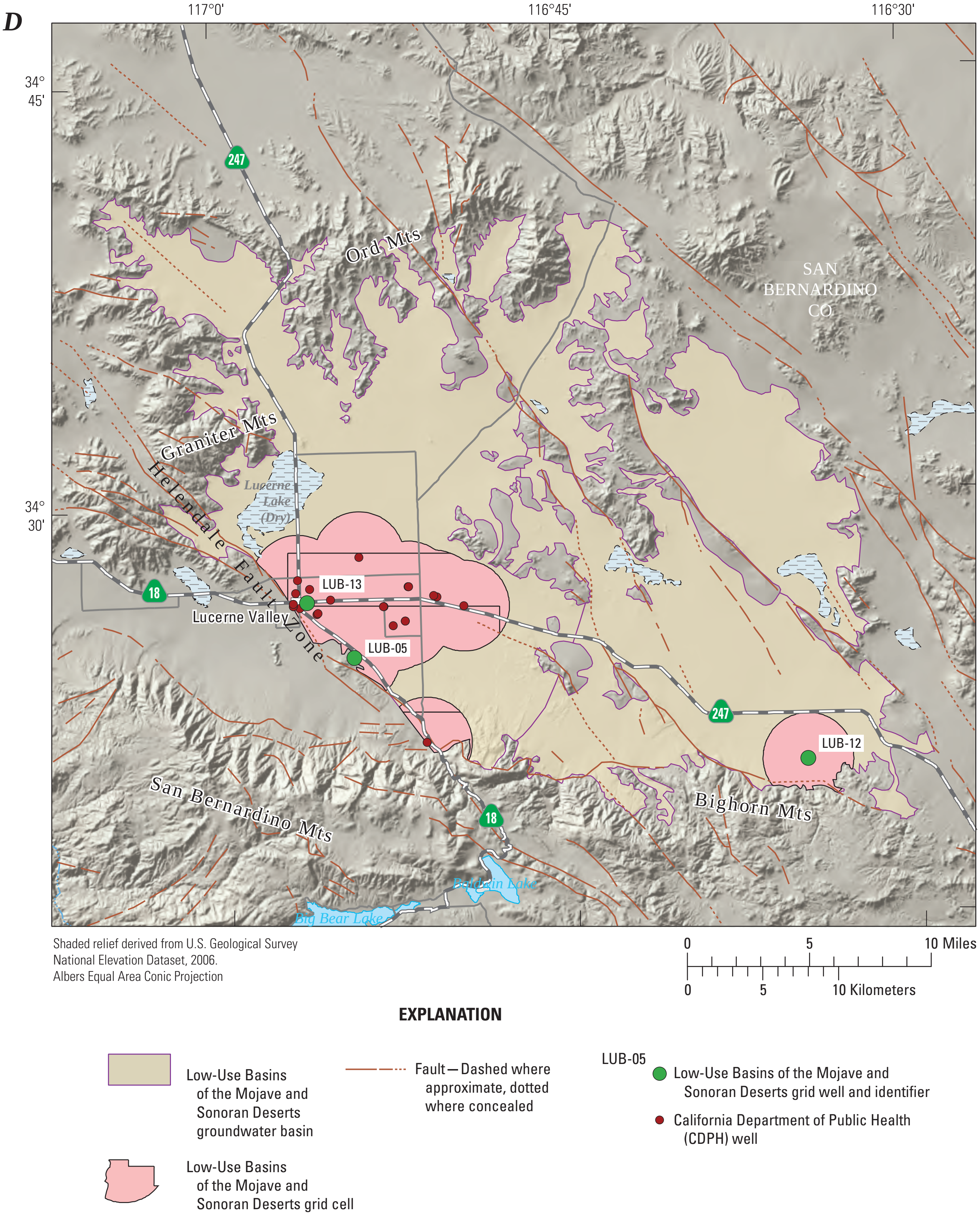
● California Department of Public Health (CDPH) well

**Figure 5.**—Continued



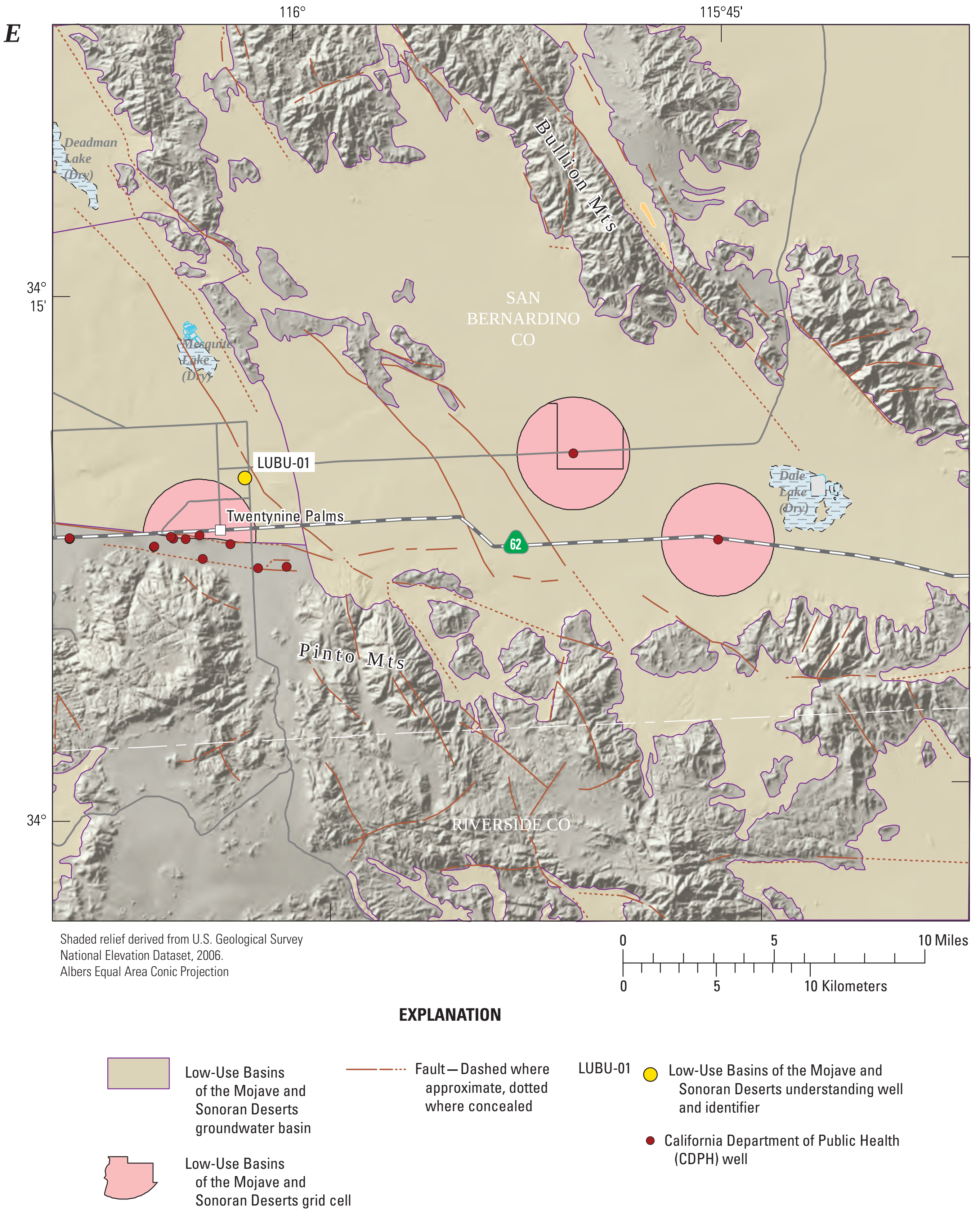
Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006.
Albers Equal Area Conic Projection

**Figure 5.**—Continued



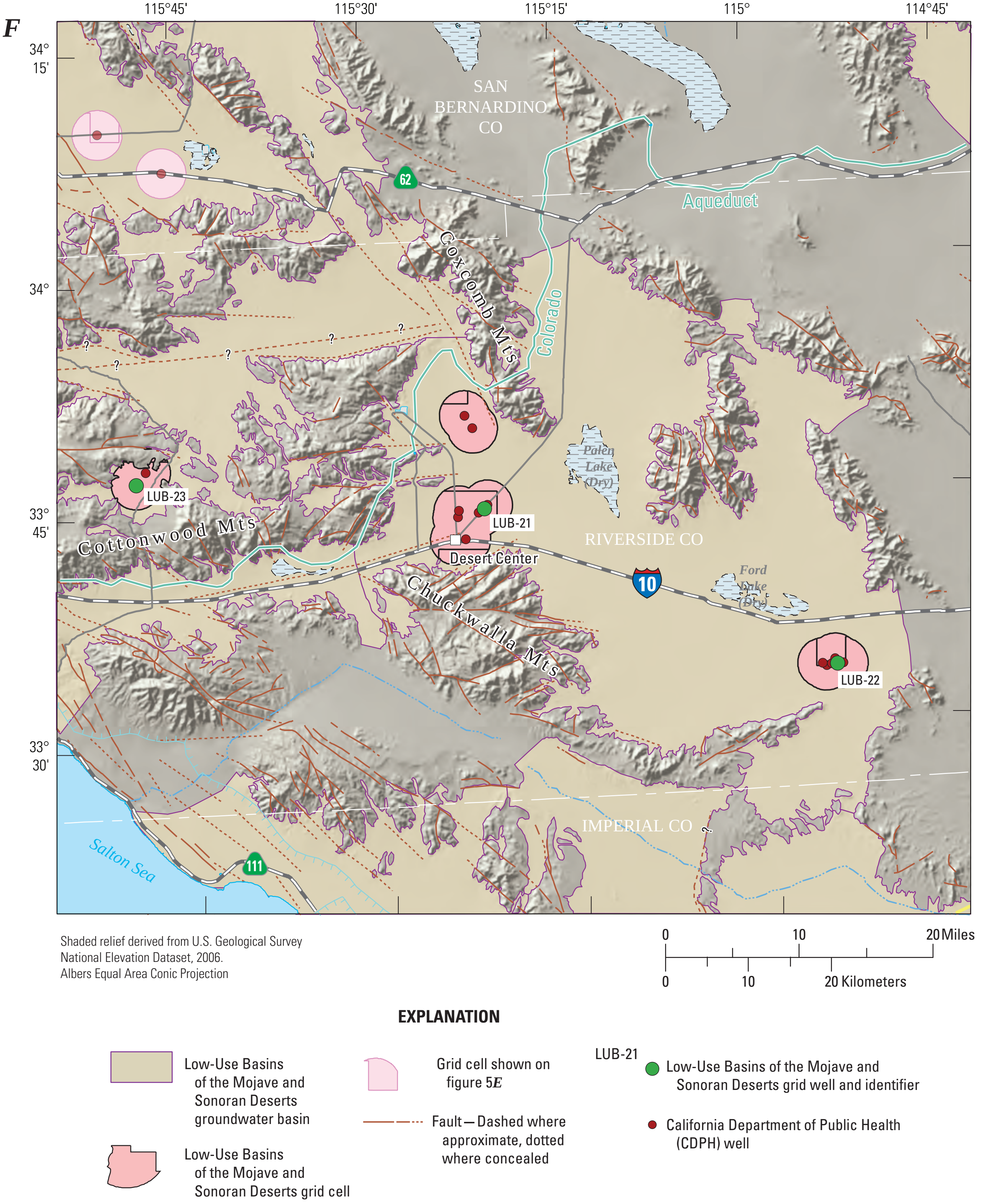
Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006.
Albers Equal Area Conic Projection

**Figure 5.**—Continued



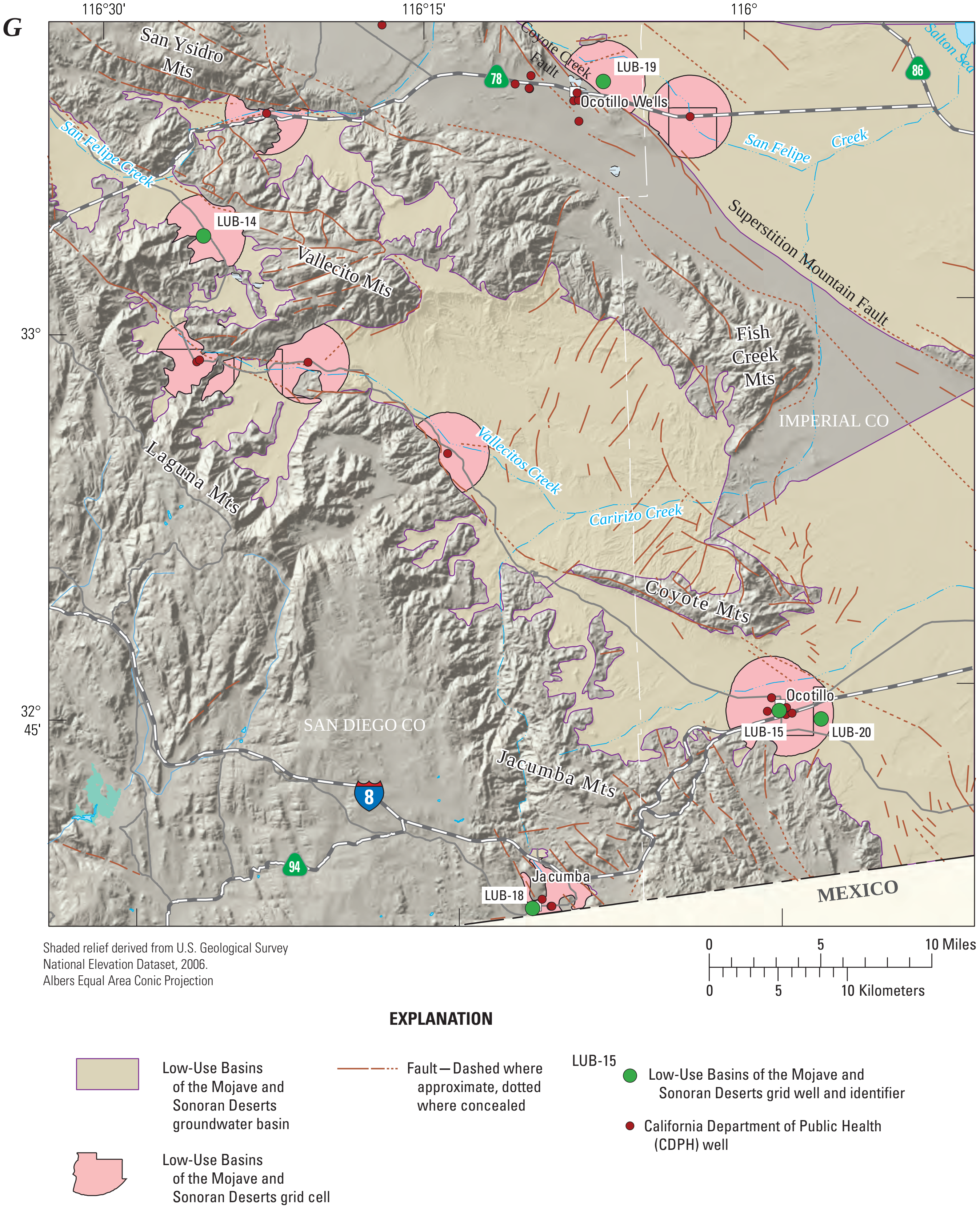
Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006.
Albers Equal Area Conic Projection

**Figure 5.**—Continued



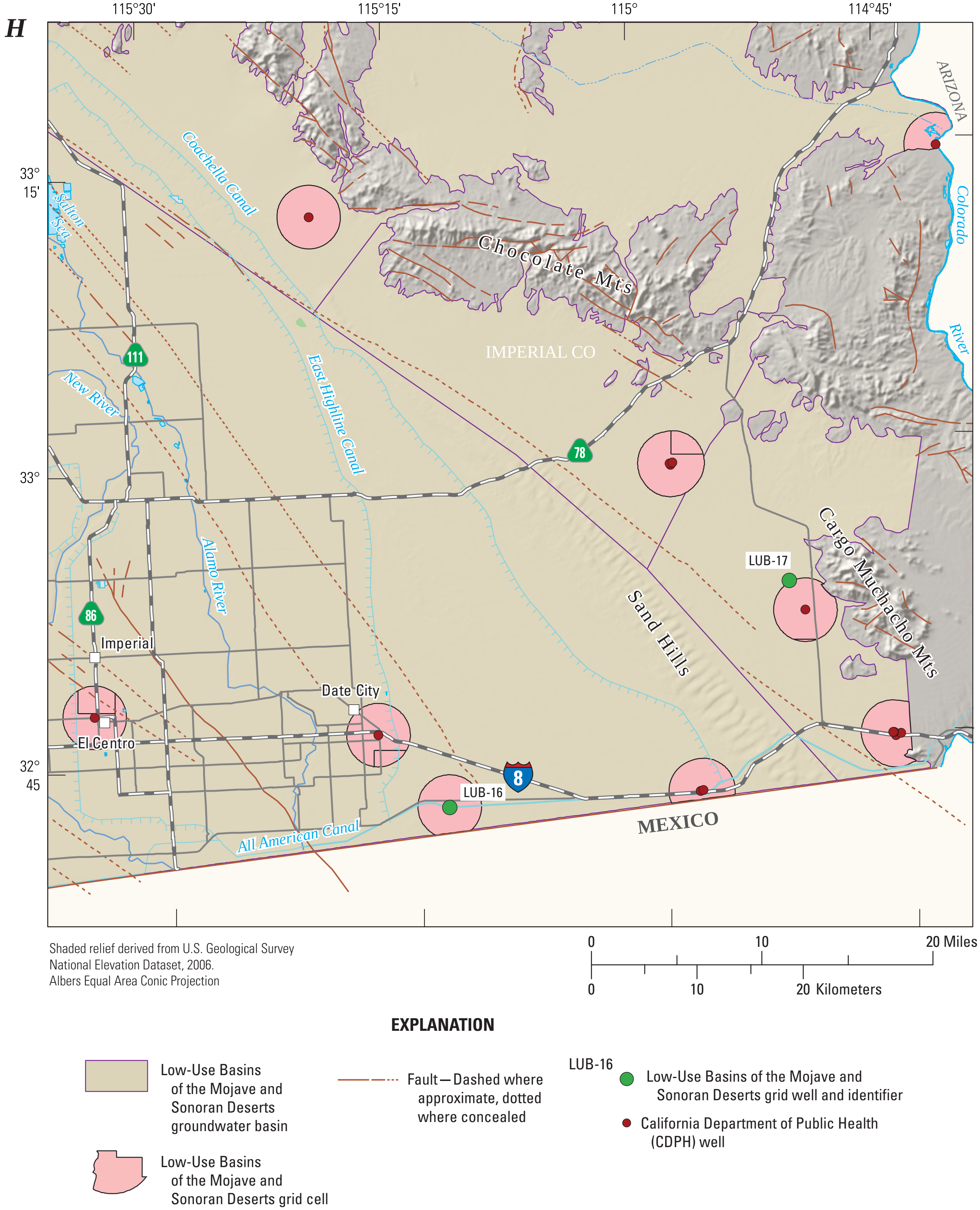
Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006.
Albers Equal Area Conic Projection

**Figure 5.**—Continued



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

**Figure 5.**—Continued



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

**Figure 5.**—Continued

The primary aquifers in the region are located in alluvium of Quaternary age. To a lesser extent, groundwater is found in Tertiary-aged alluvium that is usually overlain by the alluvium of Quaternary age. Both the Quaternary and Tertiary deposits are composed of unconsolidated to semi-consolidated gravels, sands, silts, and clays. Water-bearing formations in the study area are, on average, 850 ft thick (California Department of Water Resources 2004s, t, cc–ss).

The general direction of groundwater flow in most of the basins that make up the LUB Sonoran Desert region is towards rivers, creeks, and streams that eventually discharge into the Salton Sea. In the remaining basins, the direction of groundwater flow is from the surrounding hills and mountains towards dry lake beds. The region has numerous faults associated with the San Andreas fault zone that act as the major barriers to groundwater flow. To a lesser extent, clay deposits and bedrock act as impediments to groundwater movement (California Department of Water Resources, 2004s, t, cc–ss).

Groundwater recharge in the region occurs from a variety of sources: ambient recharge (infiltration of run off from the surrounding mountains into alluvial fan deposits, direct percolation of precipitation, seepage from ephemeral rivers, streams, and washes, agricultural return, and leaching along canals) and subsurface inflow (from non-alluvial geologic units that bound the alluvial basins) (California Department of Water Resources 2004s, t, cc–ss).

# 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 QA plan, 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. Forty-nine wells were selected to provide a statistically unbiased, spatially distributed assessment of the quality of groundwater resources used for public drinking-water supply. Wells sampled as part of the spatially distributed, randomized grid-cell network, hereinafter, are referred to as "grid wells." Three additional, non-randomized wells (hereinafter referred to as "understanding wells") were sampled in the BV and LUB study areas to aid in the understanding of groundwater-quality issues.

The spatially distributed wells were selected by using a randomized grid-based method (Scott, 1990). The randomized grid-based method divides the study areas into equal-area grid cells; however, geographic features may force a grid cell to be divided into multiple pieces to obtain the designated coverage area for each cell. For instance, a portion of a grid cell may be located on either side of a mountain range, but the grid cell is still considered one grid cell.

In the CLUB study unit, the approach was to sample one available CDPH well located within each grid cell. 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 domestic, irrigation, and (or) industrial, were considered for sampling. These "alternative" wells were identified from wells listed in USGS databases or by door-to-door canvassing. Wells with depths and screened intervals similar to those in CDPH wells in the area were selected. In this fashion, one well was selected for possible sampling in each cell to provide a spatially distributed, randomized monitoring network.

The BV study area was divided into nine equal-area grid cells, each approximately 9.7 $mi^2$ (25 square kilometers [$km^2$]) in area; wells in seven of the nine grid cells were sampled (fig. 3). The CD study area was divided into 17 equal-area grid cells, approximately 9.2 $mi^2$ (24 $km^2$) in area; wells in 15 of the 17 grid cells were sampled (fig. 4). The LUB study area was divided into 30 equal-area grid cells, approximately 20 $mi^2$ (52 $km^2$) in area; wells in 27 of the 30 grid cells were sampled (fig. *5A–H*).

The design of the grid cells differed within the CLUB study unit because of differences in the distribution of CDPH wells and the overall size of each study area. A direct sampling approach involving use of circular buffers around each CDPH well was used, as has been used in other GAMA-PBP study units with few and (or) unevenly distributed CDPH wells (Wright and others, 2005; Kulongoski and others, 2006; Fram and Belitz, 2007; Ferrari and others, 2008; Land and Belitz, 2008; Densmore and others, 2009; Fram and others, 2009; Bennett and others, 2009; Mathany and Belitz, 2009; Schmitt and others, 2009; Goldrath and others, 2010; Mathany and others, 2010). These buffers have a radius of about 3 kilometers (km), and the combined area was divided into the equal-area grid cells. In the BV and CD study areas, the CDPH wells were clustered in and around population centers, and the two study areas were relatively similar in size (BV = 238 $mi^2$ and CD = 353 $mi^2$); therefore, the size of the grid cells were similar (figs. 3 and 4). In the LUB study area, the CDPH wells were distributed sporadically, and the study area was much larger than the other study areas (LUB = 11,512 $mi^2$); consequently, the size of each grid cell was much larger than the grid cells in other study areas (fig. *5A–H*).

The 49 grid wells sampled in the CLUB study unit were numbered in the order in which samples were collected in each study area with the prefix varying by study area; "BV" for the Borrego Valley, "CD" for the Central Desert, and "LUB" for the Low-Use Basins of the Mojave and Sonoran Deserts (figs. 3, 4, and 5*A*–*H*).

The three understanding wells sampled as part of the study were not included in the statistical characterization of water quality in the CLUB study unit because inclusion of these wells would lead to the overrepresentation of some cells. These additional wells were numbered in the order of sample collection with the prefix modified from those used by the grid cells: "BVU" or "LUBU" ("U" indicates "understanding") (figs. 3, 5*B* and 5*E*).

The GAMA alphanumeric identification number for each well, along with the date sampled, sampling schedule, land-surface altitude, well type, and available well-construction information, is shown in table 1. Groundwater samples were collected from 42 CDPH wells, 4 domestic wells, 2 irrigation wells, 2 unused wells, 1 industrial well, and 1 institutional well during the period from December 2008 to March 2010.

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, and (or) other sources of construction information. Well location and information were recorded by hand on field sheets and electronically on field laptop computers using the Alternate Place Entry Form (APE) program designed by the USGS. All information was verified and then uploaded into the USGS National Water Information System (NWIS) database. Well location, well owner, and well-use information is confidential.

The wells in the CLUB study unit were sampled by using a tiered analytical approach. All wells were sampled for a standard set of constituents: water-quality indicators, VOCs, pesticides and pesticide degradates, perchlorate, stable isotopes of hydrogen and oxygen in water, stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance, tritium, and dissolved noble gases. The standard set of constituents was termed the "fast" schedule (table 2). Wells on the "slow" schedule were sampled for all constituents on the *fast* schedule, plus pharmaceutical compounds, *N*-nitrosodimethylamine (NDMA), trace elements, nutrients, major and minor ions, silica, total dissolved solids (TDS), stable isotopes of boron and strontium in water, radon-222, radium isotopes, and gross alpha and gross beta radioactivity. Species of inorganic chromium were sampled for on the CLUB study-unit *slow* sampling schedule in December 2008. Hexavalent chromium (chromium-VI, Cr-VI) analysis from a second laboratory was added to the CLUB study-unit *slow* sampling schedule starting in October 2009. Additionally, the 18 wells on the *fast* schedule in the LUB study area were sampled for trace elements, nutrients, major and minor ions, silica, and TDS (table 2).

*Fast* and *slow* refers to the relative time required to sample the well for all analytes on the schedule. Two *slow* or three *fast* wells generally could be sampled in 1 day. In the CLUB study unit, 28 of the wells were sampled on the *fast* schedule (26 grid and 2 understanding), and 24 wells were sampled on the *slow* schedule (23 grid and 1 understanding) (table 1).

## Sample Collection and Analysis

Samples were collected with modified USGS National Water-Quality Assessment (NAWQA) Program (Koterba and others, 1995) and USGS National Field Manual (NFM) (U.S. Geological Survey, variously dated) sampling protocols. 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.

Table 3A–K lists the compounds analyzed in each constituent class. Groundwater samples were analyzed for 85 VOCs (table 3A); 63 pesticides and pesticide degradates (table 3B); 13 pharmaceutical compounds (table 3C); 2 constituents of special interest (table 3D); 24 trace elements (table 3E); 5 nutrients (table 3F); 9 major and minor ions, silica, TDS, and alkalinity (table 3G); species of inorganic chromium (table 3H and 3I); 4 stable isotopes and 7 radioactive constituents, including tritium and carbon-14 abundance (table 3J); and 6 dissolved noble gases and helium isotope ratios (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." Three water-quality indicators—alkalinity, pH, and specific conductance—were measured in the field and at the USGS National Water Quality Laboratory (NWQL), and both results are reported (see the appendix section titled "Constituents on Multiple Analytical Schedules"). Total chromium and Cr-VI were measured by two different laboratories, and all results are reported (tables 8, 11, and 12). Tritium activities were measured by two different laboratories, but only one set of results were available at the time this report was published.

## Quality-Assurance Methods

The QA/QC 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 USGS NWQL, the primary laboratory used to analyze samples for this study, is described in Pirkey and Glodt (1998) and Maloney (2005).

QC samples collected in the CLUB 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/QC procedures and results are described in the appendix section titled "Quality-Assurance Methods."

# 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 NWQL blanks and QC samples collected for this and previous GAMA-PBP study units, the reporting levels for 10 VOCs and 13 trace elements were raised. Detections of the 10 VOCs with concentrations less than the raised reporting limits were removed from the set of groundwater-quality data presented in this report. Detections of the 13 trace elements with concentrations less than the raised reporting limits are flagged with a less than or equal to symbol (≤) in this report (see table A3 and additional discussion in the appendix section titled "Detections in Field Blanks and Application of SRLs"). Results from the replicates confirm that the procedures used to collect and analyze the samples were consistent. Variability for nearly 100 percent of the replicate pairs for constituents detected in samples was within the acceptable limits (table A4A–C). Median matrix-spike recoveries for 25 of the 150 organic and special-interest constituents analyzed were outside the acceptable range of between 70 and 130 percent (tables 3B and A5B). Constituents for which low recoveries occurred might not have been detected in some samples if they were present at concentrations near the laboratory reporting levels (LRLs), and 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 Results."

## Comparison 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 aquifers of the CLUB 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 concentration 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, the 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 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 (L) (2.1 quarts) of water per day over a 70-year lifetime by a 70-kilogram (154-pound) adult and that 20 percent of a person's exposure comes from drinking water.

- **RSD5–Risk-Specific Dose.** The concentration of a constituent in drinking water corresponding to an excess estimated lifetime cancer risk of 1 in 100,000. RSD5 is an acronym for risk-specific dose at $10^{-5}$. RSD5s are calculated by dividing the $10^{-4}$ cancer risk concentration established by the USEPA by 10 (RSD5-US).

For constituents with MCLs, detections in groundwater samples were compared to the MCL-US or MCL-CA. Constituents with SMCLs were compared with the SMCL-CA. For chloride, sulfate, specific conductance, and TDS, CDPH defines a "recommended" and an "upper" SMCL-CA; detections of these constituents in groundwater samples were compared with both levels. The SMCL-US for these constituents corresponds to the recommended SMCL-CA. Detected concentrations of constituents without an MCL or SMCL were compared to the NL-CA. For constituents without an MCL, SMCL, or NL-CA, detected concentrations were compared with the HAL-US. For constituents without an MCL, SMCL, NL-CA, or HAL-US, detected concentrations were compared with the RSD5-US. For constituents without an MCL, SMCL, NL-CA, HAL-US, or RSD5-US, detected concentrations were compared with the AL-US. Note that using this hierarchy to select the comparison benchmark for a constituent with more than one type of established benchmark will not necessarily result in selection of the benchmark with the lowest concentration. For example, for zinc the SMCL-CA is 5,000 µg/L and the HAL-US is 2,000 µg/L, but the comparison benchmark selected by this hierarchy is the SMCL-CA. The comparison benchmarks used in this report are listed in table 3A–K for all constituents and in tables 4–14 for constituents detected in groundwater samples from the CLUB study unit. Established benchmarks are not available for all constituents analyzed for this study. Detections of constituents at concentrations greater than the selected comparison benchmark are marked with asterisks in tables 4, 8–10, and 14C.

## Groundwater-Quality Data

Results from analyses of untreated-groundwater samples from the CLUB study unit are presented in tables 4–14. These results are separated into the three study areas that make up the CLUB study unit (BV, CD, and LUB). Groundwater samples collected in the CLUB study unit were analyzed for 221 constituents; 134 of those constituents were not detected in any of the samples, and 68 constituents were detected (table 3A–K). The LLNL results for dissolved noble gases, tritium, and helium isotope ratios have not been received yet and are not presented in this report; they will be included in a subsequent publication.

For organic and special-interest constituent classes that were analyzed at all of the grid wells, the results tables include the following summary statistics: 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 in each study area), and the total number of constituents detected at each well. For the inorganic, isotopic, and radioactive constituent classes, the tables include all of the wells, constituents, and samples analyzed.

Water-quality indicators measured in the field and at the NWQL are included in table 4. The results of groundwater analyses organized by compound classes are presented in tables 5–14:

- 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)
- Species of inorganic chromium (table 11)
- Hexavalent chromium (chromium-VI) (table 12)
- Isotopic tracers (table 13)
- Radioactive constituents
  - Radon-222 (table 14A)
  - Radium isotopes (table 14B)
  - Gross alpha and gross beta radioactivity (table 14C)

## 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 are calculated from the pH and alkalinity results. Dissolved oxygen, alkalinity, and bicarbonate and carbonate concentrations are used as indicators of natural processes that affect water chemistry. The pH value indicates the acidity of the water. Specific conductance is the measure of electrical conductivity of the water and is proportional to the amount of total dissolved solids in the water.

Field pH values for 5 of the 49 grid wells sampled (1 in the BV study area, 1 in the CD study area, and 3 in the LUB study area) in the CLUB study unit were outside of the SMCL-US range for pH (<6.5 or >8.5) (table 4). Laboratory pH values may be dissimilar to 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 for 18 of 49 of the CLUB study-unit grid-well samples were greater than the recommended SMCL-CA of 900 microsiemens per centimeter (µS/cm) (approximately 37 percent) (table 4). Field specific-conductance values for five of seven grid-well samples in the BV study area were greater than the recommended SMCL-CA, and two of these values also were greater than the upper SMCL-CA of 1,600 µS/cm. Field specific-conductance values for 1 of 15 grid-well samples in the CD study area were greater than the recommended SMCL-CA. Field specific-conductance values for 12 of 27 grid-well samples in the LUB study area were greater than the recommended SMCL-CA, and 3 of these values also were greater than the upper SMCL-CA.

## 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, 8 were detected in the CLUB study-unit groundwater samples; all detections in samples were less than health-based benchmarks (table 5). One or more VOCs were detected in 17 of the 49 CLUB study-unit grid wells sampled (about 35 percent detection frequency). Three VOCs, including chloroform (trichloromethane), were detected in two of the seven grid wells sampled in the BV study area (approximately 29 percent). Chloroform is among the most commonly detected VOCs in groundwater nationally (Zogorski and others, 2006). VOCs were detected in 3 of the 15 grid wells sampled in the CD study area (20 percent); chloroform was detected in all 3 grid wells in which VOCs were detected. VOCs were detected in 12 of the 27 grid wells sampled in the LUB study area (approximately 44 percent). Chloroform and perchloroethene (PCE) were detected in more than 10 percent of the grid wells sampled in the LUB study area. Chloroform and 1,2,4-trimethylbenzene were the only VOCs detected in one of the three understanding well samples (table 5).

Pesticides include herbicides, insecticides, and fungicides and are used to control weeds, insects, fungi, and other pests in agricultural, urban, and suburban settings. Of the 63 pesticides and pesticide degradates analyzed at 47 of the 49 grid wells in the CLUB study unit, 3 pesticides (atrazine, simazine, and metolachlor) and 3 pesticide degradates (3,4-dichloroaniline, deethylatrazine, and dieldrin) were detected in groundwater samples; all detections were less than health-based benchmarks (table 6). Atrazine, simazine, and deethylatrazine are among the nation’s most commonly detected pesticide compounds in groundwater (Gilliom and others, 2006). One or more pesticide compounds were detected in 5 of 47 grid wells sampled in the CLUB study unit (about 11 percent detection frequency). Four pesticide compounds were detected in 1 grid well sampled in the CD study area. Pesticide and (or) pesticide degradates were detected in 4 of 27 grid wells sampled in the LUB study area (approximately 15 percent). No pesticides and (or) pesticide degradates were detected in any of the seven grid wells sampled in the BV study area or in the three understanding wells sampled in the CLUB study unit.

Pharmaceutical compounds were not detected at concentrations greater than or equal to method detection limits in the CLUB study unit. Fram and Belitz (2011) present all results for pharmaceutical compounds in groundwater samples collected for the first 28 GAMA-PBP study units (May 2004 through March 2010).

## 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 analyzed for at all 52 wells in the CLUB study unit and was detected in 41 of 49 grid wells sampled (about 84 percent detection frequency; table 7). Perchlorate was detected in 4 of 7 grid wells sampled in the BV study area (approximately 57 percent). Perchlorate was detected in 14 of 15 grid wells sampled in the CD study area (approximately 93 percent). Perchlorate was detected in 23 of 27 grid wells sampled in the LUB study area (approximately 85 percent). Perchlorate was not measured at concentrations greater than the MCL-CA of 6 micrograms per liter (µg/L) in any of the grid or understanding wells sampled in the CLUB study unit. NDMA was sampled for at the 24 *slow* wells in the CLUB study unit and was not detected in any of the wells. As a result, NDMA is not included in table 7.

## Inorganic Constituents

Unlike the organic constituents and the constituents of special interest, inorganic constituents are naturally present in groundwater, although their concentrations may be influenced by human activities. Inorganic constituents were sampled for on the *slow* sampling schedule in the CLUB study unit and the *fast* sampling schedule in the LUB study area.

Regulatory health-based or non-regulatory health-based benchmarks have been established for 18 of 24 trace elements and for one of the major and minor ions analyzed in this study (table 3E, G). Of these 18 constituents with health-based benchmarks, all detections of 13 constituents had concentrations less than their respective benchmarks (table 8). Arsenic, boron, molybdenum, uranium, and fluoride were detected at concentrations greater than health-based benchmarks in samples from the CD and LUB study areas. Trace elements were not detected at concentrations greater than established health-based benchmarks in the BV study area well samples (table 8).

Arsenic concentrations greater than the MCL-US of 10 µg/L were detected in seven grid wells sampled (one in the CD study area and six in the LUB study area; table 8). Arsenic was measured at a concentration greater than the MCL-US in one LUBU well sample.

Boron concentrations greater than the CDPH notification level (NL-CA) of 1,000 µg/L were detected in four grid wells sampled in the LUB study area (table 8).

Molybdenum concentrations greater than the HAL-US of 40 µg/L were detected in six grid wells sampled (one in the CD study area and five in the LUB study area; table 8). Additionally, molybdenum was measured at a concentration greater than the HAL-US in one LUBU well sample.

Uranium concentrations greater than the MCL-US of 30 µg/L were detected in two grid wells sampled (one in the CD study area and one in the LUB study area; table 8).

Fluoride is the only major ion with a regulatory health-based benchmark (MCL-CA of 2 milligrams per liter [mg/L]); it was detected at a concentration greater than the MCL-CA in nine grid wells sampled (one in the CD study area and eight in the LUB study area; table 10). Fluoride was detected at a concentration greater than the MCL-CA in one LUBU well sample.

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 CLUB study-unit wells were less than health-based benchmarks, with the exception of nitrite plus nitrate ($NO_2^-$+$NO_3^-$), as nitrogen, detected at a concentration greater than the MCL-US of 10 mg/L in one grid well sampled in the LUB study area (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 not detected in any of the wells in the CLUB study unit (table 8). Manganese concentrations greater than the SMCL-CA of 50 µg/L were detected in one LUB study-area grid-well sample (table 8).

Chloride concentrations greater than the recommended SMCL-CA benchmark of 250 mg/L were detected in three grid wells sampled in the LUB study area (table 10). One of these three well samples also had chloride concentrations greater than the upper SMCL-CA benchmark of 500 mg/L.

Sulfate concentrations greater than the recommended SMCL-CA benchmark of 250 mg/L were detected in six grid wells sampled (one in the BV study area and five in the LUB study area; table 10).

TDS concentrations greater than the recommended SMCL-CA benchmark of 500 mg/L were detected in 20 grid wells sampled (3 in the BV study area, 1 in the CD study area, and 16 in the LUB study area; table 10). TDS concentrations greater than the upper SMCL-CA benchmark of 1,000 mg/L were detected in 2 of the 16 grid wells sampled in the LUB study area.

Silver and zinc were not detected at concentrations greater than the corresponding SMCL-CA in any of wells in the CLUB study unit (table 8). Additionally, all iron, manganese, chloride, sulfate, and TDS concentrations in the three understanding wells in the CLUB study unit were less than the SMCL-CA (tables 8, 10).

Chromium occurs 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 species can be used to aid in interpretation of the oxidation–reduction state of the aquifer. Concentrations of chromium (total) and (or) the concentrations of Cr-VI are reported in tables 11 and 12.

Species of inorganic chromium were sampled for at seven *slow* wells (three CD study-area grid wells and four LUB study-area grid wells) in December 2008. Chromium (total) and Cr-VI were detected in five grid-well samples in the CLUB study unit (three in the CD study area and two in the LUB study area; table 11). Concentrations of chromium (total) reported by the NWQL in table 8 are considered to be more accurate than the concentrations reported by the USGS National Research Program (NRP) Trace Metal Laboratory (TML), Boulder, Colorado, in table 11 (see the appendix section titled "Constituents on Multiple Analytical Schedules").

Cr-VI is a heavy metal that is frequently detected at low levels in California's drinking-water supply (California Environmental Protection Agency, 2009). Cr-VI has a variety of natural sources (oxidation of chromium-III, serpentine-containing rocks, and chromium-containing geologic formations) and anthropogenic sources (chrome-plating liquid wastes, dye and paint pigments, wood preservatives, chemical manufacturing, and the combustion of natural gas, oil, and coal) (California Environmental Protection Agency, 2009; California State Water Resources Control Board, 2009b). In January 2001, CDPH identified Cr-VI as an unregulated chemical requiring monitoring (California State Water Resources Control Board, 2009b).

Cr-VI was sampled for at 17 *slow* wells (3 BV study-area grid wells, 6 CD study-area grid wells, 7 LUB study-area grid wells, and the BVU well) in the CLUB study unit starting in October 2009. These samples were analyzed at TestAmerica Laboratories, Inc. (TALIR), Irvine, California, rather than at the NRP-TML in order to fulfill a contractual obligation with the NWQL. Cr-VI was detected in seven grid wells sampled in the CLUB study unit (four in the CD study and three in the LUB study area; table 12). Cr-VI also was detected in the BVU well sampled.

## Isotopic Tracers and Dissolved Noble Gases

The isotopic ratios, 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).

The isotopic ratios of hydrogen and oxygen in water (table 13) aid in the interpretation of the sources of groundwater recharge. These stable-isotope ratios reflect the altitude, latitude, and temperature of precipitation and also the extent of evaporation of the water in surface-water bodies or soils prior to infiltration into the aquifer.

Stable-isotope ratios of boron in water may be useful in distinguishing the sources of boron in aquifers. A geochemically-based classification of the source of boron in groundwater could potentially determine the similarity of boron to known sources or mixtures between known sources, or classify whether the relative age of the groundwater predated potential sources.

Stable-isotope ratios of strontium in water reflect the amount of strontium (and other inorganic constituents) the aquifer materials are contributing to the groundwater system. In regions that have diverse geology, strontium isotope ratios may aid in estimating groundwater-flow paths.

Tritium activities (table 13), helium isotope ratios, and carbon-14 abundance (table 13) also provide information about the age (time since recharge) of groundwater. Tritium is a short-lived radioactive isotope of hydrogen that is incorporated into the water molecule. Low levels of tritium are produced continuously by interaction of cosmic radiation with the Earth's atmosphere, and a large amount of tritium was produced as a result of atmospheric testing of nuclear weapons between 1952 and 1963. Thus, concentrations of tritium greater than background 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.

Carbon-14 (table 13) is a radioactive isotope of carbon. Low levels of carbon-14 are produced continuously by interaction of cosmic radiation with the Earth's atmosphere and 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.

Gases dissolve in water that is in contact with the atmosphere, and the solubilities of the different gas species vary with temperature. Concentrations of dissolved noble gases are used to estimate the conditions of groundwater recharge, particularly the temperature of the recharge water.

Of the isotopic tracer constituents analyzed for this study, tritium is the only one with a health-based benchmark. All measured tritium activities in samples from the well samples in the CLUB study unit were more than three orders of magnitude less than the MCL-CA benchmark (table 13).

## Radioactive Constituents

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

Activity often is used instead of concentration for reporting the presence of radioactive constituents. Activity of radioactive constituents in groundwater is measured in units of picocuries per liter (pCi/L), and 1 pCi/L is approximately equal to two atoms decaying per minute. The number of atoms decaying is equal to the number of alpha or beta particles emitted.

Radon-222 was sampled for at 22 *slow* grid wells and 1 *slow* understanding well in the CLUB study unit (table 14A). Radium isotopes (radium-226 and radium-228) and gross alpha and gross beta radioactivity were sampled for at 23 *slow* grid wells and 1 *slow* understanding well (table 14B, C).

Radon-222 activities for all wells sampled in the CLUB study unit were less than the proposed MCL-US of 4,000 pCi/L (table 14A). 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).

Radium isotope (radium-226 and radium-228) activities for all of the wells sampled in the CLUB study unit were less than the MCL-US of 5 pCi/L (table 14B). The MCL-US benchmark for radium is the sum of radium-226 and radium-228.

Gross alpha and gross beta radioactivity activities for most of the wells sampled in the CLUB study unit were less than established health-based benchmarks (table 14C). Exceptions include two detections of gross alpha radioactivity (72-hour count) and one detection of gross alpha radioactivity (30-day count) greater than the MCL-US of 15 pCi/L in two grid wells sampled in the CD study area and two detections of gross alpha radioactivity (72-hour count) in two grid wells sampled in the LUB study area.

# Future Work

Subsequent reports for the CLUB 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 CLUB 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 boron and strontium in water and the LLNL results (dissolved noble gases, tritium, and helium isotope ratios) for the CLUB study unit.

# Summary

Groundwater quality in the 12,103-square-mile Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) study unit was investigated by the U.S. Geological Survey (USGS) from December 2008 to March 2010, as part of the California State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment (GAMA) Program's Priority Basin Project (PBP). The GAMA 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 CLUB study was designed to provide a spatially unbiased assessment of untreated-groundwater quality in the primary aquifer systems and to facilitate statistically consistent comparisons of untreated-groundwater quality throughout California. The primary aquifer systems (hereinafter referred to as primary aquifers) are defined as parts of aquifers corresponding to the perforation intervals of wells listed in the California Department of Public Health (CDPH) database for the CLUB study unit. The quality of groundwater in shallow or deep water-bearing zones may differ from that in the primary aquifers; 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 CLUB study unit is located within the Mojave and Sonoran Deserts in the Desert hydrologic province and includes 47 groundwater basins and subbasins defined by the California Department of Water Resources. The CLUB study included assessment of the groundwater quality from 52 wells in San Bernardino, Riverside, San Diego, and Imperial Counties, California. Forty-nine of the wells were selected using a randomized grid approach to achieve statistically unbiased representation of groundwater used for public drinking-water supplies (grid wells). Three of the wells were selected to provide additional sampling density to aid in understanding processes affecting groundwater quality (understanding wells).

Groundwater samples were analyzed for water-quality indicators, organic constituents, naturally-occurring 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, 223 constituents and 12 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 10 percent of the wells in the CLUB study unit, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that contamination 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. Median matrix-spike recoveries were within the acceptable range (70 to 130 percent) for approximately 85 percent of the compounds.

Organic constituents were sampled for at all 49 grid wells in the CLUB study unit, and all detected concentrations were less than health-based benchmarks. Trace elements, nutrients, and major and minor ions were sampled for at 39 grid wells, and radioactive constituents were sampled for at 23 grid wells. Most detections were at concentrations less than health-based benchmarks.

In the Borrego Valley study area, all detected concentrations of trace elements, major and minor ions, and radioactive constituents were less than health-based benchmarks.

In the Central Desert study area, one detection of arsenic was greater than the USEPA maximum contaminant level (MCL-US), one detection of molybdenum was greater than the USEPA lifetime health advisory level (HAL-US), one detection of uranium was greater than the MCL-US, one detection of fluoride measured greater than the CDPH maximum contaminant level (MCL-CA), and two detections of gross alpha radioactivity (72-hour count) and one detection of gross alpha radioactivity (30-day count) were greater than the MCL-US.

In the Low-Use Basins of the Mojave and Sonoran Deserts study area, detections of arsenic were greater than the MCL-US, four detections of boron were greater than the CDPH notification level (NL-CA), five detections of molybdenum were greater than the HAL-US, one detection of uranium was at a concentration greater than the MCL-US, eight detections of fluoride were greater than the MCL-CA, one detection of nitrite plus nitrate ($NO_2^-$+$NO_3^-$), as nitrogen, was greater than the MCL-US, and two detections of gross alpha radioactivity (72-hour count) were greater than the MCL-US.

Most of the samples from the CLUB study-unit wells collected for trace elements and major ions had measured concentrations less than the non-enforceable benchmarks set for aesthetic concerns.

In the Borrego Valley study area, one detection of sulfate was greater than the recommended CDPH secondary maximum contaminant level (SMCL-CA), and three detections of TDS were greater than the recommended SMCL-CA.

In the Central Desert study area, one detection of TDS was greater than the recommended SMCL-CA.

In the Low-Use Basins of the Mojave and Sonoran Deserts study area, 1 detection of manganese was greater than the SMCL-CA, 3 detections of chloride were greater than the recommended SMCL-CA (1 of the detections was greater than the upper SMCL-CA), 5 detections of sulfate were greater than the recommended SMCL-CA, and 16 detections of TDS were greater than the recommended SMCL-CA (2 of the detections were greater than the upper SMCL-CA).

In the three understanding wells in the CLUB study unit, one detection of arsenic was greater than the MCL-US, one detection of molybdenum was greater than the HAL-US, and one detection of fluoride was greater than the MCL-CA.

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**Table 1.** Identification, sampling, and construction information for wells sampled for the Borrego, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[Sampling schedule is described in table 2. Land-surface datum (LSD) is a datum plane that is approximately at land surface at each well. The altitude of the LSD is described in feet above the North American Vertical Datum 1988 (NAVD 88). Numbered suffix indicates the order of sample collection within each study area. **GAMA well identification number:** BV, Borrego study-area grid well; BVU, Borrego study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. **Other abbreviations:** ft, foot; na, not available]

| Sampling information | | | | Construction information | | | |
|---|---|---|---|---|---|---|---|
| GAMA well identification number | Date sampled | Sampling schedule | Altitude of LSD (ft above NAVD 88) | Well type | Well depth (ft below LSD) | Depth to top perforation (ft below LSD) | Depth to bottom perforation (ft below LSD) |
| **CLUB grid wells** | | | | | | | |
| Borrego Valley study area | | | | | | | |
| BV-01 | 10-19-09 | Fast | 526 | Production | na | na | na |
| BV-02 | 10-20-09 | Fast | 731 | Production | 490 | na | na |
| BV-03 | 10-20-09 | Slow | 929 | Production | 350 | 150 | 350 |
| BV-04 | 10-26-09 | Slow | 830 | Production | 630 | 420 | 630 |
| BV-05 | 10-29-09 | Fast | 533 | Production | 580 | 248 | 568 |
| BV-06 | 11-03-09 | Fast | 383 | Production | 391 | 252 | 285 |
| BV-07 | 12-03-09 | Slow | 559 | Production | 95 | na | na |
| Central Desert study area | | | | | | | |
| CD-01 | 12-15-08 | Slow | 3,062 | Production | na | na | na |
| CD-02 | 12-15-08 | Fast | 3,471 | Production | 358 | na | na |
| CD-03 | 12-16-08 | Slow | 3,974 | Production | na | na | na |
| CD-04 | 12-17-08 | Slow | 2,512 | Production | 350 | 195 | 345 |
| CD-05 | 12-17-08 | Fast | 2,160 | Production | 430 | 220 | 420 |
| CD-06 | 12-18-08 | Fast | 2,839 | Production | na | na | na |
| CD-07 | 10-05-09 | Slow | 2,628 | Production | 740 | 470 | 720 |
| CD-08 | 10-05-09 | Fast | 2,467 | Production | 425 | na | na |
| CD-09 | 10-06-09 | Slow | 3,233 | Production | 1,115 | 550 | 1,115 |
| CD-10 | 10-06-09 | Fast | 3,285 | Production | 604 | 220 | 580 |
| CD-11 | 10-07-09 | Slow | 2,858 | Production | na | na | na |
| CD-12 | 10-07-09 | Slow | 2,793 | Production | 550 | na | na |
| CD-13 | 11-16-09 | Slow | 2,083 | Production | 260 | 147 | 247 |
| CD-14 | 11-17-09 | Slow | 2,524 | Production | 600 | 390 | 580 |
| CD-15 | 11-17-09 | Fast | 2,512 | Production | 600 | 390 | 580 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area | | | | | | | |
| LUB-01 | 12-02-08 | Slow | 2,663 | Production | 381 | 205 | 381 |
| LUB-02 | 12-02-08 | Fast | 2,423 | Unused | 543 | na | na |
| LUB-03 | 12-03-08 | Slow | 2,028 | Production | 456 | na | na |
| LUB-04 | 12-03-08 | Fast | 2,443 | Production | na | na | na |
| LUB-05 | 12-04-08 | Fast | 3,224 | Production | 490 | 322 | 480 |
| LUB-06 | 12-08-08 | Fast | 2,464 | Production | 490 | 220 | 475 |
| LUB-07 | 12-09-08 | Slow | 2,181 | Production | 660 | 160 | 440 |
| LUB-08 | 12-09-08 | Fast | 2,378 | Production | 800 | 300 | 780 |
| LUB-09 | 12-10-08 | Fast | 1,040 | Production | 224 | 184 | 224 |
| LUB-10 | 12-10-08 | Slow | 1,737 | Production | 300 | 190 | 300 |
| LUB-11 | 12-11-08 | Fast | 2,288 | Production | 600 | 452 | 590 |
| LUB-12 | 12-16-08 | Fast | 3,279 | Production | 840 | 650 | 800 |
| LUB-13 | 10-08-09 | Slow | 2,957 | Production | 500 | 100 | 500 |
| LUB-14 | 10-21-09 | Fast | 2,375 | Production | 240 | na | na |
| LUB-15 | 10-26-09 | Fast | 386 | Production | 312 | 212 | 312 |

**Table 1.** Identification, sampling, and construction information for wells sampled for the Borrego, Central Desert, and Low Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[Sampling schedule is described in table 2. Land-surface datum (LSD) is a datum plane that is approximately at land surface at each well. The altitude of the LSD is described in feet above the North American Vertical Datum 1988 (NAVD 88). Numbered suffix indicates the order of sample collection within each study area. **GAMA well identification number:** BV, Borrego study-area grid well; BVU, Borrego study-area understanding well; CD, Central Desert study-area grid well; LUB, Low Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low Use Basins of the Mojave and Sonoran Deserts study-area understanding well. **Other abbreviations:** ft, foot; na, not available]

| Sampling information | | | | Construction information | | | |
|---|---|---|---|---|---|---|---|
| GAMA well identification number | Date sampled | Sampling schedule | Altitude of LSD (ft above NAVD 88) | Well type | Well depth (ft below LSD) | Depth to top perforation (ft below LSD) | Depth to bottom perforation (ft below LSD) |
| **CLUB grid wells—Continued** | | | | | | | |
| Low-Use Basins of the Mojave and Sonoran Deserts study area—Continued | | | | | | | |
| LUB-16 | 10-28-09 | Fast | 88 | Production | 105 | 0 | 105 |
| LUB-17 | 10-28-09 | Fast | 495 | Production | 584 | 484 | 584 |
| LUB-18 | 11-02-09 | Slow | 2,851 | Production | 36 | 15 | 36 |
| LUB-19 | 11-03-09 | Slow | 177 | Production | na | na | na |
| LUB-20 | 11-04-09 | Slow | 282 | Production | 100 | 70 | na |
| LUB-21 | 11-18-09 | Fast | 627 | Production | 400 | 300 | 400 |
| LUB-22 | 11-19-09 | Fast | 459 | Production | 1,200 | 690 | 1,190 |
| LUB-23 | 12-07-09 | Slow | 2,978 | Production | 403 | 200 | 400 |
| LUB-24 | 12-08-09 | Fast | 1,175 | Production | 788 | 235 | na |
| LUB-25 | 12-08-09 | Fast | 3,057 | Production | 866 | 534 | 864 |
| LUB-26 | 12-09-09 | Slow | 4,625 | Production | 711 | na | na |
| LUB-27 | 03-04-10 | Slow | 242 | Production | 400 | 140 | 400 |
| **CLUB understanding wells** | | | | | | | |
| BVU-01 | 10-27-09 | Slow | 595 | Production | 392 | 162 | 372 |
| LUBU-01 | 12-17-08 | Fast | 1,819 | Production | 1,010 | 350 | 940 |
| LUBU-02 | 03-03-10 | Fast | 3,041 | Unused | 400 | 140 | 380 |

**Table 2.** Classes of chemical constituents and water-quality indicators collected for the slow and the fast well sampling schedules in the Borrego, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

| Analyte classes | Slow schedule | Fast schedule | Analyte list table | Results table |
|---|---|---|---|---|
| **Water-quality indicators** | | | | |
| Dissolved oxygen, temperature, pH, and specific conductance | X | X | | 4 |
| Field alkalinity, bicarbonate, and carbonate | X | | | 4 |
| **Organic constituents** | | | | |
| Volatile organic compounds (VOC) | X | X | 3A | 5 |
| Pesticides and pesticide degradates | X | X | 3B | 6 |
| Pharmaceutical compounds | X | | 3C | none [1] |
| **Constituents of special interest** | | | | |
| Perchlorate | X | X | 3D | 7 |
| *N*-nitrosodimethylamine (NDMA) | X | | 3D | none [2] |
| **Inorganic constituents** | | | | |
| Trace elements | X | X [3] | 3E | 8 |
| Nutrients | X | X [3] | 3F | 9 |
| Major and minor ions, silica, and total dissolved solids (TDS) | X | X [3] | 3G | 10 |
| Laboratory alkalinity, bicarbonate, and carbonate | X | X | 3G | 4 |
| Species of inorganic chromium | X [4] | | 3H, 3I | 11, 12 |
| **Stable isotopes** | | | | |
| Stable isotopes of hydrogen and oxygen in water | X | X | 3J | 13 |
| Stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance | X | X | 3J | 13 |
| Stable isotopes of boron in water | X | | 3J | none [5] |
| Stable isotopes of strontium in water | X | | 3J | none [5] |
| **Radioactivity and dissolved noble gases** | | | | |
| Tritium | X | X | 3J | 13 |
| Radon-222 | X | | 3J | 14A |
| Radium isotopes (radium-226 and radium-228) | X | | 3J | 14B |
| Gross alpha and gross beta radioactivity (72-hour and 30-day) | X | | 3J | 14C |
| Dissolved noble gases, tritium, and helium isotope ratios | X | X | 3K | none [6] |

[1] Pharmaceutical compounds were not detected at concentrations greater than or equal to method detection limits in the CLUB study unit.

[2] Constituent was not detected in groundwater samples.

[3] Wells sampled on the *fast* schedule in the Low-Use Basins of the Mojave and Sonoran Deserts study area included these constituents.

[4] Hexavalent chromium analysis from TestAmerica Laboratories, Inc., Irvine, California, was added to the *slow* sampling schedule starting in October 2009.

[5] Results for the stable isotopes of boron and strontium in water analyzed by U.S. Geological Survey National Research Program Metals Isotope Research Laboratory, Menlo Park, California, were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

[6] Results for dissolved noble gases, tritium, and helium isotope ratios analyzed by Lawrence Livermore National Laboratory, Livermore, California, 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 U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2020.

[**USGS parameter code:** The five-digit code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk-specific dose at a risk factor of $10^{-5}$. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; SRL, study reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; –, not detected; ≤, less than or equal to; NWIS, USGS National Water Information System]

| Constituent (synonym or abbreviation) | Primary use or source | USGS parameter code | CAS number [1] | LRL [3] or SRL (µg/L) | Benchmark type | Benchmark level (µg/L) | Detection |
|---|---|---|---|---|---|---|---|
| Acetone | Solvent | 81552 | 67-64-1 | 4, 3.4 | na | na | – (2) |
| Acrylonitrile | Organic synthesis | 34215 | 107-13-1 | 0.4, 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 | 0.016, 0.026 | MCL-CA | 1 | D |
| Bromobenzene | Solvent | 81555 | 108-86-1 | 0.02, 0.022 | na | na | – |
| Bromochloromethane | Fire retardant | 77297 | 74-97-5 | 0.06 | HAL-US | 90 | – |
| Bromodichloromethane | Disinfection byproduct (THM) | 32101 | 75-27-4 | 0.04, 0.034 | MCL-US | [4] 80 | D |
| Bromoform (Tribromomethane) | Disinfection byproduct (THM) | 32104 | 75-25-2 | 0.1 | MCL-US | [4] 80 | D |
| Bromomethane (Methyl bromide) | Fumigant | 34413 | 74-83-9 | 0.4, 0.2 | HAL-US | 10 | – |
| *n*-Butylbenzene | Gasoline hydrocarbon | 77342 | 104-51-8 | 0.08 | NL-CA | 260 | – |
| *sec*-Butylbenzene | Gasoline hydrocarbon | 77350 | 135-98-8 | 0.02, 0.034 | NL-CA | 260 | – |
| *tert*-Butylbenzene | Gasoline hydrocarbon | 77353 | 98-06-6 | 0.06 | NL-CA | 260 | – |
| Carbon disulfide | Organic synthesis | 77041 | 75-15-0 | [2] 0.03 | NL-CA | 160 | – |
| Carbon tetrachloride (Tetrachloromethane) | Solvent | 32102 | 56-23-5 | 0.06, 0.052 | MCL-CA | 0.5 | – |
| Chlorobenzene | Solvent | 34301 | 108-90-7 | 0.02, 0.016 | MCL-CA | 70 | – |
| Chloroethane | Solvent | 34311 | 75-00-3 | 0.10, 0.06 | na | na | – |
| Chloroform (Trichloromethane) | Disinfection byproduct (THM) | 32106 | 67-66-3 | 0.04, 0.03 | MCL-US | [4] 80 | D |
| Chloromethane | Solvent | 34418 | 74-87-3 | 0.14 | HAL-US | 30 | – |
| 3-Chloropropene | Organic synthesis | 78109 | 107-05-1 | 0.08 | na | na | – |
| 2-Chlorotoluene | Solvent | 77275 | 95-49-8 | 0.02, 0.028 | NL-CA | 140 | – |
| 4-Chlorotoluene | Solvent | 77277 | 106-43-4 | 0.02, 0.042 | NL-CA | 140 | – |
| Dibromochloromethane | Disinfection byproduct (THM) | 32105 | 124-48-1 | 0.12 | MCL-US | [4] 80 | – |
| 1,2-Dibromo-3-chloropropane (DBCP) | Fumigant | 82625 | 96-12-8 | 1, 0.34 | MCL-US | 0.2 | – |
| 1,2-Dibromoethane (EDB) | Fumigant | 77651 | 106-93-4 | 0.04, 0.05 | MCL-US | 0.05 | – |
| Dibromomethane | Solvent | 30217 | 74-95-3 | 0.04, 0.05 | na | na | – |
| 1,2-Dichlorobenzene | Solvent | 34536 | 95-50-1 | 0.02, 0.028 | MCL-CA | 600 | – |
| 1,3-Dichlorobenzene | Solvent | 34566 | 541-73-1 | 0.02, 0.024 | HAL-US | 600 | – |
| 1,4-Dichlorobenzene | Fumigant | 34571 | 106-46-7 | 0.02, 0.026 | MCL-CA | 5 | – |
| *trans*-1,4-Dichloro-2-butene | Organic synthesis | 73547 | 110-57-6 | 0.4, 0.36 | na | na | – |
| Dichlorodifluoromethane (CFC-12) | Refrigerant | 34668 | 75-71-8 | 0.1 | NL-CA | 1,000 | – |
| 1,1-Dichloroethane (1,1-DCA) | Solvent | 34496 | 75-34-3 | 0.04, 0.044 | MCL-CA | 5 | – |
| 1,2-Dichloroethane (1,2-DCA) | Solvent | 32103 | 107-06-2 | 0.06, 0.08 | MCL-CA | 0.5 | – |
| 1,1-Dichloroethene (1,1-DCE) | Organic synthesis | 34501 | 75-35-4 | 0.02, 0.022 | MCL-CA | 6 | – |

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

[**USGS parameter code:** The five-digit code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk-specific dose at a risk factor of $10^{-5}$. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; SRL, study reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; –, not detected; ≤, less than or equal to; NWIS, USGS National Water Information System]

| Constituent (synonym or abbreviation) | Primary use or source | USGS parameter code | CAS number [1] | LRL[3] or SRL (µg/L) | Benchmark type | Benchmark level (µg/L) | Detection |
|---|---|---|---|---|---|---|---|
| *cis*-1,2-Dichloroethene (*cis*-1,2-DCE) | Solvent | 77093 | 156-59-2 | 0.02, 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 | 0.02, 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 | 0.04, 0.03 | na | na | – |
| *cis*-1,3-Dichloropropene | Fumigant | 34704 | 10061-01-5 | 0.1 | RSD5-US | [5] 4 | – |
| *trans*-1,3-Dichloropropene | Fumigant | 34699 | 10061-02-6 | 0.10, 0.14 | RSD5-US | [5] 4 | – |
| Diethyl ether | Solvent | 81576 | 60-29-7 | 0.12, 0.08 | na | na | – |
| Diisopropyl ether (DIPE) | Gasoline oxygenate | 81577 | 108-20-3 | 0.06 | na | na | D |
| Ethylbenzene | Gasoline hydrocarbon | 34371 | 100-41-4 | [2] 0.1 | MCL-CA | 300 | – |
| Ethyl *tert*-butyl ether (ETBE) | Gasoline oxygenate | 50004 | 637-92-3 | 0.04, 0.032 | na | na | – |
| Ethyl methacrylate | Organic synthesis | 73570 | 97-63-2 | 0.14 | na | na | – |
| *o*-Ethyl toluene (1-Ethyl-2-methyl benzene) | Gasoline hydrocarbon | 77220 | 611-14-3 | 0.02, 0.032 | na | na | – |
| Hexachlorobutadiene | Organic synthesis | 39702 | 87-68-3 | 0.06 | RSD5-US | 9 | – |
| Hexachloroethane | Solvent | 34396 | 67-72-1 | 0.14 | HAL-US | 1 | – |
| 2-Hexanone (*n*-Butyl methyl ketone) | Solvent | 77103 | 591-78-6 | 0.6, 0.46 | na | na | – |
| Iodomethane (Methyl iodide) | Organic synthesis | 77424 | 74-88-4 | 0.8, 0.26 | na | na | – |
| Isopropylbenzene | Gasoline hydrocarbon | 77223 | 98-82-8 | 0.04, 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 | 0.6, 0.56 | na | na | – |
| Methyl acrylonitrile | Organic synthesis | 81593 | 126-98-7 | 0.2, 0.26 | na | na | – |
| Methyl *tert*-butyl ether (MTBE) | Gasoline oxygenate | 78032 | 1634-04-4 | 0.10, 0.1 | MCL-CA | 13 | – |
| Methyl *iso*-butyl ketone (MIBK) | Solvent | 78133 | 108-10-1 | 0.4, 0.32 | NL-CA | 120 | – |
| Methylene chloride (Dichloromethane) | Solvent | 34423 | 75-09-2 | 0.04, 0.038 | 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 | 0.20, 0.22 | na | na | – |
| Naphthalene | Gasoline hydrocarbon | 34696 | 91-20-3 | 0.2, 0.18 | NL-CA | 17 | – |
| Perchloroethene (PCE, Tetrachloroethene) | Solvent | 34475 | 127-18-4 | [6] 0.02 | MCL-US | 5 | D |
| *n*-Propylbenzene | Solvent | 77224 | 103-65-1 | 0.04, 0.036 | NL-CA | 260 | – |
| Styrene | Gasoline hydrocarbon | 77128 | 100-42-5 | 0.04, 0.03 | MCL-US | 100 | – |
| 1,1,1,2-Tetrachloroethane | Solvent | 77562 | 630-20-6 | 0.04 | HAL-US | 70 | – |
| 1,1,2,2-Tetrachloroethane | Solvent | 34516 | 79-34-5 | 0.10, 0.14 | MCL-CA | 1 | – |

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

[**USGS parameter code:** The five-digit code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type**: Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; RSD5-US, USEPA risk-specific dose at a risk factor of $10^{-5}$. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; SRL, study reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; –, not detected; ≤, less than or equal to; NWIS, USGS National Water Information System]

| Constituent (synonym or abbreviation) | Primary use or source | USGS parameter code | CAS number [1] | LRL [3] or SRL (µg/L) | Benchmark type | Benchmark level (µg/L) | Detection |
|---|---|---|---|---|---|---|---|
| Tetrahydrofuran | Solvent | 81607 | 109-99-9 | 1.4 | na | na | – |
| 1,2,3,4-Tetramethylbenzene | Gasoline hydrocarbon | 49999 | 488-23-3 | 0.08 | na | na | – |
| 1,2,3,5-Tetramethylbenzene | Gasoline hydrocarbon | 50000 | 527-53-7 | 0.08 | na | na | – |
| Toluene | Gasoline hydrocarbon | 34010 | 108-88-3 | [2] 0.69 | MCL-CA | 150 | – (2) |
| 1,2,3-Trichlorobenzene | Organic synthesis | 77613 | 87-61-6 | 0.06 | na | na | – |
| 1,2,4-Trichlorobenzene | Solvent | 34551 | 120-82-1 | 0.04, 0.08 | MCL-CA | 5 | – |
| 1,1,1-Trichloroethane (1,1,1-TCA) | Solvent | 34506 | 71-55-6 | 0.02, 0.03 | MCL-CA | 200 | – |
| 1,1,2-Trichloroethane (1,1,2-TCA) | Solvent | 34511 | 79-00-5 | 0.06, 0.046 | MCL-CA | 5 | – |
| Trichloroethene (TCE) | Solvent | 39180 | 79-01-6 | 0.02, 0.022 | MCL-US | 5 | D |
| Trichlorofluoromethane (CFC-11) | Refrigerant | 34488 | 75-69-4 | 0.08 | MCL-CA | 150 | – |
| 1,2,3-Trichloropropane (1,2,3-TCP) | Solvent/organic synthesis | 77443 | 96-18-4 | 0.12 | HAL-US [7] | 40 | – |
| Trichlorotrifluoroethane (CFC-113) | Refrigerant | 77652 | 76-13-1 | 0.04, 0.034 | MCL-CA | 1,200 | – |
| 1,2,3-Trimethylbenzene | Gasoline hydrocarbon | 77221 | 526-73-8 | 0.08, 0.06 | na | na | – |
| 1,2,4-Trimethylbenzene | Gasoline hydrocarbon | 77222 | 95-63-6 | [2] 0.56 | NL-CA | 330 | D (2) |
| 1,3,5-Trimethylbenzene | Organic synthesis | 77226 | 108-67-8 | 0.04, 0.032 | NL-CA | 330 | – |
| Vinyl bromide (Bromoethene) | Fire retardant | 50002 | 593-60-2 | 0.12 | na | na | – |
| Vinyl chloride (Chloroethene) | Organic synthesis | 39175 | 75-01-4 | 0.08, 0.06 | MCL-CA | 0.5 | – |
| *m*- and *p*-Xylene | Gasoline hydrocarbon | 85795 | 108-38-3 / 106-42-3 | [2] 0.4 | MCL-CA | [8] 1,750 | – |
| *o*-Xylene | Gasoline hydrocarbon | 77135 | 95-47-6 | [2] 0.1 | MCL-CA | [8] 1,750 | – |

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[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] SRLs were defined on the basis of examination of quality-control samples collected between May 2004 and September 2010 for the first 32 study units of the California GAMA Priority Basin Project (M.S. Fram, L.D. Olsen, and K. Belitz, U.S. Geological Survey, written commun., 2011). Values measured at concentrations less than the SRLs have been reclassified as non-detections and are not presented on table 5.

[3] For constituents with two LRLs listed, the first value was in use before 09-30-10, and the second value was in use after 10-01-10. The highest LRL is used for this report.

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

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

[6] SRL was defined based on a detection in a field blank. Values measured at concentrations less than the SRL are noted with a ≤ symbol in the USGS NWIS database and were not included in the calculations of detection frequencies.

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

[8] The MCL-CA benchmarks for *m*- and *p*-xylene and *o*-xylene are the sum of all three xylene compounds.

**Table 3B.** Pesticides and pesticide degradates, primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2003.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, USEPA maximum contaminant level; RSD5-US, USEPA risk-specific dose at a risk factor of $10^{-5}$. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; µg/L, micrograms per liter; –, not detected]

| Constituent (synonym or abbreviation) | Primary use or source | USGS parameter code | CAS number | LRL [1] (µg/L) | Benchmark type | Benchmark level (µg/L) | Detection |
|---|---|---|---|---|---|---|---|
| Acetochlor | Herbicide | 49260 | 34256-82-1 | 0.01, 0.010 | na | na | – |
| Alachlor | Herbicide | 46342 | 15972-60-8 | 0.008 | MCL-US | 2 | – |
| Atrazine | Herbicide | 39632 | 1912-24-9 | 0.007 | MCL-CA | 1 | D |
| Azinphos-methyl | Insecticide | 82686 | 86-50-0 | 0.12 | na | na | – |
| Azinphos-methyl oxon | Insecticide degradate | 61635 | 961-22-8 | 0.042 | na | na | – |
| Benfluralin | Herbicide | 82673 | 1861-40-1 | 0.014 | na | na | – (2) |
| Carbaryl | Insecticide | 82680 | 63-25-2 | 0.2, 0.06 | RSD5-US | 400 | – |
| 2-Chloro-2,6-diethylacetanilide | Herbicide degradate | 61618 | 6967-29-9 | 0.01, 0.010 | na | na | – |
| 4-Chloro-2-methylphenol | Herbicide degradate | 61633 | 1570-64-5 | 0.0050, 0.0032 | na | na | – (2) |
| Chlorpyrifos | Insecticide | 38933 | 2921-88-2 | 0.01, 0.010 | HAL-US | 2 | – (2) |
| Chlorpyrifos oxon | Insecticide degradate | 61636 | 5598-15-2 | 0.05 | na | na | – (2) |
| Cyfluthrin | Insecticide | 61585 | 68359-37-5 | 0.016 | na | na | – (2) |
| Cypermethrin | Insecticide | 61586 | 52315-07-8 | 0.02, 0.020 | na | na | – (2) |
| Dacthal (DCPA) | Herbicide | 82682 | 1861-32-1 | 0.006, 0.0076 | HAL-US | 70 | – |
| Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine) | Herbicide degradate | 04040 | 6190-65-4 | 0.014 | na | na | D (2) |
| Desulfinylfipronil | Insecticide degradate | 62170 | na | 0.012 | na | na | – |
| Desulfinylfipronil amide | Insecticide degradate | 62169 | na | 0.029 | na | na | – |
| Diazinon | Insecticide | 39572 | 333-41-5 | 0.005 | HAL-US | 1 | – |
| 3,4-Dichloroaniline | Herbicide degradate | 61625 | 95-76-1 | 0.004, 0.0042 | na | na | D |
| Dichlorvos | Insecticide | 38775 | 62-73-7 | 0.02 | na | na | – (2) |
| Dicrotophos | Insecticide | 38454 | 141-66-2 | 0.08 | na | na | – (2) |
| Dieldrin | Insecticide | 39381 | 60-57-1 | 0.009 | RSD5-US | 0.02 | – |
| 2,6-Diethylaniline | Herbicide degradate | 82660 | 579-66-8 | 0.006 | na | na | – |
| Dimethoate | Insecticide | 82662 | 60-51-5 | 0.006 | na | na | – (2) |
| Ethion | Insecticide | 82346 | 563-12-2 | 0.012, 0.008 | na | na | – (2) |
| Ethion monoxon | Insecticide degradate | 61644 | 17356-42-2 | 0.021 | na | na | – |
| 2-Ethyl-6-methylaniline | Herbicide degradate | 61620 | 24549-06-2 | 0.010, 0.0098 | na | na | – |
| Fenamiphos | Insecticide | 61591 | 22224-92-6 | 0.029, 0.030 | HAL-US | 0.7 | – |
| Fenamiphos sulfone | Insecticide degradate | 61645 | 31972-44-8 | 0.053 | na | na | – |
| Fenamiphos sulfoxide | Insecticide degradate | 61646 | 31972-43-7 | 0.08 | na | na | – (2) |
| Fipronil | Insecticide | 62166 | 120068-37-3 | 0.04, 0.018 | na | na | – |
| Fipronil sulfide | Insecticide degradate | 62167 | 120067-83-6 | 0.013 | na | na | – |
| Fipronil sulfone | Insecticide degradate | 62168 | 120068-36-2 | 0.024 | na | na | – (2) |
| Fonofos | Insecticide | 04095 | 944-22-9 | 0.01, 0.0044 | HAL-US | 10 | – |
| Hexazinone | Herbicide | 04025 | 51235-04-2 | 0.008 | HAL-US | 400 | – (2) |
| Iprodione | Fungicide | 61593 | 36734-19-7 | 0.014 | na | na | – |
| Isofenphos | Insecticide | 61594 | 25311-71-1 | 0.006 | na | na | – |
| Malaoxon | Insecticide degradate | 61652 | 1634-78-2 | 0.08 | na | na | – |
| Malathion | Insecticide | 39532 | 121-75-5 | 0.02, 0.016 | HAL-US | 100 | – |
| Metalaxyl | Fungicide | 61596 | 57837-19-1 | 0.0069, 0.007 | na | na | – |
| Methidathion | Insecticide | 61598 | 950-37-8 | 0.006 | na | na | – |
| Metolachlor | Herbicide | 39415 | 51218-45-2 | 0.014 | HAL-US | 700 | D |
| Metribuzin | Herbicide | 82630 | 21087-64-9 | 0.016, 0.012 | HAL-US | 70 | – |
| Myclobutanil | Fungicide | 61599 | 88671-89-0 | 0.01, 0.010 | na | na | – |
| 1-Naphthol | Insecticide degradate | 49295 | 90-15-3 | 0.04, 0.036 | na | na | – (2) |

**Table 3B.** Pesticides and pesticide degradates, primary uses or sources, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 2003.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency (USEPA) lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, USEPA maximum contaminant level; RSD5-US, USEPA risk-specific dose at a risk factor of $10^{-5}$. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; µg/L, micrograms per liter; –, not detected]

| Constituent (synonym or abbreviation) | Primary use or source | USGS parameter code | CAS number | LRL[1] (µg/L) | Benchmark type | Benchmark level (µg/L) | Detection |
|---|---|---|---|---|---|---|---|
| Paraoxon-methyl | Insecticide degradate | 61664 | 950-35-6 | 0.01, 0.010 | na | na | – (2) |
| Parathion-methyl | Insecticide | 82667 | 298-00-0 | 0.008 | HAL-US | 1 | – (2) |
| Pendimethalin | Herbicide | 82683 | 40487-42-1 | 0.012 | na | na | – |
| *cis*-Permethrin | Insecticide | 82687 | 54774-45-7 | 0.014 | na | na | – (2) |
| Phorate | Insecticide | 82664 | 298-02-2 | 0.02 | na | na | – (2) |
| Phorate oxon | Insecticide degradate | 61666 | 2600-69-3 | 0.027 | na | na | – |
| Phosmet | Insecticide | 61601 | 732-11-6 | 0.2, 0.034 | na | na | – (2) |
| Phosmet oxon | Insecticide degradate | 61668 | 3735-33-9 | 0.0511 | na | na | – (2) |
| Prometon | Herbicide | 04037 | 1610-18-0 | 0.012 | HAL-US | 100 | – |
| Prometryn | Herbicide | 04036 | 7287-19-6 | 0.0059, 0.006 | na | na | – |
| Pronamide (Propyzamide) | Herbicide | 82676 | 23950-58-5 | 0.004, 0.0036 | RSD5-US | 20 | – |
| Simazine | Herbicide | 04035 | 122-34-9 | 0.01, 0.006 | MCL-US | 4 | D |
| Tebuthiuron | Herbicide | 82670 | 34014-18-1 | 0.02, 0.028 | HAL-US | 500 | – (3) |
| Terbufos | Insecticide | 82675 | 13071-79-9 | 0.018 | HAL-US | 0.4 | – (2) |
| Terbufos oxon sulfone | Insecticide degradate | 61674 | 56070-15-6 | 0.045 | na | na | – |
| Terbuthylazine | Herbicide | 04022 | 5915-41-3 | 0.006 | na | na | – |
| Tribufos | Defoliant | 61610 | 78-48-8 | 0.035, 0.018 | na | na | – (2) |
| Trifluralin | Herbicide | 82661 | 1582-09-8 | 0.012, 0.018 | HAL-US | 10 | – (2) |

[1] For constituents with two LRLs listed, the first value was in use before 09-30-10, and the second value was in use after 10-01-10. The highest LRL is used for this report.

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

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Abbreviations:** CAS, Chemical Abstract Service; SRL, study reporting level; na, not available; µg/L, micrograms per liter]

| Constituent | Primary use or source | USGS parameter code | CAS number | SRL[1] (µg/L) | Benchmark type | Benchmark level | Detection |
|---|---|---|---|---|---|---|---|
| Acetaminophen | Analgesic | 62000 | 103-90-2 | 0.06 | na | na | – |
| Albuterol | Bronchodilator | 62020 | 18559-94-9 | 0.04 | na | na | – |
| Caffeine | Stimulant | 50305 | 58-08-2 | 0.10 | na | na | – |
| 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 | – |
| 1,7-Dimethylxanthine | Caffeine metabolite | 62030 | 611-59-6 | 0.06 | na | na | – |
| Diphenhydramine | Antihistamine | 62796 | 147-25-0 | 0.02 | na | na | – |
| Sulfamethoxazole | Antibacterial | 62021 | 723-46-6 | 0.08 | na | na | – |
| 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 | – |

[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 SRL 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 SRLs 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 SRLs or as non-detections less than LRLs have been recoded as non-detections less than SRLs. Results for pharmaceutical compounds in groundwater samples from the GAMA Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) study unit are presented in Fram and Belitz (2011).

**Table 3D.** Constituents of special interest, primary uses or sources, comparative benchmarks, and reporting information for Weck Laboratories, Inc., analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Minimum reporting level, benchmark type, and benchmark level as of October 1, 2008. **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:** CAS, Chemical Abstract Service; MRL, minimum reporting level; D, detected in groundwater samples (table 7); µg/L, micrograms per liter; –, not detected]

| Constituent (synonym or abbreviation) | Primary use or source | USGS parameter code | CAS number | MRL (µg/L) | Benchmark type | Benchmark level | Detection |
|---|---|---|---|---|---|---|---|
| Perchlorate | Rocket fuel, fireworks, flares | 63790 | 14797-73-0 | 0.10 | MCL-CA | 6 | D |
| *N*-nitrosodimethylamine (NDMA) | Disinfection byproduct | 34438 | 62-75-9 | 0.0020 | NL-CA | 0.010 | – |

**Table 3E.** Trace elements, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; SRL, study reporting level; D, detected in groundwater samples (table 8); na, not available; µg/L, micrograms per liter; ≤, less than or equal to; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; BQS, USGS Branch of Quality Systems]

| Constituent | USGS parameter code | CAS number | LRL[1] or SRL (µg/L) | Benchmark type | Benchmark level | Detection |
|---|---|---|---|---|---|---|
| Aluminum | 01106 | 7429-90-5 | [2] 1.6 | MCL-CA | 1,000 | D |
| Antimony | 01095 | 7440-36-0 | 0.04, 0.054 | MCL-US | 6 | D |
| Arsenic | 01000 | 7440-38-2 | 0.06, 0.044 | MCL-US | 10 | D |
| Barium | 01005 | 7440-39-3 | [2] 0.36 | MCL-CA | 1,000 | D |
| Beryllium | 01010 | 7440-41-7 | 0.02, 0.012 | MCL-US | 4 | D |
| Boron | 01020 | 7440-42-8 | 4, 2.8 | NL-CA | 1,000 | D |
| Cadmium | 01025 | 7440-43-9 | 0.02 | MCL-US | 5 | D |
| Chromium | 01030 | 7440-47-3 | [2] 0.42 | MCL-CA | 50 | D |
| Cobalt | 01035 | 7440-48-4 | [3] 0.18 | na | na | D |
| Copper | 01040 | 7440-50-8 | [2] 1.7 | AL-US | 1,300 | D |
| Iron | 01046 | 7439-89-6 | [2] 6 | SMCL-CA | 300 | D |
| Lead | 01049 | 7439-92-1 | [2] 0.65 | AL-US | 15 | D |
| Lithium | 01130 | 7439-93-2 | 1, 0.44 | na | na | D |
| Manganese | 01056 | 7439-96-5 | [2] 0.2 | SMCL-CA | 50 | D |
| Molybdenum | 01060 | 7439-98-7 | [3] 0.32 | HAL-US | 40 | D |
| Nickel | 01065 | 7440-02-0 | [2] 0.36 | MCL-CA | 100 | D |
| Selenium | 01145 | 7782-49-2 | 0.06, 0.040 | MCL-US | 50 | D |
| Silver | 01075 | 7440-22-4 | 0.008, 0.010 | SMCL-CA | 100 | D |
| Strontium | 01080 | 7440-24-6 | 0.8, 0.40 | HAL-US | 4,000 | D |
| Thallium | 01057 | 7440-28-0 | 0.04, 0.020 | MCL-US | 2 | D |
| Tungsten | 01155 | 7440-33-7 | [2] 0.11 | na | na | D |
| Uranium | 22703 | 7440-61-1 | 0.006, 0.008 | MCL-US | 30 | D |
| Vanadium | 01085 | 7440-62-2 | [2] 0.11 | NL-CA | 50 | D |
| Zinc | 01090 | 7440-66-6 | [2] 4.8 | [4] SMCL-CA | 5,000 | D |

[1] For constituents with two LRLs listed, the first value was in use before 09-30-10, and the second value was in use after 10-01-10. The highest LRL is used for this report.

[2] SRL was 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 < or = reported value, based on QC data (may include: field blanks, source-solution blanks, trip blanks, NWQL set blanks, NWQL blank water certificates, and USGS BQS Blind Blank Program data).

[3] SRL was defined based on a detection in a field blank. Values less than the SRL are reported as ≤ the value reported by the laboratory. In the USGS NWIS database, the result is accompanied with the following comment: Result is < or = reported value, based on a detection in a field blank.

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of October 1, 2008. **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:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 9); na, not available; mg/L, milligrams per liter]

| Constituent | USGS parameter code | CAS number | LRL[1] (mg/L) | Benchmark type | Benchmark level | Detection |
|---|---|---|---|---|---|---|
| Ammonia (as nitrogen) | 00608 | 7664-41-7 | 0.02 | HAL-US | [2] 24.7 | D |
| Nitrate plus nitrite (as nitrogen) | 00631 | na | 0.04 | MCL-US | 10 | D |
| Nitrite (as nitrogen) | 00613 | 14797-65-0 | 0.002 | MCL-US | 1 | D |
| Total nitrogen (ammonia, nitrite, nitrate, organic nitrogen) | 62854 | 17778-88-0 | 0.1, 0.10 | na | na | D |
| Phosphate, orthophosphate (as phosphorus) | 00671 | 14265-44-2 | 0.006 | na | na | D |

[1] For constituents with two LRLs listed, the first value was in use before 09-30-10, and the second value was in use after 10-01-10. The highest LRL is used for this report.

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

**Table 3G.** Major and minor ions, silica, total dissolved solids (TDS), and alkalinity, comparative benchmarks, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) Schedule 1948.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 10); na, not available; mg/L, milligrams per liter]

| Constituent | USGS parameter code | CAS number | LRL[1] (mg/L) | Benchmark type | Benchmark level | Detection |
|---|---|---|---|---|---|---|
| Bromide | 71870 | 24959-67-9 | 0.02 | na | na | D |
| Calcium | 00915 | 7440-70-2 | 0.02, 0.044 | na | na | D |
| Chloride | 00940 | 16887-00-6 | 0.12 | SMCL-CA | [2] 250 (500) | D |
| Fluoride | 00950 | 16984-48-8 | 0.08 | MCL-CA | 2 | D |
| Iodide | 71865 | 7553-56-2 | 0.002 | na | na | D |
| Magnesium | 00925 | 7439-95-4 | 0.012, 0.016 | na | na | D |
| Potassium | 00935 | 7440-09-7 | 0.06, 0.064 | na | na | D |
| Sodium | 00930 | 7440-23-5 | 0.12, 0.10 | na | na | D |
| Sulfate | 00945 | 14808-79-8 | 0.18 | SMCL-CA | [2] 250 (500) | D |
| Silica (as $SiO_2$) | 00955 | 7631-86-9 | 0.02, 0.058 | na | na | D |
| TDS | 70300 | na | 10 | SMCL-CA | [2] 500 (1,000) | D |
| Laboratory alkalinity (as $CaCO_3$) [3] | 29801 | na | 1 | na | na | D |

[1] For constituents with two LRLs listed, the first value was in use before 09-30-10, and the second value was in use after 10-01-10. The highest LRL is used for this report.

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

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

**Table 3H.** Species of inorganic chromium, comparative benchmarks, and reporting information for the U.S. Geological Survey Trace Metal Laboratory, Boulder, Colorado, analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Method detection limit, benchmark type, and benchmark level as of November 17, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MDL, method detection limit; Cr-VI, hexavalent chromium (chromium-VI); na, not available; µg/L, micrograms per liter; D, detected in groundwater samples (table 11); NWIS, USGS National Water Information System]

| Constituent | USGS parameter code [1] | CAS number | MDL (µg/L) | Benchmark type | Benchmark level (µg/L) | Detection |
|---|---|---|---|---|---|---|
| Chromium (total) | 01030 | 7440-47-3 | 1 | MCL-CA | 50 | D |
| Cr-VI | 01032 | 18540-29-9 | 1 | na | na | D |

[1] Data are generated from research methods and not stored in the USGS NWIS database under the listed parameter code.

**Table 3I.** Hexavalent chromium (chromium-VI, Cr-VI), comparative benchmark, and reporting information for the TestAmerica Laboratories, Inc., Irvine, California, analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Method detection limit as of October 5, 2009. **Abbreviations:** CAS, Chemical Abstract Service; MDL, method detection limit; na, not available; µg/L, micrograms per liter; D, detected in groundwater samples (table 12)]

| Constituent | USGS parameter code | CAS number | MDL (µg/L) | Benchmark type | Benchmark level | Detection |
|---|---|---|---|---|---|---|
| Cr-VI | 01032 | 18540-29-9 | 1 | na | na | D |

## **Table 3J.** Isotopic 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. Stable isotope ratios are reported in the standard delta notation ($\delta$), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Reporting level, benchmark type, and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; CAS, Chemical Abstract Service; CSU, combined standard uncertainty; ssL$_{C}$, sample-specific critical level; MRL, minimum reporting level; na, not available; H, hydrogen; O, oxygen; B, boron; Sr, strontium; pCi/L, picocuries per liter; D, detected in groundwater samples (tables 13 and 14A through 14C); NRP, USGS National Research Program]

| Constituent | USGS parameter code | CAS number | Reporting level type | Reporting level or uncertainty | Benchmark type | Benchmark level | Detection |
|---|---|---|---|---|---|---|---|
| **Stable isotope ratios (per mil)** | | | | | | | |
| $\delta^{2}$H in water [1] | 82082 | na | MU | 2 | na | na | D |
| $\delta^{18}$O in water [1] | 82085 | na | MU | 0.20 | na | na | D |
| $\delta^{11}$B in water [2] | 62648 | na | MU | na | na | na | D |
| $\delta^{13}$C in dissolved inorganic carbon [3] | 82081 | na | 1-sigma | 0.05 | na | na | D |
| **Isotope ratios (atom ratio)** | | | | | | | |
| Strontium isotope ratio ($^{87}$Sr/$^{86}$Sr) [2] | 75978 | na | MU | 0.00005 | na | na | D |
| **Radioactive constituents (percent modern)** | | | | | | | |
| Carbon-14 [3] | 49933 | 14762-75-5 | 1-sigma | 0.0015 | na | na | D |
| **Radioactive constituents (pCi/L)** | | | | | | | |
| Radon-222 [4] | 82303 | 14859-67-7 | ssL$_{C}$ | CSU | MCL-US (Proposed) | 4,000 | D |
| Tritium [5] | 07000 | 10028-17-8 | ssL$_{C}$ | CSU | MCL-CA | 20,000 | D |
| Radium-226 [6] | 09511 | 13982-63-3 | ssL$_{C}$ | CSU | MCL-US | [7] 5 | D |
| Radium-228 [6] | 81366 | 15262-20-1 | ssL$_{C}$ | CSU | MCL-US | [7] 5 | D |
| Gross alpha radioactivity, 72-hour and 30-day counts [6] | 62636, 62639 | 12587-46-1 | ssL$_{C}$ | CSU | MCL-US | 15 | D |
| Gross beta radioactivity, 72-hour and 30-day counts [6] | 62642, 62645 | 12587-47-2 | ssL$_{C}$ | CSU | 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 (contract laboratory, MA-WHAMS).

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

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

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

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

**Table 3K.** Dissolved noble gases and tritium, comparison benchmarks, and reporting information for the Lawrence Livermore National Laboratory, Livermore, California, analyses.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Method uncertainty, benchmark type, and benchmark values as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MU, method uncertainty; na, not available; $cm^3$ STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water; pCi/L, picocuries per liter]

| Constituent | USGS parameter code | CAS number | MU (percent) | Reporting units | Benchmark type | Benchmark level (pCi/L) | Detection |
|---|---|---|---|---|---|---|---|
| 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 |
| Tritium | 07000 | 10028-17-8 | 1 | pCi/L | MCL-CA | 20,000 | na |
| Helium-3 / Helium-4 | 61040 | na / 7440-59-7 | 0.75 | atom ratio | na | na | na |

**Table 4.** Water-quality indicators in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Reporting level, benchmark type, and benchmark level as of October 1, 2008. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; °C, degrees Celsius; mg/L, milligrams per liter; nc, not collected; na, not available; RL, reporting limit or range; µS/cm, microsiemens per centimeter; <, less than; >, greater than; $CaCO_3$, calcium carbonate; *, value at a concentration greater than benchmark level; **, value at a concentration greater than upper benchmark level; –, not detected]

| GAMA well identification number | Dissolved oxygen, field (mg/L) (00300) | Water temperature, field (°C) (00010) | pH, lab (standard units) (00403) | pH, field (standard units) (00400) | Specific conductance, lab (µS/cm at 25°C) (90095) | Specific conductance, field (µS/cm at 25°C) (00095) | Alkalinity, lab (mg/L as $CaCO_3$) (29801) | Alkalinity, field (mg/L as $CaCO_3$) (29802) | Bicarbonate, field (mg/L) (63786) | Bicarbonate [2] (mg/L) | Carbonate, field (mg/L) (63788) | Carbonate [2] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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** |
| **[RL]** | **[0.2]** | **[0.0–38.5]** | **[0–14]** | **[0–14]** | **[5]** | **[5]** | **[1]** | **[1]** | **[1]** | **[1]** | **[0.1]** | **[0.1]** |
| **CLUB grid wells (49 wells sampled)** | | | | | | | | | | | | |
| Borrego Valley study area | | | | | | | | | | | | |
| BV-01 | 4.1 | 28.0 | nc | 7.9 | nc | **2,060 | 69.0 | nc | nc | 83.5 | nc | 0.3 |
| BV-02 | 7.1 | 22.5 | nc | 7.2 | nc | 715 | 147 | nc | nc | 179 | nc | 0.1 |
| BV-03 | 6.2 | 25.0 | 7.6 | 7.4 | *1,080 | *1,080 | 171 | nc | nc | 208 | nc | 0.4 |
| BV-04 | 4.4 | 31.5 | 7.5 | 7.3 | *910 | *912 | 174 | nc | nc | 212 | nc | 0.3 |
| BV-05 | 1.1 | 26.5 | nc | 8.4 | nc | 490 | 61.0 | nc | nc | 72.6 | nc | 0.8 |
| BV-06 | 3.3 | 30.5 | nc | 7.7 | nc | **1,810 | 110 | nc | nc | 134 | nc | 0.3 |
| BV-07 | 2.0 | 28.5 | *8.9 | *8.9 | *974 | *956 | 79.0 | nc | nc | 89.3 | nc | 3.3 |
| Central Desert study area | | | | | | | | | | | | |
| CD-01 | 6.2 | 20.5 | 8.0 | 7.8 | 448 | 438 | 159 | nc | nc | 192 | nc | 0.9 |
| CD-02 | 4.8 | 23.0 | nc | 7.8 | nc | 547 | nc | nc | nc | nc | nc | nc |
| CD-03 | 6.6 | 17.5 | 7.9 | 7.6 | 227 | 221 | 82.0 | nc | nc | 99.3 | nc | 0.4 |
| CD-04 | 7.0 | 23.5 | 8.1 | 7.9 | 198 | 196 | 73.0 | nc | nc | 87.9 | nc | 0.5 |
| CD-05 | 5.8 | 24.5 | nc | 7.8 | nc | 251 | nc | nc | nc | nc | nc | nc |
| CD-06 | 6.2 | 20.0 | nc | 7.6 | nc | 682 | nc | nc | nc | nc | nc | nc |
| CD-07 | 4.5 | 24.5 | 8.0 | 8.1 | 319 | 312 | 105 | nc | nc | 127 | nc | 0.6 |
| CD-08 | 2.4 | 23.5 | nc | 7.9 | nc | *1,160 | 47.0 | nc | nc | 56.9 | nc | 0.2 |
| CD-09 | 6.3 | 21.0 | 7.7 | 7.6 | 429 | 413 | 84.0 | 80.1 | 97.3 | 102 | 0.1 | 0.2 |
| CD-10 | 4.4 | 23.0 | nc | 7.8 | nc | 426 | 179 | nc | nc | 217 | nc | 0.6 |
| CD-11 | 7.2 | 21.5 | 7.5 | 7.4 | 863 | 844 | 284 | nc | nc | 345 | nc | 0.5 |
| CD-12 | 3.3 | 26.0 | 8.5 | 8.5 | 310 | 309 | 92.0 | nc | nc | 109 | nc | 1.6 |
| CD-13 | 5.1 | 25.5 | 8.3 | 8.5 | 455 | 440 | 81.0 | nc | nc | 96.9 | nc | 0.9 |
| CD-14 | 1.1 | 25.5 | 8.4 | *8.6 | 332 | 334 | 60.0 | nc | nc | 71.4 | nc | 0.8 |
| CD-15 | 5.1 | 25.0 | nc | 8.3 | nc | 307 | 79.0 | 75 | 91.5 | 94.5 | -- | 0.9 |

**Table 4.** Water-quality indicators in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—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:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Reporting level, benchmark type, and benchmark level as of October 1, 2008. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; °C, degrees Celsius; mg/L, milligrams per liter; nc, not collected; na, not available; RL, reporting limit or range; µS/cm, microsiemens per centimeter; <, less than; >, greater than; $CaCO_3$, calcium carbonate; *, value at a concentration greater than benchmark level; **, value at a concentration greater than upper benchmark level; –, not detected]

| GAMA well identification number | Dissolved oxygen, field (mg/L) (00300) | Water temperature, field (°C) (00010) | pH, lab (standard units) (00403) | pH, field (standard units) (00400) | Specific conductance, lab (µS/cm at 25°C) (90095) | Specific conductance, field (µS/cm at 25°C) (00095) | Alkalinity, lab (mg/L as $CaCO_3$) (29801) | Alkalinity, field (mg/L as $CaCO_3$) (29802) | Bicarbonate, field (mg/L) (63786) | Bicarbonate [2] (mg/L) | Carbonate, field (mg/L) (63788) | Carbonate [2] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 |
| **[RL]** | [0.2] | [0.0–38.5] | [0–14] | [0–14] | [5] | [5] | [1] | [1] | [1] | [1] | [0.1] | [0.1] |
| **CLUB grid wells (49 wells sampled)—Continued** | | | | | | | | | | | | |
| Low-Use Basins of the Mojave and Sonoran Deserts study area | | | | | | | | | | | | |
| LUB-01 | 6.1 | 24.5 | 7.7 | 7.7 | *941 | *944 | 91.0 | 65.1 | 79.2 | 110 | 0.1 | 0.3 |
| LUB-02 | 5.5 | 25.0 | 8.0 | 7.9 | 767 | 777 | 193 | nc | nc | 233 | nc | 1.1 |
| LUB-03 | <0.2 | 23.5 | 7.9 | 7.7 | 721 | 740 | 225 | 219 | 266 | 272 | 0.4 | 1.0 |
| LUB-04 | 4.2 | 26.0 | 7.9 | 7.8 | 777 | 792 | 195 | nc | nc | 236 | nc | 0.9 |
| LUB-05 | 6.8 | 22.0 | 7.8 | 7.8 | 677 | 689 | 213 | nc | nc | 258 | nc | 0.7 |
| LUB-06 | 3.4 | 26.0 | 8.2 | 8.2 | 876 | 875 | 117 | nc | nc | 141 | nc | 1.0 |
| LUB-07 | 1.9 | 24.5 | 8.3 | 8.1 | 886 | 893 | 229 | 219 | 262 | 274 | 2.6 | 2.5 |
| LUB-08 | 2.6 | 28.0 | 7.8 | 7.6 | *1,340 | *1,370 | 118 | nc | nc | 143 | nc | 0.4 |
| LUB-09 | 3.9 | 27.0 | 8.0 | 7.8 | **1,950 | **1,980 | 254 | nc | nc | 307 | nc | 1.4 |
| LUB-10 | <0.2 | 25.5 | *9.0 | *9.2 | 849 | 855 | 279 | 293 | 312 | 311 | 21.9 | 14.3 |
| LUB-11 | 1.2 | 26.5 | 7.7 | 7.7 | 694 | 700 | 171 | nc | nc | 208 | nc | 0.5 |
| LUB-12 | 2.3 | 30.0 | 8.1 | 8.1 | 579 | 592 | 126 | nc | nc | 152 | nc | 0.9 |
| LUB-13 | 3.5 | 23.5 | 8.1 | 7.9 | 398 | 393 | 170 | nc | nc | 205 | nc | 1.2 |
| LUB-14 | 2.1 | 24.0 | 7.2 | 7.3 | *1,270 | *1,230 | 78.0 | nc | nc | 95.0 | nc | 0.1 |
| LUB-15 | 2.9 | 29.0 | 7.5 | 8.0 | 605 | 635 | 125 | nc | nc | 152 | nc | 0.2 |
| LUB-16 | 2.0 | 22.5 | 7.7 | 7.6 | *1,220 | *1,220 | 155 | 149 | 182 | 188 | -- | 0.4 |
| LUB-17 | 1.9 | 35.0 | 7.9 | 7.8 | **2,210 | **2,250 | 69.0 | nc | nc | 83.5 | nc | 0.3 |
| LUB-18 | 1.2 | 24.5 | 7.1 | 6.9 | 598 | 599 | 120 | nc | nc | 146 | nc | 0.1 |
| LUB-19 | 0.4 | 36.0 | 8.4 | 8.4 | *1,580 | **1,620 | 29.0 | 23.9 | 26.5 | 34.4 | 1.0 | 0.4 |
| LUB-20 | 3.6 | 28.5 | 7.2 | 7.7 | *1,140 | *1,120 | 131 | nc | nc | 160 | nc | 0.1 |

**Table 4.** Water-quality indicators in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—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:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Reporting level, benchmark type, and benchmark level as of October 1, 2008. **Benchmark type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; °C, degrees Celsius; mg/L, milligrams per liter; nc, not collected; na, not available; RL, reporting limit or range; µS/cm, microsiemens per centimeter; <, less than; >, greater than; $CaCO_3$, calcium carbonate; *, value at a concentration greater than benchmark level; **, value at a concentration greater than upper benchmark level; –, not detected]

| GAMA well identification number | Dissolved oxygen, field (mg/L) (00300) | Water temperature, field (°C) (00010) | pH, lab (standard units) (00403) | pH, field (standard units) (00400) | Specific conductance, lab (µS/cm at 25°C) (90095) | Specific conductance, field (µS/cm at 25°C) (00095) | Alkalinity, lab (mg/L as $CaCO_3$) (29801) | Alkalinity, field (mg/L as $CaCO_3$) (29802) | Bicarbonate, field (mg/L) (63786) | Bicarbonate [2] (mg/L) | Carbonate, field (mg/L) (63788) | Carbonate [2] (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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** |
| **[RL]** | **[0.2]** | **[0.0–38.5]** | **[0–14]** | **[0–14]** | **[5]** | **[5]** | **[1]** | **[1]** | **[1]** | **[1]** | **[0.1]** | **[0.1]** |
| **CLUB grid wells (49 wells sampled)—Continued** | | | | | | | | | | | | |
| Low-Use Basins of the Mojave and Sonoran Deserts study area—Continued | | | | | | | | | | | | |
| LUB-21 | 2.6 | 28.5 | *8.9 | *8.9 | *1,330 | *1,320 | 40.0 | nc | nc | 45.0 | nc | 1.6 |
| LUB-22 | <0.2 | 41.0 | *8.9 | *8.8 | *1,370 | *1,420 | 70.0 | nc | nc | 79.0 | nc | 2.9 |
| LUB-23 | 7.6 | 15.0 | 7.8 | 7.7 | 442 | 428 | 123 | 120 | 146 | 149 | 0.4 | 0.4 |
| LUB-24 | 1.3 | 23.0 | 7.6 | 7.5 | 852 | 857 | 156 | nc | nc | 190 | nc | 0.3 |
| LUB-25 | 3.6 | 31.0 | 8.1 | 8.2 | *907 | *935 | 125 | nc | nc | 151 | nc | 0.9 |
| LUB-26 | 3.8 | 24.5 | 7.7 | 7.6 | *1,420 | *1,430 | 175 | 166 | 201 | 212 | 0.8 | 0.5 |
| LUB-27 | 2.5 | 33.0 | 8.0 | 8.0 | 570 | 558 | 112 | nc | nc | 135 | nc | 0.6 |
| **CLUB understanding wells (3 wells sampled)** | | | | | | | | | | | | |
| BVU-01 | 2.0 | 27.0 | 8.2 | 8.3 | 445 | 448 | 88.0 | nc | nc | 106 | nc | 0.8 |
| LUBU-01 | 2.4 | 27.0 | 8.2 | 8.4 | 565 | 572 | 165 | nc | nc | 198 | nc | 1.4 |
| LUBU-02 | 2.9 | 25.5 | 7.9 | 7.8 | 365 | 367 | 102 | nc | nc | 123 | nc | 0.5 |

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

[2] Bicarbonate and carbonate concentrations were calculated from the laboratory alkalinity and pH values using the advanced speciation method (http://or.water.usgs.gov/alk/methods.html) with $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_W = 14$.

**Table 5.** Volatile organic compounds (VOCs) detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the 49 grid wells. All analytes are listed in table 3A. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; NWIS, USGS National Water Information System]

| Primary use or source | Trihalomethane | Solvent | Gasoline | Gasoline | Trihalomethane | Trihalomethane | Solvent | | |
|---|---|---|---|---|---|---|---|---|---|
| GAMA well identification number | Chloroform (Trichloromethane) (µg/L) (32106) | Perchloroethene (PCE, Tetrachloroethene) (µg/L) (34475) | 1.2.4-trimethylbenzene (µg/L) (77222) | Benzene (µg/L) (34030) | Bromodichloromethane (µg/L) (32101) | Bromoform, (Tribromethane) (µg/L) (32104) | Trichloroethane (TCE) (µg/L) (39180) | Detections per well | VOC detection summary [1] |
| Benchmark type<br>Benchmark level<br>[LRL or SRL] | MCL-US<br>[2] 80<br>[0.04] | MCL-US<br>5<br>[4] [0.02] | NL-CA<br>330<br>[1] [0.56] | MCL-CA<br>1<br>[0.026] | MCL-US<br>[2] 80<br>[0.04] | MCL-US<br>[2] 80<br>[0.1] | MCL-US<br>5<br>[0.022] | | |
| **CLUB grid wells (49 wells sampled)** | | | | | | | | | |
| Number of wells with detections | 13 | 4 | 2 | 1 | 1 | 1 | 1 | | 17 |
| Detection frequency (percent) | 26.5 | 8.2 | 4.1 | 2.0 | 2.0 | 2.0 | 2.0 | | 35 |
| Total detections | | | | | | | | | 25 |
| **Borrego Valley study area (7 grid wells sampled)** | | | | | | | | | |
| BV-03 | – | ≤0.01 | – | – | – | – | – | 0 | |
| BV-04 | E0.07 | – | – | – | E0.03 | – | – | 2 | |
| BV-07 | – | – | 1.60 | – | – | – | – | 1 | |
| Number of wells with detections | 1 | 0 | 1 | 0 | 1 | 0 | 0 | | 2 |
| Detection frequency (percent) | 14.3 | 0 | 14 | 0 | 14.3 | 0 | 0 | | 29 |
| Total detections | | | | | | | | | 3 |
| **Central Desert study area (15 grid wells sampled)** | | | | | | | | | |
| CD-03 | E0.05 | – | – | – | – | – | – | 1 | |
| CD-11 | E0.08 | – | – | – | – | – | – | 1 | |
| CD-12 | E0.03 | – | – | – | – | 0.11 | – | 2 | |
| Number of wells with detections | 3 | 0 | 0 | 0 | 0 | 1 | 0 | | 3 |
| Detection frequency (percent) | 20.0 | 0 | 0 | 0 | 0 | 6.7 | 0 | | 20 |
| Total detections | | | | | | | | | 4 |
| **Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled)** | | | | | | | | | |
| LUB-01 | E0.04 | E0.03 | – | – | – | – | – | 2 | |
| LUB-06 | E0.05 | – | – | E0.03 | – | – | 0.17 | 4 | |
| LUB-09 | E0.02 | – | – | – | – | – | – | 2 | |
| LUB-12 | E0.03 | – | – | – | – | – | – | 1 | |

**Table 5.** Volatile organic compounds (VOCs) detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the 49 grid wells. All analytes are listed in table 3A. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; NWIS, USGS National Water Information System]

| Primary use or source | Trihalomethane | Solvent | Gasoline | Gasoline | Trihalomethane | Trihalomethane | Solvent | | |
|---|---|---|---|---|---|---|---|---|---|
| GAMA well identification number | Chloroform (Trichloro-methane) (µg/L) (32106) | Perchloro-ethene (PCE, Tetra-chloroethene) (µg/L) (34475) | 1.2.4-trimethyl-benzene (µg/L) (77222) | Benzene (µg/L) (34030) | Bromo-dichloro-methane (µg/L) (32101) | Bromoform, (Tribromethane) (µg/L) (32104) | Trichloro-ethane (TCE) (µg/L) (39180) | Detections per well | VOC detection summary [1] |
| Benchmark type<br>Benchmark level<br>[LRL or SRL] | MCL-US<br>[2] 80<br>[0.04] | MCL-US<br>5<br>[4] [0.02] | NL-CA<br>330<br>[1] [0.56] | MCL-CA<br>1<br>[0.026] | MCL-US<br>[2] 80<br>[0.04] | MCL-US<br>[2] 80<br>[0.1] | MCL-US<br>5<br>[0.022] | | |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled)—Continued | | | | | | | | | |
| LUB-13 | – | E0.02 | – | – | – | – | – | 1 | |
| LUB-14 | – | E0.02 | – | – | – | – | – | 1 | |
| LUB-16 | E0.02 | E0.02 | – | – | – | – | – | 2 | |
| LUB-18 | E0.07 | – | – | – | – | – | – | 1 | |
| LUB-20 | – | – | 0.98 | – | – | – | – | 1 | |
| LUB-23 | E0.02 | – | – | – | – | – | – | 1 | |
| LUB-25 | – | ≤0.01 | – | – | – | – | – | 0 | |
| LUB-26 | E0.01 | – | – | – | – | – | – | 1 | |
| LUB-27 | 0.06 | – | – | – | – | – | – | 1 | |
| Number of wells with detections | 9 | 4 | 1 | 1 | 0 | 0 | 1 | | 12 |
| Detection frequency (percent) | 33.3 | 14.8 | 3.7 | 3.7 | 0 | 0 | 3.7 | | 44 |
| Total detections | | | | | | | | | 18 |
| CLUB understanding wells (3 wells sampled) [4] | | | | | | | | | |
| BVU-01 | E0.04 | 1.82 | – | – | – | – | – | 2 | |

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[1] SRLs for acetone (all data), toluene (0.69 µg/L), and 1,2,4-trimethylbenzene (0.56 µg/L) were defined on the basis of examination of quality-control samples collected between May 2004 and September 2010 for the first 32 study units of the California GAMA Priority Basin Project (M.S. Fram, L.D. Olsen, and K. Belitz, U.S. Geological Survey, written commun., 2011). Detections of these three constituents in samples from the CLUB study unit had concentrations less than the SRLs: acetone (LUB-06: 7 µg/L), toluene (BV-07: E0.01 µg/L; LUB-01: E0.02 µg/L), and 1,2,4-trimethylbenzene (BV-03: E0.02 µg/L; CD-13: 0.24 µg/L; CD-14: E0.08 µg/L; LUB-16: E0.03 µg/L; LUB-22: E0.08 µg/L; LUB-23: 0.23 µg/L; LUB-25: 0.14 µg/L; LUB-26: 0.19 µg/L; LUB-27: 0.24 µg/L) and have been reclassified as non-detections.

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

[3] SRL was defined based on a detection in a field blank. Values measured at concentrations less than the SRL are noted with a ≤ symbol in the USGS NWIS database and were not included in the calculations of detection frequencies.

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

**Table 6.** Pesticides and pesticide degradates detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 50 wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the 47 grid wells sampled. All analytes are listed in table 3B. **GAMA well identification number:** CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; HAL-US, USEPA lifetime health advisory level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, micrograms per liter; na, not available; –, not detected]

| Primary use or source | Herbicide | Herbicide degradate | Herbicide | Herbicide degradate | Herbicide | Insecticide degradate | | |
|---|---|---|---|---|---|---|---|---|
| **GAMA well identification number** | **Atrazine (µg/L) (39632)** | **Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine) (µg/L) (04040)** | **Simazine (µg/L) (04035)** | **3,4-Dichloroaniline (µg/L) (61625)** | **Metolachlor (µg/L) (39415)** | **Dieldrin (µg/L) (39381)** | **Pesticide detections per well** | **Pesticide detection summary** |
| **Benchmark type** | **MCL-CA** | **na** | **MCL-US** | **na** | **HAL-US** | **RSD5-US** | | |
| **Benchmark level** | **1** | **na** | **4** | **na** | **700** | **0.02** | | |
| **[LRL]** | **[0.007]** | **[0.014]** | **[0.01]** | **[0.0042]** | **[0.014]** | **[0.009]** | | |
| **CLUB grid wells (47 wells sampled)[1]** | | | | | | | | |
| Number of wells with detections | 3 | 2 | 2 | 2 | 1 | 1 | | 5 |
| Detection frequency (percent) | 6.4 | 4.3 | 4.3 | 4.3 | 2.1 | 2.1 | | 11 |
| Total detections | | | | | | | | 11 |
| Central Desert study area (13 grid wells sampled)[1] | | | | | | | | |
| CD-09 | 0.011 | – | 0.022 | E0.018 | E0.011 | – | 2 | |
| Number of wells with detections | 1 | 0 | 1 | 1 | 1 | 0 | | 1 |
| Detection frequency (percent) | 7.7 | 0 | 7.7 | 7.7 | 7.7 | 0 | | 8 |
| Total detections | | | | | | | | 4 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled) | | | | | | | | |
| LUB-01 | E0.007 | E0.009 | 0.025 | E0.005 | – | – | 4 | |
| LUB-06 | – | – | – | – | – | E0.004 | 1 | |
| LUB-16 | – | E0.007 | – | – | – | – | 1 | |
| LUB-27 | E0.006 | – | – | – | – | – | 1 | |
| Number of wells with detections | 2 | 2 | 1 | 1 | 0 | 1 | | 4 |
| Dectection frequency (percent) | 7.0 | 7.0 | 3.7 | 3.7 | 0 | 3.7 | | 15 |
| Total detections | | | | | | | | 7 |

[1] Samples from CD-10 and CD-12 were ruined during sample preparation at the USGS National Water Quality Laboratory.

**Table 7.** Perchlorate detected in the samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about the analyte given in table 3D. Samples from all 52 wells were analyzed for perchlorate, but only samples with detections are listed. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Minimum reporting level, benchmark type, and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations**: USGS, U.S. Geological Survey; MRL, minimum reporting level; µg/L, micrograms per liter]

| GAMA well identification number | Perchlorate (µg/L) (63790) |
|---|---|
| **Benchmark type** | **MCL-CA** |
| **Benchmark level** | **6** |
| **[MRL]** | **[0.10]** |
| **CLUB grid wells (49 wells sampled)** | |
| Number of wells with detections | 41 |
| Detection frequency (percent) | 84 |
| CLUB Borrego Valley study area (7 grid wells sampled) | |
| BV-01 | 0.19 |
| BV-04 | 0.57 |
| BV-06 | 0.88 |
| BV-07 | 0.30 |
| Number of wells with detections | 4 |
| Detection frequency (percent) | 57 |
| CLUB Central Desert study area (15 grid wells sampled) | |
| CD-01 | 0.48 |
| CD-02 | 0.59 |
| CD-03 | 0.30 |
| CD-04 | 0.39 |
| CD-05 | 0.44 |
| CD-06 | 0.19 |
| CD-07 | 0.43 |
| CD-09 | 0.19 |
| CD-10 | 0.38 |
| CD-11 | 0.52 |
| CD-12 | 0.50 |
| CD-13 | 0.26 |
| CD-14 | 0.29 |
| CD-15 | 0.59 |
| Number of wells with detections | 14 |
| Detection frequency (percent) | 93 |
| CLUB Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled) | |
| LUB-01 | 0.28 |
| LUB-02 | 0.17 |
| LUB-04 | 0.14 |
| LUB-05 | 0.55 |
| LUB-06 | 0.67 |
| LUB-07 | 0.28 |
| LUB-08 | 1.12 |
| LUB-09 | 1.83 |
| LUB-11 | 0.64 |
| LUB-12 | 0.35 |
| LUB-13 | 0.33 |
| LUB-14 | 0.37 |
| LUB-15 | 0.28 |
| LUB-16 | 1.29 |
| LUB-17 | 1.87 |
| LUB-19 | 0.10 |
| LUB-20 | 0.33 |
| LUB-21 | 0.87 |
| LUB-23 | 0.95 |
| LUB-24 | 0.47 |
| LUB-25 | 1.48 |
| LUB-26 | 3.59 |
| LUB-27 | 0.71 |
| Number of wells with detections | 23 |
| Detection frequency (percent) | 85 |
| **CLUB understanding wells (3 wells sampled)** | |
| BVU-01 | 0.27 |
| LUBU-02 | 0.83 |

**Table 8.** Trace elements detected in the samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3E. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; *, value at a concentration greater than benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; QC, quality control; BQS, USGS Branch of Quality Systems; QA, quality assurance]

| 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) (01025) | 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** |
| **[LRL or SRL]** | **[1] [1.6]** | **[0.054]** | **[0.06]** | **[1] [0.36]** | **[0.02]** | **[4.0]** | **[0.02]** | **[1] [0.42]** | **[2] [0.18]** | **[1] [1.7]** | **[1] [6]** | **[1] [0.65]** |
| **CLUB grid wells (39 wells sampled)** | | | | | | | | | | | | |
| Borrego Valley study area (3 grid wells sampled) | | | | | | | | | | | | |
| BV-03 | – | – | 0.70 | 25.0 | – | 183 | E0.05 | ≤0.41 | ≤0.14 | – | 15 | ≤0.09 |
| BV-04 | – | – | 0.76 | 342 | – | 56.0 | 0.03 | ≤0.12 | ≤0.13 | 2.3 | ≤5 | ≤0.22 |
| BV-07 | 10.3 | E0.03 | 6.2 | 30.0 | – | 113 | 0.02 | ≤0.34 | 0.22 | – | 7 | ≤0.05 |
| Central Desert study area (9 grid wells sampled) | | | | | | | | | | | | |
| CD-01 | E2.3 | – | 2.9 | 40.0 | – | 97.0 | 0.03 | 3.2 | ≤0.04 | ≤0.72 | – | ≤0.15 |
| CD-03 | – | – | *123 | 13.0 | – | 174 | E0.01 | 0.68 | ≤0.02 | ≤0.51 | 18 | ≤0.04 |
| CD-04 | – | – | 5.1 | 14.0 | – | 57.0 | – | 0.75 | ≤0.01 | ≤1.3 | – | ≤0.43 |
| CD-07 | – | – | 1.1 | 41.0 | – | 60.0 | 0.02 | 17.1 | ≤0.03 | ≤0.81 | – | ≤0.12 |
| CD-09 | – | – | 2.9 | 48.0 | – | 42.0 | E0.01 | 1.6 | ≤0.09 | ≤1.1 | 20 | ≤0.20 |
| CD-11 | – | – | 0.13 | 46.0 | – | 47.0 | 0.12 | 0.65 | ≤0.12 | – | – | ≤0.07 |
| CD-12 | 4.1 | E0.03 | 6.2 | 5.0 | – | 177 | E0.02 | ≤0.16 | ≤0.03 | ≤1.1 | – | ≤0.33 |
| CD-13 | 4.8 | – | 7.0 | 17.0 | – | 307 | 0.26 | 9.7 | ≤0.06 | 2.5 | – | 0.90 |
| CD-14 | E2.6 | – | 1.6 | 16.0 | – | 39.0 | 0.02 | 2.5 | ≤0.05 | ≤0.75 | ≤4 | 1.0 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled) | | | | | | | | | | | | |
| LUB-01 | – | 0.10 | 1.6 | 64.0 | – | 84.0 | E0.01 | 5.7 | ≤0.05 | ≤0.69 | 40 | ≤0.53 |
| LUB-02 | – | 0.26 | 5.9 | 27.0 | – | 397 | 0.42 | 9.5 | ≤0.01 | – | ≤2 | ≤0.16 |
| LUB-03 | 9.1 | 0.10 | 3.7 | 147 | – | 391 | 0.08 | – | ≤0.04 | ≤0.79 | 22 | 0.82 |
| LUB-04 | – | 0.41 | 6.4 | 26.0 | – | 423 | 0.45 | 7.4 | ≤0.01 | ≤0.56 | 8 | 0.86 |
| LUB-05 | – | 0.08 | 3.3 | 52.0 | – | 105 | 0.04 | 1.2 | ≤0.03 | ≤1.1 | 18 | 1.7 |

**Table 8.** Trace elements detected in the samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3E. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; *, value at a concentration greater than benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; QC, quality control; BQS, USGS Branch of Quality Systems; QA, quality assurance]

| 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) (01025) | 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** |
| **[LRL or SRL]** | **[1] [1.6]** | **[0.054]** | **[0.06]** | **[1] [0.36]** | **[0.02]** | **[4.0]** | **[0.02]** | **[1] [0.42]** | **[2] [0.18]** | **[1] [1.7]** | **[1] [6]** | **[1] [0.65]** |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled)—Continued | | | | | | | | | | | | |
| LUB-06 | – | 0.20 | *39.3 | 27.0 | – | *1,350 | 0.17 | 6.0 | ≤0.01 | – | 6 | ≤0.22 |
| LUB-07 | – | 0.06 | 7.3 | 13.0 | – | 828 | 0.13 | 2.3 | – | – | ≤2 | ≤0.21 |
| LUB-08 | – | 0.07 | 3.4 | 35.0 | – | 719 | 0.04 | 2.7 | ≤0.04 | – | 9 | ≤0.21 |
| LUB-09 | – | 0.05 | 6.1 | 61.0 | – | *2,670 | 0.04 | 17.6 | ≤0.02 | 1.7 | – | 0.88 |
| LUB-10 | 4.4 | – | *42.0 | 6.0 | – | *2,070 | 0.04 | ≤0.06 | ≤0.01 | – | – | – |
| LUB-11 | – | 0.11 | *10.2 | 58.0 | – | 539 | 0.02 | 0.73 | ≤0.02 | – | 13 | ≤0.07 |
| LUB-12 | 5.6 | E0.02 | 2.5 | 18.0 | – | 169 | 0.05 | 3.9 | ≤0.02 | ≤0.51 | 23 | ≤0.09 |
| LUB-13 | – | 0.11 | 6.6 | 49.0 | – | 62.0 | 0.02 | 2.6 | ≤0.04 | ≤0.79 | 6 | ≤0.09 |
| LUB-14 | – | – | 0.6 | 18.0 | – | 203 | 0.06 | 1.7 | ≤0.11 | – | 9 | ≤0.52 |
| LUB-15 | E2.1 | E0.05 | 4.1 | 79.0 | – | 460 | 0.04 | 2.5 | ≤0.08 | – | 7 | ≤0.20 |
| LUB-16 | – | 0.07 | 1.8 | 32.0 | – | 175 | 0.02 | ≤0.14 | ≤0.15 | ≤1.5 | – | ≤0.53 |
| LUB-17 | E2.0 | – | 6.4 | 69.0 | E0.01 | 921 | 0.04 | 8.2 | ≤0.12 | ≤1.0 | E11 | ≤0.57 |
| LUB-18 | 20.0 | 0.09 | 2.0 | 85.0 | E0.01 | 323 | E0.02 | – | 1.5 | 4.9 | 17 | ≤0.57 |
| LUB-19 | 7.9 | – | 3.2 | 30.0 | – | 377 | 0.08 | 0.49 | ≤0.07 | – | – | ≤0.08 |
| LUB-20 | – | – | 3.0 | 77.0 | – | 742 | 0.03 | 2.5 | ≤0.09 | ≤1.3 | – | ≤0.11 |
| LUB-21 | 9.5 | 0.13 | *66.2 | 32.0 | E0.01 | 998 | 0.25 | 7.9 | ≤0.08 | – | 9 | ≤0.57 |
| LUB-22 | 9.3 | 0.11 | *37.5 | 39.0 | 0.01 | *1,580 | 0.28 | ≤0.10 | ≤0.10 | – | 7 | ≤0.25 |
| LUB-23 | – | – | 2.1 | 43.0 | – | 162 | 0.05 | ≤0.10 | ≤0.12 | – | 9 | ≤0.04 |
| LUB-24 | – | 0.13 | 1.8 | 20.0 | – | 71.0 | E0.02 | ≤0.14 | 0.31 | ≤0.55 | 25 | ≤0.19 |
| LUB-25 | – | E0.04 | 4.6 | 42.0 | – | 400 | 0.06 | 18.5 | ≤0.15 | – | 45 | ≤0.07 |
| LUB-26 | – | 0.18 | 0.58 | 29.0 | – | 299 | E0.02 | ≤0.16 | 0.42 | – | 16 | ≤0.26 |
| LUB-27 | 6.6 | 0.12 | *16.5 | 95.0 | – | 385 | 0.09 | 11.4 | ≤0.09 | – | ≤5 | ≤0.05 |

**Table 8.** Trace elements detected in the samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3E. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; *, value at a concentration greater than benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; QC, quality control; BQS, USGS Branch of Quality Systems; QA, quality assurance]

| 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) (01025) | 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** |
| **[LRL or SRL]** | **$^{1}$ [1.6]** | **[0.054]** | **[0.06]** | **$^{1}$ [0.36]** | **[0.02]** | **[4.0]** | **[0.02]** | **$^{1}$ [0.42]** | **$^{2}$ [0.18]** | **$^{1}$ [1.7]** | **$^{1}$ [6]** | **$^{1}$ [0.65]** |
| | | | | | | **CLUB understanding wells (3 wells sampled)** | | | | | | |
| BVU-01 | E3.3 | E0.03 | 9.9 | 55.0 | – | 90.0 | 0.05 | 1.1 | ≤0.04 | ≤0.84 | – | ≤0.03 |
| LUBU-01 | 8.3 | – | 5.3 | 26.0 | – | 325 | 0.26 | 5.5 | – | 2.8 | – | 2.3 |
| LUBU-02 | – | 0.13 | *15.0 | 59.0 | – | 309 | 0.07 | 1.6 | ≤0.08 | – | 16 | ≤0.02 |

**Table 8.** Trace elements detected in the samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3E. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; *, value at a concentration greater than benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; QC, quality control; BQS, USGS Branch of Quality Systems; QA, quality assurance]

| 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** |
| **[LRL or SRL]** | **[1.0]** | **[1] [0.2]** | **[2] [0.32]** | **[1] [0.36]** | **[0.06]** | **[0.010]** | **[0.8]** | **[0.04]** | **[1] [0.11]** | **[0.008]** | **[1] [0.11]** | **[1] [4.8]** |
| **CLUB grid wells (39 wells sampled)** | | | | | | | | | | | | |
| Borrego Valley study area (3 grid wells sampled) | | | | | | | | | | | | |
| BV-03 | 22.8 | 1.1 | 10.3 | 0.61 | 1.6 | – | 426 | – | 0.69 | 9.86 | 11.3 | 80.5 |
| BV-04 | 16.4 | ≤0.1 | 5.0 | 0.62 | 2.3 | 0.02 | 642 | – | 0.14 | 0.91 | 18.0 | ≤4.7 |
| BV-07 | 10.1 | 0.8 | 9.2 | ≤0.35 | 4.1 | – | 460 | – | 1.1 | 0.67 | 44.2 | 5.5 |
| Central Desert study area (9 grid wells sampled) | | | | | | | | | | | | |
| CD-01 | 9.7 | – | 8.0 | ≤0.33 | 0.76 | – | 219 | – | 0.89 | 9.60 | 6.0 | ≤2.4 |
| CD-03 | 25.1 | 1.3 | 5.4 | ≤0.18 | 0.21 | – | 246 | – | 0.21 | 0.79 | 19.8 | 26.5 |
| CD-04 | 10.2 | E0.2 | 2.9 | ≤0.12 | 0.45 | – | 166 | – | 2.2 | 2.67 | 9.2 | ≤1.6 |
| CD-07 | 8.2 | – | 11.2 | ≤0.27 | 0.91 | – | 129 | E0.01 | 0.30 | 2.64 | 14.5 | ≤2.1 |
| CD-09 | 24.3 | 0.8 | 2.5 | 0.46 | 0.51 | – | 346 | – | 0.79 | 9.44 | 4.2 | ≤4.1 |
| CD-11 | 2.8 | – | 37.4 | 1.1 | 0.88 | – | 742 | – | 0.21 | *33.9 | 5.9 | 13.7 |
| CD-12 | 12.4 | – | 4.9 | ≤0.23 | 1.1 | – | 108 | E0.01 | 2.5 | 17.4 | 14.8 | ≤2.1 |
| CD-13 | 6.2 | ≤0.1 | *46.3 | ≤0.16 | 0.74 | – | 297 | – | 46.8 | 7.19 | 22.8 | – |
| CD-14 | 3.0 | 0.5 | 3.8 | ≤0.19 | 0.59 | – | 420 | – | 0.41 | 1.49 | 10.1 | – |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled) | | | | | | | | | | | | |
| LUB-01 | 14.3 | 1.5 | 2.0 | 0.69 | 0.48 | – | 899 | – | ≤0.06 | 1.96 | 9.2 | 10.5 |
| LUB-02 | 32.3 | ≤0.1 | *153 | ≤0.15 | 0.67 | – | 252 | – | 0.25 | 8.38 | 19.6 | ≤2.0 |
| LUB-03 | 11.6 | *376 | 19.3 | 0.41 | 0.06 | 0.03 | 846 | – | 0.34 | 15.0 | 2.4 | 27.5 |
| LUB-04 | 35.5 | ≤0.1 | *157 | ≤0.20 | 0.66 | – | 296 | – | 0.34 | 8.99 | 13.2 | ≤4.1 |
| LUB-05 | 5.9 | 1.2 | 9.5 | ≤0.32 | 1.9 | – | 511 | – | 0.40 | 7.35 | 14.3 | 218 |

**Table 8.** Trace elements detected in the samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

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| GAMA well identification number | Lithium (µg/L) (01130) | Manganese (µg/L) (01056) | Molybdenum (µg/L) (01060) | Nickel (µg/L) (01065) | Selenium (µg/L) (01145) | Silver (µg/L) (01075) | Strontium (µg/L) (01080) | Thallium (µg/L) (01057) | Tungsten (µg/L) (01155) | Uranium (µg/L) (22703) | Vanadium (µg/L) (01085) | Zinc (µg/L) (01090) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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** |
| **[LRL or SRL]** | **[1.0]** | $^{1}$ **[0.2]** | $^{2}$ **[0.32]** | $^{1}$ **[0.36]** | **[0.06]** | **[0.010]** | **[0.8]** | **[0.04]** | $^{1}$ **[0.11]** | **[0.008]** | $^{1}$ **[0.11]** | $^{1}$ **[4.8]** |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled)—Continued | | | | | | | | | | | | |
| LUB-06 | 43.2 | 0.4 | *55.8 | ≤0.13 | 0.75 | – | 108 | – | 18.0 | 4.94 | 23.4 | ≤2.1 |
| LUB-07 | 42.1 | E0.2 | *42.9 | ≤0.08 | 0.51 | – | 238 | – | 1.3 | 12.6 | 30.0 | ≤2.6 |
| LUB-08 | 57.1 | 0.6 | 10.0 | 0.55 | 2.0 | – | 688 | – | 0.60 | 12.2 | 7.1 | ≤2.4 |
| LUB-09 | 107 | ≤0.1 | 11.6 | ≤0.21 | 2.8 | – | 1,690 | – | 0.30 | *30.8 | 23.0 | ≤3.2 |
| LUB-10 | 18.4 | 3.7 | 16.6 | ≤0.08 | – | – | 45.0 | – | 13.5 | 0.22 | 0.50 | – |
| LUB-11 | 36.6 | 0.6 | 6.7 | 0.36 | 3.1 | – | 697 | – | 0.29 | 4.33 | 12.9 | 14.2 |
| LUB-12 | 3.3 | 5.0 | 17.0 | ≤0.30 | 1.3 | – | 349 | – | 13.5 | 5.67 | 21.2 | ≤2.4 |
| LUB-13 | 3.7 | 0.3 | 11.6 | 0.36 | 1.1 | – | 177 | – | 0.88 | 2.35 | 12.8 | 22.9 |
| LUB-14 | 61.7 | E0.6 | 13.8 | 0.73 | 3.2 | 0.05 | 328 | – | 0.19 | 0.50 | 8.6 | – |
| LUB-15 | 8.6 | 0.5 | 7.6 | ≤0.21 | 0.97 | – | 187 | – | 3.3 | 0.40 | 27.4 | ≤2.3 |
| LUB-16 | 76.6 | 8.0 | 5.9 | 1.7 | 2.5 | – | 1,560 | E0.01 | ≤0.04 | 8.83 | 2.6 | 63.4 |
| LUB-17 | 128 | 0.3 | 15.0 | ≤0.35 | 6.8 | E0.01 | 1,970 | – | 3.5 | 7.90 | 9.4 | 12.7 |
| LUB-18 | 77.2 | 8.1 | 2.9 | 0.84 | 2.3 | E0.01 | 335 | – | 3.8 | 2.52 | 13.7 | 20.1 |
| LUB-19 | 23.5 | ≤0.1 | 28.5 | ≤0.25 | 13.2 | E0.01 | 491 | – | 12.7 | 0.08 | 30.9 | ≤4.7 |
| LUB-20 | 21.3 | – | 9.8 | ≤0.30 | 3.0 | – | 347 | – | 3.9 | 2.92 | 18.4 | ≤2.5 |
| LUB-21 | 191 | 0.7 | 37.1 | ≤0.25 | 2.6 | – | 477 | – | 89.7 | 0.16 | 33.5 | 208 |
| LUB-22 | 146 | 1.2 | *56.7 | ≤0.11 | 0.04 | – | 188 | – | 48.6 | 0.02 | 1.3 | – |
| LUB-23 | 15.0 | 2.0 | 16.7 | 0.85 | 2.6 | – | 324 | – | 0.58 | 3.46 | 5.8 | 237 |
| LUB-24 | 10.3 | 3.5 | 5.0 | 2.4 | 0.48 | – | 1,230 | – | 0.52 | 1.38 | 1.6 | ≤3.2 |
| LUB-25 | 52.3 | 3.9 | 22.1 | 0.40 | 2.2 | – | 376 | – | 0.59 | 2.69 | 7.5 | – |
| LUB-26 | 7.2 | 3.7 | 5.8 | 2.8 | 6.2 | – | 903 | – | 0.71 | 14.2 | 3.9 | 148 |
| LUB-27 | 48.4 | E0.2 | 13.1 | ≤0.26 | 1.0 | – | 411 | – | 1.3 | 3.63 | 12.9 | ≤3.9 |

**Table 8.** Trace elements detected in the samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3E. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency (USEPA) action level; HAL-US, USEPA lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, USEPA maximum contaminant level; NL-CA, CDPH notification level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting level; µg/L, micrograms per liter; na, not available; –, not detected; ≤, less than or equal to; *, value at a concentration greater than benchmark level; NWIS, USGS National Water Information System; NWQL, USGS National Water Quality Laboratory; QC, quality control; BQS, USGS Branch of Quality Systems; QA, quality assurance]

| 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** |
| **[LRL or SRL]** | **[1.0]** | **[1] [0.2]** | **[2] [0.32]** | **[1] [0.36]** | **[0.06]** | **[0.010]** | **[0.8]** | **[0.04]** | **[1] [0.11]** | **[0.008]** | **[1] [0.11]** | **[1] [4.8]** |
| **CLUB understanding wells (3 wells sampled)** | | | | | | | | | | | | |
| BVU-01 | 4.4 | – | 9.6 | ≤0.19 | 1.3 | – | 171 | – | 4.2 | 0.43 | 67.3 | 8.8 |
| LUBU-01 | 14.6 | – | *94.8 | ≤0.10 | 0.52 | – | 242 | – | 19.4 | 16.8 | 21.7 | ≤2.1 |
| LUBU-02 | 15.0 | 1.6 | 11.8 | ≤0.25 | 0.92 | – | 186 | – | 1.0 | 0.58 | 30.2 | 6.8 |

**Table 9.** Nutrients detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3F. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **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; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; mg/L, milligram per liter; na, not available; –, not detected; *, value is at a concentration greater than benchmark level]

| 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) | Phosphate, orthophosphate (as phosphorus) (mg/L) (00671) |
|---|---|---|---|---|---|
| **Benchmark type** | **HAL-US** | **MCL-US** | **MCL-US** | **na** | **na** |
| **Benchmark level** | **[1]24.7** | **1** | **10** | **na** | **na** |
| **[LRL]** | **[0.02]** | **[0.002]** | **[0.04]** | **[0.10]** | **[0.006]** |
| **CLUB grid wells (39 wells sampled)** | | | | | |
| Borrego Valley study area (3 grid wells sampled) | | | | | |
| BV-03 | – | – | 0.28 | [2]0.27 | 0.019 |
| BV-04 | – | – | 2.44 | 2.46 | 0.033 |
| BV-07 | – | E0.001 | 0.99 | 1.01 | 0.013 |
| Central Desert study area (9 grid wells sampled) | | | | | |
| CD-01 | – | – | 1.55 | [2]1.51 | 0.016 |
| CD-03 | – | – | 2.03 | 2.06 | 0.025 |
| CD-04 | – | – | 1.41 | 1.42 | 0.018 |
| CD-07 | – | – | 2.62 | 2.68 | 0.027 |
| CD-09 | – | – | 2.20 | 2.25 | 0.027 |
| CD-11 | – | – | 1.24 | 1.30 | 0.027 |
| CD-12 | – | E0.001 | 1.90 | 2.00 | 0.014 |
| CD-13 | – | – | 1.63 | 1.91 | 0.009 |
| CD-14 | – | E0.001 | 1.19 | 1.20 | 0.009 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled) | | | | | |
| LUB-01 | – | – | *12.1 | 12.3 | 0.011 |
| LUB-02 | – | – | 0.41 | [2]0.39 | 0.022 |
| LUB-03 | 0.04 | 0.011 | 0.09 | [2]E0.10 | 0.051 |
| LUB-04 | – | – | 0.38 | [2]0.36 | 0.017 |
| LUB-05 | – | – | 1.03 | 1.04 | 0.012 |
| LUB-06 | – | 0.014 | 3.60 | [2]3.55 | 0.015 |
| LUB-07 | – | – | 1.57 | [2]1.50 | 0.011 |
| LUB-08 | – | – | 4.94 | 4.96 | 0.029 |
| LUB-09 | – | – | 5.11 | 5.22 | 0.018 |
| LUB-10 | 0.16 | – | – | 0.21 | 0.096 |
| LUB-11 | – | E0.001 | 4.10 | [2]4.06 | 0.017 |
| LUB-12 | – | 0.006 | 1.50 | 1.56 | 1.35 |
| LUB-13 | – | – | 0.92 | 0.94 | 0.014 |
| LUB-14 | – | – | 0.60 | [2]0.58 | 0.024 |
| LUB-15 | – | – | 2.06 | 2.09 | 0.013 |

**Table 9.** Nutrients detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3F. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **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; E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; mg/L, milligram per liter; na, not available; –, not detected; *, value is at a concentration greater than benchmark level]

| 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) | Phosphate, orthophosphate (as phosphorus) (mg/L) (00671) |
|---|---|---|---|---|---|
| **Benchmark type** | **HAL-US** | **MCL-US** | **MCL-US** | **na** | **na** |
| **Benchmark level** | **[1] 24.7** | **1** | **10** | **na** | **na** |
| **[LRL]** | **[0.02]** | **[0.002]** | **[0.04]** | **[0.10]** | **[0.006]** |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled)—Continued | | | | | |
| LUB-16 | – | – | 0.35 | 0.42 | 0.009 |
| LUB-17 | – | – | 1.35 | 1.41 | E0.008 |
| LUB-18 | – | – | 0.25 | 0.28 | 0.160 |
| LUB-19 | – | – | 1.22 | [2] 1.18 | E0.007 |
| LUB-20 | – | – | 1.71 | 1.77 | 0.018 |
| LUB-21 | – | 0.005 | 4.51 | 4.68 | 0.008 |
| LUB-22 | 0.093 | E0.001 | – | 0.21 | 0.010 |
| LUB-23 | – | – | 1.47 | 1.48 | 0.014 |
| LUB-24 | – | E0.002 | 0.65 | 0.66 | 0.011 |
| LUB-25 | – | 0.002 | 3.03 | [2] 3.02 | E0.008 |
| LUB-26 | – | – | 4.55 | [2] 4.32 | 0.010 |
| LUB-27 | – | – | 2.69 | 2.72 | 0.021 |
| **CLUB understanding wells (3 wells sampled)** | | | | | |
| BVU-01 | – | – | 2.02 | 2.07 | 0.016 |
| LUBU-01 | – | – | 0.33 | 0.34 | 0.011 |
| LUBU-02 | – | 0.004 | 2.48 | 2.52 | 0.042 |

[1] 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.”

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

**Table 10.** Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3G. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; LRL, laboratory reporting level; mg/L, milligrams per liter; $SiO_2$, silicon dioxide; E, estimated or having a higher degree of uncertainty; na, not available; –, not detected; *, value is at a concentration greater than recommended benchmark level, **, value is at a concentration greater than upper benchmark level; BQS, USGS Branch of Quality Systems; NWQL, USGS National Water Quality Laboratory; QA, quality assurance]

| 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) | Sodium (mg/L) (00930) | Sulfate (mg/L) (00945) | Silica (as $SiO_2$) (mg/L) (00955) | TDS (mg/L) (70300) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Benchmark type** | **na** | **na** | **SMCL-CA** | **MCL-CA** | **na** | **na** | **na** | **na** | **SMCL-CA** | **na** | **SMCL-CA** |
| **Benchmark level** | **na** | **na** | **[1] 250 (500)** | **2** | **na** | **na** | **na** | **na** | **[1] 250 (500)** | **na** | **[1] 500 (1,000)** |
| **[LRL]** | **[0.02]** | **[0.044]** | **[0.12]** | **[0.08]** | **[0.002]** | **[0.016]** | **[0.064]** | **[0.12]** | **[0.18]** | **[0.058]** | **[10]** |
| **CLUB grid wells (39 wells sampled)** | | | | | | | | | | | |
| Borrego Valley study area (3 grid wells sampled) | | | | | | | | | | | |
| BV-03 | 0.24 | 103 | 61.3 | 0.82 | – | 19.6 | 11.6 | 103 | *299 | 26.7 | *734 |
| BV-04 | 0.52 | 63.5 | 158 | 0.41 | – | 11.7 | 5.93 | 95.9 | 25.7 | 32.4 | *512 |
| BV-07 | 0.50 | 20.0 | 135 | 0.41 | 0.019 | 0.67 | 2.58 | 168 | 169 | 12.2 | *571 |
| Central Desert study area (9 grid wells sampled) | | | | | | | | | | | |
| CD-01 | 0.14 | 37.3 | 19.1 | 0.78 | – | 6.2 | 2.42 | 47.9 | 35.6 | 22.7 | 271 |
| CD-03 | 0.04 | 14.0 | 8.1 | 1.6 | E0.002 | 1.9 | 1.69 | 33.4 | 14.1 | 37.5 | 161 |
| CD-04 | 0.05 | 19.9 | 8.4 | 0.58 | – | 2.2 | 1.28 | 17.7 | 8.6 | 33.2 | 139 |
| CD-07 | 0.10 | 15.4 | 14.7 | 0.64 | – | 3.7 | 2.14 | 43.3 | 22.6 | 22.3 | 199 |
| CD-09 | 0.20 | 38.8 | 49.5 | 0.30 | 0.003 | 5.4 | 1.43 | 30.4 | 31.3 | 30.5 | 254 |
| CD-11 | 0.11 | 86.3 | 17.5 | 1.1 | – | 31.6 | 7.74 | 47.8 | 163 | 21.3 | *553 |
| CD-12 | 0.10 | 7.2 | 15.9 | 0.96 | – | 0.08 | 1.41 | 58.0 | 29.6 | 17.2 | 186 |
| CD-13 | 0.13 | 13.6 | 19.8 | *7.1 | 0.015 | 2.5 | 2.72 | 79.2 | 79.2 | 14.8 | 281 |
| CD-14 | 0.11 | 15.9 | 31.2 | 0.54 | 0.006 | 0.37 | 3.08 | 53.0 | 42.5 | 15.6 | 203 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled) | | | | | | | | | | | |
| LUB-01 | 0.35 | 106 | 123 | 0.17 | 0.006 | 15.8 | 2.33 | 61.5 | 134 | 26.5 | *588 |
| LUB-02 | 0.17 | 22.1 | 67.8 | 1.4 | 0.003 | 6.0 | 2.53 | 149 | 85.1 | 25.4 | 466 |
| LUB-03 | 0.13 | 62.6 | 26.4 | 0.74 | 0.068 | 11.4 | 2.08 | 83.6 | 120 | 28.7 | 475 |
| LUB-04 | 0.18 | 26.7 | 70.0 | 1.2 | 0.003 | 6.6 | 2.83 | 134 | 90.5 | 24.7 | 472 |
| LUB-05 | 0.21 | 44.9 | 30.0 | 0.66 | – | 36.8 | 4.75 | 46.0 | 104 | 28.1 | 443 |

**Table 10.** Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3G. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; LRL, laboratory reporting level; mg/L, milligrams per liter; $SiO_2$, silicon dioxide; E, estimated or having a higher degree of uncertainty; na, not available; –, not detected; *, value is at a concentration greater than recommended benchmark level, **, value is at a concentration greater than upper benchmark level; BQS, USGS Branch of Quality Systems; NWQL, USGS National Water Quality Laboratory; QA, quality assurance]

| 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) | Sodium (mg/L) (00930) | Sulfate (mg/L) (00945) | Silica (as $SiO_2$) (mg/L) (00955) | TDS (mg/L) (70300) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Benchmark type** | na | na | SMCL-CA | MCL-CA | na | na | na | na | SMCL-CA | na | SMCL-CA |
| **Benchmark level** | na | na | $^1$ 250 (500) | 2 | na | na | na | na | $^1$ 250 (500) | na | $^1$ 500 (1,000) |
| **[LRL]** | [0.02] | [0.044] | [0.12] | [0.08] | [0.002] | [0.016] | [0.064] | [0.12] | [0.18] | [0.058] | [10] |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled)—Continued | | | | | | | | | | | |
| LUB-06 | 0.33 | 15.7 | 76.5 | *8.5 | 0.017 | 1.7 | 10.3 | 158 | 145 | 65.2 | *590 |
| LUB-07 | 0.26 | 8.1 | 51.0 | *8.5 | 0.027 | 2.3 | 3.08 | 188 | 111 | 26.1 | *556 |
| LUB-08 | 0.25 | 67.4 | 248 | 1.0 | 0.007 | 10.7 | 9.35 | 186 | 137 | 43.6 | *798 |
| LUB-09 | 0.52 | 21.9 | *277 | 1.2 | 0.017 | 23.2 | 8.51 | 365 | 245 | 30.5 | **1,170 |
| LUB-10 | 0.12 | 1.3 | 73.7 | *5.0 | 0.069 | 0.10 | 1.95 | 196 | 35.0 | 65.2 | *564 |
| LUB-11 | 0.32 | 40.2 | 45.8 | 0.33 | 0.004 | 13.9 | 6.13 | 88.6 | 89.1 | 36.6 | 438 |
| LUB-12 | 0.30 | 19.7 | 40.2 | 0.76 | 0.004 | 4.5 | 4.93 | 98.5 | 91.8 | 14.5 | 354 |
| LUB-13 | 0.04 | 22.9 | 8.2 | 0.71 | – | 11.2 | 1.78 | 43.5 | 25.8 | 20.4 | 247 |
| LUB-14 | 0.63 | 92.0 | 142 | 0.59 | E0.001 | 26.3 | 9.28 | 136 | *327 | 39.3 | *836 |
| LUB-15 | 0.26 | 21.0 | 82.8 | 1.5 | 0.003 | 3.3 | 4.36 | 93.8 | 31.4 | 29.8 | 356 |
| LUB-16 | 0.11 | 84.7 | 112 | 0.44 | 0.004 | 33.6 | 4.30 | 125 | *295 | 14.6 | *796 |
| LUB-17 | 0.53 | 62.1 | **555 | 1.9 | 0.013 | 1.1 | 5.77 | 367 | 141 | 19.4 | **1,220 |
| LUB-18 | 0.33 | 37.8 | 81.5 | 1.6 | 0.019 | 8.4 | 1.83 | 64.2 | 38.3 | 39.1 | 369 |
| LUB-19 | 0.56 | 44.1 | *271 | 0.72 | 0.010 | 1.8 | 5.55 | 244 | *295 | 13.2 | *953 |
| LUB-20 | 0.61 | 42.9 | 199 | 0.85 | 0.012 | 11.5 | 5.31 | 163 | 85.5 | 41.9 | *675 |
| LUB-21 | 0.48 | 19.5 | 203 | *12.6 | 0.019 | 0.12 | 1.50 | 225 | 213 | 17.8 | *763 |
| LUB-22 | 0.29 | 8.0 | 226 | *9.6 | 0.069 | 0.16 | 1.56 | 251 | 213 | 30.6 | *805 |
| LUB-23 | 0.22 | 36.5 | 40.1 | *2.9 | E0.002 | 6.9 | 1.75 | 39.5 | 26.9 | 33.3 | 304 |
| LUB-24 | 0.10 | 96.0 | 12.8 | 0.45 | – | 39.4 | 4.09 | 27.4 | *292 | 29.7 | *637 |
| LUB-25 | 0.35 | 16.7 | 160 | *3.2 | 0.005 | 5.2 | 2.63 | 159 | 70.1 | 24.2 | *542 |
| LUB-26 | 1.0 | 128 | 167 | 0.63 | 0.008 | 28.7 | 3.17 | 122 | *292 | 26.4 | *928 |
| LUB-27 | 0.13 | 20.5 | 62.1 | *3.6 | 0.004 | 4.1 | 5.54 | 81.3 | 46.8 | 39.7 | 356 |

**Table 10.** Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 42 wells were analyzed. Information about the analytes given in table 3G. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; SMCL-CA, CDPH secondary maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; LRL, laboratory reporting level; mg/L, milligrams per liter; $SiO_2$, silicon dioxide; E, estimated or having a higher degree of uncertainty; na, not available; –, not detected; *, value is at a concentration greater than recommended benchmark level, **, value is at a concentration greater than upper benchmark level; BQS, USGS Branch of Quality Systems; NWQL, USGS National Water Quality Laboratory; QA, quality assurance]

| 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) | Sodium (mg/L) (00930) | Sulfate (mg/L) (00945) | Silica (as $SiO_2$) (mg/L) (00955) | TDS (mg/L) (70300) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Benchmark type** | **na** | **na** | **SMCL-CA** | **MCL-CA** | **na** | **na** | **na** | **na** | **SMCL-CA** | **na** | **SMCL-CA** |
| **Benchmark level** | **na** | **na** | **[1] 250 (500)** | **2** | **na** | **na** | **na** | **na** | **[1] 250 (500)** | **na** | **[1] 500 (1,000)** |
| **[LRL]** | **[0.02]** | **[0.044]** | **[0.12]** | **[0.08]** | **[0.002]** | **[0.016]** | **[0.064]** | **[0.12]** | **[0.18]** | **[0.058]** | **[10]** |
| **CLUB understanding wells (3 wells sampled)** | | | | | | | | | | | |
| BVU-01 | 0.20 | 15.0 | 44.3 | 0.43 | E0.002 | 1.9 | 3.02 | 71.4 | 46.9 | 16.6 | 271 |
| LUBU-01 | 0.14 | 15.2 | 22.0 | *5.6 | 0.031 | 3.2 | 2.45 | 105 | 70.5 | 17.4 | 347 |
| LUBU-02 | 0.12 | 17.2 | 20.5 | 0.60 | E0.002 | 2.8 | 8.29 | 47.5 | 35.9 | 71.5 | 289 |

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

**Table 11.** Species of inorganic chromium detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008.

[Data in this table was generated at the USGS Trace Metals Laboratory, Boulder, Colorado, using research methods and are not stored in the USGS National Water Information System database. Information about the analytes given in table 3H. Samples from 7 slow wells in December 2008 were analyzed. **GAMA well identification number:** CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well. Method detection limit, benchmark type, and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; Cr-VI, hexavalent chromium, chromium-VI; MDL, method detection limit; µg/L, micrograms per liter; na, not available; E, estimated or having a high degree of uncertianty; –, not detected]

| GAMA well identification number | Chromium (µg/L) | Cr-VI (µg/L) |
|---|---|---|
| **Benchmark type** | **MCL-CA** | **na** |
| **Benchmark level** | **50** | **na** |
| **[MDL]** | **[1]** | **[1]** |
| **CLUB grid wells (7 wells sampled)** | | |
| Borrego Valley study area (3 grid wells sampled) | | |
| CD-01 | 3.0 | 2.3 |
| CD-03 | E0.6 | E0.5 |
| CD-04 | E0.6 | E0.6 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (4 grid wells sampled) | | |
| LUB-01 | 6.4 | 5.3 |
| LUB-03 | – | – |
| LUB-07 | 2.1 | 1.9 |
| LUB-10 | – | – |

**Table 12.** Hexavalent chromium (chromium-VI, Cr-VI) detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, October 2009 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Data in this table were generated at TestAmerica Laboratories, Inc., Irvine, California. Samples from 17 slow wells were analyzed. Information about the analyte given in table 3I. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well. Method detection limit as of October 5, 2009. **Other abbreviations**: USGS, U.S. Geological Survey; na, not available; MDL, method detection limit; µg/L, micrograms per liter; –, not detected]

| GAMA well identification number | Cr-VI (µg/L) |
|---|---|
| **Benchmark type** | **na** |
| **Benchmark level** | **na** |
| **[MDL]** | **[1]** |
| **CLUB grid wells (16 wells sampled)** | |
| Borrego Valley study area (3 grid wells sampled) | |
| BV-01 | 3.0 |
| BV-03 | E0.6 |
| BV-04 | E0.6 |
| Central Desert study area (6 grid wells sampled) | |
| CD-07 | 18.0 |
| CD-09 | 1.9 |
| CD-11 | – |
| CD-12 | – |
| CD-13 | 10.0 |
| CD-14 | 2.4 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (7 grid wells sampled) | |
| LUB-13 | 3.1 |
| LUB-18 | – |
| LUB-19 | – |
| LUB-20 | 2.8 |
| LUB-23 | – |
| LUB-26 | – |
| LUB-27 | 13.0 |
| **CLUB understanding wells (1 well sampled)** | |
| BVU-01 | 1.1 |

**Table 13.** Results for analyses of stable isotope ratios, tritium activity, and carbon-14 abundance detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[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 3J. Samples from all 52 wells were analyzed for stable isotopes of hydrogen and oxygen in water and tritium activities. Samples from 51 wells were analyzed for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Tritium values less than the sample-specific critical level (ssL$_C$) are reported as non-detections (–). **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL–CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; H, hydrogen; O, oxygen; C, carbon; CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; –, not detected; ±, plus or minus; na, not available]

| GAMA well identification number | $\delta^{2}$H (per mil) (82082) | $\delta^{18}$O (per mil) (82085) | Tritium (pCi/L) (07000) | | $\delta^{13}$C (per mil) (82081) | Carbon-14 (percent modern) (49933) |
|---|---|---|---|---|---|---|
| **Benchmark type** | na | na | MCL–CA | | na | na |
| **Benchmark level** | na | na | 20,000 | | na | na |
| | | | **Result ± CSU** | **ssL$_C$** | | |
| **CLUB grid wells (49 wells sampled)** | | | | | | |
| Borrego Valley study area (7 grid wells sampled) | | | | | | |
| BV–01 | –56.90 | –8.17 | 0.4 ± 0.32 | 0.32 | –9.48 | 42.41 |
| BV–02 | –56.40 | –8.34 | 3.8 ± 0.35 | 0.32 | –10.64 | 112.6 |
| BV–03 | –60.90 | –8.73 | 2.5 ± 0.32 | 0.32 | –13.10 | 99.29 |
| BV–04 | –64.00 | –8.90 | – | 0.32 | –12.78 | 79.08 |
| BV–05 | –59.90 | –8.83 | 0.5 ± 0.32 | 0.32 | –11.30 | 27.45 |
| BV–06 | –73.10 | –8.57 | – | 0.32 | –10.94 | 4.390 |
| BV–07 | –67.30 | –9.45 | – | 0.35 | na[1] | na[1] |
| Central Desert study area (15 grid wells sampled) | | | | | | |
| CD–01 | –83.80 | –11.4 | – | 0.35 | –8.81 | 85.11 |
| CD–02 | –82.30 | –11.0 | – | 0.45 | –9.44 | 84.73 |
| CD–03 | –78.70 | –11.1 | 4.5 ± 0.38 | 0.35 | –12.13 | 75.81 |
| CD–04 | –80.60 | –11.5 | 2.8 ± 0.45 | 0.41 | –12.40 | 87.65 |
| CD–05 | –81.60 | –11.5 | 0.5 ± 0.45 | 0.45 | –11.85 | 79.42 |
| CD–06 | –78.70 | –11.1 | 4.4 ± 0.45 | 0.38 | –10.50 | 92.91 |
| CD–07 | –77.80 | –11.0 | – | 0.32 | –11.10 | 59.77 |
| CD–08 | –89.50 | –11.9 | 0.5 ± 0.32 | 0.32 | –10.03 | 12.69 |
| CD–09 | –73.90 | –9.98 | 6.9 ± 0.41 | 0.32 | –10.92 | 91.04 |
| CD–10 | –80.50 | –11.2 | 2.5 ± 0.35 | 0.32 | –9.99 | 90.55 |
| CD–11 | –73.50 | –10.6 | 4.6 ± 0.41 | 0.35 | –12.27 | 107.1 |
| CD–12 | –77.00 | –10.7 | – | 0.32 | –12.21 | 26.62 |
| CD–13 | –83.40 | –11.3 | – | 0.32 | –9.59 | 31.86 |
| CD–14 | –83.10 | –11.3 | – | 0.32 | –11.03 | 26.31 |
| CD–15 | –82.20 | –11.3 | – | 0.32 | –8.52 | 54.81 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled) | | | | | | |
| LUB–01 | –69.00 | –8.67 | 2.7 ± 0.38 | 0.35 | –9.23 | 45.07 |
| LUB–02 | –78.30 | –10.9 | – | 0.35 | –6.74 | 21.29 |
| LUB–03 | –82.70 | –11.1 | 0.7 ± 0.38 | 0.38 | –11.66 | 50.48 |
| LUB–04 | –78.50 | –10.9 | – | 0.38 | –6.82 | 19.27 |
| LUB–05 | –88.50 | –11.9 | – | 0.38 | –9.24 | 60.23 |

**Table 13.** Results for analyses of stable isotope ratios, tritium activity, and carbon-14 abundance detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—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 3J. Samples from all 52 wells were analyzed for stable isotopes of hydrogen and oxygen in water and tritium activities. Samples from 51 wells were analyzed for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. Tritium values less than the sample-specific critical level ($ssL_C$) are reported as non-detections (–). **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL–CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; H, hydrogen; O, oxygen; C, carbon; CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; –, not detected; ±, plus or minus; na, not available]

| GAMA well identification number | $\delta^{2}$H (per mil) (82082) | $\delta^{18}$O (per mil) (82085) | Tritium (pCi/L) (07000) | | $\delta^{13}$C (per mil) (82081) | Carbon-14 (percent modern) (49933) |
|---|---|---|---|---|---|---|
| **Benchmark type** | na | na | MCL–CA | | na | na |
| **Benchmark level** | na | na | 20,000 | | na | na |
| | | | **Result ± CSU** | **$ssL_C$** | | |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (27 grid wells sampled)—Continued | | | | | | |
| LUB–06 | –93.40 | –11.4 | 0.5 ± 0.38 | 0.35 | –8.64 | 22.24 |
| LUB–07 | –95.90 | –11.9 | – | 0.35 | –5.82 | 6.020 |
| LUB–08 | –97.50 | –12.4 | – | 0.35 | –8.31 | 8.220 |
| LUB–09 | –85.90 | –10.6 | – | 0.38 | –3.27 | 22.04 |
| LUB–10 | –69.10 | –9.49 | – | 0.35 | –7.30 | 14.51 |
| LUB–11 | –102.0 | –13.1 | – | 0.35 | –9.33 | 6.820 |
| LUB–12 | –90.20 | –11.9 | – | 0.35 | –9.97 | 25.31 |
| LUB–13 | –89.70 | –12.4 | – | 0.32 | –8.85 | 15.90 |
| LUB–14 | –65.00 | –9.17 | – | 0.32 | –12.80 | 56.20 |
| LUB–15 | –73.10 | –10.2 | – | 0.32 | –10.13 | 31.76 |
| LUB–16 | –94.30 | –11.4 | 17.8 ± 0.67 | 0.32 | –7.89 | 89.60 |
| LUB–17 | –54.40 | –7.26 | – | 0.32 | –8.52 | 9.440 |
| LUB–18 | –57.30 | –8.27 | 1.2 ± 0.32 | 0.32 | –14.97 | 89.61 |
| LUB–19 | –67.50 | –8.55 | – | 0.32 | –10.30 | 30.84 |
| LUB–20 | –73.00 | –10.2 | – | 0.32 | –10.41 | 34.20 |
| LUB–21 | –79.80 | –10.6 | – | 0.32 | –10.07 | 14.74 |
| LUB–22 | –73.70 | –9.69 | – | 0.32 | –5.43 | 3.040 |
| LUB–23 | –70.80 | –9.78 | 0.3 ± 0.35 | 0.35 | –9.88 | 53.99 |
| LUB–24 | –88.00 | –12.1 | 0.6 ± 0.35 | 0.35 | –6.46 | 4.230 |
| LUB–25 | –79.50 | –10.5 | 0.6 ± 0.32 | 0.32 | –8.11 | 9.790 |
| LUB–26 | –75.20 | –10.1 | 3.9 ± 0.41 | 0.35 | –8.98 | 99.20 |
| LUB–27 | –83.70 | –11.4 | – | 0.35 | –8.37 | 10.44 |
| **CLUB understanding wells (3 wells sampled)** | | | | | | |
| BVU–01 | –70.40 | –9.73 | – | 0.32 | –11.27 | 18.51 |
| LUBU–01 | –79.40 | –11.1 | – | 0.38 | –10.33 | 38.49 |
| LUBU–02 | –98.30 | –12.7 | – | 0.35 | –9.48 | 18.50 |

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[1] Sample bottle broken during shipment to the laboratory.

**Table 14A.** Radon-222 detected in samples collected for the Borrego Valley , Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from 23 slow wells were analyzed. Information about the analytes given in table 3J. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; CSU, combined standard uncertainty; pCi/L, picocuries per liter; $ssL_C$, sample-specific critical level; ±, plus or minus]

| GAMA well identification number | Radon-222 (pCi/L) (82303) | |
|---|---|---|
| | Result ± CSU | $ssL_C$ |
| **Benchmark type** | **Proposed MCL-US** | |
| **Benchmark level** | **4,000** | |
| **CLUB Grid wells (22 wells sampled) [1]** | | |
| Borrego Valley study area (3 grid wells sampled) | | |
| BV-03 | 390 ± 26 | 13 |
| BV-04 | 175 ± 15 | 13 |
| BV-07 | 600 ± 36 | 12 |
| Central Desert study area (8 grid wells sampled)[1] | | |
| CD-01 | 630 ± 38 | 12 |
| CD-03 | 1,090 ± 61 | 10 |
| CD-04 | 1,700 ± 95 | 12 |
| CD-07 | 510 ± 32 | 12 |
| CD-09 | 1,080 ± 61 | 11 |
| CD-11 | 810 ± 47 | 11 |
| CD-12 | 810 ± 47 | 13 |
| CD-14 | 670 ± 40 | 12 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (11 grid wells sampled) | | |
| LUB-01 | 400 ± 26 | 13 |
| LUB-03 | 570 ± 35 | 13 |
| LUB-07 | 830 ± 48 | 11 |
| LUB-10 | 1,540 ± 86 | 12 |
| LUB-13 | 660 ± 39 | 11 |
| LUB-18 | 240 ± 19 | 14 |
| LUB-19 | 270 ± 20 | 13 |
| LUB-20 | 340 ± 22 | 11 |
| LUB-23 | 1,400 ± 79 | 15 |
| LUB-26 | 760 ± 45 | 14 |
| LUB-27 | 490 ± 30 | 11 |
| **CLUB understanding wells (1 well sampled)** | | |
| BVU-01 | 330 ± 22 | 12 |

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[1] Sample from CD-13 was not collected.

**Table 14B.** Radium isotopes detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the 24 slow wells were analyzed. Information about the analytes given in table 3J. Values less than the sample-specific critical level ($ssL_C$) are reported as non-detections. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; CSU, combined standard uncertainty; pCi/L, picocuries per liter; ±, plus or minus; –, not detected]

| GAMA well identification number | Radium-226 (pCi/L) (09511) | | Radium-228 (pCi/L) (81366) | |
|---|---|---|---|---|
| | Result ± CSU | $ssL_C$ | Result ± CSU | $ssL_C$ |
| **Benchmark type** | **MCL-US** | | **MCL-US** | |
| **Benchmark level** | **[1] 5** | | **[1] 5** | |
| **CLUB grid wells (22 wells sampled) [1]** | | | | |
| Borrego Valley study area (3 grid wells sampled) | | | | |
| BV-03 | 0.08 ± 0.011 | 0.013 | 0.55 ± 0.085 | 0.17 |
| BV-04 | 0.07 ± 0.015 | 0.017 | – | 0.20 |
| BV-07 | 0.036 ± 0.011 | 0.016 | 0.29 ± 0.13 | 0.20 |
| Central Desert study area (8 grid wells sampled) | | | | |
| CD-01 | 0.048 ± 0.013 | 0.015 | 0.82 ± 0.11 | 0.22 |
| CD-03 | 0.103 ± 0.017 | 0.014 | 0.48 ± 0.098 | 0.22 |
| CD-04 | 0.097 ± 0.016 | 0.014 | – | 0.27 |
| CD-07 | 0.068 ± 0.011 | 0.010 | – | 0.18 |
| CD-09 | 0.188 ± 0.021 | 0.017 | 0.27 ± 0.12 | 0.24 |
| CD-11 | 0.09 ± 0.016 | 0.016 | 0.57 ± 0.12 | 0.23 |
| CD-12 | 0.035 ± 0.012 | 0.015 | – | 0.18 |
| CD-13 | 0.0331 ± 0.0084 | 0.015 | – | 0.18 |
| CD-14 | 0.05 ± 0.01 | 0.016 | – | 0.17 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (11 grid wells sampled) | | | | |
| LUB-01 | 0.035 ± 0.01 | 0.014 | – | 0.20 |
| LUB-03 | 0.114 ± 0.016 | 0.011 | 0.344 ± 0.092 | 0.21 |
| LUB-07 | 0.04 ± 0.013 | 0.015 | – | 0.21 |
| LUB-10 | 0.018 ± 0.011 | 0.015 | – | 0.22 |
| LUB-13 | 0.067 ± 0.015 | 0.016 | – | 0.17 |
| LUB-18 | 0.137 ± 0.016 | 0.014 | – | 0.20 |
| LUB-19 | 0.058 ± 0.011 | 0.015 | 0.244 ± 0.096 | 0.22 |
| LUB-20 | 0.085 ± 0.016 | 0.017 | – | 0.20 |
| LUB-23 | 0.114 ± 0.019 | 0.016 | 0.78 ± 0.14 | 0.18 |
| LUB-26 | 0.088 ± 0.013 | 0.013 | 0.355 ± 0.077 | 0.16 |
| **CLUB understanding wells (1 well sampled)** | | | | |
| BVU-01 | 0.03 ± 0.01 | 0.015 | 0.26 ± 0.13 | 0.26 |

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

**Table 14C.** Gross alpha and beta radioactivity detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[The five-digit USGS parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the 24 slow wells were analyzed. Information about the analytes given in table 3J. The reference nuclide for measurement of gross alpha is thorium-230, and the reference nuclide for measurement of gross beta is cesium-137. Measured values less than the sample-specific critical level (ssL$_C$) are reported as non-detections. **GAMA well identification number:** BV, Borrego Valley study-area grid well; BVU, Borrego Valley study-area understanding well; CD, Central Desert study-area grid well; LUB, Low-Use Basins of the Mojave and Sonoran Deserts study-area grid well; LUBU, Low-Use Basins of the Mojave and Sonoran Deserts study-area understanding well. Benchmark type and benchmark level as of October 1, 2008. **Benchmark type:** Maximum contaminant level benchmarks are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** USGS, U.S. Geological Survey; CSU, 1-sigma combined standard uncertainty; pCi/L, picocuries per liter; –, not detected; ±, plus or minus; *, value is at a concentration greater than benchmark level]

| GAMA well identification number | Gross alpha radioactivity, 72-hour count (pCi/L) (62636) | | Gross alpha radioactivity, 30-day count (pCi/L) (62639) | | Gross beta radioactivity, 72-hour count (pCi/L) (62642) | | Gross beta radioactivity, 30-day count (pCi/L) (62645) | |
|---|---|---|---|---|---|---|---|---|
| | Result ± CSU | ssL$_C$ | Result ± CSU | ssL$_C$ | Result ± CSU | ssL$_C$ | Result ± CSU | ssL$_C$ |
| **Benchmark type** | **MCL-US** | | **MCL-US** | | **MCL-CA** | | **MCL-CA** | |
| **Benchmark level** | **15** | | **15** | | **50** | | **50** | |
| **CLUB grid wells (23 wells sampled)** | | | | | | | | |
| Borrego Valley study area (3 grid wells sampled) | | | | | | | | |
| BV-03 | 9.4 ± 1.7 | 1.2 | 6.3 ± 1.5 | 1.3 | [1] 10.7 ± 0.76 | 0.51 | 21.4 ± 1.4 | 0.84 |
| BV-04 | – | 1.4 | – | 1.2 | 5.8 ± 0.72 | 0.89 | 5.35 ± 0.71 | 0.91 |
| BV-07 | 2.54 ± 0.89 | 0.97 | – | 0.94 | 2.61 ± 0.57 | 0.83 | 1.87 ± 0.56 | 0.83 |
| Central Desert study area (9 grid wells sampled) | | | | | | | | |
| CD-01 | 12.7 ± 1.7 | 0.83 | 8.2 ± 1.2 | 0.60 | 4.76 ± 0.45 | 0.46 | 6.27 ± 0.52 | 0.46 |
| CD-03 | 3.2 ± 1.0 | 1.3 | 1.21 ± 0.81 | 1.2 | 1.99 ± 0.34 | 0.48 | 2.12 ± 0.35 | 0.48 |
| CD-04 | 3.92 ± 0.68 | 0.46 | 4.33 ± 0.75 | 0.60 | 1.46 ± 0.31 | 0.43 | 2.19 ± 0.46 | 0.71 |
| CD-07 | 7.0 ± 1.0 | 0.51 | 3.42 ± 0.83 | 0.62 | 2.85 ± 0.38 | 0.48 | 3.14 ± 0.52 | 0.68 |
| CD-09 | 10.8 ± 1.7 | 1.4 | 3.5 ± 1.2 | 1.5 | 1.97 ± 0.46 | 0.66 | 3.75 ± 0.51 | 0.66 |
| CD-11 | * 28.7 ± 3.7 | 1.2 | 14.4 ± 2.3 | 1.4 | 8.32 ± 0.68 | 0.66 | 17.0 ± 1.2 | 0.86 |
| CD-12 | * 20.8 ± 2.4 | 0.36 | * 21.0 ± 2.5 | 1.2 | 1.09 ± 0.33 | 0.46 | 6.09 ± 0.51 | 0.47 |
| CD-13 | 10.5 ± 1.4 | 0.64 | 9.1 ± 1.3 | 0.60 | 3.17 ± 0.48 | 0.65 | 3.67 ± 0.44 | 0.52 |
| CD-14 | 2.23 ± 0.51 | 0.43 | 2.23 ± 0.51 | 0.46 | 2.43 ± 0.36 | 0.48 | 2.74 ± 0.34 | 0.43 |
| Low-Use Basins of the Mojave and Sonoran Deserts study area (11 grid wells sampled) | | | | | | | | |
| LUB-01 | – | 2.2 | – | 1.5 | 1.64 ± 0.39 | 0.58 | 2.09 ± 0.50 | 0.75 |
| LUB-03 | * 17.3 ± 2.5 | 1.3 | 13.5 ± 2.0 | 1.2 | 3.44 ± 0.63 | 0.82 | 5.21 ± 0.94 | 1.4 |
| LUB-07 | [1] 10.5 ± 2.1 | 1.9 | 14.3 ± 2.4 | 1.7 | 3.11 ± 0.40 | 0.48 | 6.24 ± 0.65 | 0.83 |
| LUB-10 | 3.0 ± 1.4 | 2.0 | – | 1.5 | 3.26 ± 0.42 | 0.54 | 0.64 ± 0.33 | 0.53 |
| LUB-13 | 4.72 ± 0.85 | 0.49 | 2.02 ± 0.59 | 0.60 | 2.5 ± 0.40 | 0.54 | 2.03 ± 0.33 | 0.45 |
| LUB-18 | 5.0 ± 1.0 | 0.75 | 3.65 ± 0.88 | 0.73 | 2.49 ± 0.48 | 0.66 | 2.28 ± 0.48 | 0.67 |
| LUB-19 | – | 1.6 | – | 1.6 | 5.4 ± 0.62 | 0.83 | 4.47 ± 0.51 | 0.60 |
| LUB-20 | 4.0 ± 1.2 | 1.3 | 3.3 ± 1.2 | 1.3 | 4.3 ± 0.52 | 0.67 | 6.4 ± 0.53 | 0.49 |
| LUB-23 | 13.4 ± 1.8 | 0.55 | 4.9 ± 0.9 | 0.66 | 1.88 ± 0.39 | 0.54 | 2.68 ± 0.41 | 0.54 |
| LUB-26 | [1] * 19.1 ± 3.1 | 1.9 | 13.7 ± 2.6 | 1.9 | [1] 4.31 ± 0.55 | 0.68 | 7.41 ± 0.68 | 0.68 |
| LUB-27 | 6.6 ± 1.1 | 0.54 | 5.6 ± 0.99 | 0.73 | 4.96 ± 0.66 | 0.87 | 5.5 ± 0.58 | 0.74 |
| **CLUB understanding wells (1 well sampled)** | | | | | | | | |
| BVU-01 | 0.7 ± 0.44 | 0.59 | – | 1.3 | 2.67 ± 0.42 | 0.58 | 2.6 ± 0.37 | 0.49 |

[1] 72-hour holding time exceeded by 4 to 7 days. A delay in the counting by the laboratory may result in lower activities than may have been observed for these analytes if the count had been performed within the 72-hour time period

# Appendix

This appendix includes discussions of the methods used to collect and analyze groundwater samples and to 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 CLUB study unit, groundwater samples were collected and QA/QC 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

Prior to sampling, each well was pumped continuously to purge at least three casing-volumes of water from the well (Wilde and others, 1999). Wells were sampled using Teflon® tubing with brass and stainless-steel fittings attached to a sampling point on the well discharge pipe as close to the well 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 using a Hach® field test kit. For the *fast* schedule, samples were collected at the well head using a foot-long length of Teflon® tubing. For the *slow* schedule, the samples were either collected in the same manner as the *fast* schedule or collected inside an enclosed chamber located inside a mobile laboratory and connected to the well head by a 10–50 ft length of the Teflon® tubing (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) 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 temperature, dissolved oxygen, 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 on field record sheets and electronically in the Personal Computer Field Form (PCFF) program. Analytical service requests for the NWQL were generated by PCFF, whereas analytical service requests for non-NWQL analysis were entered into laboratory-specific spreadsheets. Information from PCFF was uploaded directly into the USGS NWIS database at the end of every week of sample collection.

Prior to sample collection, polyethylene sample bottles were pre-rinsed two times using deionized water, and then once with 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 species of inorganic chromium, tritium, stable isotopes of hydrogen and oxygen in water, stable isotopes of boron and strontium in water, and dissolved noble gases were shipped monthly. Temperature- or time-sensitive samples for VOCs, pesticides and pesticide degradates, pharmaceutical compounds, perchlorate, NDMA, trace elements, nutrients, major and minor ions, silica, TDS, laboratory alkalinity, chromium-IV, radon-222, radium isotopes, and gross alpha and gross beta radioactivity were shipped daily. The temperature-sensitive samples for stable isotopes of carbon in dissolved inorganic carbon and carbon-14 abundance were stored on ice, archived in a laboratory refrigerator, and shipped after all of the alkalinity measurements were collected.

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-mL sample vials that were purged with three vial volumes of 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-milliliter (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-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.

Pesticides and pesticide degradates, pharmaceutical compounds, and NDMA samples were collected in 1-L baked amber glass bottles. Pesticide and pharmaceutical samples were filtered through a 0.7-µm nominal pore-size glass fiber filter during collection, whereas the NDMA samples were filtered at Weck Laboratories, Inc., City of Industry, California, prior to analysis. NDMA sample containers, treated with 0.05 gram (g) of sodium thiosulfate ($Na_2S_2O_3$) as a preservative, were provided by Weck Laboratories, Inc.

Groundwater samples for trace elements, major and minor ions, silica, and TDS analyses required filling one 250-mL polyethylene bottle with unfiltered groundwater and one 500-mL and one 250-mL polyethylene bottle with filtered groundwater (Wilde and others, 2004). Filtration was done using either a 0.45-µm pore-size Whatman® vented capsule filter or 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. The 250-mL filtered sample then was preserved with 7.5-Normal (N) nitric acid. Nutrient samples were collected by filtering groundwater into a 125-mL brown polyethylene bottle. Cr-VI samples for analysis at TALIR were collected by filtering groundwater into a 500-mL polyethylene bottle and buffering to a pH range of 9.3 to 9.7 with a solution consisting of ammonium sulfate, ammonium hydroxide, and ultrapure water. Stable isotopes of boron and strontium in water samples were filtered into one 250-mL polyethylene bottle and secured with electrical tape to prevent leakage and evaporation. Radium isotope and gross alpha and gross beta radioactivity samples were each filtered into individual 1-L polyethylene bottles and then preserved 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 groundwater. These samples had no headspace and were sealed with conical caps to avoid atmospheric contamination. Samples for laboratory or field alkalinity titrations were collected by filtering groundwater into a 500-mL polyethylene bottle.

Species of inorganic chromium, radon-222, and noble gases samples were collected from the hose bib at the well head, regardless of the sampling schedule (fast or slow).

Species of inorganic chromium samples for analysis at the NRP-TML were collected 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, 4 mL of sample water was forced through the disk filter; the next 2 mL of the groundwater was filtered slowly into a small centrifuge vial for analysis of total chromium. Cr-VI then was collected by attaching a small cation-exchange column to the syringe filter and, after conditioning the column with 2 mL of sample water, 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 McClesky, 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 partially closed to create back pressure, and a 10-mL groundwater sample was taken through a Teflon® septum on the valve assembly using a glass syringe affixed with a stainless-steel needle. The sample was then injected into a 25-mL vial partially filled with a scintillation mixture (mineral oil) 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. 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 are updated accordingly. NWQL maintains the National Environmental Laboratory Accreditation Program (NELAP) and other certifications (http://www.nelac-institute.org/accred-labs.php). In addition, the 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 the USGS NWIS database. Some laboratory QC data are stored in the USGS NWIS database also.

## Data Reporting

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

### Reporting Limits

The NWQL uses the LRL as a benchmark 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 NWQL updates LRL values regularly, and the values listed in this report were in effect during the period groundwater samples from the CLUB study unit were analyzed (December 2008 to March 2010). LRL values for some constituents changed on October 1, 2009; therefore, two LRLs are reported (table 3A, 3B, 3E–G): the LRL for samples collected before October 1, 2009, and the LRL for samples collected on or after October 1, 2009. The highest LRL is used for this report.

The LRL usually is set at two times the long-term method detection level (LT-MDL). The LT-MDL is derived from the standard deviation of at least 24 method detection level (MDL) determinations made over an extended period of time. The MDL is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the concentration is greater than zero (at the MDL there is less than 1 percent chance of a false positive). LT-MDLs continually are monitored and updated (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.

Concentrations between the LRL and the LT-MDL are reported as estimated concentrations (coded by the letter “E” preceding the values in the tables and text). For information-rich methods, detections less than the LT-MDL have high certainty of detection, but the precise concentration is uncertain. These values are also E-coded. Information-rich methods are those that utilize gas chromatography or high-performance liquid chromatography (HPLC) with mass spectrometry detection, such as those methods used to analyze VOCs and pesticides. Compounds are identified by 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).

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

Results for most constituents are presented using the LRL, MDL, or MRL values provided by the analyzing laboratories. Results for some organic and inorganic constituents are presented using study reporting levels (SRL) derived from assessment of data from QC samples associated with groundwater samples collected as part of the GAMA-PBP (see the appendix section titled “Assessment of Blank Results and SRLs”).

The methods used for analysis of radiochemical constituents (tritium, radon-222, radium isotopes, and gross alpha and gross beta radioactivity) measure activities by counting techniques (table A1). The reporting limits for radiochemical constituents are based on sample-specific critical levels ($ssL_C$) (McCurdy and others, 2008). The critical level is analogous to the LT-MDL used for reporting analytical results for organic and non-radioactive inorganic constituents. Here, the critical level is defined as the minimum measured activity that indicates a positive detection of the radionuclide in the sample with less than a 5-percent probability of a false positive detection. Sample-specific critical levels are used for radiochemical measurements because the critical level is sensitive to sample size and sample yield during analytical processing and is dependent on instrument background, on counting times for the sample and background, and on the characteristics of the instrument being used and the nuclide being measured. An $ssL_C$ is calculated for each sample, and the measured activity in the sample is compared to the $ssL_C$ associated with that sample. Measured activities less than the $ssL_C$ are reported as non-detections 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 (CSU). The CSU is reported at the 68-percent confidence level (1-sigma).

### Notation

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

$$\delta^{i}E=\left[\frac{R_{sample}}{R_{reference}}-1\right]\times 1{,}000 \text{ per mil,} \qquad \text{(A1)}$$

where

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

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

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

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

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned $\delta^{18}$O and $\delta^{2}$H values of 0 per mil (note than $\delta^{2}$H is sometimes 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 boron is the National Institute of Standards and Technology (NIST) reference material SRM 951 boric acid, which is assigned a $\delta^{11}$B value of 0 per mil. The reference material for carbon is Vienna Pee Dee Belemnite (VPDB), which is assigned a $\delta^{13}$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.

Stable 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

Six constituents targeted in this study were measured by more than one analytical method or by more than one laboratory (table A2). The preferred methods for these constituents were selected on the basis of the procedure recommended by the NWQL (http://wwwnwql.cr.usgs.gov/dyn.shtml?Preferred_method_selection_procedure).

The water-quality indicators—alkalinity, pH, and specific conductance—were measured in the field and at the NWQL. The field measurements are the preferred method for all three constituents; however, both measurements are reported on table 4. Field values are generally preferred because field conditions are considered more representative of groundwater conditions (Hem, 1985).

For total chromium concentrations, the approved method (Schedule 1948, which is used by the NWQL) is preferred over the research methods used by the NRP-TML; however, both measurements are reported (tables 8 and 11). The concentrations measured by the NRP-TML only are used to calculate ratios of the abundance of the oxidized species to the abundance of the reduced species for the element.

For example,

$$\frac{\text{Cr(III)}}{\text{Cr(VI)}}=\frac{\text{Cr(T)}-\text{Cr(VI)}}{\text{Cr(VI)}}, \qquad \text{(A2)}$$

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).

Cr-VI was measured at two laboratories—NRP-TML and TALIR—and both sets of results are reported.

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

# Quality-Assurance Methods

The purpose of QA 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 used in this study: (1) blank samples were collected to assess positive bias as a result of contamination during sample handling or analysis, (2) replicate samples were collected to assess variability, (3) matrix-spike tests were done to assess positive or negative bias, and (4) surrogate compounds were added to samples analyzed for organic constituents to assess bias of laboratory analytical methods. Results that were found to have significant contamination bias, on the basis of the QC data collected from this study and previous studies, were flagged with an appropriate remark code (described in subsequent sections) and rejected from subsequent use, including calculations of detection frequency.

## Blanks

The primary purposes of collecting blanks are to evaluate the magnitude of potential contamination of samples with compounds of interest during sample collection, processing, transport, and (or) analysis, and to identify and mitigate these sources of sample contamination.

## Blank Collection and Analysis

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

Field blanks were analyzed for VOCs, pesticides and pesticide degradates, perchlorate, NDMA, trace elements, nutrients, major and minor ions, silica, TDS, species of inorganic chromium, radium isotopes, and gross alpha and gross beta radioactivity. Field blanks were not collected for tritium or 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. Stable-isotopic ratios of boron, carbon, hydrogen, oxygen, and strontium are an intrinsic property of any of these elements; therefore, the concept of a blank does not apply to these ratios.

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

## Assessment of Blank Results and SRLs

Contamination in blanks may originate from several different types of sources that require different strategies for assessment of potential contamination of groundwater samples during sample collection, handling, and analysis. Four primary modes of contamination are assessed in the event of detections in blanks or atypical results in groundwater samples: (1) impurities in the water used to collect the blanks, (2) contamination during sample collection and handling from a known source or condition present at the field site, (3) carry-over of material on the sampling equipment from one sample to the next sample, (4) systematic and random contamination from field and laboratory equipment and processes. The fourth source of contamination (systematic and random) is being addressed using a larger set of blank results from multiple studies, in addition to the results from the field blanks collected from the CLUB study unit. The development of this approach and its methods are described by M.S. Fram, L.D. Olsen, and K. Belitz, U.S. Geological Survey, written commun. (2011) for VOCs and by Olsen and others (2010) for trace elements.

The first potential mode that was evaluated is the presence of impurities in the water used to collect the blank. Because the blanks were collected using blank water certified by the NWQL to contain less than the LRL, MDL, or MRL of the analytes investigated in the study, the blank water is rarely the source of constituents detected in blanks. However, blank water sometimes is used before the certification process has been completed; thus, the certificates of analysis always must be checked. Blank water used in the CLUB study unit was certified by the NWQL prior to field blank collection.

The second potential mode that was evaluated is contamination from identifiable, known sources present at a specific field site. Contamination from specific sources may produce distinctive patterns of detections in blanks and groundwater samples, particularly for the VOCs. Substances that may be encountered at the field site contain recognizable associations of VOC constituents. For example, cements used on polyvinyl chloride (PVC) piping are primarily composed of tetrahydrofuran with lesser amounts of acetone and methyl ethyl ketone (2-butanone). However, detection of these recognizable associations of VOC constituents in groundwater samples does not necessarily indicate contamination during sample collection because these VOC constituents also may occur together in groundwater.

If a recognizable association of VOC constituents was detected in a field blank or in a groundwater sample, the field notes and photographs from the site at which the field blank or groundwater sample was collected were examined for conditions that may have caused the field blank or the groundwater sample to be contaminated. If such conditions were present, the detections of VOC constituents in the field blank or groundwater sample were considered suspect.

The third potential mode of contamination that was evaluated was carry-over from the previous groundwater sample or blank collected with the same equipment. Carry-over between samples is rare because the procedures used to clean the equipment between samples have been developed and extensively tested to assure that carry-over is mitigated as much as possible. Potential carry-over was evaluated using time-series analysis to look for patterns suggestive of carry-over of constituents from a sample with high concentrations to the next groundwater sample or blank collected with the same equipment. If non-detections were reported in blanks or groundwater samples collected after the collection of groundwater samples containing high concentrations of the constituent, then carry-over as a mode of contamination was ruled out.

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

The SRLs for some VOCs were defined on the basis of concentrations and detection frequencies in field blanks and source-solution blanks collected for the first 32 GAMA-PBP study units (May 2004 through September 2010) and in NWQL instrument and preparation blanks analyzed during the same time period as the samples (M.S. Fram, L.D. Olsen, and K. Belitz, U.S. Geological Survey, written commun., 2011). SRLs were defined for five hydrocarbons (ethylbenzene, toluene, 1,2,4-trimethylbenzene, *m*- and *p*-xylenes, and *o*-xylene), three solvents (acetone, 2-butanone, and tetrahydrofuran), and one VOC that occurs naturally and also is used in industrial processes (carbon disulfide).

For organic and special-interest constituents detected less frequently in blanks than in groundwater samples, the concentration corresponding to the 95th percentile of the cumulative frequency distribution of the field blanks, source-solution blanks, or laboratory blanks, whichever was highest, was defined as the SRL. For most constituents, the 95th percentiles of the cumulative frequency distributions were non-detections (values below the RL); thus, no SRLs were required. Concentrations of those constituents reported by the laboratory that were less than the SRL are flagged with a less than or equal to (≤) symbol preceding the reported value. Organic and special-interest constituent results flagged with a ≤ symbol were not considered detections in the GAMA-PBP study and were not included in the calculations of detection frequencies.

The SRLs for all trace elements except cobalt and molybdenum were determined by statistical assessment of results from the field blanks collected in the first 20 GAMA-PBP study units (May 2004 through January 2008) (Olsen and others, 2010). 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. The resulting SRLs for trace elements were set at concentrations representing a confidence limit of 90 percent for the 90th percentile of the 86 field blanks used in the assessment. Concentrations of those constituents reported by the NWQL that were less than the SRL are flagged with a ≤ symbol preceding the reported value.

For all other inorganic constituents, the SRL for applying the ≤ symbol was determined from assessment of the field blanks collected in the CLUB study unit and was defined as equal to the highest concentration measured in the field blanks.

## Replicates

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

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.

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

- For concentrations less than five times the RL (<5 RL), an SD of <½ the RL is acceptable.
- For concentrations greater than (or equal to) five times the RL (≥5 RL), an RSD of <10 percent is acceptable. For comparison, an RSD of 10 percent is equivalent to a relative percent difference (RPD) of 14 percent.
- For activities of radiochemical constituents (except carbon-14), replicate pairs with values that are statistically indistinguishable at a confidence level (α) of $\alpha = 0.05$ are defined as acceptable.

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

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.
- 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):

$$z = \frac{\left|R_1 - R_2\right|}{\sqrt{\left(CSU_1^2 + CSU_2^2\right)}}, \qquad \text{(A3)}$$

where

$z$ is the test statistic,

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

$CSU_1^2$ and $CSU_2^2$ are the combined standard uncertainties associated with the results.

Values of $z < 1.65$ correspond to significant levels (p) $< \alpha = 0.05$, and thus indicate replicate pairs with acceptable precision.

## Matrix Spikes

Addition of a known concentration of a constituent (spike) to a replicate environmental sample enables the analyzing laboratory to determine the effect of the matrix, in this case groundwater, on the analytical technique used to measure the constituent. The known compounds added in matrix spikes are the same as those being analyzed in the method. This enables an analysis of matrix interferences on a compound-by-compound basis. For this study, matrix spikes were added by the laboratory performing the analysis. Low matrix-spike recovery may indicate that the compound might not be detected in some samples if it 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 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 many constituents, an acceptable range of 70 to 130 percent for matrix-spike recovery was more restrictive than the acceptable control limits for laboratory-set spike recoveries. Laboratory-set spikes are aliquots of laboratory blank water to which the same spike solution used for the matrix spikes has been added. One set spike is analyzed with each set of samples. Acceptable control limits for set spikes are defined relative to the long-term variability in recovery. For example, for many NWQL schedules, acceptable set-spike recovery is within ± 3 F-pseudosigma of the median recovery for at least 30 set spikes (Conner 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 spikes were performed for VOCs, pesticides and pesticide degradates, pharmaceutical compounds, perchlorate, and NDMA because the analytical methods for these constituents may be susceptible to matrix interferences.

## Surrogates

Surrogate compounds are added to groundwater 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, and pharmaceutical compounds. Most of the surrogate compounds are deuterated analogs of compounds being analyzed. For example, the surrogate toluene-*d*8 that is used for the VOC analytical method has the same chemical structure as toluene, except that the eight hydrogen-1 atoms on the molecule have been replaced by deuterium (hydrogen-2). Toluene-*d*8 and toluene behave very similarly in the analytical procedure, but the small mass difference between the two results in slightly different chromatographic retention times; thus, the use of a toluene-*d*8 surrogate does not interfere with the analysis of toluene (Grob, 1995). Only 0.015 percent of hydrogen atoms are deuterium (Firestone and others, 1996); thus, deuterated compounds such as toluene-*d*8 do not occur naturally and are not detected in groundwater samples. Surrogates are used to identify general problems that may arise during laboratory sample analysis that could affect the analysis results for all compounds in that sample. Potential problems include matrix interferences (such as high levels of DOC) 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).

# Quality-Control Results

## 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 CLUB study unit. Field blanks were collected at approximately 2 to 10 percent of the sites sampled in the CLUB study unit.

Of the five field blanks analyzed for VOCs, PCE was detected in one blank. The PCE detection was considered to be random contamination, likely from a field process, but the exact source could not be identified. This blank detection had an equal chance of affecting each groundwater sample. PCE was detected in the field blank at a concentration of E0.02 µg/L, creating an SRL of 0.02 µg/L. PCE was detected at concentrations less than the SRL in two groundwater samples, and these concentrations were flagged with a ≤ symbol. These groundwater samples were reclassified as non-detections and were not included in the calculations of PCE detection frequencies (tables 5 and A3).

GAMA SRLs from M.S. Fram, L.D. Olsen, and K. Belitz, U.S. Geological Survey, written commun. (2011) were used for nine VOCs. Of these VOCs with SRLs, three were detected in field blanks and (or) groundwater samples from the CLUB study unit. Toluene was detected in 1 of 5 field blanks at a concentration of E0.02 µg/L (table A3) and in two groundwater samples at concentrations of E0.01 µg/L and E0.02 µg/L (table 5). Both detections were measured at concentrations less than the SRL of 0.69 µg/L and were reclassified as non-detections. The source of the toluene contamination is uncertain.

1,2,4-trimethylbenzene was detected in 12 of 52 groundwater samples at concentrations ranging from E0.01 µg/L to 1.82 µg/L (median 0.21 µg/L) (table 5). Nine of the detections were measured at concentrations less than the SRL of 0.56 µg/L and were reclassified as non-detections. The three remaining detections were considered to be representative of groundwater quality and are presented on table 5. For the GAMA-PBP, detections of 1,2,4-trimethylbenzene in blanks and groundwater samples are correlated with the presence in field vehicles of equipment used for collecting radon samples (M.S. Fram, L.D. Olsen, and K. Belitz, U.S. Geological Survey, written commun., 2011). The vials used to collect radon samples contain a scintillation cocktail made of mineral oil and 1,2,4-trimethylbenzene. Radon samples were collected at 22 wells in the CLUB study unit; therefore, there was a potential for the contamination of groundwater samples.

Acetone was detected in one groundwater sample at a concentration of 7 µg/L (table 5). Contamination of groundwater samples and field blanks by acetone, tetrahydrofuran, and (or) 2-butanone is associated with presence of PVC-cement at sample collection sites (some wells are plumbed with PVC piping) and with contamination of sample collection equipment by the methanol used for cleaning equipment (M.S. Fram, L.D. Olsen, and K. Belitz, U.S. Geological Survey, written commun., 2011). Field blanks with contamination from either of these two sources were not considered representative; therefore, no QC assessment could be made for these three solvents, and no concentration threshold could be established for the SRL. The SRL consists of reclassifying these three solvents as "not analyzed" and detections in groundwater samples as non-detections.

Five field blanks were collected for analysis of trace elements. Five trace elements were detected in at least one field blank—cobalt, copper, iron, lead, and molybdenum (table A3). The detections of copper, iron, and lead were measured at concentrations less than the SRL assigned by Olsen and others (2010). SRLs for cobalt (0.18 µg/L) and molybdenum (0.32 µg/L) were established on the basis of the highest detected concentration in the two field blanks. Measured concentrations that were less than the SRL were flagged with a ≤ symbol (table 8). There were no other trace elements detected in any of the field blanks in the CLUB study unit.

GAMA SRLs from Olsen and others (2010) were used for aluminum, barium, chromium, copper, iron, lead, manganese, nickel, tungsten, vanadium, and zinc. Measured concentrations that were less than the SRL were flagged with a ≤ symbol in table 8.

Two field blanks were collected for analysis of radioactive constituents. Results from field blanks were not used to define SRLs for radiochemical constituents because the low activities of these constituents occasionally reported in GAMA-PBP blanks are thought to be an artifact of the algorithms used to convert instrument response to activities for blank samples, rather than to reflect presence of these constituents in blank samples (Sylvia Stork, U.S. Geological Survey, written commun., 2010). Activities of radiochemical constituents reported in field blanks were lower than most of the activities reported in the CLUB study-unit groundwater samples, indicating that groundwater samples likely were not significantly contaminated by these constituents during collection, handling, or analysis (tables 14 and A3).

Constituents were not detected in the field blanks for the following analyte groups: pesticides and pesticide degradates (five field blanks); perchlorate (three field blanks); NDMA (two field blanks); nutrients (five field blanks); major and minor ions, silica, and TDS (five field blanks); species of inorganic chromium (one field blank); Cr-VI from TALIR (one field blank); radium-228 (two field blanks); gross alpha radioactivity (30-day count, two field blanks); and gross beta radioactivity (72-hour and 30-day counts, two field blanks).

## Variability in Replicate Samples

Table A4A–C summarizes the results of replicate analyses for constituents detected in groundwater samples collected in the CLUB study unit. Replicate analyses were made on approximately 4 to 10 percent of the samples collected.

Of the 944 replicate pairs of constituents analyzed, 269 were for constituents detected in at least one groundwater sample. Of these 269 pairs, 2 pairs (tritium) were outside the limits for acceptable precision. Results for replicate analyses for constituents that were not detected in groundwater samples are not reported in table A4A–C.

Five replicate pairs of samples were analyzed for the 85 VOCs, and all pairs were composed of two values reported as non-detections or two values ≤-coded with the exception of two replicate pairs of chloroform and PCE and one replicate pair of diisopropyl ether (DIPE), benzene, and trichloroethene (TCE) (table A4A). These replicate pairs either yielded two values reported as detections or one value reported as a detection and one reported as a non-detection. All replicate pair analyses resulted in SDs and RSDs within acceptable precision.

Five replicate pairs of samples were analyzed for the 63 pesticide and pesticide degradate compounds and all pairs were composed of two values reported as non-detections with the exception of one replicate pair of atrazine, deethylatrazine, 3,4-dichloroaniline, and dieldrin (table A4A). The replicate pairs all yielded two values reported as detections, and all replicate pair analyses resulted in SDs within acceptable precision.

Five replicate pairs for perchlorate and two replicate pairs for NDMA were analyzed at Weck Laboratories, Inc., for variability (table A4A). One of the replicate pairs for perchlorate and both replicate pairs for NDMA were composed of two values reported as non-detections. The other four replicate pairs for perchlorate yielded two values reported as detections, and all replicate pair analyses resulted in SDs or RSDs within acceptable precision.

Replicate pairs of samples were analyzed for the 24 trace elements (four pairs); 5 nutrients (four pairs); 9 major and minor ions, silica, and TDS (four pairs); Cr-VI from TALIR (two pairs); and 4 isotope tracers (four pairs). The SD or RSD values for all pairs were within acceptable precision (table A4B).

Five replicate pairs for tritium were analyzed for variability (table A4C). Two of these replicate pairs resulted in values of $p > 0.05$, which indicates that these replicate pairs do not have acceptable precision. However, these samples were reported as non-detections and (or) concentrations more than four orders of magnitude less than the corresponding MCL-CA (tables 3J and 13). For tritium concentrations less than health-based benchmarks, precision that is less than acceptable will not affect the assessments of groundwater quality being made by the GAMA-PBP.

Two replicate pairs for radon-222, radium isotopes, and gross alpha and gross beta radioactivity were analyzed for variability (table A4C). All replicate pairs for these radioactive constituents yielded statistically similar results ($p \leq 0.05$) and were, therefore, considered acceptable.

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

## Matrix-Spike Recoveries

Table A5A–C presents a summary of matrix-spike recoveries for the CLUB study unit. Replicate samples for spike additions were collected at approximately 2 to 10 percent of the wells sampled.

Five groundwater samples were spiked with VOCs to calculate matrix-spike recoveries (table A5A). Median matrix-spike recoveries for all 85 VOC spike compounds were between 70 and 130 percent. Eight VOC spike compounds had one matrix-spike recovery greater than 130 percent. Of these VOC spike compounds, one constituent, chloroform, also was detected in groundwater samples (tables 3A and 5). Three VOC spike compounds had one matrix-spike recovery less than 70 percent, and none of these VOC spike compounds were detected in groundwater samples (tables 3A and A5A).

Five groundwater samples were spiked with pesticide and pesticide degradate compounds to calculate matrix-spike recoveries (table A5B). Median matrix-spike recoveries for 40 of the 63 spike compounds were between 70 and 130 percent. Twenty-four of the compounds had median matrix-spike recoveries less than 70 percent. One compound (tebuthiuron) had a median matrix-spike recovery greater than 130 percent.

Two of the three compounds detected in groundwater samples (3,4-dichloroaniline and atrazine) had median matrix-spike recoveries within the acceptable range (tables 3B and 6).

The median matrix-spike recovery for the third compound detected in groundwater samples, deethylatrazine, had a median matrix-spike recovery less than the acceptable range (63 percent). Deethylatrazine was detected at concentrations (E0.009 µg and E0.007 µg) less than the LRL of 0.014 µg in two grid wells in the LUB study area (table 6). Because deethylatrazine was detected at concentrations much lower than the LRL, it was determined that the less than acceptable median matrix-spike recovery did not affect the analysis and results from the NWQL. Tebuthiuron had a median matrix-spike recovery of 149 percent, but this compound was not detected in groundwater samples.

At least one matrix-spike recovery for six pesticide and pesticide degradate spike compounds was greater than 130 percent (table A5B). Of these six, four pesticide and pesticide degradate spike compounds had at least one matrix-spike recovery greater than 130 percent and one matrix-spike recovery less than 70 percent. At least one matrix-spike recovery for 48 pesticide and pesticide degradate spike compounds was less than 70 percent. Of these pesticide and pesticide degradate spike compounds, 3,4-dichloroaniline and deethylatrazine were detected in groundwater samples (tables 3B, 6, and A5B). A similar pattern of unusually low matrix-spike recoveries that started in March 2008 was noted in an assessment of method performance by the Organic Blind Sample Program (OBSP) of the BQS (http://bqs.usgs.gov/OBSP/).

One groundwater sample was spiked with perchlorate, and two groundwater samples were spiked with NDMA to calculate matrix-spike recoveries at Weck Laboratories, Inc. (table A5C). All median matrix-spike recoveries were between 70 and 130 percent.

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

## Surrogate Compound Recoveries

Table A6 presents a summary of the surrogate recoveries for the CLUB study unit. The table lists the surrogate, the analytical schedule on which it was applied, the number of analyses for blank and environmental samples, the number of surrogate recoveries less than 70 percent, and the number of surrogate recoveries greater than 130 percent for the blank and environmental samples. Blank and environmental samples were considered separately to assess whether or not the matrixes present in environmental samples affect surrogate recoveries.

Most surrogate recoveries for the blank and environmental samples were within the acceptable range of 70 to 130 percent. In total, 93 percent of the blank and 83 percent of the environmental sample surrogate recoveries for VOC analyses were within the acceptable range (table A6). In addition, 100 percent of the blank and 90 percent of the environmental sample surrogate recoveries for pesticide and pesticide degradate analyses were within the acceptable range (table A6). There were no significant differences between VOC and pesticide and pesticide degradate surrogate recoveries in blank and environmental samples (Wilcoxon rank sum test, $p < 0.05$).

Environmental detections were not modified on the basis of the surrogate recovery analysis.

## Other Quality-Control Results

Two other laboratory QC matters arose during the analysis of samples collected for CLUB 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 is when a sample is analyzed past the given holding time for a particular analysis. The remote sampling areas within the CLUB study unit did not allow for immediate shipment of a few radioactive samples for the analysis of gross alpha and beta radioactivity. This resulted in the later arrival times at the laboratory; thus, the analysis was completed after the holding time. This may be important because a delay in the analysis at the laboratory may result in lower measured activities than what may have been present in the groundwater.

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 change with time. Generally, gross alpha decreases during the first 10 days due to decay of unsupported members of the thorium-232 decay series (in particular, Ra-224 and its progeny). At least one result from the analysis of gross alpha and beta radioactivity (72-hour count) was analyzed past the holding time for three groundwater samples. The results for these three samples are footnoted in table 14C. Gross alpha and beta radioactivity (72-hour count) will be lower in samples analyzed late. If there were samples with a gross alpha or beta radioactivity count just over the benchmark (or just over ½ benchmark) that were present in the groundwater, then late analysis could result in the reported activities for these samples being below the benchmark. One of the late samples in the CLUB study unit may be in this category: gross alpha radioactivity (72-hour count) in LUB-07 was measured at 10.5 ± 2.1 pCi/L. This sample was analyzed 4 days past the holding 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 an independent, external QA project called the Inorganic Blind Sample Project (IBSP) 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 that contain known concentrations of the inorganic constituents (Farrar and Long, 1997). The IBSP samples are disguised as regular groundwater samples for submission to the NWQL. The BQS uses results from the IBSP samples to evaluate potential bias, positive or negative, in the results reported by the NWQL on a continuous basis. The BQS IBSP data are readily available on the BQS website, and the BQS issues monthly summaries of the results, reporting the amount of bias (if any) observed in the results (http://bqs.usgs.gov/ibsp/).

The BQS monthly summaries were examined for the period of time during which samples were analyzed for the CLUB study unit. In summary, the BQS reported that four inorganic constituents showed evidence of bias: a positive bias for cadmium, sulfate, and zinc and a negative bias for magnesium. Examination of the results for the IBSP samples for these four constituents indicated that the analytical biases reported by the BQS were not significant for the data collected for the CLUB study unit.

The IBSP samples for cadmium had concentrations ranging from 0.18 µg/L to 1.8 µg/L. The average difference between the measured and expected concentrations was 0.14 µg/L (standard deviation = 0.08 µg/L), and the average relative percent difference between the measured and expected concentrations was 16 percent (standard deviation = 22 percent). The MCL-US for cadmium is 5 µg/L, thus the estimate of bias from the ISBP samples would be relevant for assessment of whether groundwater samples have cadmium concentrations greater than or less than the MCL-US concentration or greater than or less than ½ of the MCL-US concentration. However, the maximum concentration of cadmium in samples from the CLUB study unit was 0.45 µg/L (table 8); thus, a potential positive bias of 0.14 µg/L or 16 percent would not result in a measured concentration above either threshold when the true concentration would have been below the threshold.

The IBSP samples for sulfate had concentrations ranging from 14.9 mg/L to 31.3 mg/L. The average difference between the measured and expected concentrations was 0.7 mg/L (standard deviation = 1.1 mg/L), and the average relative percent difference between the measured and expected concentrations was 4 percent (standard deviation = 6 percent). The upper SMCL-CA for sulfate is 500 mg/L, a concentration much higher than the maximum concentration in the IBSP samples. A positive bias of 4 percent or 0.7 mg/L for groundwater samples with measured concentrations of less than 31.3 mg/L (table 10) does not affect assessment of whether groundwater samples in the CLUB study unit have sulfate concentrations greater than or less than the upper SMCL-CA concentration or greater than or less than ½ of the upper SMCL-CA concentration. Moreover, a determination of bias at low concentrations does not imply that there is equivalent bias at higher concentrations.

The IBSP samples for zinc had concentrations ranging from 5.9 µg/L to 36.4 µg/L. The average difference between the measured and expected concentrations was 1.6 µg/L (standard deviation = 1.9 µg/L), and the average relative percent difference between the measured and expected concentrations was 8 percent (standard deviation = 15 percent). The SMCL-CA for zinc is 5,000 µg/L, a concentration much higher than the maximum concentration in the IBSP samples. A positive bias of 8 percent or 1.6 µg/L for groundwater samples with measured concentrations of less than 36.4 µg/L (table 8) does not affect assessment of whether groundwater samples in the CLUB study unit have sulfate concentrations greater than or less than the SMCL-CA concentration or greater than or less than ½ of the SMCL-CA concentration.

The IBSP samples for magnesium had concentrations ranging from 0.05 mg/L to 7.3 mg/L. The average difference between the measured and expected concentrations was –0.19 mg/L (standard deviation = 0.2 mg/L), and the average relative percent difference between the measured and expected concentrations was –6 percent (standard deviation = 3 percent). A negative bias of 6 percent or 0.2 mg/L can only potentially affect measured concentrations of less than 7.3 mg/L in CLUB study unit groundwater samples (table 10). Magnesium does not currently have an established regulatory or non-regulatory health-based benchmark or a non-regulatory benchmark established for aesthetic concerns; therefore, this negative bias will not affect the assessments of groundwater quality being made by the GAMA-PBP.

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

[Laboratory entity codes in the USGS National Water Information System (NWIS) database for laboratories other than the USGS NWQL are given in parentheses after the laboratory names. UV, ultraviolet; USEPA, U.S. Environmental Protection Agency; VOC, volatile organic compound; NRP, USGS National Reasearch Program; HPLC, high-performance liquid chromatography]

| 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 |
| 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 (CA-WECK), 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 (CA-WECK), 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 and trace elements | Atomic absorption spectrometry, colorimetry, ion-exchange chromatography, inductively-coupled plasma atomic emission spectrometry and mass spectrometry | NWQL, Schedule 1948 | Fishman and Friedman, 1989; Fishman, 1993; Faires, 1993; McLain, 1993; Garbarino, 1999; American Public Health Association, 1998; Garbarino and others, 2006 |
| Species of inorganic chromium | Various techniques of ultraviolet visible (UV-VIS) spectrophotometry and atomic absorbance spectroscopy | USGS NRP Trace Metal Laboratory [TML], Boulder, Colorado (USGSTMCO) | Ball and McCleskey, 2003a,b |
| Hexavalent chromium (chromium-VI, Cr-VI) | Ion chromatography (USEPA Methods 218.6 and 7199) | TestAmerica Laboratories Inc. [TALIR], Irvine, California (CA-TALIR), standard operating procedure IR-WET-CRIC, Rev. 1 | U.S. Environmental Protection Agency, 1994, 1996 |

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

[Laboratory entity codes in the USGS National Water Information System (NWIS) database for laboratories other than the USGS NWQL are given in parentheses after the laboratory names. UV, ultraviolet; USEPA, U.S. Environmental Protection Agency; VOC, volatile organic compound; NRP, USGS National Reasearch Program; HPLC, high-performance liquid chromatography]

| Analyte | Analytical method | Laboratory and analytical schedule | Citation(s) |
|---|---|---|---|
| **Stable isotopes** | | | |
| Stable isotopes of hydrogen and oxygen in water | Gaseous hydrogen and carbon dioxide-water equilibration and stable-isotope mass spectrometry | USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA), NWQL Schedule 1142 | Epstein and Mayeda, 1953; Coplen and others, 1991; Coplen, 1994 |
| Stable isotopes of boron 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 |
| Stable isotopes of strontium in water | Chemical separations and thermal-ionization mass spectrometry | USGS NRP Metals Isotope Research Laboratory, Menlo Park, California (USGSMICA) | Bullen and others, 1996 |
| Stable isotopes of carbon in dissolved inorganic carbon 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 |
| **Radioactivity and gases** | | | |
| Tritium | Electrolytic enrichment-liquid scintillation | USGS Stable Isotope and Tritium Laboratory [SITL], Menlo Park, California (USGSH3CA), NWQL Schedule 1565 | Thatcher and others, 1977 |
| Radon-222 | Liquid scintillation counting | NWQL, Schedule 1369 | American Society for Testing and Materials, 1998 |
| Radium isotopes | Alpha activity counting  (USEPA Methods 903 and 904) | Eberline Analytical Services, Richmond, California (CA-EBERL), NWQL Schedule 1262 | Kreiger and Whittaker, 1980 |
| 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 | Kreiger and Whittaker, 1980 |
| Dissolved noble gases, tritium, and helium isotope ratios | Helium-3 in-growth and mass spectrometry | Lawrence Livermore National Laboratory [LLNL], Livermore, California (CA-LLNL) | Moran and others, 2002; Eaton and others, 2004 |

**Table A2.** Preferred analytical schedules for selected constituents collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[Preferred analytical schedules/methods are selected on the basis of the procedure recommended by the USGS National Water Quality Laboratory (NWQL) (http://wwwnwql.cr.usgs.gov/dyn.shtml?Preferred_method_selection_procedure). **Abbreviations:** TML, USGS Trace Metal Laboratory, Boulder, Colorado; TALIR, TestAmerica, Inc., Irvine, California; np, no preference; SITL, USGS Stable Isotope Laboratory, Reston, Virginia; LLNL, Lawrence Livermore National Laboratory, Livermore, California; USGS, U.S. Geological Survey]

| Constituent | Primary constituent classification | Analytical schedules | Preferred analytical schedule |
|---|---|---|---|
| **Results from both methods reported** | | | |
| Alkalinity | Water-quality indicator | Field, 1948 | Field |
| pH | Water-quality indicator | Field, 1948 | Field |
| Specific conductance | Water-quality indicator | Field, 1948 | Field |
| Chromium, total | Trace element | 1948, TML | 1948 |
| Hexavalent chromium (chromium-VI, Cr-VI) | Trace element species | TML, TALIR | np |
| Tritium | Inorganic tracer | SITL, LLNL | np |

**Table A3.** Constituents detected in field blanks and the study reporting level (SRL) analysis for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[**Sources of study reporting level (SRL):** CLUB field blanks, the SRL was assigned a value equal to the highest concentration in field blanks collected for this study unit; report by Olsen and others (2010): the SRL was defined on the basis of the examination of quality-control samples collected for the first 20 GAMA study units; Fram and others, written commun. from M.S. Fram, L.D. Olsen, and K. Belitz, U.S. Geological Survey (2011): the SRL was defined on the basis of examination of quality-control samples collected for the first 32 GAMA study units. Abbreviations: ≤, less than or equal to; LRL, laboratory reporting level; E, estimated or having a higher degree of uncertainty; µg/L, micrograms per liter; –, not detected; PCE, perchloroethene (tetrachloroethene); pCi/L, picocuries per liter; ±, plus or minus; $ssL_C$, sample-specific critical level]

| Constituent | Number of field blank detections/ total number of field blanks | Concentrations detected in field blanks | SRL concentration | Source of SRL | Number of groundwater samples ≤-coded | Number of groundwater samples excluded from dataset |
|---|---|---|---|---|---|---|
| **Volatile organic compounds (VOC) (µg/L)** | | | | | | |
| Acetone | 0/5 | – | All data | Fram and others, 2011 | 0 | 1 |
| Carbon disulfide | 0/5 | – | 0.03 | Fram and others, 2011 | 0 | 0 |
| Ethylbenzene | 0/5 | – | 0.1 | Fram and others, 2011 | 0 | 0 |
| 2-Hexanone (*n*-Butyl methyl ketone) | 0/5 | – | All data | Fram and others, 2011 | 0 | 0 |
| PCE | 1/5 | E0.02 | 0.02 | CLUB field blanks | 1 | 1 |
| Tetrahydrofuran | 0/5 | – | All data | Fram and others, 2011 | 0 | 0 |
| Toluene | 1/5 | E0.02 | 0.69 | Fram and others, 2011 | 0 | 2 |
| 1,2,4-trimethylbenzene | 0/5 | – | 0.56 | Fram and others, 2011 | 0 | 9 |
| *m*-Xylene plus *p*-xylene | 0/5 | – | 0.4 | Fram and others, 2011 | 0 | 0 |
| *o*-Xylene | 0/5 | – | 0.1 | Fram and others, 2011 | 0 | 0 |
| **Trace elements (µg/L)** | | | | | | |
| Aluminum | 0/5 | – | 1.6 | Olsen and others, 2010 | 0 | 0 |
| Barium | 0/5 | – | 0.36 | Olsen and others, 2010 | 0 | 0 |
| Chromium | 0/5 | – | 0.42 | Olsen and others, 2010 | 10 | 0 |
| Cobalt | 2/5 | 0.18, 0.12 | 0.18 | CLUB field blanks | 36 | 0 |
| Copper | 1/5 | E0.50 | 1.7 | Olsen and others, 2010 | 18 | 0 |
| Iron | 1/5 | E2.7 | 6 | Olsen and others, 2010 | 5 | 0 |
| Lead | 1/5 | 0.04 | 0.65 | Olsen and others, 2010 | 34 | 0 |
| Manganese | 0/5 | – | 0.2 | Olsen and others, 2010 | 6 | 0 |
| Molybdenum | 2/5 | 0.32, E0.17 | 0.32 | CLUB field blanks | 0 | 0 |
| Nickel | 0/5 | – | 0.36 | Olsen and others, 2010 | 26 | 0 |
| Tungsten | 0/5 | – | 0.11 | Olsen and others, 2010 | 1 | 0 |
| Vanadium | 0/5 | – | 0.1 | Olsen and others, 2010 | 0 | 0 |
| Zinc | 0/5 | – | 4.8 | Olsen and others, 2010 | 19 | 0 |
| **Radioactive constiuents (pCi/L)** | | | | | | |
| Radium-226 | 2/2 | 0.0348 ± 0.0099, $ssL_C = 0.012$; 0.039 ± 0.011, $ssL_C = 0.011$ | – | CLUB field blanks | 0 | 0 |
| Gross alpha radioactivity, 72-hour count | 1/2 | 0.33 ± 0.17, $ssL_C = 0.20$ | – | CLUB field blanks | 0 | 0 |

**Table A4A.** Quality-control summary for replicate analyses of organic constituents and perchlorate detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[**Abbreviations:** SD, percent standard deviation; RSD, percent relative standard deviation; ≤, less than or equal to; >, greater than; <, less than; ≥, greater than or equal to; RL, reporting level; nv, no value in category]

| Constituent | Number of non-detections/ number of replicates | Number of ≤-coded replicates | Replicates with concentrations <5 times the RL | | Replicates with concentrations ≥5 times the RL | |
|---|---|---|---|---|---|---|
| | | | Number of SDs >½ RL/number of replicates | Concentrations of replicates with SDs >½ the RL (environmental, replicate) | Number of RSDs >10 percent/ number of replicates | Concentrations of replicates with RSDs >10 percent (environmental, replicate) |
| **Volatile organic compounds (VOC)** | | | | | | |
| Chloroform (Trichloromethane) | 3/5 | nv | 0/2 | nv | nv | nv |
| Perchloroethene (PCE, tetrachloroethene) | 3/5 | nv | 0/2 | nv | nv | nv |
| 1,2,4-trimethylbenzene | 3/5 | 2/5 | nv | nv | nv | nv |
| Diisopropyl ether (DIPE) | 4/5 | nv | nv | nv | 0/1 | nv |
| Benzene | 4/5 | nv | 0/1 | nv | nv | nv |
| Bromodichloromethane | 5/5 | nv | nv | nv | nv | nv |
| Bromoform (Tribromomethane) | 5/5 | nv | nv | nv | nv | nv |
| Trichloroethene (TCE) | 4/5 | nv | nv | nv | 0/1 | nv |
| **Pesticides and pesticide degradates** | | | | | | |
| Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine) | 4/5 | nv | 0/1 | nv | nv | nv |
| Simazine | 5/5 | nv | nv | nv | nv | nv |
| 3,4-Dichloroaniline | 4/5 | nv | 0/1 | nv | nv | nv |
| Atrazine | 4/5 | nv | 0/1 | nv | nv | nv |
| Metolachlor | 5/5 | nv | nv | nv | nv | nv |
| Dieldrin | 4/5 | nv | 0/1 | nv | nv | nv |
| **Constituent of special interest** | | | | | | |
| Perchlorate | 1/5 | nv | 0/1 | nv | 0/3 | nv |

**Table A4B.** Quality-control summary for replicate analyses of inorganic constituents and isotope tracers detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[**Abbreviations:** SD, percent standard deviation; RSD, percent relative standard deviation; >, greater than; <, less than; ≥, greater than or equal to; RL, reporting level; µg/L, micrograms per liter; Cr-VI, hexavalent chromium (chromium-VI); TALIR, TestAmerica Laboratories, Inc., Irvine, California; $SiO_2$, silicon dioxide; H, hydrogen; O, oxygen; C, carbon; ≤, less than or equal to; nv, no value in category]

| Constituent | Number of non-detections or ≤-coded replicates/ number of replicates | Replicates with concentrations <5 times the RL | | Replicates with concentrations ≥5 times the RL | |
|---|---|---|---|---|---|
| | | Number of SDs > ½ the RL/number of replicates | Concentrations of replicates with SDs >½ the RL (environmental, replicate) | Number of RSDs >10 percent/number of replicates | Concentrations of replicates with RSDs >10 percent (environmental, replicate) |
| **Trace elements** | | | | | |
| Aluminum | 3/4 | 0/1 | nv | nv | nv |
| Antimony | 2/4 | 0/2 | nv | nv | nv |
| Arsenic | 0/4 | nv | nv | 0/4 | nv |
| Barium | 0/4 | nv | nv | 0/4 | nv |
| Beryllium | 3/4 | 0/1 | nv | nv | nv |
| Boron | 0/4 | nv | nv | 0/4 | nv |
| Cadmium | 0/4 | 0/3 | nv | 0/1 | nv |
| Chromium | 0/4 | 0/2 | nv | 0/2 | nv |
| Cr-VI (TALIR) | 1/2 | 0/1 | nv | nv | nv |
| Cobalt | 0/4 | 0/3 | nv | 0/1 | nv |
| Copper | 3/4 | 0/1 | nv | nv | nv |
| Iron | 3/4 | 0/1 | nv | nv | nv |
| Lead | 4/4 | nv | nv | nv | nv |
| Lithium | 0/4 | nv | nv | 0/4 | nv |
| Manganese | 1/4 | 0/2 | nv | 0/1 | nv |
| Molybdenum | 0/4 | nv | nv | 0/4 | nv |
| Nickel | 0/4 | 0/3 | nv | 0/1 | nv |
| Selenium | 0/4 | nv | nv | 0/4 | nv |
| Silver | 3/4 | 0/1 | nv | nv | nv |
| Strontium | 0/4 | nv | nv | 0/4 | nv |
| Thallium | 3/4 | 0/1 | nv | nv | nv |
| Tungsten | 0/4 | nv | nv | 0/4 | nv |
| Uranium | 0/4 | nv | nv | 0/4 | nv |
| Vanadium | 0/4 | nv | nv | 0/4 | nv |
| Zinc | 0/4 | 0/4 | nv | nv | nv |
| **Nutrients** | | | | | |
| Ammonia (as nitrogen) | 4/4 | nv | nv | nv | nv |
| Nitrate plus nitrite (as nitrogen) | 0/4 | nv | nv | 0/4 | nv |
| Nitrite (as nitrogen) | 3/4 | nv | nv | 0/1 | nv |
| Total nitrogen (ammonia + nitrite + nitrate + organic nitrogen) | 0/4 | 0/1 | nv | 0/3 | nv |
| Phosphate, orthophosphate (as phosphorus) | 0/4 | 0/4 | nv | nv | nv |

**Table A4B.** Quality-control summary for replicate analyses of inorganic constituents and isotope tracers detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[**Abbreviations:** SD, percent standard deviation; RSD, percent relative standard deviation in percent; >, greater than; <, less than; ≥, greater than or equal to; RL, reporting level; µg/L, micrograms per liter; Cr-VI, hexavalent chromium (chromium-VI); TALIR, TestAmerica Laboratories, Inc., Irvine, California; $SiO_2$, silicon dioxide; H, hydrogen; O, oxygen; C, carbon; ≤, less than or equal to; nv, no value in category]

| Constituent | Number of non-detections or ≤-coded replicates/ number of replicates | Replicates with concentrations <5 times the RL | | Replicates with concentrations ≥5 times the RL | |
|---|---|---|---|---|---|
| | | Number of SDs > ½ the RL/number of replicates | Concentrations of replicates with SDs >½ the RL (environmental, replicate) | Number of RSDs >10 percent/number of replicates | Concentrations of replicates with RSDs >10 percent (environmental, replicate) |
| **Major and minor ions, silica, and total dissolved solids (TDS)** | | | | | |
| Bromide | 0/4 | 0/4 | nv | nv | nv |
| Calcium | 0/4 | nv | nv | 0/4 | nv |
| Chloride | 0/4 | nv | nv | 0/4 | nv |
| Fluoride | 0/4 | 0/3 | nv | 0/1 | nv |
| Iodide | 0/4 | 0/2 | nv | 0/2 | nv |
| Magnesium | 0/4 | nv | nv | 0/4 | nv |
| Potassium | 0/4 | nv | nv | 0/4 | nv |
| Sodium | 0/4 | nv | nv | 0/4 | nv |
| Sulfate | 0/4 | nv | nv | 0/4 | nv |
| Silica (as $SiO_2$) | 0/4 | nv | nv | 0/4 | nv |
| TDS | 0/4 | nv | nv | 0/4 | nv |
| **Isotope tracers and radioactivity** | | | | | |
| $\delta^{2}H$ in water | 0/4 | nv | nv | 0/4 | nv |
| $\delta^{18}O$ in water | 0/4 | nv | nv | 0/4 | nv |
| $\delta^{13}C$ in dissolved inorganic carbon | 0/4 | nv | nv | 0/4 | nv |
| Carbon-14 | 0/4 | nv | nv | 0/4 | nv |

**Table A4C.** Quality-control summary for replicate analyses of radioactive constiuents detected in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

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

| Constituent | Number of pairs with p > 0.05/total number of replicates | Activites for replicate pairs with p > 0.05 (environmental, replicate) (pCi/L) |
|---|---|---|
| Tritium | 2/5 | (17.8 ± 0.67, 20.3 ± 0.77), (– , 0.7 ± 0.32) |
| Radon-222 | 0/2 | nv |
| Radium-226 | 0/2 | nv |
| Radium-228 | 0/2 | nv |
| Gross alpha radioactivity, 72-hour count | 0/2 | nv |
| Gross alpha radioactivity, 30-day count | 0/2 | nv |
| Gross beta radioactivity, 72-hour count | 0/2 | nv |
| Gross beta radioactivity, 30-day count | 0/2 | nv |

**Table A5A.** Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOC) in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|---|---|---|---|---|
| Acetone | 5 | 106 | 138 | 122 |
| Acrylonitrile | 5 | 98 | 124 | 107 |
| *tert*-Amyl methyl ether (TAME) | 5 | 89 | 115 | 104 |
| Benzene [1] | 5 | 91 | 109 | 105 |
| Bromobenzene | 5 | 94 | 109 | 101 |
| Bromochloromethane | 5 | 106 | 129 | 116 |
| Bromodichloromethane [1] | 5 | 89 | 111 | 108 |
| Bromoform (Tribromomethane) [1] | 5 | 96 | 117 | 102 |
| Bromomethane (Methyl bromide) | 5 | 100 | 147 | 127 |
| *n*-Butylbenzene | 5 | 75 | 102 | 82 |
| *sec*-Butylbenzene | 5 | 79 | 100 | 93 |
| *tert*-Butylbenzene | 5 | 93 | 107 | 99 |
| Carbon disulfide | 5 | 68 | 97 | 73 |
| Carbon tetrachloride (Tetrachloromethane) | 5 | 87 | 123 | 114 |
| Chlorobenzene | 5 | 94 | 104 | 97 |
| Chloroethane | 5 | 81 | 117 | 115 |
| Chloroform (Trichloromethane) [1] | 5 | 84 | 131 | 119 |
| Chloromethane | 5 | 80 | 115 | 100 |
| 3-Chloropropene | 5 | 94 | 119 | 114 |
| 2-Chlorotoluene | 5 | 95 | 108 | 101 |
| 4-Chlorotoluene | 5 | 95 | 110 | 98 |
| Dibromochloromethane | 5 | 99 | 117 | 105 |
| 1,2-Dibromo-3-chloropropane (DBCP) | 5 | 92 | 125 | 102 |
| 1,2-Dibromoethane (EDB) | 5 | 99 | 116 | 112 |
| Dibromomethane | 5 | 94 | 125 | 115 |
| 1,2-Dichlorobenzene | 5 | 97 | 120 | 117 |
| 1,3-Dichlorobenzene | 5 | 90 | 115 | 104 |
| 1,4-Dichlorobenzene | 5 | 89 | 107 | 104 |
| *trans*-1,4-Dichloro-2-butene | 5 | 97 | 111 | 104 |
| Dichlorodifluoromethane (CFC-12) | 5 | 53 | 117 | 97 |
| 1,1-Dichloroethane (1,1-DCA) [1] | 5 | 92 | 120 | 117 |
| 1,2-Dichloroethane (1,2-DCA) | 5 | 88 | 124 | 122 |
| 1,1-Dichloroethene (1,1-DCE) | 5 | 93 | 105 | 103 |
| *cis*-1,2-Dichloroethene (*cis*-1,2-DCE) | 5 | 97 | 113 | 106 |
| *trans*-1,2-Dichloroethene (*trans*-1,2-DCE) | 5 | 93 | 121 | 112 |
| 1,2-Dichloropropane | 5 | 90 | 110 | 102 |
| 1,3-Dichloropropane | 5 | 99 | 117 | 110 |
| 2,2-Dichloropropane | 5 | 83 | 95 | 92 |
| 1,1-Dichloropropene | 5 | 82 | 103 | 93 |
| *cis*-1,3-Dichloropropene | 5 | 83 | 98 | 89 |
| *trans*-1,3-Dichloropropene | 5 | 84 | 98 | 92 |
| Diethyl ether | 5 | 100 | 124 | 114 |
| Diisopropyl ether (DIPE) [1] | 5 | 88 | 119 | 108 |

**Table A5A.** Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOC) in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.—Continued

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|---|---|---|---|---|
| Ethylbenzene | 5 | 80 | 97 | 91 |
| Ethyl *tert*-butyl ether (ETBE) | 5 | 83 | 110 | 97 |
| Ethyl methacrylate | 5 | 85 | 105 | 99 |
| *o*-Ethyl toluene (1-Ethyl-2-methyl benzene) | 5 | 82 | 97 | 90 |
| Hexachlorobutadiene | 5 | 65 | 98 | 86 |
| Hexachloroethane | 5 | 83 | 119 | 108 |
| 2-Hexanone (*n*-Butyl methyl ketone) | 5 | 90 | 130 | 108 |
| Iodomethane (Methyl iodide) | 5 | 111 | 137 | 125 |
| Isopropylbenzene | 5 | 78 | 98 | 89 |
| 4-Isopropyl-1-methyl benzene | 5 | 82 | 102 | 86 |
| Methyl acrylate | 5 | 101 | 121 | 116 |
| Methyl acrylonitrile | 5 | 105 | 137 | 120 |
| Methyl *tert*-butyl ether (MTBE) [1] | 5 | 103 | 117 | 109 |
| Methyl *iso*-butyl ketone (MIBK) | 5 | 84 | 114 | 102 |
| Methylene chloride (Dichloromethane) | 5 | 86 | 116 | 110 |
| Methyl ethyl ketone (2-butanone, MEK) | 5 | 103 | 194 | 111 |
| Methyl methacrylate | 5 | 83 | 102 | 100 |
| Naphthalene | 5 | 81 | 104 | 90 |
| Perchloroethene (PCE, Tetrachloroethene) [1] | 5 | 98 | 126 | 104 |
| *n*-Propylbenzene | 5 | 85 | 98 | 88 |
| Styrene | 5 | 70 | 97 | 88 |
| 1,1,1,2-Tetrachloroethane | 5 | 92 | 117 | 113 |
| 1,1,2,2-Tetrachloroethane | 5 | 90 | 120 | 110 |
| Tetrahydrofuran | 5 | 94 | 124 | 109 |
| 1,2,3,4-Tetramethylbenzene | 5 | 74 | 101 | 87 |
| 1,2,3,5-Tetramethylbenzene | 5 | 81 | 117 | 91 |
| Toluene | 5 | 92 | 102 | 98 |
| 1,2,3-Trichlorobenzene | 5 | 95 | 110 | 103 |
| 1,2,4-Trichlorobenzene | 5 | 81 | 94 | 89 |
| 1,1,1-Trichloroethane (1,1,1-TCA) | 5 | 90 | 127 | 117 |
| 1,1,2-Trichloroethane (1,1,2-TCA) | 5 | 102 | 122 | 110 |
| Trichloroethene (TCE) [1] | 5 | 90 | 105 | 100 |
| Trichlorofluoromethane (CFC-11) | 5 | 83 | 129 | 118 |
| 1,2,3-Trichloropropane (1,2,3-TCP) | 5 | 95 | 129 | 106 |
| Trichlorotrifluoroethane (CFC-113) | 5 | 76 | 134 | 98 |
| 1,2,3-Trimethylbenzene | 5 | 92 | 119 | 99 |
| 1,2,4-Trimethylbenzene [1] | 5 | 84 | 108 | 95 |
| 1,3,5-Trimethylbenzene | 5 | 81 | 99 | 92 |
| Vinyl bromide (Bromoethene) | 5 | 88 | 123 | 96 |
| Vinyl chloride (Chloroethene) [1] | 5 | 76 | 138 | 115 |
| *m*- and *p*-Xylene | 5 | 85 | 104 | 100 |
| *o*-Xylene | 5 | 89 | 97 | 89 |

[1] Constituents detected in groundwater samples.

**Table A5B.** Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|---|---|---|---|---|
| Acetochlor | 5 | 67 | 117 | 88 |
| Alachlor | 5 | 73 | 116 | 90 |
| Atrazine [1] | 5 | 80 | 118 | 88 |
| Azinphos-methyl | 5 | 67 | 116 | 83 |
| Azinphos-methyl oxon | 5 | 37 | 100 | 70 |
| Benfluralin | 5 | 53 | 84 | 56 |
| Carbaryl | 5 | 66 | 156 | 103 |
| 2-Chloro-2,6-diethylacetanilide | 5 | 71 | 125 | 84 |
| 4-Chloro-2-methylphenol | 5 | 34 | 80 | 70 |
| Chlorpyrifos | 5 | 54 | 90 | 63 |
| Chlorpyrifos-oxon | 5 | 16 | 40 | 37 |
| Cyfluthrin | 5 | 39 | 86 | 50 |
| Cypermethrin | 5 | 38 | 75 | 53 |
| Dacthal (DCPA) | 5 | 93 | 108 | 98 |
| Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-*s*-triazine) [1] | 5 | 30 | 85 | 63 |
| Desulfinylfipronil | 5 | 65 | 128 | 93 |
| Desulfinylfipronil amide | 5 | 71 | 112 | 79 |
| Diazinon | 5 | 73 | 105 | 82 |
| 3,4-Dichloroaniline [1] | 5 | 61 | 102 | 70 |
| Dichlorvos | 5 | 5 | 51 | 14 |
| Dicrotophos | 5 | 17 | 76 | 32 |
| Dieldrin [1] | 5 | 65 | 93 | 77 |
| 2,6-Diethylaniline | 5 | 86 | 95 | 95 |
| Dimethoate | 5 | 30 | 65 | 42 |
| Ethion | 5 | 50 | 95 | 65 |
| Ethion monoxon | 5 | 55 | 113 | 82 |
| 2-Ethyl-6-methylaniline | 5 | 81 | 95 | 91 |
| Fenamiphos | 5 | 72 | 115 | 86 |
| Fenamiphos sulfone | 5 | 61 | 138 | 91 |
| Fenamiphos sulfoxide | 5 | 7 | 90 | 35 |
| Fipronil | 5 | 74 | 126 | 96 |
| Fipronil sulfide | 5 | 60 | 120 | 80 |
| Fipronil sulfone | 5 | 56 | 74 | 67 |
| Fonofos | 5 | 62 | 103 | 80 |
| Hexazinone | 5 | 48 | 95 | 69 |
| Iprodione | 5 | 50 | 101 | 75 |
| Isofenphos | 5 | 61 | 118 | 110 |
| Malaoxon | 5 | 53 | 112 | 108 |
| Malathion | 5 | 56 | 116 | 108 |
| Metalaxyl | 5 | 73 | 146 | 114 |
| Methidathion | 5 | 67 | 103 | 90 |
| Metolachlor [1] | 5 | 68 | 103 | 93 |
| Metribuzin | 5 | 60 | 110 | 83 |
| Myclobutanil | 5 | 63 | 134 | 80 |
| 1-Naphthol | 5 | 11 | 23 | 19 |
| Paraoxon-methyl | 5 | 30 | 80 | 65 |
| Parathion-methyl | 5 | 60 | 106 | 70 |

**Table A5B.** Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010—Continued

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|---|---|---|---|---|
| Pendimethalin | 5 | 59 | 107 | 88 |
| *cis*-Permethrin | 5 | 36 | 66 | 50 |
| Phorate | 5 | 34 | 81 | 59 |
| Phorate oxon | 5 | 67 | 122 | 95 |
| Phosmet | 5 | 7 | 89 | 35 |
| Phosmet oxon | 5 | 12 | 78 | 40 |
| Prometon | 5 | 66 | 103 | 79 |
| Prometryn | 5 | 67 | 118 | 93 |
| Pronamide (Propyzamide) | 5 | 71 | 111 | 80 |
| Simazine [1] | 5 | 72 | 118 | 87 |
| Tebuthiuron | 5 | 94 | 205 | 149 |
| Terbufos | 5 | 60 | 95 | 67 |
| Terbufos oxon sulfone | 5 | 44 | 154 | 102 |
| Terbuthylazine | 5 | 80 | 116 | 92 |
| Tribufos | 5 | 34 | 66 | 57 |
| Trifluralin | 5 | 60 | 94 | 69 |

[1] Constituents detected in groundwater samples.

**Table A5C.** Quality-control summary for matrix-spike recoveries of constituents of special interest in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[Acceptable recovery range is between 70 and 130 percent]

| Constituent | Number of spike samples | Minimum recovery (percent) | Maximum recovery (percent) | Median recovery (percent) |
|---|---|---|---|---|
| Perchlorate [1] | 1 | | | [2] 94 |
| *N*-nitrosodimethylamine (NDMA) | 2 | 113 | 120 | 116.5 |

[1] Constituent detected in groundwater samples.

[2] Median recovery represented by the single spike value.

**Table A6.** Quality-control summary for surrogate recoveries of volatile organic compounds and pesticides and pesticide degradates in samples collected for the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts (CLUB) Groundwater Ambient Monitoring and Assessment (GAMA) study, California, December 2008 to March 2010.

[**Abbreviation**: VOC, volatile organic compound]

| Surrogate | Analytical schedule | Constituent or constituent class analyzed | Number of blanks analyzed | Median recovery in blanks (percent) | Number of surrogate recoveries less than 70 percent in blanks | Number of surrogate recoveries greater than 130 percent in blanks | Number of samples analyzed | Median recovery in samples (percent) | Number of surrogate recoveries less than 70 percent in samples | Number of surrogate recoveries greater than 130 percent in samples |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-Bromo-4-fluorobenzene | 2020 | VOC | 5 | 82 | 0 | 0 | 52 | 81 | 0 | 0 |
| 1,2-Dichloroethane-*d*4 | 2020 | VOC | 5 | 123 | 0 | 1 | 52 | 131 | 0 | 26 |
| Toluene-*d*8 | 2020 | VOC | 5 | 97 | 0 | 0 | 52 | 94 | 0 | 0 |
| Diazinon-*d*10 | 2003 | Pesticide | 5 | 80 | 0 | 0 | 49 | 78 | 10 | 0 |
| α-HCH-*d*6 | 2003 | Pesticide | 5 | 85 | 0 | 0 | 49 | 85 | 0 | 0 |

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