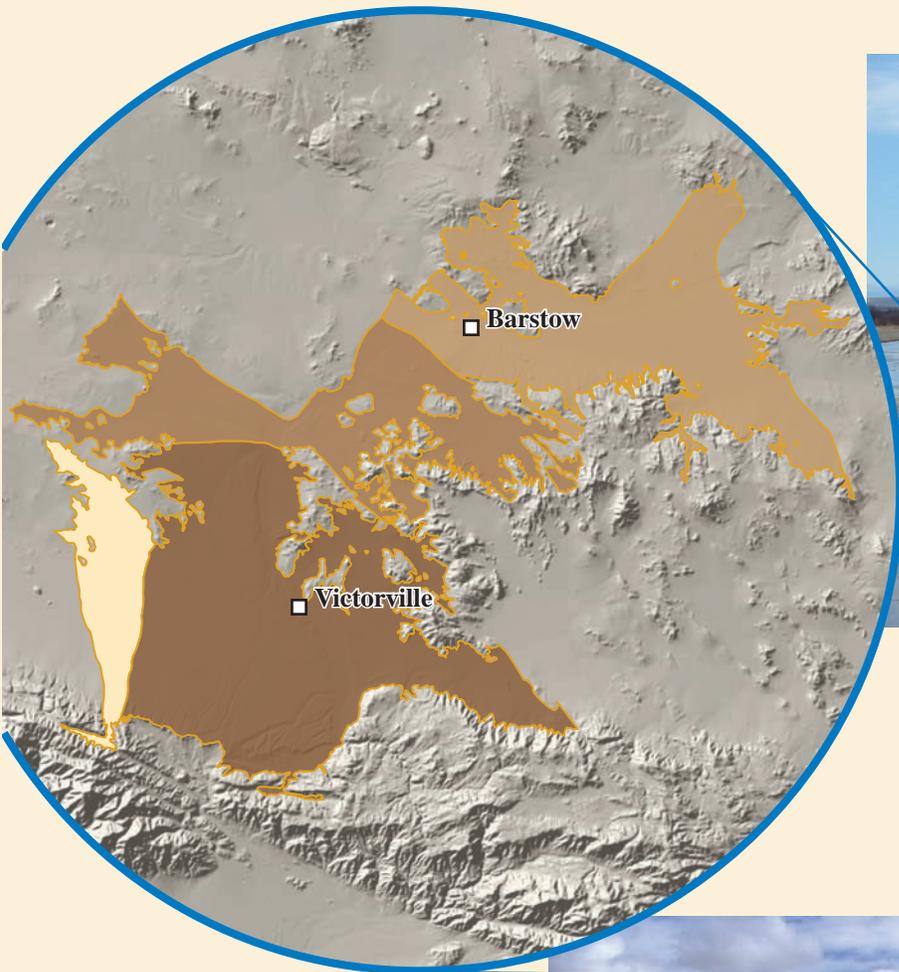


Prepared in cooperation with the California State Water Resources Control Board
A product of the California Groundwater Ambient Monitoring and Assessment (GAMA) Program

Groundwater Quality Data in the Mojave Study Unit, 2008: Results from the California GAMA Program



Data Series 440

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



Cover Photographs:

Top: Mojave River at Helendale, California. (Photograph taken by Michael Wright, U.S. Geological Survey.)

Bottom: Production well, Apple Valley, California. (Photograph taken by Peter Bennett, U.S. Geological Survey.)

Groundwater Quality Data in the Mojave Study Unit, 2008: Results from the California GAMA Program

By Timothy M. Mathany and Kenneth Belitz

In cooperation with the California State Water Resources Control Board

Data Series 440

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

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

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

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

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Abbreviations and Acronyms

AB	Assembly Bill (through the California State Assembly)
AL-US	action level (USEPA)
CAS	Chemical Abstract Service (American Chemical Society)
CASRN	Chemical Abstract Service (American Chemical Society) Registry Number®
CSU	combined standard uncertainty
D	detected
E	estimated or having a higher degree of uncertainty
GAMA	Groundwater Ambient Monitoring and Assessment program
GPS	Global Positioning System
HAL-US	lifetime health advisory level (USEPA)
HPLC	high-performance liquid chromatography
LRL	laboratory reporting level
LSD	land-surface datum
LT-MDL	long-term method detection level
MCL-US	maximum contaminant level (USEPA)
MCL-CA	maximum contaminant level (CDPH)
MDL	method detection limit
MOJO	Mojave study unit
MOJOU	Mojave study unit understanding (well)
MRL	minimum reporting level
MU	method uncertainty
N	Normal (1-gram-equivalent per liter of solution)
na	not available
nc	sample not collected
NL-CA	notification level (CDPH)
nv	no measured values with RSD greater than 20 percent
np	no preference
NWIS	National Water Information System (USGS)
PCFF	portable computer field forms program designed for USGS sampling
QC	quality control
RL	reporting level
RSD	relative standard deviation
RSD5	risk-specific dose at 10 ⁻⁵ (USEPA)
SMCL-CA	secondary maximum contaminant level (CDPH)
SRL	study reporting limit (concentration cutoff for applying the ≤ symbol)
ssL _c	sample-specific critical level
U.S.	United States
UV	ultraviolet
V	analyte detected in sample and associated blank, thus data are not included in groundwater quality assessment
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)

Symbols

=	equal to
>	greater than
<	less than
≤	less than or equal to
—	not detected
±	plus or minus
*	value above threshold level or outside threshold range
**	value is above upper threshold level

Organizations

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

Selected chemical names

CaCO ₃	calcium carbonate
CO ₃ ⁻²	carbonate
CFC	chlorofluorocarbon
DOC	dissolved organic carbon
HCl	hydrochloric acid
HCO ₃ ⁻	bicarbonate
MTBE	methyl tert-butyl ether
Na ₂ S ₂ O ₃	sodium thiosulfate
NDMA	<i>N</i> -nitrosodimethylamine
NO ₂ +NO ₃	nitrite plus nitrate, as nitrogen
PCE	perchloroethene (tetrachloroethene)
SiO ₂	silicon dioxide
TCE	trichloroethene
TCP	trichloropropane
TDS	total dissolved solids
THM	trihalomethane
VOC	volatile organic compound

Units of measurement

C	Celsius
cm ³ STP/g	cubic centimeters of gas at standard temperature and pressure (0 degrees Celsius and 1 atmosphere of pressure) per gram of water
ft	foot (feet)
km	kilometer

km ²	square kilometer
L	liter
mg/L	milligrams per liter (parts per million)
mi	mile
mi ²	square mile
mL	milliliter
µg/L	micrograms per liter (parts per billion)
µm	micrometer
NTU	nephelometric turbidity unit
NAD	North American Datum of 1983
NAVD	North American Vertical Datum of 1988
pCi/L	picocuries per liter
pH	measure of the acidity or basicity of water
pK _{1,2}	acid dissociation constant of carbonic acid
pK _w	acid dissociation constant of water
ppb	parts per billion
ppm	parts per million
δ'E	delta notation, the ratio of a heavier isotope of an element (ⁱ E) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil

Notes

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

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

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

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

Altitude, as used in this report, refers to distance above the vertical datum.

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).

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Groundwater Quality Data in the Mojave Study Unit, 2008: Results from the California GAMA Program

By Timothy M. Mathany and Kenneth Belitz

Abstract

Groundwater quality in the approximately 1,500 square-mile Mojave (MOJO) study unit was investigated from February to April 2008, as part of the Priority Basin Project of the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA Priority Basin Project was developed in response to the Groundwater Quality Monitoring Act of 2001 and is being conducted by the U.S. Geological Survey (USGS) in cooperation with the California State Water Resources Control Board (SWRCB). MOJO was the 23rd of 37 study units to be sampled as part of the GAMA Priority Basin Project.

The MOJO study was designed to provide a spatially unbiased assessment of the quality of untreated groundwater used for public water supplies within MOJO, and to facilitate statistically consistent comparisons of groundwater quality throughout California. Samples were collected from 59 wells in San Bernardino and Los Angeles Counties. Fifty-two of the wells were selected using a spatially distributed, randomized grid-based method to provide statistical representation of the study area (grid wells), and seven were selected to aid in evaluation of specific water-quality issues (understanding wells).

The groundwater samples were analyzed for a large number of 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 (nutrients, dissolved organic carbon [DOC], major and minor ions, silica, total dissolved solids [TDS], and trace elements), and radioactive constituents (gross alpha and gross beta radioactivity, radium isotopes, and radon-222). Naturally occurring isotopes (stable isotopes of hydrogen, oxygen, and carbon, stable isotopes of nitrogen and oxygen in nitrate, and activities of tritium and carbon-14), and dissolved noble gases also were measured to help identify the sources and ages of the sampled groundwater. In total, over 230 constituents and water-quality indicators (field parameters) were investigated.

Three types of quality-control samples (blanks, replicates, and matrix spikes) each were collected at approximately 5–8 percent of the wells, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that contamination was not a significant source of bias in the data for the groundwater samples. Differences between replicate samples generally were within acceptable ranges, indicating acceptable analytical reproducibility. Matrix spike recoveries were within acceptable ranges for most compounds.

This study did not attempt to evaluate the quality of water delivered to consumers; after withdrawal from the ground, untreated groundwater typically is treated, disinfected, or blended with other waters to maintain water quality. Regulatory thresholds apply to water that is served to the consumer, not to 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 thresholds established by the U.S. Environmental Protection Agency (USEPA) and California Department of Public Health (CDPH) and thresholds established for aesthetic and technical concerns by CDPH. Comparisons between data collected for this study and thresholds for drinking-water are for illustrative purposes only, and are not indicative of compliance or non-compliance with those thresholds.

Most constituents that were detected in groundwater samples in the 59 wells in MOJO were found at concentrations below drinking-water thresholds. In MOJO's 52 grid wells, volatile organic compounds (VOCs) were detected in 40 percent of the wells, and pesticides and pesticide degradates were detected in 23 percent of the grid wells. Results for health-based thresholds in MOJO grid wells showed that all of the detections of organic compounds in samples from MOJO grid wells were below health-based thresholds, with the exception of a single detection of NDMA above the California Department of Public Health notification level (NL-CA).

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Trace elements and radioactive constituents were sampled for at 19 MOJO grid wells and most detections were below health-based thresholds. Exceptions include: six detections of arsenic above the USEPA maximum contaminant level (MCL-US), two detections of boron and one detection of vanadium above the NL-CA, one detection each of molybdenum and strontium that were above the USEPA lifetime health advisory level (HAL-US), and one detection of fluoride just above the MCL-CA of 2 µg/L. Most detections of radioactive constituents in the MOJO grid wells were below health-based thresholds, with the exception of one detection of gross alpha radioactivity (72-hour count and 30-day count) above the MCL-CA, and 17 grid wells (of 19 sampled) that had activities of radon-222 above the proposed MCL-US of 300 pCi/L, but all were below the proposed alternative MCL-US of 4,000 pCi/L.

All of the samples collected from the 19 MOJO grid wells for trace elements, and most of the samples for major ions and total dissolved solids (TDS), had measured concentrations below the non-enforceable thresholds set for aesthetic concerns. Four grid wells had TDS concentrations above the California Department of Public Health secondary maximum contaminant level (SMCL-CA) recommended threshold of 500 mg/L, and three of these wells were also above the SMCL-CA upper threshold of 1,000 mg/L. Four grid wells (of 19 sampled) had sulfate measured at concentrations above the recommended SMCL-CA threshold of 250 mg/L, and one of these detections was also above the upper SMCL-CA threshold of 500 mg/L. One grid well had chloride levels at a concentration above the upper SMCL-CA threshold of 500 mg/L. Eleven grid wells (of 52 sampled) had pH values outside of the SMCL-US range for pH.

Introduction

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

The SWRCB initiated the GAMA Priority Basin project in response to Legislative mandates (Supplemental Report of the 1999 Budget Act 1999-00 Fiscal Year; and, the Groundwater Quality Monitoring Act of 2001 {Sections 10780-10782.3 of the California Water Code, Assembly Bill 599}) to assess

and monitor the quality of groundwater used as public supply for municipalities in California. The GAMA Priority Basin Project is a comprehensive assessment of statewide groundwater quality designed to help better understand and identify risks to groundwater resources, and to increase the availability of information about groundwater quality to the public. For the Priority Basin Project, the USGS, in collaboration with the SWRCB, developed the monitoring plan to assess groundwater basins through direct and other statistically reliable sample approaches (Belitz and others, 2003; State Water Resources Control Board, 2003). Key aspects of the project are inter-agency collaboration, and cooperation with local water agencies and well owners. Local participation in the project is entirely voluntary.

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

The range of hydrologic, geologic, and climatic conditions that exist in California must be considered in an assessment of groundwater quality. Belitz and others (2003) partitioned the State into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics (*fig. 1*), and representative regions in all 10 provinces were included in the project design. Eighty percent of California's approximately 16,000 public-supply wells are located in groundwater basins within these hydrologic provinces. These groundwater basins, defined by the California Department of Water Resources (CDWR), generally consist of relatively permeable, unconsolidated deposits of alluvial or volcanic origin (California Department of Water Resources, 2003). Groundwater basins were prioritized for sampling based upon the number of public-supply wells in the basin, with secondary consideration given to municipal groundwater use, agricultural pumping, the number of formerly leaking underground fuel tanks, and pesticide applications within the basins (Belitz and others, 2003). In addition, some groundwater basins or groups of adjacent similar basins with relatively few public-supply wells were assigned high priority so that all hydrogeologic provinces would be represented in the subset of basins sampled. The 116 priority basins were grouped into 37 study units. Some areas not in the defined groundwater basins were



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 Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study unit.

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included in the nearest respective study unit to achieve representation of the 20 percent of public-supply wells not located in the groundwater basins.

Three types of water-quality assessments are being conducted with the data collected in each study unit: (1) *Status*: assessment of the current quality of the groundwater resource, (2) *Trends*: detection of changes in groundwater quality, and (3) *Understanding*: identification of the natural and human factors affecting groundwater quality (Kulongoski and Belitz, 2004). This status report is one of a series of reports presenting water-quality data collected in each study unit (Wright and others, 2005; Bennett and others, 2006; Kulongoski and others, 2006; Fram and Belitz, 2007; Kulongoski and Belitz, 2007; Burton and Belitz, 2008; Dawson and others, 2008; Ferrari and others, 2008; Land and Belitz, 2008; Landon and Belitz, 2008; Mathany and others, 2008; Schmitt and others, 2008; Shelton and others, 2008; Montrella and Belitz, 2009; and, Ray and others, 2009). Subsequent reports will address the *status*, *trends*, and *understanding* aspects of the water-quality assessments of each study unit.

The Mojave GAMA study unit, hereafter referred to as MOJO, contains four groundwater basins. MOJO was considered high priority for sampling, to provide adequate representation of the Desert Hydrologic Province; Mojave River Basin (Belitz and others, 2003).

Purpose and Scope

The purposes of this report are to describe: (1) the study design, including the hydrogeologic setting of MOJO and the study methods; (2) the results of quality-control tests; and (3) the analytical results for groundwater samples collected in MOJO. Groundwater samples were analyzed for water-quality indicators (field parameters), organic and inorganic constituents, radioactive constituents, naturally occurring isotopes, and dissolved noble gases. The chemical data presented in this report were evaluated by comparison to State and Federal drinking water regulatory and other non-regulatory health-based standards that are applied to treated drinking water. Regulatory and non-regulatory thresholds considered for this report are those established by the United States Environmental Protection Agency (USEPA) and the California Department of Public Health (CDPH). The data presented in this report are intended to characterize the quality of untreated groundwater resources within the study unit, not the treated drinking water delivered to consumers by water purveyors. Discussion of the factors that influence the distribution and occurrence of the constituents detected in groundwater samples will be the subject of subsequent publications.

Hydrogeologic Setting

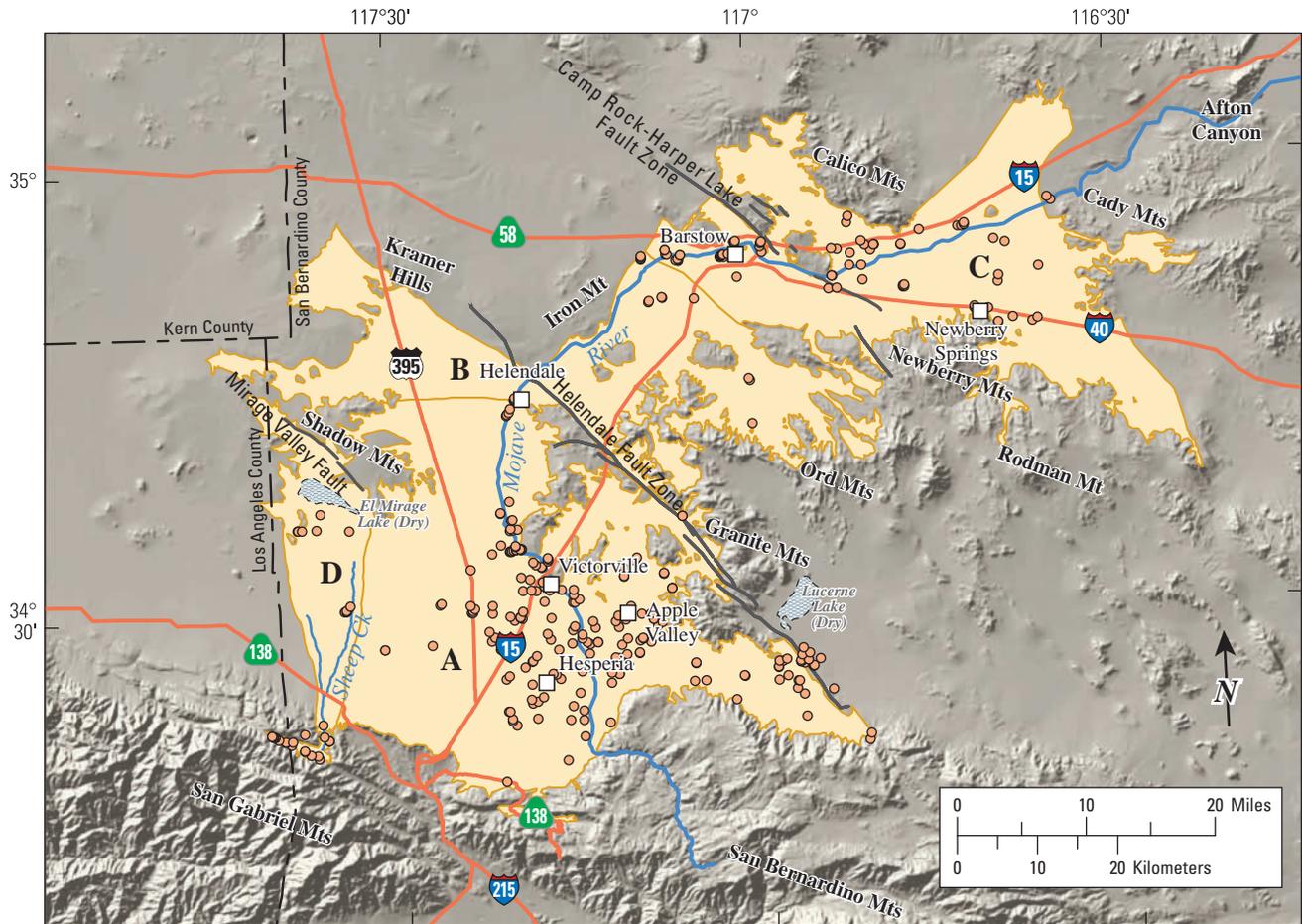
The Mojave study unit (MOJO) lies within the Desert Hydrogeologic Province described by Belitz and others (2003), and includes four California Department of Water

Resources (CDWR) South Lahontan Hydrologic Regional groundwater basins: Upper, Middle, and Lower Mojave River Basins (hereafter referred to as the Mojave River Valley Basin system), and the El Mirage Valley Basin (California Department of Water Resources, 2004a,b,c,d). Combined, these basins define the extent of MOJO, and cover an area of approximately 1,500 square miles (mi²), in San Bernardino, Kern, and Los Angeles Counties, California (fig. 2).

The MOJO study unit is located in the western part of the Mojave Desert, and has an altitude ranging from 1,700 ft to 6,400 ft above sea level. The topography of the study area is characterized as a alluvial plain, incised by the Mojave River, and is bounded on the west by the Los Angeles County Line, the Shadow Mountains, and the Kramer Hills. It is bordered to the north by Iron Mountain, the Camp Rock–Harper Lake Fault Zone, and the Calico Mountains. The eastern boundaries of the study unit include; Afton Canyon, the Cady, Rodman, Newberry, Ord, and Granite Mountains, and the Helendale Fault Zone. The southernmost border of MOJO is formed by the San Gabriel and San Bernardino Mountains. The major drainage of the MOJO study unit is the Mojave River, which has its headwaters in the San Bernardino Mountains and is dry for most of the year.

The climate throughout the MOJO study unit is classified as arid desert, characterized by hot, dry summers and cold winters. Most precipitation falls during the winter rainy season (November through March), and in most of the study unit the average annual precipitation is less than 6 inches (Izbicki and others, 2004).

There are two distinct and separate water-bearing formations within the Mojave River Valley basin system—the regional aquifer and the floodplain aquifer. The regional aquifer underlies the basin system, and consists of regional Pliocene deposits and younger alluvial fan deposits. The regional aquifer is less permeable than the floodplain aquifer, except where highly-permeable deposits from the ancestral Mojave River are present (Izbicki and Michel, 2003). The floodplain aquifer, the aerial extent of which is outlined in figure 3, consists of overlying Pleistocene and younger river channel floodplain deposits (California Department of Water Resources, 2004a,b, c). This unconsolidated alluvial aquifer is highly permeable, and is composed of sand and gravel weathered from granitic rocks in the San Gabriel and San Bernardino Mountains. The floodplain aquifer is surrounded and underlain by the regional aquifer (Stamos and Predmore, 1995; Izbicki and Michel, 2003). Other potential, but not regionally significant, water-bearing units include older alluvium, old fan deposits, old lake and lakeshore deposits, and dune sand deposits (California Department of Water Resources, 2004a,b,c). The water-bearing formations of El Mirage Valley consist of Quaternary alluvium and include unconsolidated younger alluvial deposits and underlying unconsolidated to semi-consolidated older alluvial deposits (California Department of Water Resources, 2004d).



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

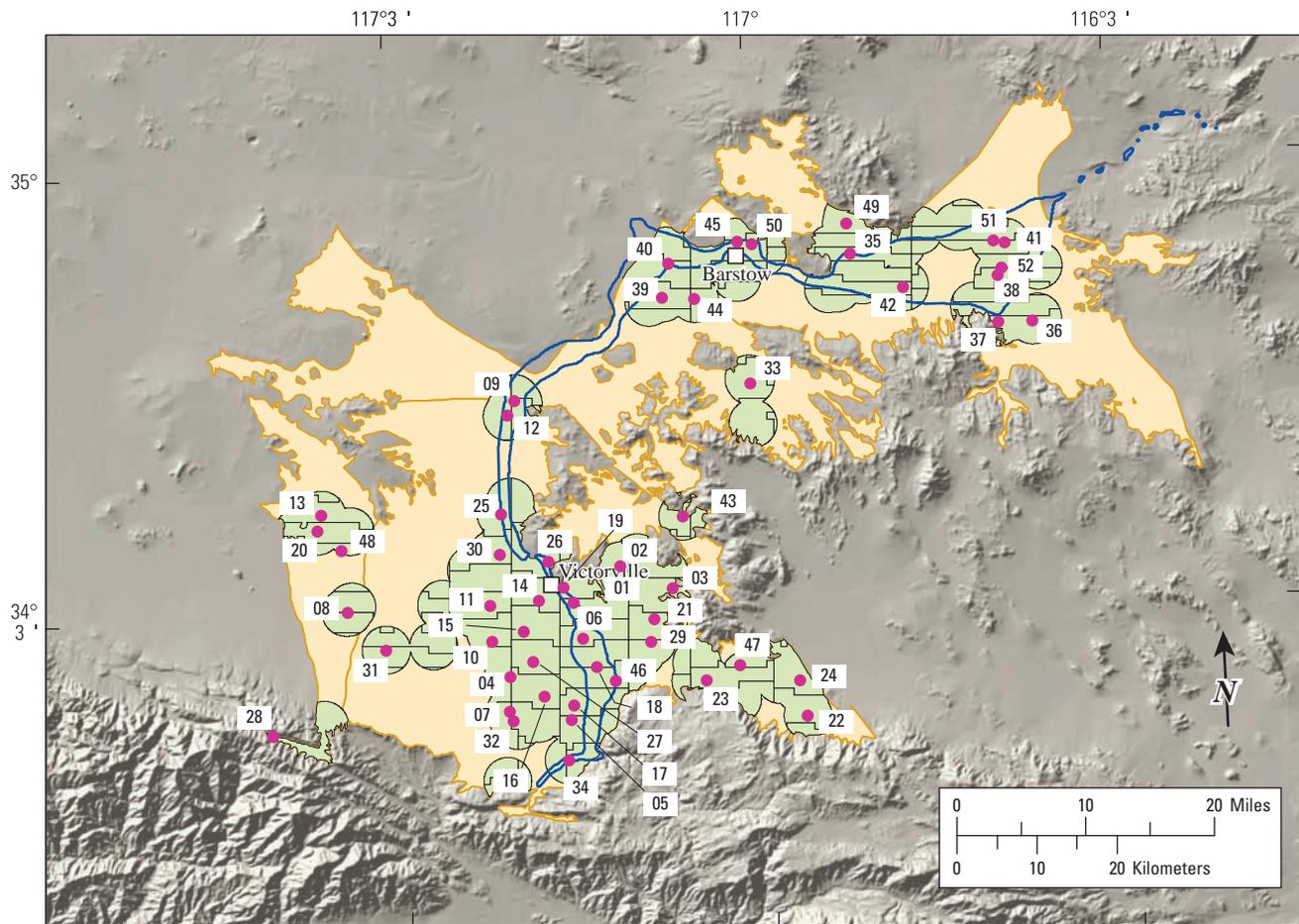
Faults from Cal Div of Mines and Geology

EXPLANATION

-  California Department of Water Resources defined groundwater basin and identifier
-  Public-supply well—With record in California Department of Public Health database
- A** Upper Mojave River
- B** Middle Mojave River
- C** Lower Mojave River
- D** El Mirage Valley

Figure 2. The Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the California Department of Water Resources groundwater basins within the study unit, location of public supply wells, major cities, roads, topographic features, and hydrologic features.

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

EXPLANATION

-  California Department of Water Resources defined groundwater basin
-  Aerial outline of flood-plain aquifer
-  MOJO grid cell
-  ²⁷ MOJO grid well
"MOJO" identifier has been omitted from figure due to spatial concerns

Figure 3. The Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the 3-kilometer buffer zones around all public-supply wells, the distribution of study-area grid cells, the aerial extent of the floodplain aquifer, and the location of sampled grid wells. Alphanumeric identification numbers for grid wells have the prefix "MOJO", but only the numeric portions are shown on the map.

The aquifers of the Mojave River Basin receive recharge from natural and engineered sources. Natural recharge is infrequent; as in most of the arid southwestern United States, recharge from the direct infiltration of precipitation does not typically occur in the study area (Izbicki and Michel, 2003). Under present-day climatic conditions, any natural recharge of the regional aquifer is small compared to the recharge of the floodplain aquifer. The recharge that does occur in the regional aquifer results primarily as infiltration from small streams near the flanks of the San Gabriel and San Bernardino Mountains that flow as a result of winter stormflows and snowmelt runoff (Izbicki and Michel, 2003). The floodplain aquifer is recharged readily by surface-water infiltration along the Mojave River, the principal source of which is runoff from snowmelt and precipitation in the San Bernardino Mountains (Densmore and others, 2005). Engineered recharge in the Mojave River Basin system occurs from septic tank effluent, treated wastewater effluent, effluent from two fish hatchery operations, and irrigation that reaches the saturated zone, and irrigation runoff, which are allowed to percolate into the ground and recharge the groundwater system (California Department of Water Resources, 2004a,b,c).

The general groundwater-flow direction is toward the active channel of the Mojave River and then beneath the course of the river in the downstream direction. Groundwater flow northeast of Apple Valley is also affected by the Helendale Fault Zone, which forms a barrier directing groundwater flow northwestward under a surface drainage divide into the Mojave River drainage instead of northeastward into Lucerne Lake (dry) in the Lucerne Valley basin (*fig. 2*) (Stamos and Predmore, 1995; Lines, 1996).

The El Mirage Valley basin is recharged chiefly from snowmelt and rainfall runoff in the San Gabriel Mountains, percolating through alluvial deposits at the mouth of Sheep Creek. Groundwater moves northwards, as does the surface flow, towards El Mirage Lake (dry). Groundwater flow also is affected by the Mirage Valley fault, located in the northern part of the basin (*fig. 2*), which may impede the movement of groundwater (California Department of Water Resources, 2004d).

Methods

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

descriptions of the sample-collection protocols and analytical methods, the quality-assurance plan, and the results of analyses of quality-control samples.

Study Design

The wells selected for sampling in this study reflect the combination of two well selection strategies. Fifty-two “grid” wells were selected to provide a statistically unbiased, spatially distributed assessment of the quality of groundwater resources used for public drinking-water supply, and seven additional “understanding” wells were selected to provide greater sampling density in several areas to aid in understanding of specific groundwater quality issues in the study unit.

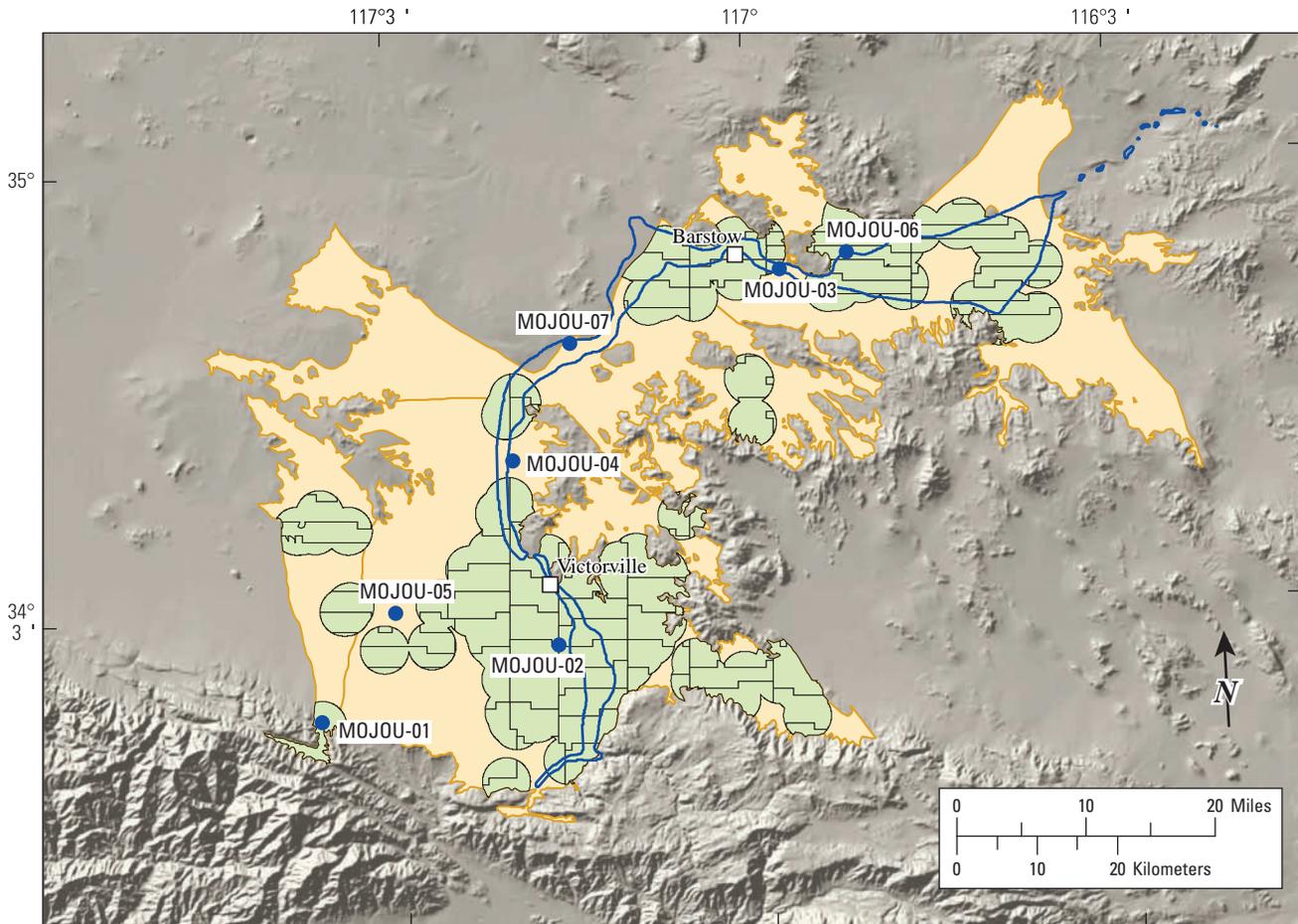
The spatially distributed wells were selected using a randomized grid-based method (Scott, 1990). The randomized grid-based method generates equal area grid cells; however, geographic features of the study unit may force the same grid cell to be divided into multiple pieces in order to obtain the designated 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. MOJO had relatively few public-supply wells, and these wells were not distributed evenly (*fig. 2*). To minimize the number of grid cells without any wells, only the portion of MOJO in close proximity to a public-supply well was included in the grid area. Location of public-supply wells listed in the statewide database maintained by the CDPH were plotted and 1.86-mi- (3-km) radius circles were drawn around each well. The area encompassed by the circles then was divided into sixty-five 25- km² grid cells (*fig. 3*). The objective was to select one public-supply well per grid cell. Fifty-two of the 65 grid cells were sampled in MOJO; the other 13 grid cells did not contain active or accessible wells. If a grid cell contained more than one public-supply well, each well randomly was assigned a rank. The highest ranking well that met basic sampling criteria (for example, sampling point located prior to treatment, capability to pump for several hours, and available well-construction information), and for which permission to sample could be obtained, then was sampled. If a grid cell contained no accessible public-supply wells, other types of wells, such as domestic or irrigation, were considered for sampling. An attempt was made to select “alternative” wells that had depths and screened intervals similar to those in public-supply wells in the area. In this fashion, one well was selected in each cell to provide a spatially distributed, randomized monitoring network for the study area. Wells sampled as part of the spatially distributed, randomized grid-cell network, hereafter, are referred to as “grid wells.” Grid wells in MOJO were numbered in the order of sample collection and by using the prefix “MOJO” (*fig. 3*).

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Additional wells were sampled to evaluate changes in water chemistry along selected groundwater flow paths or between shallow and deep portions of the aquifers. Wells sampled as part of these studies were not included in the statistical characterization of water quality in MOJO because inclusion of these wells would have caused overrepresentation of certain cells. These additional, non-randomized wells were selected along the slope of the San Gabriel Mountains, within the central portion of the Upper Mojave River Valley basin, and along the Mojave River floodplain aquifer, and were

numbered in the order of sample collection and by using the prefix “MOJOU” (“U” indicating “understanding”) (fig. 4).

The GAMA alphanumeric identification number for each well, along with the date sampled, sampling schedule, well elevation, well type, and well-construction information is shown in *table 1*. Groundwater samples were collected from 39 public-supply wells, 9 domestic wells, 4 irrigation wells, 4 monitoring (observation) wells, 2 standby wells, and 1 well used for mining activities, from February to April 2008.



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

EXPLANATION

-  California Department of Water Resources defined groundwater basin
-  Aerial outline of floodplain aquifer
-  MOJO grid cell
-  MOJO understanding well and identifier

Figure 4. The Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the 3-kilometer buffer zones around all public-supply wells, the distribution of study-area grid cells, the floodplain aquifer, and the location of sampled understanding wells. Alphanumeric identification numbers for understanding wells have the prefix “MOJOU”.

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

The wells in MOJO were sampled using a tiered analytical approach. All wells were sampled for a standard set of constituents, including VOCs, pesticides and pesticide degradates, perchlorate, stable isotopes of hydrogen and oxygen in water, dissolved noble gases, tritium, and helium isotopes. The standard set of constituents was termed the "fast" schedule (*table 2*). Wells on the "slow" schedule were sampled for all the constituents on the fast schedule, plus pharmaceuticals, NDMA, nutrients, major and minor ions, silica, total dissolved solids (TDS), trace elements, arsenic, chromium, and iron speciation, tritium, gross alpha and gross beta radioactivity, radium isotopes, radon-222, stable isotopes of carbon, carbon-14 abundance, and stable isotopes of nitrogen and oxygen in nitrate (*table 2*). There also were wells on both the fast and slow schedules for which dissolved organic carbon (DOC) was added to the sampling schedule; this addition coincided with the well's locality along the Mojave River floodplain aquifer. Fast and slow refer to the time required to sample the well for all the analytes on the schedule. Generally, three fast or two slow wells could be sampled in 1 day. In MOJO, 26 wells were sampled on the fast schedule (25 grid and 1 understanding), 9 wells were sampled on the fast plus DOC schedule (8 grid and 1 understanding), 17 wells were sampled on the slow schedule (12 grid and 5 understanding), and 7 grid wells were sampled on the slow plus DOC schedule.

Sample Collection and Analysis

Samples were collected in accordance with the protocols established by the USGS National Water Quality Assessment (NAWQA) program (Koterba and others, 1995) and the USGS National Field Manual (U.S. Geological Survey, variously dated). These sampling protocols ensure that representative samples of groundwater are collected at each site and that the samples are collected and handled in ways that minimizes the potential for contamination.

Tables 3A-I list the compounds analyzed in each constituent class. Groundwater samples were analyzed for 85 VOCs (*table 3A*); 63 pesticides and pesticide degradates (*table 3B*); 14 pharmaceutical compounds (*table 3C*); 2 constituents of special interest (*table 3D*); 5 nutrients and dissolved organic carbon (DOC) (*table 3E*); 9 major and minor ions, silica, total dissolved solids (TDS), and 24 trace elements (*table 3F*); arsenic, chromium, and iron species (*table 3G*); stable isotopes of hydrogen and oxygen, as well as the radioactive constituent of carbon in water; stable isotopes of nitrogen and oxygen in nitrate; and 7 radioactive constituents, including carbon-14 (*table 3H*); 5 dissolved noble gases, tritium, and helium stable isotope ratios (*table 3I*). The methods used for sample collection and analysis are described in the Appendix section "*Sample Collection and Analysis*."

Data Reporting

The methods and conventions used for reporting the data are described in the *Appendix*. Seven constituents analyzed in this study were measured by more than one analytical schedule or more than one laboratory, and all results are reported for these constituents.

Quality-Assurance

The quality-assurance and quality-control procedures used for this study followed the protocols used by the USGS NAWQA program (Koterba and others, 1995) and described in the USGS National Field Manual (U.S. Geological Survey, variously dated). The quality-assurance plan followed by the USGS National Water Quality Laboratory (NWQL), the primary laboratory used to analyze samples for this study, is described in Maloney (2005) and Pirkey and Glodt (1998). Quality-control (QC) samples collected in the MOJO study include: source-solution blanks, field 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. Quality-control procedures and quality-control results are described in the Appendix section "*Quality Assurance*."

Water-Quality Results

Quality-Control Results

Results of quality-control analyses (blanks, replicates, matrix spikes, and surrogates) were used to evaluate the quality of the data for the groundwater samples. On the basis of detections in field blanks collected for this and previous GAMA study units, detections reported by the laboratory for one organic compound (DOC) was considered suspect and therefore was removed from the set of groundwater quality data presented in this report (see *table A3* and additional discussion in *Appendix*). Results from the replicates confirm that the procedures used to collect and analyze the samples were consistent. Ninety-nine percent of the replicate pairs for constituents detected in samples had variability within acceptable limits; additional discussion can be found in the *Appendix*. Median matrix-spike recoveries for 31 of the 150 organic constituents analyzed were lower than the acceptable limits (*table 3B*), which may indicate that these constituents might not have been detected in some samples if they were present in the samples at concentrations near the LRLs. The quality-control results are described in the *Appendix* section “*Quality-Control Results*.”

Comparison Thresholds

Concentrations of constituents detected in groundwater samples were compared with CDPH and USEPA regulatory and non regulatory drinking-water health-based thresholds and thresholds established for aesthetic purposes (California Department of Public Health, 2008a,b; U.S. Environmental Protection Agency, 2008a,b,c). The chemical data presented in this report are meant to characterize the quality of the untreated groundwater resources within MOJO, 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 exposure to the atmosphere prior to its delivery to consumers. Comparisons of untreated groundwater to thresholds are for illustrative purposes only, and are not indicative of compliance or non-compliance with drinking-water regulations.

The following thresholds were used for comparisons:

- **MCL**—Maximum Contaminant Level. Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of contaminants in drinking water. MCLs established by the USEPA are the minimum standards with which states are required to comply, and individual states may choose to set more stringent standards. CDPH has established MCLs for additional constituents not regulated by the USEPA, as well as lowered the threshold concentration for a number of

constituents with MCLs established by the USEPA. In this report, a threshold set by the USEPA and adopted by CDPH is labeled “MCL-US”, and one set by CDPH that is more stringent than the MCL-US is labeled “MCL-CA.” CDPH is notified when constituents are detected at concentrations greater than an MCL-US or MCL-CA thresholds in samples collected for the GAMA Priority Basin Project, but these detections do not constitute violations of CDPH regulations.

- **AL**—Action Level. Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of copper and lead in drinking water. Detections of copper or lead above the action-level thresholds trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and CDPH are the same, thus, the thresholds are labeled “AL-US” in this report.
- **SMCL**—Secondary Maximum Contaminant Level. Non-enforceable standards applied to constituents that affect the aesthetic qualities of drinking water, such as taste, odor, and color, or technical qualities of drinking water, such as scaling and staining. Both the USEPA and CDPH define SMCLs, but unlike MCLs, SMCLs established by CDPH are not required to be at least as stringent as those established by USEPA. SMCLs established by CDPH are used in this report (SMCL-CA) for all constituents that have SMCL-CA values. The SMCL-US is used for pH because no SMCL-CA has been defined.
- **NL**—Notification Level. Health-based notification levels established by CDPH for some of the constituents in drinking water that lack MCLs (NL-CA). If a constituent is detected above its NL-CA, California state law requires timely notification of local governing bodies and recommends consumer notification.
- **HAL**—Lifetime Health Advisory Level. The maximum concentration of a constituent at which its presence in drinking water is not expected to cause any adverse carcinogenic effects for a lifetime of exposure. HALs are established by the USEPA (HAL-US) and are calculated assuming consumption of 2 liters (2.1 quarts) of water per day over a 70-year lifetime by a 70-kilogram (154-pound) adult and that 20 percent of a person’s exposure comes from drinking water.
- **RSD5**—Risk-Specific Dose. The concentration of a constituent in drinking water corresponding to an excess estimated lifetime cancer risk of 1 in 100,000. RSD5 is an acronym for risk-specific dose at 10^{-5} . RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 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 total dissolved solids, CDPH defines a “recommended” and an “upper” SMCL-CA; detections of these constituents in groundwater samples were compared with both levels. The SMCL-US for these constituents corresponds to the recommended SMCL-CA. Detected concentrations of constituents that lack an MCL or SMCL were compared to the NL-CA. For constituents that lack an MCL, SMCL, or NL-CA, detected concentrations were compared with the HAL-US. For constituents that lack an MCL, SMCL, NL-CA, or HAL-US, detected concentrations were compared with the RSD5-US. Note that if a constituent has more than one type of established threshold, using this hierarchy to select the comparison threshold will not necessarily result in selection of the threshold with the lowest concentration. For example, zinc has an SMCL-CA of 5,000 µg/L and a HAL-US of 2,000 µg/L, and the comparison threshold selected by this hierarchy is the SMCL-CA. The comparison thresholds used in this report are listed in *tables 3A–I* for all constituents and in *tables 4–13* for constituents detected in groundwater samples from MOJO. Not all constituents analyzed for this study have established thresholds available. Detections of constituents at concentrations greater than the selected comparison threshold are marked with asterisks in *tables 4–13*.

Groundwater-Quality Data

Results from analyses of untreated groundwater samples from MOJO are presented in *tables 4–13*. Groundwater samples collected in MOJO were analyzed for up to 234 constituents, and 144 of those constituents were not detected in any of the samples (*tables 3A–I*). The results tables present only the constituents that were detected (with the exception of *table 10*); all results tables list only the wells that had at least one constituent detected. For constituent classes that were analyzed at all of the grid wells, the tables include the number of wells at which each analyte was detected, the frequency at which it was detected (in relation to the number of grid wells), and the total number of constituents detected at each well. Results from the understanding wells are presented in the tables, but these results were excluded from the detection frequency calculations to avoid statistically over-representing the areas in the vicinity of the understanding wells.

Table 4 includes water-quality indicators (field parameters) measured in the field and at the NWQL. *Tables 5–13* present the results of groundwater analyses organized by compound classes:

- Organic constituents
 - Volatile organic compounds (VOCs) (*table 5*)
 - Pesticides and pesticide degradates (*table 6*)

- Constituents of special interest (*table 7*)
- Inorganic constituents
 - Nutrients and dissolved organic carbon (DOC) (*table 8*)
 - Major and minor ions, silica, and total dissolved solids (TDS) (*table 9*)
 - Trace elements (*table 10*)
 - Arsenic, chromium, and iron speciation (*table 11*)
- Isotopic tracers (*table 12*)
- Radioactive constituents (*tables 13A,B,C*)
- Results for pharmaceutical compounds are not presented in the MOJO data report; they will be included in a subsequent publication. In addition, as of the publishing date of this data report, the samples collected in MOJO for noble gases and tritium and helium isotope ratios were not available from LLNL; therefore, these results are not included at this time.

Water-Quality Indicators (Field Parameters)

Field and laboratory measurements of dissolved oxygen, pH, specific conductance, alkalinity, and associated parameters (turbidity, water temperature, bicarbonate, and carbonate) are presented in *table 4*. Alkalinity, dissolved oxygen, bicarbonate, and carbonate are used as indicators of natural processes that affect water chemistry. Specific conductance is the measure of electrical conductivity of the water, and is proportional to the amount of total dissolved solids (TDS) in the water. The pH value indicates the acidity or basicity of the water. Nineteen percent of MOJO’s grid wells (10 of 52 wells) had field specific conductance values above the recommended SMCL-CA of 900 µS/cm; five of these grid wells also were above the upper threshold of 1,600 µS/cm. Two understanding wells (of seven sampled) had field specific conductance values above the SMCL-CA upper threshold of 1,600 µS/cm. Eleven grid wells (of 52 sampled) and 2 understanding wells (of 7 sampled) had pH values outside of the SMCL-US range for pH (*table 4*). (Laboratory pH values may be dissimilar to field pH values because the pH of groundwater may change upon exposure to the atmosphere [see *Appendix*]).

Organic Constituents

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

Of the 85 VOCs analyzed in MOJO, 20 were detected in groundwater samples; all detections were below health-based thresholds (*table 5*). Chloroform, a byproduct of drinking-water disinfection, and 1,2,4-trimethylbenzene, a gasoline hydrocarbon, were detected in more than 10 percent of the grid well samples. One or more VOCs were detected in 21 out of the 52 grid wells and in 5 of the 7 understanding wells.

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 in the MOJO study, 10 pesticides were detected in groundwater samples; all detections were well below health-based thresholds (*table 6*). The herbicides simazine, and deethylatrazine (a degradate of atrazine), were detected in more than or 10 percent of the grid well samples. These two compounds are among the nation's most commonly detected pesticide compounds in groundwater (Gilliom and others, 2006). One or more pesticide compounds were detected in 12 out of the 52 grid wells and in 3 of the 7 understanding wells.

Constituents of Special Interest

Perchlorate and NDMA are constituents of special interest in California because they may adversely affect water quality and recently have been found in water supplies (California Department of Public Health, 2008b). Perchlorate was analyzed for at all 59 wells in MOJO and was detected in approximately 63 percent of the grid wells (33 of 52 wells); however all of these detections were below the MCL-CA (*table 7*). NDMA was analyzed for at the 24 slow wells (19 grid and 5 understanding) in MOJO, and was detected in one slow grid well (MOJO-42), at a level above the NL-CA threshold of 0.010 µg/L.

Inorganic Constituents

Unlike the organic constituents and the constituents of special interest, most of the inorganic constituents are naturally present in groundwater, although their concentrations may be influenced by human activities. Inorganic constituents, including arsenic, chromium, and iron species were sampled on the slow sampling schedule in MOJO (24 of 59 wells). Dissolved organic carbon was sampled only on the fast plus DOC and the slow plus DOC sampling schedules (16 of 59 wells).

Twenty-one of 24 trace elements analyzed in this study have regulatory or non-regulatory health-based thresholds. Of the 17 trace elements with health-based thresholds, 1 trace element (thallium) was not detected, and most detections of the other 16 trace elements were below health-based thresholds (*table 10*). In MOJO, samples from 6 grid wells (of 19 sampled) and 3 understanding wells (of 5 sampled) had arsenic and 1 understanding well was found to have uranium at concentrations above their respective MCL-US thresholds. Two

out of the 19 grid wells sampled had concentrations of boron above the NL-CA. Additionally, 1 grid well (of 19 sampled) and 1 understanding well (of 5 sampled) were found to have concentrations of vanadium above the NL-CA. A single grid well (of 19 sampled) had molybdenum and strontium above their respective HAL-US thresholds (*table 10*).

Nutrients (nitrogen and phosphorus) and dissolved organic carbon (DOC) 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 nitrate, nitrite, ammonia, and DOC measured in samples from MOJO wells were below health-based thresholds (*table 8*). It should be noted that the nutrients sample for MOJO-49 exceeded maximum allowable temperature at the NWQL before sample analysis; footnotes have been added in NWIS and *table 8* to reflect.

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

Concentrations of chloride measured in samples from the MOJO wells were below the recommended SMCL-CA (*table 9*), with the exception of one grid well. Four grid wells (of 19 sampled) and 1 understanding well (of 5 sampled) had sulfate concentration above the recommended SMCL-CA, but only one of these samples (a grid well), was above the upper SMCL-CA of 500 mg/L. Four grid wells (of 19 sampled) and 3 understanding wells (of 5 sampled) had TDS values above the recommended SMCL-CA, and 3 of the grid and 1 understanding well also were above the upper SMCL-CA. Fluoride is the only major ion with a MCL-CA threshold (2 µg/L); it was detected at concentrations above this threshold in 1 of the 19 grid and 2 of the 5 understanding samples.

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 was detected in 7 of the 19 grid and 2 of the 5 understanding well samples, and none of these concentrations were above the SMCL-CA. Concentration of manganese in MOJO wells also were low, with only a single understanding well (of 5 sampled) having a concentration above the SMCL-CA of 50 µg/L (*table 10*).

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

Isotopic Tracers and Noble Gases

The isotopic ratios of oxygen and hydrogen in water, the tritium and carbon-14 activities, and the concentrations of dissolved noble gases may be used as tracers of hydrologic processes. The isotopic ratios of hydrogen and oxygen in water (*table 12*) aid in the interpretation of the sources of groundwater recharge. These stable isotopic ratios reflect the altitude, latitude, and temperature of precipitation and also the extent of evaporation of the water in surface water bodies or soils prior to infiltration into the aquifer. Concentrations of dissolved noble gases are used to estimate the conditions of groundwater recharge, particularly the temperature of the recharge water. Noble gas analyses were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

Additional stable-isotope ratios of nitrogen and oxygen of dissolved nitrate (*table 12*) can be used to aid in interpretation of sources and processes affecting this solute in aquifers.

Tritium activities (*table 12*) and carbon-14 activities (*table 12*), and helium isotope ratios 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 atmospheric testing of nuclear weapons between 1952 and 1963. Thus, concentrations of tritium above background generally indicate the presence of water recharged since the early 1950s. Helium isotope ratios are used in conjunction with tritium concentrations to estimate ages for young groundwater. Helium isotope ratio analyses were not completed in time for inclusion in this report; results will be presented in a subsequent publication.

Carbon-14 (*table 12*) 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.

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

Radioactive Constituents

Radioactivity is the release of energy or energetic particles during changes in the structure of the nucleus of an atom. Most of the radioactivity in groundwater comes from decay of naturally occurring isotopes of uranium and thorium that are present in minerals in the sediments or fractured rocks of the aquifer. Both uranium and thorium decay in a series of steps, eventually forming stable isotopes of lead. 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 one picocurie is approximately equal to two atoms decaying per minute. The number of atoms decaying is equal to the number of alpha or beta particles emitted.

The 24 MOJO slow samples were analyzed for radioactive constituents and all had activities of radium-226, radium-228 and of gross beta radioactivity less than established health-based thresholds (*tables 13A,B*). Gross alpha radioactivity (30-day count and 72-hour count) exceeded the MCL-US of 15 pCi/L in 1 grid well (of 19 sampled) and 1 understanding well (of 5 sampled) (*table 13B*). Activities of radon-222 in samples from 17 grid wells (of 19 sampled) and 3 understanding wells (of 5 sampled) were above the proposed MCL-US of 300 pCi/L, although no samples had activities that were above the proposed alternative MCL-US of 4,000 pCi/L (*table 13C*). The proposed alternative 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).

Future Work

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

Summary

Groundwater quality in the approximately 1,500 square-mile (mi²) Mojave study unit (MOJO) was investigated from February to April 2008 as part of the Priority Basin Project of the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The California State Water Resources Control Board (SWRCB), in collaboration with the U.S. Geological Survey (USGS) and the Lawrence Livermore National Laboratory, is implementing the GAMA Program (<http://www.waterboards.ca.gov/gama/>). The Priority Basin Project was designed by the USGS and the SWRCB in response to the Groundwater Quality Monitoring Act of 2001 (Belitz and others, 2003; State Water Resources Control Board, 2003). The project is a comprehensive assessment of statewide groundwater quality designed to identify and characterize risks to groundwater resources, and to increase the availability of information about groundwater quality to the public. MOJO was the 23rd of 37 study units to be sampled as part of the GAMA Priority Basin Project.

MOJO is located in the Desert hydrogeologic province and includes four groundwater basins defined by the California Department of Water Resources (California Department of Water Resources, 2004a,b,c,d). The MOJO study included assessment of the groundwater quality from 59 wells in San Bernardino and Los Angeles Counties. Fifty-two of the wells were selected using a randomized grid approach to achieve statistically unbiased representation of groundwater used for public drinking-water supplies. Seven of the wells were selected to provide additional sampling density to aid in understanding processes affecting groundwater quality.

Groundwater samples were analyzed for volatile organic compounds (VOCs), pesticides and pesticide degradates, pharmaceutical compounds, perchlorate, NDMA, nutrients, dissolved organic carbon (DOC), major and minor ions, silica, total dissolved solids (TDS), trace elements, and radioactivity (gross alpha and gross beta radiation, radium isotopes, and radon-222). Naturally occurring isotopes (stable isotopes of hydrogen, oxygen, and carbon, stable isotopes of nitrogen and oxygen in nitrate, and activities of tritium and carbon-14) and dissolved noble gases also were measured to provide a data

set that will be used to help interpret the sources and ages of the sampled groundwater. In total, over 230 constituents and water-quality indicators (field parameters) were investigated for this study. This report describes the sampling, analytical, and quality-assurance methods used in the study, and presents the results of the chemical analyses made of the groundwater samples collected from February to April 2008.

Three types of quality-control samples (blanks, replicates, and matrix spikes) each were collected at approximately 5–8 percent of the wells, and the results for these samples were used to evaluate the quality of the data for the groundwater samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that contamination was not a significant source of bias in the data for the groundwater samples. Differences between replicate samples generally were within acceptable ranges, indicating acceptable analytical reproducibility. Matrix spike recoveries were within acceptable ranges for most compounds.

This study did not attempt to evaluate the quality of water delivered to consumers; after withdrawal from the ground, water typically is treated, disinfected, and blended with other waters to maintain acceptable water quality. Regulatory thresholds apply to treated water that is served to the consumer, not to 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 thresholds established by the U.S. Environmental Protection Agency (USEPA) and California Department of Public Health (CDPH) and non-regulatory thresholds established for aesthetic and technical concerns by CDPH.

All detections of VOCs and pesticides in samples from all 59 MOJO grid and understanding wells were below health-based thresholds and all of the detections of organic compounds (constituents of special interest) from MOJO wells were below health-based thresholds, with the exception of a single grid well detection of NDMA above the NL-CA.

Trace elements and radioactive constituents were sampled for at 19 MOJO grid wells and most detections were below health-based thresholds. Exceptions include; six detections of arsenic above the USEPA maximum contaminant level (MCL-US), two detections of boron and one detection of vanadium above the NL-CA, one detection each of molybdenum and strontium that were above the USEPA lifetime health advisory level (HAL-US), and one detection of fluoride just above the MCL-CA of 2 µg/L. Most detections of radioactive constituents in the MOJO grid wells were below health-based thresholds, with the exception of one detection of gross alpha radioactivity (72-hour count and 30-day count) above the MCL-CA, and 17 grid wells (of 19 sampled) having activities of radon-222 above the proposed lower MCL-US of 300 pCi/L, but all were below the proposed alternative MCL-US of 4,000 pCi/L.

All of the samples collected from the 19 MOJO grid wells for trace elements and most of the samples for major ions and total dissolved solids (TDS) had concentrations measured below the non-enforceable thresholds set for aesthetic concerns. Four grid wells had TDS concentrations above the SMCL-CA recommended lower threshold and three of these wells also had concentrations above the upper threshold (SMCL-CA threshold for total dissolved solids (TDS) has a recommended value of 500 mg/L, an upper value of 1,000 mg/L). Sulfate was measured at concentrations above the recommended SMCL-CA threshold in 3 grid wells (of 19 sampled). One grid well had sulfate and one grid well had chloride detected at concentrations above the upper threshold (both sulfate and chloride have a SMCL-CA recommended threshold value of 250 mg/L, an upper value of 500 mg/L). Eleven grid wells (of 52 sampled) had pH values outside of the SMCL-US range for pH.

Results from MOJO's seven understanding wells showed three detections of arsenic and one detection of uranium that were above the USEPA maximum contaminant levels (MCL-US). Two understanding wells (of seven sampled) had fluoride concentrations above the MCL-CA, and one had vanadium above the NL-CA. A single understanding well had a detection of manganese above the SMCL-CA of 50 µg/L. One understanding well had gross alpha radioactivity (72-hour count and 30-day count) above the MCL-CA of 15 pCi/L and three understanding wells (of seven sampled) had activities of radon-222 above the proposed lower MCL-US, but all were below the alternative MCL-US of 4,000 pCi/L. Two understanding wells (of seven sampled) had pH values outside of the SMCL-US range for pH.

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Tables

22 Groundwater Quality Data in the Mojave Study Unit, 2008: Results from the California GAMA Program

Table 1. Well identification, sampling, and construction information for wells sampled for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[Sampling schedules are described in *table 2*. Land-surface datum (LSD) is a datum plane that is approximately at land surface at each well. The elevation of the LSD is described in feet above the North American Vertical Datum 1988. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. **Other abbreviations:** DOC, dissolved organic carbon; ft, feet; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

GAMA well identification No.	Sampling information		Elevation of LSD (ft above NAVD 88)	Well type	Construction information		
	Date sampled (mm/dd/yyyy)	Sampling schedule			Well depth (ft below LSD)	Top perforation (ft below LSD)	Bottom perforation (ft below LSD)
Grid wells							
MOJO-01	02/04/2008	Fast plus DOC	2,790	Production	393	168	373
MOJO-02	02/04/2008	Fast	2,922	Production	330	133	330
MOJO-03	02/04/2008	Fast	3,017	Production	310	221	310
MOJO-04	02/05/2008	Fast	3,173	Production	877	445	865
MOJO-05	02/05/2008	Fast plus DOC	3,204	Production	700	420	700
MOJO-06	02/06/2008	Fast plus DOC	2,822	Production	na	164	334
MOJO-07	02/06/2008	Fast	3,530	Production	na	na	na
MOJO-08	02/06/2008	Fast	3,348	Production	660	na	na
MOJO-09	02/07/2008	Fast plus DOC	2,431	Production	425	150	415
MOJO-10	02/07/2008	Fast	3,238	Production	1,010	600	na
MOJO-11	02/07/2008	Fast	3,055	Production	630	310	610
MOJO-12	02/11/2008	Slow plus DOC	2,465	Production	360	110	360
MOJO-13	02/11/2008	Slow	2,867	Production	na	na	na
MOJO-14	02/12/2008	Slow	2,945	Production	530	365	505
MOJO-15	02/12/2008	Slow	3,055	Production	720	495	700
MOJO-16	02/13/2008	Slow	3,255	Production	1,000	515	1,000
MOJO-17	02/13/2008	Slow plus DOC	3,098	Production	810	410	810
MOJO-18	02/14/2008	Slow plus DOC	2,858	Production	460	200	450
MOJO-19	02/14/2008	Slow plus DOC	2,783	Production	420	160	400
MOJO-20	02/25/2008	Fast	2,914	Production	na	na	na
MOJO-21	02/25/2008	Fast	2,943	Production	na	na	na
MOJO-22	02/26/2008	Fast	3,963	Production	na	na	na
MOJO-23	02/26/2008	Fast	3,483	Production	na	na	na
MOJO-24	02/26/2008	Fast	3,161	Production	300	120	300
MOJO-25	02/27/2008	Slow plus DOC	2,623	Production	na	na	na
MOJO-26	02/27/2008	Fast plus DOC	2,713	Production	390	180	390
MOJO-27	02/28/2008	Slow	3,368	Production	1,110	850	1,110
MOJO-28	03/03/2008	Fast	6,404	Production	230	50	165
MOJO-29	03/03/2008	Slow	3,013	Production	480	na	na
MOJO-30	03/04/2008	Slow plus DOC	2,901	Production	650	430	630
MOJO-31	03/05/2008	Slow	3,683	Production	1,130	660	1,120
MOJO-32	03/06/2008	Fast	3,571	Production	800	na	na
MOJO-33	03/17/2008	Fast	2,873	Production	140	105	140
MOJO-34	03/17/2008	Fast plus DOC	3,070	Production	na	na	na
MOJO-35	03/18/2008	Slow	1,957	Production	400	160	400
MOJO-36	03/19/2008	Slow	1,797	Production	140	na	na
MOJO-37	03/19/2008	Fast	1,830	Production	na	na	na
MOJO-38	03/19/2008	Fast	1,835	Production	na	na	na
MOJO-39	03/20/2008	Slow	2,300	Production	na	na	na
MOJO-40	03/24/2008	Fast plus DOC	2,197	Production	350	190	350

Table 1. Well identification, sampling, and construction information for wells sampled for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[Sampling schedules are described in *table 2*. Land-surface datum (LSD) is a datum plane that is approximately at land surface at each well. The elevation of the LSD is described in feet above the North American Vertical Datum 1988. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. **Other abbreviations:** DOC, dissolved organic carbon; ft, feet; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

GAMA well identification No.	Sampling information		Elevation of LSD (ft above NAVD 88)	Well type	Construction information		
	Date sampled (mm/dd/yyyy)	Sampling schedule			Well depth (ft below LSD)	Top perforation (ft below LSD)	Bottom perforation (ft below LSD)
MOJO-41	03/25/2008	Slow plus DOC	1,822	Production	na	na	na
MOJO-42	03/26/2008	Slow	1,920	Production	388	242	na
MOJO-43	03/26/2008	Fast	3,378	Production	na	na	na
MOJO-44	03/27/2008	Fast	2,410	Production	700	na	na
MOJO-45	03/27/2008	Fast	2,104	Production	200	na	na
MOJO-46	03/31/2008	Fast	3,068	Production	606	258	565
MOJO-47	03/31/2008	Fast	2,971	Production	na	na	na
MOJO-48	04/01/2008	Fast	2,978	Production	540	200	520
MOJO-49	04/01/2008	Slow	2,007	Production	400	200	390
MOJO-50	04/01/2008	Fast	2,084	Production	150	na	na
MOJO-51	04/02/2008	Fast plus DOC	1,822	Production	300	na	na
MOJO-52	04/02/2008	Fast	1,829	Production	na	na	na
Understanding wells							
MOJOU-01	03/05/2008	Slow	4,873	Production	451	251	451
MOJOU-02	03/10/2008	Slow	2,986	Monitoring	790	770	790
MOJOU-03	03/11/2008	Slow	2,036	Monitoring	610	590	610
MOJOU-04	03/12/2008	Slow	2,593	Monitoring	583	534	574
MOJOU-05	03/13/2008	Slow	3,263	Monitoring	750	730	750
MOJOU-06	03/18/2008	Fast	1,960	Production	na	na	na
MOJOU-07	03/24/2008	Fast plus DOC	2,353	Production	150	90	150

Table 2. Classes of chemical constituents and water-quality indicators (field parameters) collected for the slow and fast well sampling schedules in the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

Analyte classes	Slow schedule	Fast schedule	Analyte list table	Results table
Water-quality indicators				
Dissolved oxygen, pH, temperature, specific conductance	X	X		4
Alkalinity, bicarbonate, and carbonate	X			4
Turbidity	X			4
Organic constituents				
Volatile organic compounds (VOCs)	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
<i>N</i> -nitrosodimethylamine (NDMA)	X		3D	7
Inorganic constituents				
Nutrients	X		3E	
Dissolved organic carbon (DOC) ²	X ²	X ²	3E	8
Major and minor ions and trace elements	X		3F	9,10
Arsenic, chromium, and iron speciation	X		3G	11
Stable isotopes				
Stable isotopes of hydrogen and oxygen in water	X	X	3H	12
Stable isotopes of nitrogen and oxygen in nitrate	X		3H	12
Stable isotopes of carbon and carbon-14 abundance	X		3H	12
Radioactivity and noble gases				
Tritium	X	X	3I	13
Tritium and noble gases	X	X	3I	none ¹
Radium isotopes	X		3I	13
Radon-222	X		3I	13
Gross alpha and gross beta radiation	X		3I	13

¹ Results for pharmaceutical compounds are not presented in the MOJO data report; they will be included in a subsequent publication. In addition, as of the publishing date of this data report, the samples collected in MOJO for noble gases and tritium and helium isotope ratios were not available from LLNL; therefore, these results are not included at this time.

² Dissolved organic carbon was sampled for at eight slow and eight fast wells.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. This report contains CAS Registry Numbers®, which is a Registered Trademark of the American Chemical Society. CAS recommends the verification of the CAS registry numbers through CAS Client ServicesSM. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. Threshold type and threshold level as of April 2, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10⁻⁵. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; THM, trihalomethane; D, detected in groundwater samples (table 5); na, not available; µg/L, micrograms per liter; —, not detected]

Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type	Threshold level (µg/L)	Detection
Acetone	Solvent	81552	67-64-1	4	na	na	—
Acrylonitrile	Organic synthesis	34215	107-13-1	0.4	RSD5-US	0.6	—
<i>tert</i> -Amyl methyl ether (TAME)	Gasoline oxygenate	50005	994-05-8	0.06	na	na	—
Benzene	Gasoline hydrocarbon	34030	71-43-2	0.016	MCL-CA	1	—
Bromobenzene	Solvent	81555	108-86-1	0.02	na	na	—
Bromochloromethane	Fire retardant	77297	74-97-5	0.06	HAL-US	90	—
Bromodichloromethane	Disinfection by-product (THM)	32101	75-27-4	0.04	MCL-US	¹ 80	D
Bromoform (Tribromomethane)	Disinfection by-product (THM)	32104	75-25-2	0.08	MCL-US	¹ 80	D
Bromomethane (Methyl bromide)	Fumigant	34413	74-83-9	0.4	HAL-US	10	—
<i>n</i> -Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	0.14	NL-CA	260	—
<i>sec</i> -Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	0.04	NL-CA	260	—
<i>tert</i> -Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	0.06	NL-CA	260	—
Carbon disulfide	Organic synthesis	77041	75-15-0	0.06	NL-CA	160	—
Carbon tetrachloride (Tetrachloromethane)	Solvent	32102	56-23-5	0.08	MCL-CA	0.5	D
Chlorobenzene	Solvent	34301	108-90-7	0.02	MCL-CA	70	D
Chloroethane	Solvent	34311	75-00-3	0.10	na	na	—
Chloroform (Trichloromethane)	Disinfection by-product (THM)	32106	67-66-3	0.02	MCL-US	¹ 80	D
Chloromethane	Solvent	34418	74-87-3	0.10	HAL-US	30	—
3-Chloropropene	Organic synthesis	78109	107-05-1	0.08	na	na	—
2-Chlorotoluene	Solvent	77275	95-49-8	0.04	NL-CA	140	—
4-Chlorotoluene	Solvent	77277	106-43-4	0.04	NL-CA	140	—
Dibromochloromethane	Disinfection by-product (THM)	32105	124-48-1	0.12	MCL-US	¹ 80	D

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

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Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type	Threshold level (µg/L)	Detection
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	0.5	MCL-US	0.2	—
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.04	MCL-US	0.05	—
Dibromomethane	Solvent	30217	74-95-3	0.04	na	na	—
1,2-Dichlorobenzene	Solvent	34536	95-50-1	0.02	MCL-CA	600	—
1,3-Dichlorobenzene	Solvent	34566	541-73-1	0.04	HAL-US	600	D
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	0.02	MCL-CA	5	—
<i>trans</i> -1,4-Dichloro-2-butene	Organic synthesis	73547	110-57-6	0.6	na	na	—
Dichlorodifluoromethane (CFC-12)	Refrigerant	34668	75-71-8	0.14	NL-CA	1,000	—
1,1-Dichloroethane (1,1-DCA)	Solvent	34496	75-34-3	0.04	MCL-CA	5	D
1,2-Dichloroethane (1,2-DCA)	Solvent	32103	107-06-2	0.06	MCL-CA	0.5	D
1,1-Dichloroethene (1,1-DCE)	Organic synthesis	34501	75-35-4	0.02	MCL-CA	6	D
<i>cis</i> -1,2-Dichloroethene (<i>cis</i> -1,2-DCE)	Solvent	77093	156-59-2	0.02	MCL-CA	6	D
<i>trans</i> -1,2-Dichloroethene (<i>trans</i> -1,2-DCE)	Solvent	34546	156-60-5	0.018	MCL-CA	10	D
1,2-Dichloropropane	Fumigant	34541	78-87-5	0.02	MCL-US	5	—
1,3-Dichloropropane	Fumigant	77173	142-28-9	0.06	na	na	—
2,2-Dichloropropane	Fumigant	77170	594-20-7	0.06	na	na	—
1,1-Dichloropropene	Organic synthesis	77168	563-58-6	0.04	na	na	—
<i>cis</i> -1,3-Dichloropropene	Fumigant	34704	10061-01-5	0.1	RSD5-US	² 4	—
<i>trans</i> -1,3-Dichloropropene	Fumigant	34699	10061-02-6	0.10	RSD5-US	² 4	—
Diethyl ether	Solvent	81576	60-29-7	0.12	na	na	—
Diisopropyl ether (DIPE)	Gasoline oxygenate	81577	108-20-3	0.06	na	na	—
Ethylbenzene	Gasoline hydrocarbon	34371	100-41-4	0.04	MCL-CA	300	—
Ethyl <i>tert</i> -butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.04	na	na	—
Ethyl methacrylate	Organic synthesis	73570	97-63-2	0.14	na	na	—
<i>o</i> -Ethyl toluene (1-Ethyl-2-methyl benzene)	Gasoline hydrocarbon	77220	611-14-3	0.04	na	na	—
Hexachlorobutadiene	Organic synthesis	39702	87-68-3	0.06	RSD5-US	9	—

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

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Constituent (synonym or abbreviation)	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type	Threshold level (µg/L)	Detection
Hexachloroethane	Solvent	34396	67-72-1	0.14	HAL-US	1	—
2-Hexanone (n-Butyl methyl ketone)	Solvent	77103	591-78-6	0.6	na	na	—
Iodomethane (Methyl iodide)	Organic synthesis	77424	74-88-4	0.4	na	na	—
Isopropylbenzene	Gasoline hydrocarbon	77223	98-82-8	0.04	NL-CA	770	—
4-Isopropyl-1-methyl benzene	Gasoline hydrocarbon	77356	99-87-6	0.08	na	na	—
Methyl acrylate	Organic synthesis	49991	96-33-3	0.6	na	na	—
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	0.2	na	na	—
Methyl <i>tert</i> -butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.10	MCL-CA	13	D
Methyl <i>iso</i> -butyl ketone (MIBK)	Solvent	78133	108-10-1	0.4	NL-CA	120	—
Methylene chloride (Dichloromethane)	Solvent	34423	75-09-2	0.04	MCL-US	5	D
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	na	na	—
Naphthalene	Gasoline hydrocarbon	34696	91-20-3	0.2	NL-CA	17	—
Perchloroethene (PCE, tetrachloroethene)	Solvent	34475	127-18-4	0.04	MCL-US	5	D
<i>n</i> -Propylbenzene	Solvent	77224	103-65-1	0.04	NL-CA	260	—
Styrene	Gasoline hydrocarbon	77128	100-42-5	0.04	MCL-US	100	—
1,1,1,2-Tetrachloroethane	Solvent	77562	630-20-6	0.04	HAL-US	70	—
1,1,1,2-Tetrachloroethane	Solvent	34516	79-34-5	0.10	MCL-CA	1	—
Tetrahydrofuran	Solvent	81607	109-99-9	1.4	na	na	D
1,2,3,4-Tetramethylbenzene	Gasoline hydrocarbon	49999	488-23-3	0.14	na	na	—
1,2,3,5-Tetramethylbenzene	Gasoline hydrocarbon	50000	527-53-7	0.12	na	na	—
Toluene	Gasoline hydrocarbon	34010	108-88-3	0.018	MCL-CA	150	D
1,2,3-Trichlorobenzene	Organic synthesis	77613	87-61-6	0.08	na	na	—

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

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

¹The MCL-US thresholds for trihalomethanes is the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

²The RSD5 threshold for 1,3-dichloropropene is the sum of its isomers (*cis* and *trans*).

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

⁴The MCL-CA thresholds for *m*- and *p*-Xylene and *o*-Xylene is the sum all three xylene compounds.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Threshold type and threshold level as of April 2, 2008. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (table 6); na, not available; $\mu\text{g/L}$, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL ($\mu\text{g/L}$)	Threshold type	Threshold level ($\mu\text{g/L}$)	Detection
Acetochlor	Herbicide	49260	34256-82-1	0.006	na	na	—
Alachlor	Herbicide	46342	15972-60-8	0.006	MCL-US	2	—
Atrazine	Herbicide	39632	1912-24-9	0.007	MCL-CA	1	D
Azinphos-methyl	Insecticide	82686	86-50-0	0.12	na	na	— ⁽¹⁾
Azinphos-methyl oxon	Insecticide degradate	61635	961-22-8	0.042	na	na	— ⁽¹⁾
Benfluralin	Herbicide	82673	1861-40-1	0.01	na	na	— ⁽¹⁾
Carbaryl	Insecticide	82680	63-25-2	0.06	RSD5-US	400	—
2-Chloro-2,6-diethylacetanilide	Herbicide degradate	61618	6967-29-9	0.01	na	na	—
4-Chloro-2-methylphenol	Herbicide degradate	61633	1570-64-5	0.0050	na	na	— ⁽¹⁾
Chlorpyrifos	Insecticide	38933	2921-88-2	0.005	HAL-US	2	— ⁽¹⁾
Chlorpyrifos oxon	Insecticide degradate	61636	5598-15-2	0.0562	na	na	— ⁽¹⁾
Cyfluthrin	Insecticide	61585	68359-37-5	0.016	na	na	— ⁽¹⁾
Cypermethrin	Insecticide	61586	52315-07-8	0.014	na	na	— ⁽¹⁾
Dacthal (DCPA)	Herbicide	82682	1861-32-1	0.003	HAL-US	70	—
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine)	Herbicide degradate	04040	6190-65-4	0.014	na	na	D ⁽¹⁾
Desulfinylfipronil	Insecticide degradate	62170	na	0.012	na	na	D
Desulfinylfipronil amide	Insecticide degradate	62169	na	0.029	na	na	—
Diazinon	Insecticide	39572	333-41-5	0.005	HAL-US	1	—
3,4-Dichloroaniline	Herbicide degradate	61625	95-76-1	0.006	na	na	D
Dichlorvos	Insecticide	38775	62-73-7	0.013	na	na	— ⁽¹⁾
Dicrotophos	Insecticide	38454	141-66-2	0.0843	na	na	— ⁽¹⁾
Dieldrin	Insecticide	39381	60-57-1	0.009	RSD5-US	0.02	D
2,6-Diethylaniline	Herbicide degradate	82660	579-66-8	0.006	na	na	—
Dimethoate	Insecticide	82662	60-51-5	0.006	na	na	— ⁽¹⁾
Ethion	Insecticide	82346	563-12-2	0.006	na	na	—
Ethion monoxon	Insecticide degradate	61644	17356-42-2	0.021	na	na	— ⁽¹⁾
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	0.0049	na	na	— ⁽¹⁾

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Threshold type and threshold level as of April 2, 2008. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 6*); na, not available; $\mu\text{g/L}$, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL ($\mu\text{g/L}$)	Threshold type	Threshold level ($\mu\text{g/L}$)	Detection
Fenamiphos	Insecticide	61591	22224-92-6	0.029	HAL-US	0.7	—
Fenamiphos sulfone	Insecticide degradate	61645	31972-44-8	0.053	na	na	—
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	0.2	na	na	— ⁽¹⁾
Fipronil	Insecticide	62166	120068-37-3	0.02	na	na	D ⁽¹⁾
Fipronil sulfide	Insecticide degradate	62167	120067-83-6	0.013	na	na	D ⁽¹⁾
Fipronil sulfone	Insecticide degradate	62168	120068-36-2	0.024	na	na	— ⁽¹⁾
Fonofos	Insecticide	04095	944-22-9	0.01	HAL-US	10	—
Hexazinone	Herbicide	04025	51235-04-2	0.008	HAL-US	400	— ⁽¹⁾
Iprodione	Fungicide	61593	36734-19-7	0.01	na	na	— ⁽¹⁾
Isofenphos	Insecticide	61594	25311-71-1	0.006	na	na	—
Malaoxon	Insecticide degradate	61652	1634-78-2	0.02	na	na	— ⁽¹⁾
Malathion	Insecticide	39532	121-75-5	0.016	HAL-US	100	—
Metalaxyl	Fungicide	61596	57837-19-1	0.0069	na	na	—
Methidathion	Insecticide	61598	950-37-8	0.004	na	na	—
Metolachlor	Herbicide	39415	51218-45-2	0.010	HAL-US	700	D
Metribuzin	Herbicide	82630	21087-64-9	0.012	HAL-US	70	—
Myclobutanil	Fungicide	61599	88671-89-0	0.01	na	na	—
1-Naphthol	Insecticide degradate	49295	90-15-3	0.04	na	na	— ⁽¹⁾
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	0.01	na	na	— ⁽¹⁾
Parathion-methyl	Insecticide	82667	298-00-0	0.008	HAL-US	1	— ⁽¹⁾
Pendimethalin	Herbicide	82683	40487-42-1	0.012	na	na	—
<i>cis</i> -Permethrin	Insecticide	82687	54774-45-7	0.01	na	na	— ⁽¹⁾
Phorate	Insecticide	82664	298-02-2	0.04	na	na	— ⁽¹⁾
Phorate oxon	Insecticide degradate	61666	2600-69-3	0.027	na	na	—
Phosmet	Insecticide	61601	732-11-6	0.0079	na	na	— ⁽¹⁾
Phosmet oxon	Insecticide degradate	61668	3735-33-9	0.0511	na	na	— ⁽¹⁾
Prometon	Herbicide	04037	1610-18-0	0.01	HAL-US	100	D
Prometryn	Herbicide	04036	7287-19-6	0.0059	na	na	—
Pronamide (Propyzamide)	Herbicide	82676	23950-58-5	0.004	RSD5-US	20	—

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Threshold type and threshold level as of April 2, 2008. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} . **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 6*); na, not available; $\mu\text{g/L}$, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL ($\mu\text{g/L}$)	Threshold type	Threshold level ($\mu\text{g/L}$)	Detection
Simazine	Herbicide	04035	122-34-9	0.006	MCL-US	4	D
Tebuthiuron	Herbicide	82670	34014-18-1	0.016	HAL-US	500	—
Terbufos	Insecticide	82675	13071-79-9	0.018	HAL-US	0.4	—
Terbufos oxon sulfone	Insecticide degradate	61674	56070-15-6	0.045	na	na	— ⁽¹⁾
Terbuthylazine	Herbicide	04022	5915-41-3	0.0083	na	na	—
Tribufos	Defoliant	61610	78-48-8	0.035	na	na	—
Trifluralin	Herbicide	82661	1582-09-8	0.009	HAL-US	10	— ⁽¹⁾

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

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

[The California Groundwater Ambient Monitoring and Assessment (GAMA) program uses more conservative reporting limits for the pharmaceutical compounds than recommended by the USGS National Water Quality Laboratory. For albuterol, carbamazepine, codeine, dehydronifedipine, diltiazem, sulfamethoxazole, thiabendazole, trimethoprim, and warfarin, the MDL corresponds to the long-term method detection limit determined by the USGS Branch of Quality Systems in October 2007 (BQS LT-MDL). For acetaminophen, caffeine, cotinine, diphenhydramine, and xanthine, the MDL corresponds to the study reporting levels determined from assessment of quality-control data associated with GAMA samples collected from May 2004 through September 2007 (GAMA SRL). The GAMA SRLs are higher than the BQS LT-MDL for those compounds. Detections reported by the USGS National Water Quality Laboratory with concentrations lower than the BQS LT-MDL or GAMA SRL are reported as non-detections by the GAMA program. The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. **Abbreviations:** CAS, Chemical Abstract Service; MDL, method detection limit; na, not available; µg/L, micrograms per liter]

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

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

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Threshold type and threshold level as of April 2, 2008. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** CAS, Chemical Abstract Service; MRL, minimum reporting level; D, detected in groundwater samples (*table 7*); µg/L, micrograms per liter]

Constituent	Primary use or source	USGS parameter code	CAS number	MRL (µg/L)	Threshold type	Threshold level (µg/L)	Detection
Perchlorate	Rocket fuel, fireworks, flares	63790	14797-73-0	0.10	MCL-CA	6	D
<i>N</i> -nitrosodimethylamine (NDMA)	Disinfection by-product	34438	62-75-9	0.0020	NL-CA	0.010	D

Table 3E. Nutrients and dissolved organic carbon (DOC), comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2755 and laboratory code 2612.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Threshold type and threshold level as of April 2, 2008. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 8*); na, not available; mg/L, milligrams per liter]

Constituent	USGS parameter code	CAS number	LRL (mg/L)	Threshold type	Threshold level (mg/L)	Detection
Ammonia (as nitrogen)	00608	7664-41-7	0.02	HAL-US	¹ 24.7	D
Nitrite (as nitrogen)	00613	14797-65-0	0.002	MCL-US	1	D
Nitrate plus nitrite (as nitrogen)	00631	na	0.04	MCL-US	10	D
Total nitrogen (ammonia, nitrite, nitrate, organic nitrogen)	62854	17778-88-0	0.06	na	na	D
Phosphate, orthophosphate (as phosphorus)	00671	14265-44-2	0.006	na	na	D
Dissolved organic carbon (DOC)	00681	na	0.4	na	na	D

¹The 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."

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Threshold type and threshold level as of April 2, 2008. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. The recommended SMCL-CA thresholds for chloride, sulfate, and TDS are listed with the upper SMCL-CA thresholds in parentheses. **Threshold type:** AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; SRL, study reporting limit; D, detected in groundwater samples (tables 9 and 10); na, not available; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not detected]

Constituent	USGS parameter code	CAS number	LRL/SRL	Threshold type	Threshold level	Detection
Major and minor ions, silica, and total dissolved solids (TDS) (mg/L)						
Bromide	71870	24959-67-9	0.02	na	na	D
Calcium	00915	7440-70-2	0.04	na	na	D
Chloride	00940	16887-00-6	0.12	SMCL-CA	250 (500)	D
Fluoride	00950	16984-48-8	0.12	MCL-CA	2	D
Iodide	71865	7553-56-2	0.002	na	na	D
Magnesium	00925	7439-95-4	0.02	na	na	D
Potassium	00935	7440-09-7	0.02	na	na	D
Silica (as SiO ₂)	00955	7631-86-9	0.018	na	na	D
Sodium	00930	7440-23-5	0.12	na	na	D
Sulfate	00945	14808-79-8	0.18	SMCL-CA	250 (500)	D
Residue on evaporation (total dissolved solids, TDS)	70300	na	10	SMCL-CA	500 (1,000)	D
Trace elements (µg/L)						
Aluminum	01106	7429-90-5	1.6	MCL-CA	1,000	D
Antimony	01095	7440-36-0	0.14	MCL-US	6	D
Arsenic	01000	7440-38-2	0.06	MCL-US	10	D
Barium	01005	7440-39-3	0.4	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	0.008	MCL-US	4	D
Boron	01020	7440-42-8	6	NL-CA	1,000	D
Cadmium	01025	7440-43-9	0.04	MCL-US	5	D
Chromium	01030	7440-47-3	0.12	MCL-CA	50	D
Cobalt	01035	7440-48-4	0.02	na	na	D
Copper	01040	7440-50-8	1	AL-US	1,300	D
Iron	01046	7439-89-6	8	SMCL-CA	300	D
Lead	01049	7439-92-1	0.08	AL-US	15	D
Lithium	01130	7439-93-2	1	na	na	D
Manganese	01056	7439-96-5	0.2	SMCL-CA	50	D
Molybdenum	01060	7439-98-7	0.2	HAL-US	40	D
Nickel	01065	7440-02-0	0.2	MCL-CA	100	D
Selenium	01145	7782-49-2	0.04	MCL-US	50	D
Silver	01075	7440-22-4	0.1	SMCL-CA	100	—
Strontium	01080	7440-24-6	0.8	HAL-US	4,000	D
Thallium	01057	7440-28-0	0.04	MCL-US	2	—
Tungsten	01155	7440-33-7	0.06	na	na	D
Uranium	22703	7440-61-1	0.02	MCL-US	30	D
Vanadium	01085	7440-62-2	0.04	NL-CA	50	D
Zinc	01090	7440-66-6	1.8	SMCL-CA ¹	5,000	D

¹The secondary maximum contaminant level for zinc is listed as SMCL-CA since SMCLs established by CDPH are used in this report for all constituents that have SMCL-CA values.

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

[The five-digit USGS parameter code is used to uniquely identify specific constituents or property. Threshold type and threshold level as of April 2, 2008.
Threshold type: Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level.
Other abbreviations: CAS, Chemical Abstract Service; MDL, method detection limit; na, not available; µg/L, micrograms per liter; D, detected in groundwater samples (*table 11*)]

Constituent	USGS parameter code	CAS number	MDL (µg/L)	Threshold type	Threshold level (µg/L)	Detection
Arsenic (III)	99034	22569-72-8	1	na	na	D
Arsenic (total)	99033	7440-38-2	0.5	MCL-US	10	D
Chromium (VI)	01032	18540-29-9	1	na	na	D
Chromium (total)	01030	7440-47-3	1	MCL-CA	50	D
Iron (II)	01047	7439-89-6	2	na	na	D
Iron (total)	01046	7439-89-6	2	SMCL-US	300	D

Table 3H. Isotopic and radioactive constituents, comparative thresholds, and reporting information for laboratory analyses.

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. 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. Threshold type and threshold level as of April 2, 2008. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; CSU, combined standard uncertainty; ssL_c , sample-specific critical level; MRL, minimum reporting level; MU, method uncertainty; na, not available; pCi/L, picocuries per liter; 2SCU, 2-sigma combined uncertainty; D, detected in groundwater samples (tables 12 and 13)]

Constituent	USGS parameter code	CAS number	Reporting level type	Reporting level or uncertainty	Threshold type	Threshold level	Detection
Stable isotope ratios (per mil)							
$\delta^2\text{H}$ of water ¹	82082	na	MU	2	na	na	D
$\delta^{18}\text{O}$ of water ¹	82085	na	MU	0.20	na	na	D
$\delta^{15}\text{N}$ of nitrate ¹	82690	na	MU	0.50	na	na	D
$\delta^{18}\text{O}$ of nitrate ¹	63041	na	MU	1.00	na	na	D
$\delta^{13}\text{C}$ of dissolved carbonates ²	82081	na	1 sigma	0.05	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	na	2SCU	Prop. MCL-US	⁵ 300 (4,000)	D
Tritium ⁶	07000	10028-17-8	MRL	1	MCL-CA	20,000	D
Gross alpha radioactivity, 72-hour and 30-day counts ⁷	99920, 99921	12587-46-1	ssL_c	CSU	MCL-US	15	D
Gross beta radioactivity, 72-hour and 30-day counts ⁷	99922, 99923	12587-47-2	ssL_c	CSU	MCL-CA	50	D
Radium-226 ⁷	99915	13982-63-3	ssL_c	CSU	MCL-US	⁸ 5	D
Radium-228 ⁷	99916	15262-20-1	ssL_c	CSU	MCL-US	⁸ 5	D

¹USGS Stable Isotope Laboratory, Reston, Virginia.

²University of Waterloo (contract laboratory).

³University of Arizona, Accelerator Mass Spectrometry Laboratory (contract laboratory).

⁴USGS National Water Quality Laboratory.

⁵Two MCLs have been proposed for Radon-222. The proposed alternative MCL is in parentheses.

⁶USGS Stable Isotope and Tritium Laboratory, Menlo Park, California.

⁷Eberline Analytical Services (contract laboratory).

⁸The MCL-US threshold for radium is the sum of radium-226 and radium-228.

Table 31. Noble gases and tritium, comparison thresholds and reporting information for the Lawrence Livermore National Laboratory analyses.

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Threshold type and threshold values as of April 2, 2008. **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MU, method uncertainty; na, not available; cm³ STP/g, cubic centimeters of gas at standard temperature and pressure per gram of water; pCi/L, picocuries per liter; D, detected in groundwater samples]

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

Table 4. Water-quality indicators (field parameters) in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. The SMCL-CA for specific conductance has recommended and upper threshold values. The upper value is shown in parentheses. **Threshold type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** C, Celsius; mg/L, milligrams per liter; nc, sample not collected; na, not available; NTU, nephelometric turbidity unit; RL, reporting limit or range; μS/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO₃, calcium carbonate; *, value above threshold level or outside threshold range; **, value above upper threshold level]

GAMA well identification No.	Turbidity, field (NTU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (degrees C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (μS/cm at 25 degrees C) (90095)		Specific conductance, field (μS/cm at 25C) (00095)		Alkalinity, lab (mg/L as CaCO ₃) (29801)	Alkalinity, field (mg/L as CaCO ₃) (29802)	Bicarbonate, field (mg/L) (63786)	Carbonate, field (mg/L) (63788)
						SMCL-US	SMCL-CA	SMCL-US	SMCL-CA				
Threshold type	na	na	na				na	na	na	na	na	na	na
Threshold level	na	na	na	<6.5–8.5>	<6.5–8.5>	900 (1,600)	900 (1,600)	900 (1,600)	na	na	na	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[5]	[5]	[5]	[1]	[1]	[1]	[1]	[1]
Grid wells (52 wells sampled)													
MOJO-01	nc	5.4	17.0	nc	*8.8	nc	nc	173	nc	nc	nc	nc	nc
MOJO-02	nc	1.4	21.0	nc	8.0	nc	nc	882	nc	nc	nc	nc	nc
MOJO-03	nc	4.2	23.0	nc	7.8	nc	nc	714	nc	nc	nc	nc	nc
MOJO-04	nc	7.2	22.0	nc	8.5	nc	nc	187	nc	nc	nc	nc	nc
MOJO-05	nc	4.3	17.0	nc	7.6	nc	nc	273	nc	nc	nc	nc	nc
MOJO-06	nc	5.5	15.0	nc	7.8	nc	nc	185	nc	nc	nc	nc	nc
MOJO-07	nc	1.5	27.0	nc	*8.9	nc	nc	206	nc	nc	nc	nc	nc
MOJO-08	nc	2.1	27.0	nc	8.1	nc	nc	494	nc	nc	nc	nc	nc
MOJO-09	nc	<0.2	20.0	nc	8.1	nc	nc	*981	nc	nc	nc	nc	nc
MOJO-10	nc	<0.2	31.5	nc	*9.3	nc	nc	289	nc	nc	nc	nc	nc
MOJO-11	nc	0.3	27.5	nc	*8.6	nc	nc	422	nc	nc	nc	nc	nc
MOJO-12	nc	0.6	18.0	7.5	7.3	613	613	606	172	163	199	<1.0	<1.0
MOJO-13	nc	0.3	20.5	8.1	8.3	*905	*905	*910	52	48.3	58	<1.0	<1.0
MOJO-14	nc	5.0	23.0	*9.4	*9.3	230	230	228	102	100	98	11.7	11.7
MOJO-15	nc	4.1	27.5	*9.6	*9.6	216	216	221	97	91.5	78	15.6	15.6

Table 4. Water-quality indicators (field parameters) in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. The SMCL-CA for specific conductance has recommended and upper threshold values. The upper value is shown in parentheses. **Threshold type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** C, Celsius; mg/L, milligrams per liter; nc, sample not collected; na, not available; NTU, nephelometric turbidity unit; RL, reporting limit or range; $\mu\text{S}/\text{cm}$, microsiemens per centimeter; <, less than; >, greater than; CaCO_3 , calcium carbonate; *, value above threshold level or outside threshold range; **, value above upper threshold level]

GAMA well identification No.	Turbidity, field (NTU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (degrees C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab ($\mu\text{S}/\text{cm}$ at 25 degrees C) (90095)		Specific conductance, field ($\mu\text{S}/\text{cm}$ at 25C) (00095)		Alkalinity, lab (mg/L as CaCO_3) (29801)	Alkalinity, field (mg/L as CaCO_3) (29802)	Bicarbonate, field (mg/L) (63786)	Carbonate, field (mg/L) (63788)
						SMCL-US	SMCL-CA	SMCL-US	SMCL-CA				
Threshold type	na	na	na	SMCL-US	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	SMCL-CA	na	na	na	na
Threshold level	na	na	na	<6.5–8.5>	<6.5–8.5>	<6.5–8.5>	900 (1,600)	900 (1,600)	900 (1,600)	na	na	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[0–14]	[5]	[5]	[5]	[1]	[1]	[1]	[1]
MOJO-16	nc	5.6	22.5	8.5	*8.6	*8.6	178	177	81	73.3	89	89	<1.0
MOJO-17	nc	10.0	14.5	7.3	7.0	7.0	417	405	109	100	122	122	<1.0
MOJO-18	nc	9.6	12.5	7.6	7.3	7.3	213	199	65	nc	nc	nc	nc
MOJO-19	nc	5.3	19.5	8.5	*8.6	*8.6	453	371	67	nc	nc	nc	nc
MOJO-20	nc	1.5	14.5	nc	8.3	8.3	nc	502	nc	nc	nc	nc	nc
MOJO-21	nc	7.2	22.0	nc	7.8	7.8	nc	*1,420	nc	nc	nc	nc	nc
MOJO-22	nc	5.1	26.5	nc	8.1	8.1	nc	809	nc	nc	nc	nc	nc
MOJO-23	nc	6.6	26.0	nc	8.0	8.0	nc	425	nc	nc	nc	nc	nc
MOJO-24	nc	6.7	25.0	nc	7.3	7.3	nc	443	nc	nc	nc	nc	nc
MOJO-25	0.1	0.3	20.5	7.4	7.5	7.5	656	668	144	138	167	167	<1.0
MOJO-26	nc	0.7	19.0	nc	7.8	7.8	nc	525	nc	nc	nc	nc	nc
MOJO-27	0.1	1.6	28.0	*9.0	*9.0	*9.0	202	209	74	nc	nc	nc	nc
MOJO-28	nc	7.9	10.5	nc	6.9	6.9	nc	529	nc	nc	nc	nc	nc
MOJO-29	0.1	2.5	23.0	7.7	7.6	7.6	**2,750	**2,750	94	90.0	109	109	<1.0
MOJO-30	0.3	2.9	22.0	8.4	8.4	8.4	559	547	77	73.2	87	87	1.0

Table 4. Water-quality indicators (field parameters) in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. GAMA well identification No.: MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. The SMCL-CA for specific conductance has recommended and upper threshold values. The upper value is shown in parentheses. **Threshold type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** C, Celsius; mg/L, milligrams per liter; nc, sample not collected; na, not available; NTU, nephelometric turbidity unit; RL, reporting limit or range; μ S/cm, microsiemens per centimeter; <, less than; >, greater than; CaCO₃, calcium carbonate; *, value above threshold level or outside threshold range; **, value above upper threshold level]

GAMA well identification No.	Turbidity, field (NTU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (degrees C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab		Specific conductance, field		Alkalinity, lab (mg/L as CaCO ₃) (29801)	Alkalinity, field (mg/L as CaCO ₃) (29802)	Bicarbonate, field (mg/L) (63786)	Carbonate, field (mg/L) (63788)
						(μ S/cm at 25 degrees C) (90095)	SMCL-CA (90095)	(μ S/cm at 25C) (00095)	SMCL-CA (00095)				
Threshold type	na	na	na	SMCL-US	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	SMCL-CA	na	na	na	na
Threshold level	na	na	na	<6.5–8.5>	<6.5–8.5>	<6.5–8.5>	900 (1,600)	900 (1,600)	900 (1,600)	na	na	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[0–14]	[5]	[5]	[5]	[1]	[1]	[1]	[1]
MOJO-31	3.3	0.4	27.0	8.4	8.3	8.3	482	485	485	90	85.5	102	1.0
MOJO-32	nc	5.4	25.5	nc	*8.7	*8.7	nc	195	195	nc	nc	nc	nc
MOJO-33	nc	9.5	22.5	nc	7.7	7.7	nc	418	418	nc	nc	nc	nc
MOJO-34	nc	8.7	15.5	nc	6.8	6.8	nc	231	231	nc	nc	nc	nc
MOJO-35	0.5	5.1	21.5	7.5	7.7	7.7	610	600	600	148	142	173	<1.0
MOJO-36	nc	0.2	23.0	8.0	8.0	8.0	540	537	537	152	nc	nc	nc
MOJO-37	nc	2.2	25.5	nc	8.0	8.0	nc	411	411	nc	nc	nc	nc
MOJO-38	nc	4.4	23.5	nc	7.8	7.8	nc	486	486	nc	nc	nc	nc
MOJO-39	13.0	8.6	22.0	7.8	8.2	8.2	**1,630	*1,570	*1,570	156	nc	nc	nc
MOJO-40	nc	3.9	22.5	nc	7.7	7.7	nc	**3,210	**3,210	nc	nc	nc	nc
MOJO-41	0.2	5.3	22.5	7.7	7.6	7.6	722	728	728	191	180	219	1.0
MOJO-42	0.4	4.5	22.5	8.0	7.9	7.9	451	450	450	151	140	170	1.0
MOJO-43	nc	4.7	24.5	nc	7.4	7.4	nc	710	710	nc	nc	nc	nc
MOJO-44	nc	5.5	23.5	nc	7.9	7.9	nc	**2,350	**2,350	nc	nc	nc	nc
MOJO-45	nc	5.4	20.0	nc	7.2	7.2	nc	868	868	nc	nc	nc	nc

Table 4. Water-quality indicators (field parameters) in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. The SMCL-CA for specific conductance has recommended and upper threshold values. The upper value is shown in parentheses. **Threshold type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** C, Celsius; mg/L, milligrams per liter; nc, sample not collected; na, not available; NTU, nephelometric turbidity unit; RL, reporting limit or range; $\mu\text{S}/\text{cm}$, microsiemens per centimeter; <, less than; >, greater than; CaCO_3 , calcium carbonate; *, value above threshold level or outside threshold range; **, value above upper threshold level]

GAMA well identification No.	Turbidity, field (NTU) (63676)	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (degrees C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab ($\mu\text{S}/\text{cm}$ at 25 degrees C) (90095)		Specific conductance, field ($\mu\text{S}/\text{cm}$ at 25C) (00095)	Alkalinity, lab (mg/L as CaCO_3) (29801)	Alkalinity, field (mg/L as CaCO_3) (29802)	Bicarbonate, field (mg/L) (63786)	Carbonate, field (mg/L) (63788)
						SMCL-US	SMCL-CA					
Threshold type	na	na	na	SMCL-US	SMCL-US	SMCL-US	SMCL-CA	SMCL-CA	na	na	na	na
Threshold level	na	na	na	<6.5–8.5>	<6.5–8.5>	<6.5–8.5>	900 (1,600)	900 (1,600)	na	na	na	na
[RL]	[0.1]	[0.2]	[0.0–38.5]	[0–14]	[0–14]	[0–14]	[5]	[5]	[1]	[1]	[1]	[1]
MOJO-46	nc	7.0	15.5	nc	7.5	nc	176	176	nc	nc	nc	nc
MOJO-47	nc	5.4	18.5	nc	8.1	nc	**1820	**1820	nc	nc	nc	nc
MOJO-48	nc	0.3	27.0	nc	*9.8	nc	462	462	nc	nc	nc	nc
MOJO-49	0.2	3.3	26.0	7.7	7.9	**3,020	**2,990	**2,990	122	117	141	<1.0
MOJO-50	nc	7.6	18.9	nc	7.5	nc	*957	*957	nc	nc	nc	nc
MOJO-51	nc	2.5	22.0	nc	7.8	nc	520	520	nc	nc	nc	nc
MOJO-52	nc	1.8	24.5	nc	8.0	nc	384	384	nc	nc	nc	nc
Understanding wells (7 wells sampled)												
MOJOU-01	0.3	6.1	15.0	7.3	7.2	*953	*939	*939	307	299	364	<1.0
MOJOU-02	nc	0.3	20.5	*9.6	*9.4	301	298	298	146	141	125	21.9
MOJOU-03	nc	1.1	21.0	7.5	7.4	**1,660	**1,610	**1,610	228	212	258	<1.0
MOJOU-04	2.3	0.8	24.0	8.3	8.4	*956	*952	*952	143	133	158	1.6
MOJOU-05	45	0.3	25.5	*9.7	*9.7	332	338	338	137	127	109	21.4
MOJOU-06	nc	8.0	22.0	nc	7.9	nc	608	608	nc	nc	nc	nc
MOJOU-07	nc	5.6	20.0	nc	7.1	nc	**3,080	**3,080	nc	nc	nc	nc

Table 5. Volatile organic compounds (VOC) detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all fifty-nine wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the fifty-two grid wells. All analytes are listed in *table 3A*. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; Y, analyte detected in sample and an associated blank, thus data are not included in groundwater quality assessment; µg/L, microgram per liter; na, not available; —, not detected]

GAMA well identification No.	Trihalomethane		Gasoline		Trihalomethane		Solvent		Trihalomethane		Solvent		Trihalomethane		Solvent		Solvent		
	Chloroform (Trichloromethane) (µg/L) (32106)	Bromoform (µg/L) (32101)	1,2,4-Trimethylbenzene (µg/L) (77222)	Bromodichloromethane (µg/L) (32101)	Perchloroethene (PCE, Tetrachloroethene) (µg/L) (34475)	Dibromochloromethane (µg/L) (32105)	Bromoform (Tribromomethane) (µg/L) (32104)	1,1-Dichloroethane (1,1-DCE) (µg/L) (34496)	1,2-Dichloroethane (1,2-DCE) (µg/L) (32103)	1,3-Dichlorobenzene (µg/L) (34566)	Chlorobenzene (µg/L) (34301)	MCL-US	MCL-CA	NL-CA	MCL-US	MCL-CA	HAL-US	MCL-CA	MCL-CA
MOJO-03	0.14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-09	E0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-14	—	E0.06	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-15	—	E0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-17	0.28	E0.09	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-19	E0.03	—	—	—	0.11	—	—	—	—	—	—	—	—	—	—	E0.01	—	—	—
MOJO-22	E0.05	E0.04	—	E0.04	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-25	0.47	E0.04	—	E0.04	—	—	—	—	—	—	—	—	—	—	—	—	—	—	E0.01
MOJO-26	1.31	0.72	—	0.72	—	0.7	0.47	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-27	—	—	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-30	0.18	E0.05	—	E0.05	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-32	—	—	E0.01	—	—	—	—	—	—	—	—	—	—	—	E0.04	—	—	—	—
MOJO-35	E0.04	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-39	E0.06	—	E0.02	—	E0.06	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-40	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MOJO-41	E0.05	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Threshold type	MCL-US	MCL-US	NL-CA	MCL-US	MCL-US	MCL-US	MCL-US	MCL-US	MCL-US	MCL-US	MCL-US	MCL-US	MCL-US	MCL-US	MCL-US	HAL-US	MCL-CA	MCL-CA	MCL-CA
Threshold level	'80	'80	330	'80	5	'80	'80	5	'80	'80	'80	5	0.5	600	70	[0.04]	[0.06]	[0.02]	[0.02]
[LRL]	[0.02]	[0.04]	[0.04]	[0.04]	[0.04]	[0.12]	[0.08]	[0.04]	[0.04]	[0.06]	[0.04]	[0.04]	[0.06]	[0.04]	[0.02]	[0.04]	[0.06]	[0.02]	[0.02]
Grid wells (52 wells sampled)																			

Table 5. Volatile organic compounds (VOCs) detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all fifty-nine wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the fifty-two grid wells. All analytes are listed in *table 3A*. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **GAMA well identification number:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; V, analyte detected in sample and an associated blank, thus data are not included in groundwater quality assessment; µg/L, microgram per liter; na, not available; —, not detected]

GAMA identification no.	Solvent		Solvent		Solvent		Solvent		Solvent		Solvent		Refrigerant		Organic synthesis		Gasoline		Fumigant		Methyl tert-butyl ether (MTBE) (µg/L) (78032)	Detections per well	Any VOC
	cis-1,2-Dichloroethene (cis-1,2-DCE) (µg/L) (77093)	Methylene chloride (dichloromethane) (µg/L) (34423)	Carbon tetrachloride (tetrachloromethane) (µg/L) (32102)	Tetrahydrofuran (µg/L) (81607)	trans-1,2-Dichloroethene (trans-1,2-DCE) (µg/L) (34546)	Trichloroethene (TCE) (µg/L) (39180)	Trichlorofluoromethane (CFC-11) (µg/L) (34488)	1,1-Dichloroethene (1,1-DCE) (µg/L) (34501)	Toluene (µg/L) (34010)	1,1-Dichloroethene (1,1-DCE) (µg/L) (34501)	Trichloroethene (TCE) (µg/L) (39180)	Trichlorofluoromethane (CFC-11) (µg/L) (34488)	1,1-Dichloroethene (1,1-DCE) (µg/L) (34501)	Toluene (µg/L) (34010)	Methyl tert-butyl ether (MTBE) (µg/L) (78032)	Detections per well	Any VOC						
Threshold type	MCL-CA	MCL-US	MCL-CA	na	MCL-CA	MCL-US	MCL-CA	MCL-CA	MCL-CA	MCL-US	MCL-CA	MCL-CA	MCL-CA	MCL-CA	MCL-CA	MCL-CA	MCL-CA	MCL-CA	MCL-CA	MCL-CA			
Threshold level	6	5	0.5	na	10	5	150	6	150	5	150	150	6	150	13								
[LRL]	[0.02]	[0.04]	[0.08]	[1.4]	[0.018]	[0.02]	[0.08]	[0.02]	[0.018]	[0.02]	[0.08]	[0.02]	[0.018]	[0.10]									
MOJO-41	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
MOJO-44	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
MOJO-45	—	—	—	—	—	—	—	—	—	—	E0.06	—	—	—	—	—	—	—	—	—	—	2	2
MOJO-49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
MOJO-50	0.12	—	—	—	E0.06	0.43	—	—	—	—	—	—	0.43	—	—	—	—	—	—	—	—	8	8
MOJO-52	—	—	E0.09	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	6
Number of wells with detections	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	21	21
Detection frequency (percent)	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	0	1.9	1.9	1.9	1.9	0	0	40	40
Total Detections	Understanding wells ² (7 wells sampled)																						48
MOJOU-01	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	3	3
MOJOU-03	—	—	—	3	—	—	—	—	—	—	—	—	—	—	E0.1	V0.04	—	—	—	—	—	3	3
MOJOU-05	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.06	—	—	—	—	—	1	1
MOJOU-06	—	—	—	—	—	—	—	—	—	0.11	—	—	E0.03	—	—	—	—	—	—	—	—	3	3
MOJOU-07	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1

¹ The MCL-US threshold for trihalomethanes is for the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

² Understanding wells were not included in statistical calculations.

Table 6. Pesticides and pesticide degradates detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from all fifty-nine wells were analyzed, but only samples with detections are listed. Analytes are listed in order of decreasing detection frequency in the fifty-two grid wells. All analytes are listed in *table 3B*. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. Understanding wells were not included in statistical calculations. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10⁻⁵. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; µg/L, microgram per liter; na, not available; —, not detected]

GAMA well identification No.	Simazine (µg/L) (04035)	Deethyl-atrazine (2-Chloro-4-isopropyl-amino-6-amino-s-triazine) (µg/L) (04040)	Atrazine (µg/L) (39632)	3,4-Dichloro-aniline (µg/L) (61625)	Prometon (µg/L) (04037)	Desulfinyl-fipronil (µg/L) (62170)	Dieldrin (µg/L) (39381)	Fipronil (µg/L) (62166)	Fipronil sulfide (µg/L) (62167)	Pesticide detections per well	Any pesticide
Threshold type	MCL-US	na	MCL-CA	na	HAL-US	na	RSD5-US	na	na	na	na
Threshold level	4	na	1	na	100	na	0.02	na	na	na	na
[LRL]	[0.006]	[0.014]	[0.007]	[0.006]	[0.01]	[0.012]	[0.009]	[0.02]	[0.013]		
MOJO-05	—	E0.005	—	—	—	—	—	—	—	—	1
MOJO-06	0.008	E0.005	—	—	—	—	—	—	—	—	2
MOJO-09	0.008	—	—	—	—	—	—	—	—	—	1
MOJO-12	0.008	—	—	—	—	—	—	—	—	—	1
MOJO-17	—	E0.007	—	E0.004	—	—	—	—	—	—	2
MOJO-18	E0.006	E0.007	E0.007	—	—	—	—	—	—	—	3
MOJO-19	E0.007	E0.009	E0.008	E0.006	—	—	—	—	—	—	4
MOJO-25	0.016	—	—	E0.057	E0.01	E0.004	—	E0.006	E0.005	6	
MOJO-30	E0.006	—	—	—	E0.01	—	E0.006	—	—	3	
MOJO-44	—	E0.007	—	—	—	—	—	—	—	1	
MOJO-45	E0.008	E0.007	0.008	—	—	—	—	—	—	3	

Grid wells (52 wells sampled)

Table 7. Constituents of special interest (perchlorate and *N*-nitrosodimethylamine [NDMA]) detected in samples collected in the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about the analytes given in *table 3D*. Samples from all fifty-nine wells were analyzed for perchlorate; samples from the twenty-four slow wells were sampled for NDMA; only wells with at least one detection are listed; detection frequency presented for perchlorate only. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-CA, California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** MRL, method reporting level; µg/L, microgram per liter; nc, not collected; —, not detected; *, value above threshold level]

GAMA well identification No.	Perchlorate (µg/L) (63790)	<i>N</i> -nitrosodimethylamine ¹ (NDMA) (µg/L) (34438)	GAMA well identification No.	Perchlorate (µg/L) (63790)	<i>N</i> -nitrosodimethylamine ¹ (NDMA) (µg/L) (34438)
Threshold type	MCL-CA	NL-CA	Threshold type	MCL-CA	NL-CA
Threshold level	6	0.010	Threshold level	6	0.010
[MRL]	[0.10]	[0.0020]	[MRL]	[0.10]	[0.0020]
Grid wells (52 wells sampled)			Grid wells (52 wells sampled)—Continued		
MOJO-02	0.35	nc	MOJO-31	0.15	—
MOJO-03	1.0	nc	MOJO-32	0.70	nc
MOJO-04	0.23	nc	MOJO-33	0.82	nc
MOJO-05	0.35	nc	MOJO-38	0.10	nc
MOJO-06	0.18	nc	MOJO-39	0.40	—
MOJO-07	0.78	nc	MOJO-40	0.35	nc
MOJO-08	0.38	nc	MOJO-42	—	*0.0540
MOJO-11	0.11	nc	MOJO-43	0.27	nc
MOJO-13	0.25	—	MOJO-44	2.8	nc
MOJO-16	0.12	—	MOJO-45	0.21	nc
MOJO-17	0.35	—	MOJO-46	0.41	nc
MOJO-18	0.70	—	MOJO-49	1.7	—
MOJO-19	0.33	—	MOJO-50	1.6	nc
MOJO-21	0.35	nc	Number of wells with detections	33	
MOJO-22	0.16	nc	Detection frequency (percent)	63	
MOJO-23	1.2	nc	Understanding wells ¹ (7 wells sampled)		
MOJO-24	0.31	nc	MOJOU-02	0.31	—
MOJO-25	0.17	—	MOJOU-04	0.40	—
MOJO-27	0.67	—	MOJOU-07	0.38	nc
MOJO-29	0.41	—			
MOJO-30	0.34	—			

¹ Understanding wells were not included in statistical calculations.

Table 8. Nutrients and dissolved organic carbon (DOC) detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the twenty-four slow wells were analyzed for nutrients. Samples from eight fast wells and eight slow wells were analyzed for dissolved organic carbon (DOC). All analytes are listed in *table 3E*. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. 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.” **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; mg/L, milligram per liter; na, not available; V, analyte detected in sample and an associated blank, thus data are not included in groundwater quality assessment; ≤, less than or equal to; nc, not collected; —, not detected]

GAMA well identification No.	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-nitrogen) as nitrogen (mg/L) (62854)	Phosphate, ortho-phosphate (as phosphorus) (mg/L) (00671)	Dissolved organic carbon (DOC) (mg/L) (00681)
	HAL-US	MCL-US	MCL-US	na	na	na
Threshold level	24.7	10	1	na	na	na
[LRL]	[0.02]	[0.04]	[0.002]	[0.06]	[0.006]	[0.4]
Grid wells (19 wells sampled)						
MOJO-01	nc	nc	nc	nc	nc	V0.2
MOJO-05	nc	nc	nc	nc	nc	V0.4
MOJO-06	nc	nc	nc	nc	nc	V0.3
MOJO-09	nc	nc	nc	nc	nc	0.6
MOJO-12	—	0.53	—	0.54	0.020	0.6
MOJO-13	—	0.64	—	0.65	0.010	nc
MOJO-14	E0.011	0.27	—	¹ 0.24	0.019	nc
MOJO-15	—	0.49	—	¹ 0.50	0.018	nc
MOJO-16	—	0.40	—	0.40	0.008	nc
MOJO-17	—	4.09	—	4.27	0.038	0.6
MOJO-18	—	0.57	—	¹ 0.55	0.036	V0.3
MOJO-19	—	2.63	—	2.76	0.007	V0.3
MOJO-25	—	8.94	E0.002	9.55	0.040	0.7
MOJO-26	nc	nc	nc	nc	nc	V0.3
MOJO-27	—	2.31	E0.001	¹ 2.26	0.009	nc
MOJO-29	—	1.07	—	¹ 1.04	0.011	nc
MOJO-30	E0.012	1.51	E0.001	¹ 1.49	0.022	0.5
MOJO-31	—	0.65	0.002	0.67	0.011	nc
MOJO-34	nc	nc	nc	nc	nc	V0.3
MOJO-35	—	0.91	—	0.93	0.048	nc
MOJO-36	—	0.06	0.009	E0.04	0.029	nc
MOJO-39	—	1.56	—	1.64	0.012	nc
MOJO-40	nc	nc	nc	nc	nc	—
MOJO-41	E0.011	0.12	—	¹ 0.11	0.011	V0.3
MOJO-42	—	0.47	—	¹ 0.44	0.016	nc
MOJO-49	² —	² 4.19	² —	² 4.43	² 0.015	nc
MOJO-51	nc	nc	nc	nc	nc	V0.3
Understanding wells (5 wells sampled)						
MOJOU-01	—	4.00	—	4.19	E0.005	nc
MOJOU-02	0.021	—	—	—	0.034	nc
MOJOU-03	0.028	5.84	0.016	6.07	0.079	nc
MOJOU-04	—	0.18	—	0.18	0.016	nc
MOJOU-05	0.055	≤0.02	—	0.08	0.074	nc
MOJOU-07	nc	nc	nc	nc	nc	V0.4

¹ 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.

²Storage refrigerator exceeded maximum allowable temperature at NWQL before sample analysis.

Table 9. Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the twenty-four slow wells were analyzed. Information about analytes given in *table 3F*. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. Bicarbonate and carbonate concentrations were calculated from the laboratory measured alkalinity and pH values using the advanced speciation method (<http://or.water.usgs.gov/alk/methods.htm>) with $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_w = 14$. See *table 4* for the results of the preferred method (samples for which field alkalinities were performed). **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. The SMCL-CA for chloride, sulfate, and total dissolved solids (TDS) have recommended and upper threshold values. The upper value is shown in parentheses. MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** LRL, laboratory reporting level; mg/L, milligrams per liter; E, estimated or having a higher degree of uncertainty; na, not available; —, not detected; <, less than; *, value above threshold level; **, value above upper threshold level]

GAMA well identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Bicarbonate (mg/L)	Carbonate (mg/L)	Bromide (mg/L) (71870)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica, as SiO ₂ (mg/L) (00955)	Sulfate (mg/L) (00945)	Residue on evaporation (TDS) (mg/L) (70300)
Threshold type	na	na	na	na	na	na	na	SMCL-CA	MCL-CA	na	na	SMCL-CA	SMCL-CA
Threshold level	na	na	na	na	na	na	na	250 (500)	2	na	na	250 (500)	500 (1,000)
[LRL]	[0.04]	[0.02]	[0.02]	[0.12]	[1]	[1]	[0.02]	[0.12]	[0.12]	[0.002]	[0.018]	[0.18]	[10]
Grid wells (19 wells sampled)													
MOJO-12	60.1	8.19	2.09	57.6	210	<1.0	0.09	39.8	0.32	0.004	26.0	75.2	383
MOJO-13	72.3	11.0	4.37	93.5	22	20.8	0.12	58.3	0.41	0.013	16.3	*295	*612
MOJO-14	3.93	0.299	0.62	48.8	102	10.5	0.02	3.88	0.49	0.006	17.5	9.24	146
MOJO-15	0.95	E0.018	0.34	47.2	85	15.1	E0.02	4.96	0.52	—	18.4	3.18	133
MOJO-16	10.9	0.574	1.24	28.6	96	1.3	0.03	6.17	0.16	—	20.2	2.69	117
MOJO-17	48.2	9.1	2.13	22.5	133	<1.0	0.09	34.6	0.35	—	25.9	25.7	263
MOJO-18	24.1	3.95	1.49	12.7	79	<1.0	0.05	15.6	0.27	—	25.7	13.6	144
MOJO-19	23.3	1.72	1.46	68.0	80	1.1	0.20	51.7	0.60	E0.001	16.8	56.9	277
MOJO-25	53.7	8.96	1.73	60.5	175	<1.0	0.11	59.7	0.62	0.013	28.3	52.7	414
MOJO-27	5.07	0.479	1.26	38.0	82	4.0	0.05	10.0	0.54	0.004	15.4	4.89	129
MOJO-29	155	40.9	5.96	335	104	5.0	1.21	**639	0.41	0.006	33.2	*309	**1,660
MOJO-30	25.6	4.36	1.94	80.2	92	1.0	0.14	30.3	0.71	0.003	20.0	128	357
MOJO-31	27.9	5.33	2.81	60.4	107	1.0	E0.02	3.06	0.30	0.004	16.1	134	316
MOJO-35	46.7	8.09	2.67	66.7	180	<1.0	0.24	50.5	0.70	—	23.2	67.1	366
MOJO-36	19.2	3.21	2.4	89.5	184	1.0	0.09	36.8	1.94	0.035	40.8	49.9	341
MOJO-39	116	22.3	4.63	188	190	1.0	0.58	215	1.32	0.014	33.9	*306	**1,050
MOJO-41	58.8	6.44	1.14	84.2	232	1.0	0.19	84.2	0.26	—	27.5	48.7	435
MOJO-42	33.2	5.25	1.96	56.2	183	1.0	0.06	23.4	0.65	E0.001	29.2	39.1	279

Table 9. Major and minor ions, silica, and total dissolved solids (TDS) detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the twenty-four slow wells were analyzed. Information about analytes given in *table 3F*. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. Bicarbonate and carbonate concentrations were calculated from the laboratory measured alkalinity and pH values using the advanced speciation method (<http://or.water.usgs.gov/alk/methods.htm>) with $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_w = 14$. See *table 4* for the results of the preferred method (samples for which field alkalinities were performed). **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. The SMCL-CA for chloride, sulfate, and total dissolved solids (TDS) have recommended and upper threshold values. The upper value is shown in parentheses. MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** LRL, laboratory reporting level; mg/L, milligrams per liter; E, estimated or having a higher degree of uncertainty; na, not available; —, not detected; <, less than; *, value above threshold level; **, value above upper threshold level]

GAMA well identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Bicarbonate (mg/L)	Carbonate (mg/L)	Bromide (mg/L) (71870)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica, as SiO ₂ (mg/L) (00955)	Sulfate (mg/L) (00945)	Residue on evaporation (TDS) (mg/L) (70300)	
													SMCL-CA	SMCL-CA
Threshold type	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Threshold level	na	na	na	na	na	na	na	250 (500)	2	na	na	250 (500)	500 (1,000)	
[LRL]	[0.04]	[0.02]	[0.02]	[0.12]	[1]	[1]	[0.02]	[0.12]	[0.12]	[0.002]	[0.018]	[0.18]	[10]	
MOJO-49	122	51.0	14.4	463	148	<1.0	0.55	214	*2.61	0.012	48.6	**1,120	**2,240	
Understanding wells (5 wells sampled)														
MOJOU-01	134	39.1	5.93	14.6	373	<1.0	0.04	23.7	0.37	—	14.1	173	*623	
MOJOU-02	0.89	0.031	0.27	64.7	126	24.2	—	1.69	1.76	0.014	18.1	2.32	184	
MOJOU-03	147	22.9	4.29	169	277	<1.0	0.49	185	0.44	0.099	22.6	*276	**1,050	
MOJOU-04	13.0	0.664	2.68	177	170	1.8	0.12	77.2	*4.52	0.004	29.2	180	*581	
MOJOU-05	1.26	E0.016	0.26	76.3	114	25.0	E0.02	1.98	*2.81	0.061	21.0	21.2	207	

Table 10. Trace elements collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the twenty-four slow wells were analyzed. All analytical data are listed in *Table 10*. GAMA Identification No.: MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. The threshold type parameter code is listed in *Table 10* as of April 2, 2008. Threshold type: Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. Other abbreviations: E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting limit; µg/L, microgram per liter; na, not available; —, not detected; ≤, less than or equal to; *, value above threshold level]

GAMA well identification No.	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead
	(µg/L) (01106)	(µg/L) (01095)	(µg/L) (01000)	(µg/L) (01005)	(µg/L) (01010)	(µg/L) (01020)	(µg/L) (01025)	(µg/L) (01030)	(µg/L) (01035)	(µg/L) (01040)	(µg/L) (01046)	(µg/L) (01049)
Threshold type	MCL-CA	MCL-US	MCL-US	MCL-CA	MCL-US	NL-CA	MCL-US	MCL-CA	na	AL-US	SMCL-CA	AL-US
Threshold level	1,000	6	10	1,000	4	1,000	5	50	na	1,300	300	15
[LRL/SRL]	[1.6]	[0.14]	[0.06]	[0.36]	[0.008]	[6]	[0.04]	[0.42]	[0.02]	[1.7]	[6]	[0.65]
Grid wells (19 wells sampled)												
MOJO-12	—	—	1.3	61	—	94	—	≤0.07	0.18	≤1.1	≤6	≤0.08
MOJO-13	—	0.15	1.6	45	—	15	—	6.0	E0.01	—	—	≤0.11
MOJO-14	14.1	—	*12.6	5.0	—	45	—	3.3	—	—	—	≤0.08
MOJO-15	35.4	0.15	*17.1	0.62	—	21	—	11.3	—	≤0.83	—	≤0.12
MOJO-16	4.1	—	0.85	10	—	8	—	7.6	—	—	—	≤0.08
MOJO-17	—	—	0.25	47	—	18	—	≤0.23	—	≤1.2	—	≤0.50
MOJO-18	—	—	0.18	25	—	11	—	≤0.37	—	≤1.1	—	≤0.58
MOJO-19	3.1	—	4.7	37	—	146	—	4.4	—	≤0.72	—	≤0.11
MOJO-25	≤1.0	E0.09	4.3	89	E0.01	191	E0.03	≤0.23	0.56	2.0	11	1.55
MOJO-27	12.7	—	2.9	6.0	—	11	—	14.6	—	—	—	≤0.04
MOJO-29	—	—	1.1	29	—	*1,280	—	4.0	0.10	—	18	0.70
MOJO-30	≤1.0	E0.09	*14.6	50	—	85	—	2.3	E0.02	—	22	≤0.35
MOJO-31	7.5	E0.09	2.9	23	E0.01	19	—	1.4	E0.02	—	≤6	≤0.53
MOJO-35	9.0	—	1.6	75	—	383	—	1.3	0.03	—	≤6	—
MOJO-36	—	E0.09	*50.5	40	—	639	—	≤0.08	—	≤0.88	—	≤0.34
MOJO-39	—	—	*19.7	45	—	771	E0.03	1.8	0.04	—	15	≤0.36
MOJO-41	—	—	1.5	152	—	154	—	2.0	0.02	≤0.75	—	0.99
MOJO-42	≤0.8	—	1.5	53	—	252	—	8.2	E0.01	≤0.86	—	≤0.61
MOJO-49	E1.8	0.55	*27.4	12	—	*5,690	0.10	4.6	0.06	≤1.4	—	1.95
Understanding wells (5 wells sampled)												
MOJOU-01	≤1.0	—	0.12	32	E0.01	23	E0.02	≤0.37	0.07	2.3	≤6	3.10
MOJOU-02	28.7	E0.08	*39.8	0.82	—	148	—	—	—	—	—	—
MOJOU-03	6.4	E0.09	2.6	38	—	748	0.06	0.54	6.0	≤1.0	—	≤0.17
MOJOU-04	≤1.2	0.31	*68.7	19	—	857	0.04	1.2	—	—	—	—
MOJOU-05	36.5	E0.08	*62.2	2.0	—	145	0.05	—	—	—	≤6	—

Table 10. Trace elements collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008. —Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the twenty-four slow wells were analyzed. All analytes are listed in *table 3F. GAMA well identification*. No.: MOJO, Mojave study unit grid well; MOJOU, Mojave study unit grid well; MOJOU, Mojave study unit grid well. Threshold type and threshold level as of April 2, 2008. **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated or having a higher degree of uncertainty; LRL, laboratory reporting level; SRL, study reporting limit; µg/L, microgram per liter; na, not available; —, not detected; ≤, less than or equal to; *, value above threshold level]

GAMA well identification No.	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)	Threshold type	
													SMCL-CA	SMCL-CA
	na	50	40	100	50	100	4,000	2	na	30	50	5,000	MCL-US	MCL-CA
[LRL/SRL]	[1]	[0.2]	[0.2]	[0.36]	[0.04]	[0.1]	[0.8]	[0.04]	[0.11]	[0.02]	[0.11]	[4.8]	[0.02]	[0.11]
Grid wells (19 wells sampled)														
MOJO-12	4.1	0.8	2.2	0.39	—	—	464	—	0.12	8.88	4.0	≤2.9	—	—
MOJO-13	1.8	0.6	4.6	≤0.15	1.6	—	1,210	—	0.19	1.20	15.3	≤4.7	—	—
MOJO-14	2.8	—	4.5	—	0.11	—	96.7	—	0.62	1.21	43.6	—	—	—
MOJO-15	1.7	—	1.6	—	0.13	—	18.2	—	0.69	0.80	*126	—	—	—
MOJO-16	1.8	—	—	—	0.07	—	192	—	E0.04	0.73	27.7	—	—	—
MOJO-17	6.3	≤0.1	0.9	≤0.12	0.06	—	418	—	—	7.24	1.9	≤2.1	—	—
MOJO-18	5.2	—	0.8	—	E0.03	—	206	—	—	0.74	2.1	≤1.6	—	—
MOJO-19	6.9	≤0.2	1.3	—	0.41	—	410	—	0.79	2.04	37.0	≤2.0	—	—
MOJO-25	11.6	0.6	5.7	2.3	0.06	—	1,310	—	0.37	1.73	12.5	17.6	—	—
MOJO-27	2.4	—	2.0	—	0.57	—	152	—	0.16	0.59	40.2	—	—	—
MOJO-29	42.8	1.0	3.1	0.91	1.0	—	2,150	—	0.27	3.94	8.1	79.6	—	—
MOJO-30	12.3	3.0	5.3	≤0.15	1.1	—	870	—	3.9	1.38	15.0	≤2.5	—	—
MOJO-31	6.1	1.9	3.0	≤0.11	1.9	—	429	—	0.22	1.06	24.6	6.9	—	—
MOJO-35	9.6	0.4	4.4	≤0.29	0.34	—	499	—	0.24	10.8	6.8	—	—	—
MOJO-36	39.3	17.4	9.9	—	0.32	—	268	—	2.2	2.72	16.5	≤2.8	—	—
MOJO-39	89.9	1.3	11.6	0.42	1.9	—	2,480	—	4.3	12.6	14.4	≤3.8	—	—
MOJO-41	16.6	0.4	1.2	≤0.18	0.13	—	684	—	0.06	7.27	11.5	32.1	—	—
MOJO-42	15.7	1.3	5.8	≤0.12	0.13	—	331	—	0.13	8.68	7.7	≤1.0	—	—
MOJO-49	429	0.6	*55.9	0.68	3.2	—	*8,210	—	0.15	4.17	10.9	145	—	—
Understanding wells (5 wells sampled)														
MOJOU-01	4.2	≤0.2	4.0	0.71	2.6	—	976	—	—	3.08	0.86	≤4.6	—	—
MOJOU-02	2.1	0.4	4.0	—	—	—	17.6	—	3.5	3.14	*190	—	—	—
MOJOU-03	31.1	*111	5.3	10.6	0.50	—	1,630	—	1.0	*36.2	3.7	≤2.8	—	—
MOJOU-04	21.2	0.4	37.6	—	0.18	—	172	—	15.2	2.39	27.6	—	—	—
MOJOU-05	1.5	0.5	20.6	—	—	—	34.3	—	9.2	0.13	2.6	—	—	—

¹Study reporting limit (SRL) defined based on examination of GAMA quality-control samples collected from May 2004 through January 2008 (L.D. Olsen and M.S. Fram, U.S. Geological Survey, unpub. data, 2009). Values below 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).

Table 11. Species of inorganic arsenic, chromium, and iron detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[Data in this table analyzed at U.S. Geological Survey (USGS) Trace Metals Laboratory using research methods and are not stored in the USGS NWIS database. Information about analytes given in *table 3G*. Samples from the twenty-four slow wells were analyzed; only wells with at least one detection are listed. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA, California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** MDL, method detection limit; na, not available; µg/L, microgram per liter; —, not detected; *, value above threshold level]

GAMA well identification No.	Iron (µg/L)	Iron (II) (µg/L)	Arsenic (µg/L)	Arsenic (III) (µg/L)	Chromium (µg/L)	Chromium (VI) (µg/L)
Threshold type	SMCL-CA	na	MCL-US	na	MCL-CA	na
Threshold level	300	na	10	na	50	na
[MDL]	[2]	[2]	[0.5]	[1]	[1]	[1]
Grid wells (19 wells sampled)						
MOJO-12	7	4	0.83	—	—	—
MOJO-13	3	—	0.73	—	7	4
MOJO-14	—	—	8.5	1	3	3
MOJO-15	—	—	*13	—	12	10
MOJO-16	—	—	—	—	8	8
MOJO-19	—	—	3.1	—	5	4
MOJO-25	7	3	2.7	—	—	—
MOJO-27	—	—	1.3	—	18	16
MOJO-29	18	3	—	—	5	4
MOJO-30	17	5	7.3	—	3	2
MOJO-31	4	—	1.6	—	1	1
MOJO-35	8	—	0.71	—	1	1
MOJO-36	—	—	*27	—	—	—
MOJO-39	13	5	*13	—	2	2
MOJO-41	3	—	0.65	—	2	2
MOJO-42	—	—	0.57	—	10	9
MOJO-49	8	—	10	—	5	5
Understanding wells (5 wells sampled)						
MOJOU-01	4	—	—	—	—	—
MOJOU-02	—	—	*25	—	—	—
MOJOU-03	—	—	1.4	—	—	—
MOJOU-04	—	—	*32	—	2	1
MOJOU-05	—	—	*39	17	—	—

Table 12. Results for analyses of stable isotope ratios and tritium and carbon-14 activities detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about analytes given in *table 3H*. Samples from all fifty-nine wells were analyzed for stable isotopes of water and tritium; samples from twenty-three of the slow wells were analyzed for carbon activities; samples from twenty-two of the slow wells were analyzed for isotopes of nitrate. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** na, not available; nc, not collected; pCi/L, picocuries per liter; <, less than]

GAMA well identification No.	$\delta^2\text{H}$ (per mil) (82082)	$\delta^{18}\text{O}$ (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{15}\text{N}$ of nitrate ¹ (per mil) (82690)	$\delta^{18}\text{O}$ of nitrate ¹ (per mil) (63041)	$\delta^{13}\text{C}^2$ (per mil) (82081)	Carbon-14 ² (percent modern) (49933)
Threshold type	na	na	MCL-CA	na	na	na	na
Threshold level	na	na	20,000	na	na	na	na
Grid wells (52 wells sampled)							
MOJO-01	-63.00	-9.38	<1.0	nc	nc	nc	nc
MOJO-02	-88.70	-11.90	<1.0	nc	nc	nc	nc
MOJO-03	-88.20	-11.77	<1.0	nc	nc	nc	nc
MOJO-04	-58.90	-8.81	<1.0	nc	nc	nc	nc
MOJO-05	-62.30	-8.87	8.6	nc	nc	nc	nc
MOJO-06	-62.80	-9.28	5.1	nc	nc	nc	nc
MOJO-07	-72.60	-10.40	<1.0	nc	nc	nc	nc
MOJO-08	-82.40	-11.66	<1.0	nc	nc	nc	nc
MOJO-09	-71.00	-9.71	2.6	nc	nc	nc	nc
MOJO-10	-90.00	-12.53	<1.0	nc	nc	nc	nc
MOJO-11	-82.50	-11.75	<1.0	nc	nc	nc	nc
MOJO-12	-62.20	-8.81	1.6	11.96	6.10	-12.95	96.57
MOJO-13	-82.30	-11.76	<1.0	18.39	10.04	-10.00	8.97
MOJO-14	-67.50	-9.88	<1.0	4.53	-0.70	-11.39	48.32
MOJO-15	-63.70	-9.54	<1.0	3.74	-0.15	-13.16	38.63
MOJO-16	-57.70	-8.74	<1.0	2.76	-0.85	-13.71	63.64
MOJO-17	-60.90	-8.50	9.6	7.65	1.26	-12.47	113.00
MOJO-18	-63.20	-9.31	9.3	3.11	1.50	-11.38	104.60
MOJO-19	-65.60	-9.68	1	7.66	1.34	-11.17	61.12
MOJO-20	-83.70	-11.73	<1.0	nc	nc	nc	nc
MOJO-21	-83.20	-11.67	<1.0	nc	nc	nc	nc
MOJO-22	-89.30	-12.35	<1.0	nc	nc	nc	nc
MOJO-23	-78.20	-10.18	<1.0	nc	nc	nc	nc
MOJO-24	-86.20	-11.97	<1.0	nc	nc	nc	nc
MOJO-25	-66.30	-9.40	2.2	16.40	3.44	-13.97	81.24
MOJO-26	-62.90	-8.90	1.6	nc	nc	nc	nc
MOJO-27	-72.00	-10.31	<1.0	3.70	0.98	-12.39	18.14
MOJO-28	-79.50	-11.42	10.9	nc	nc	nc	nc
MOJO-29	-85.90	-11.48	<1.0	8.78	-0.21	-10.25	26.54
MOJO-30	-80.30	-11.09	1.0	7.30	3.08	-11.52	35.72

Table 12. Results for analyses of stable isotope ratios and tritium and carbon-14 activities detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.—Continued

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Information about analytes given in *table 3H*. Samples from all fifty-nine wells were analyzed for stable isotopes of water and tritium; samples from twenty-three of the slow wells were analyzed for carbon activities; samples from twenty-two of the slow wells were analyzed for isotopes of nitrate. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** na, not available; nc, not collected; pCi/L, picocuries per liter; <, less than]

GAMA well identification No.	$\delta^2\text{H}$ (per mil) (82082)	$\delta^{18}\text{O}$ (per mil) (82085)	Tritium (pCi/L) (07000)	$\delta^{15}\text{N}$ of nitrate ¹ (per mil) (82690)	$\delta^{18}\text{O}$ of nitrate ¹ (per mil) (63041)	$\delta^{13}\text{C}^2$ (per mil) (82081)	Carbon-14 ² (percent modern) (49933)
Threshold type	na	na	MCL-CA	na	na	na	na
Threshold level	na	na	20,000	na	na	na	na
MOJO-31	-83.70	-11.7	<1.0	9.05	6.48	-12.36	27.81
MOJO-32	-66.00	-9.30	<1.0	nc	nc	nc	nc
MOJO-33	-90.60	-11.96	<1.0	nc	nc	nc	nc
MOJO-34	-58.10	-8.27	8.3	nc	nc	nc	nc
MOJO-35	-61.10	-8.61	1.0	7.62	1.68	-11.11	90.49
MOJO-36	-62.10	-8.62	<1.0	16.65	6.36	-8.64	36.03
MOJO-37	-60.90	-8.59	<1.0	nc	nc	nc	nc
MOJO-38	-59.30	-8.39	<1.0	nc	nc	nc	nc
MOJO-39	-66.60	-8.86	<1.0	8.20	-0.46	-7.63	71.89
MOJO-40	-73.90	-9.70	<1.0	nc	nc	nc	nc
MOJO-41	-51.70	-6.52	<1.0	6.17	-1.70	-13.16	81.57
MOJO-42	-61.00	-8.64	<1.0	5.25	-1.14	-11.94	87.91
MOJO-43	-87.40	-11.58	<1.0	nc	nc	nc	nc
MOJO-44	-60.50	-8.45	1.0	nc	nc	nc	nc
MOJO-45	-61.00	-8.67	2.9	nc	nc	nc	nc
MOJO-46	-63.00	-9.27	2.6	nc	nc	nc	nc
MOJO-47	-87.70	-12.10	<1.0	nc	nc	nc	nc
MOJO-48	-93.10	-12.91	<1.0	nc	nc	nc	nc
MOJO-49	-88.00	-10.78	<1.0	9.44	3.43	nc	nc
MOJO-50	-63.50	-8.98	6.7	nc	nc	nc	nc
MOJO-51	-54.10	-7.16	<1.0	nc	nc	nc	nc
MOJO-52	-59.00	-8.45	<1.0	nc	nc	nc	nc
Understanding wells (5 wells sampled)							
MOJOU-01	-81.00	-11.42	8.3	7.76	-1.71	-12.13	91.28
MOJOU-02	-86.00	-12.14	<1.0	nc	nc	-9.12	1.99
MOJOU-03	-61.40	-8.03	6.7	17.46	9.03	-12.87	91.96
MOJOU-04	-84.10	-11.51	<1.0	6.58	2.39	-10.02	19.00
MOJOU-05	-95.90	-13.17	<1.0	nc	nc	-11.71	1.85
MOJOU-06	-60.50	-8.45	1.0	nc	nc	nc	nc
MOJOU-07	-70.50	-9.37	2.2	nc	nc	nc	nc

¹Isotopes of nitrate were sampled at 22 slow wells.

²Carbon activities were sampled for at the 24 slow wells.

Table 13A. Radium isotope activity levels detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the twenty-four slow wells were analyzed. *Table 3H* contains additional information about the analytes. Values less than the sample-specific critical level (ssL_c) are reported as non-detections (—). **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocurie per liter; —, not detected; \leq , less than or equal to]

GAMA well identification No.	Radium-226 (pCi/L) (09511)		Radium-228 (pCi/L) (81366)	
	MCL-US		MCL-US	
	15		15	
Threshold type				
Threshold level	result \pm CSU	ssL_c	result \pm CSU	ssL_c
Grid wells (19 wells sampled)				
MOJO-12	0.113 \pm 0.016	0.017	—	0.22
MOJO-13	0.072 \pm 0.037	0.017	—	0.23
MOJO-14	0.056 \pm 0.013	0.016	—	0.23
MOJO-15	\leq 0.038 \pm 0.012	0.014	—	0.22
MOJO-16	\leq 0.034 \pm 0.012	0.016	—	0.25
MOJO-17	0.069 \pm 0.016	0.018	0.30 \pm 0.11	0.25
MOJO-18	0.055 \pm 0.014	0.014	—	0.26
MOJO-19	0.077 \pm 0.017	0.018	—	0.25
MOJO-25	0.045 \pm 0.012	0.014	0.25 \pm 0.076	0.18
MOJO-27	\leq 0.020 \pm 0.011	0.013	—	0.20
MOJO-29	0.120 \pm 0.021	0.013	0.68 \pm 0.092	0.18
MOJO-30	0.063 \pm 0.014	0.013	0.26 \pm 0.091	0.22
MOJO-31	\leq 0.040 \pm 0.012	0.013	—	0.22
MOJO-35	0.164 \pm 0.024	0.016	0.23 \pm 0.086	0.21
MOJO-36	0.119 \pm 0.019	0.014	—	0.22
MOJO-39	0.065 \pm 0.015	0.014	0.38 \pm 0.100	0.22
MOJO-41	0.133 \pm 0.021	0.016	0.32 \pm 0.082	0.19
MOJO-42	\leq 0.020 \pm 0.012	0.016	—	0.17
MOJO-49	\leq 0.023 \pm 0.011	0.015	—	0.20
Understanding wells (5 wells sampled)				
MOJOU-01	0.082 \pm 0.015	0.015	0.43 \pm 0.100	0.23
MOJOU-02	—	0.017	—	0.18
MOJOU-03	0.059 \pm 0.015	0.017	0.35 \pm 0.097	0.19
MOJOU-04	0.046 \pm 0.015	0.017	0.20 \pm 0.071	0.17
MOJOU-05	—	0.016	—	0.19

¹The MCL-US threshold for radium is the sum of radium-226 and radium-228.

Table 13B. Gross alpha and gross beta radioactivity detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the twenty-four slow wells were analyzed. *Table 3H* contains additional information about the analytes. The reference nuclide for measurement of gross alpha is thorium-230 and the reference nuclide for measurement of gross beta is cesium-137. Measured values less than the sample-specific critical level (ssL_c) are reported as non-detections (—). **GAMA Identification number:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocurie per liter; —, not detected; *, value above threshold 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)	
	MCL-US		MCL-US		MCL-CA		MCL-CA	
Threshold level	15		15		50		50	
	result ± CSU	ssL_c	result ± CSU	ssL_c	result ± CSU	ssL_c	result ± CSU	ssL_c
Grid wells (19 wells sampled)								
MOJO-12	11.1 ± 1.6	0.70	8.60 ± 1.4	0.44	2.60 ± 0.61	0.77	4.86 ± 0.77	0.85
MOJO-13	—	1.7	1.04 ± 1.1	1.7	4.97 ± 0.78	1.0	6.90 ± 1.1	1.2
MOJO-14	1.25 ± 0.51	0.50	0.73 ± 0.48	0.59	0.88 ± 0.40	0.60	—	1.0
MOJO-15	0.71 ± 0.35	0.34	0.82 ± 0.47	0.82	—	0.59	—	0.71
MOJO-16	1.20 ± 0.49	0.49	1.43 ± 0.48	0.37	1.47 ± 0.46	0.68	1.11 ± 0.39	0.59
MOJO-17	9.40 ± 1.5	0.60	2.98 ± 0.81	0.53	2.77 ± 0.77	1.1	4.00 ± 0.54	0.66
MOJO-18	2.43 ± 0.70	0.61	—	0.63	1.56 ± 0.61	1.0	—	0.99
MOJO-19	5.00 ± 1.1	0.77	3.15 ± 0.86	0.67	1.61 ± 0.66	1.0	1.91 ± 0.46	0.66
MOJO-25	1.86 ± 0.77	0.99	—	0.69	2.41 ± 0.51	0.80	2.67 ± 0.86	1.3
MOJO-27	—	0.45	0.88 ± 0.35	0.36	1.62 ± 0.41	0.58	1.58 ± 0.41	0.58
MOJO-29	11.0 ± 3.1	2.9	8.00 ± 2.7	2.8	3.55 ± 0.50	0.68	3.18 ± 0.67	1.1
MOJO-30	2.96 ± 0.95	0.82	1.62 ± 0.82	0.97	2.18 ± 0.48	0.66	2.42 ± 0.49	0.67
MOJO-31	2.11 ± 0.69	0.56	1.20 ± 0.61	0.65	2.50 ± 0.49	0.67	2.60 ± 0.49	0.66
MOJO-35	11.4 ± 1.7	0.63	11.0 ± 1.8	1.2	3.10 ± 0.58	0.77	6.84 ± 0.84	1.1
MOJO-36	4.38 ± 0.92	0.71	4.05 ± 0.86	0.54	1.82 ± 0.71	1.0	3.64 ± 0.50	0.64
MOJO-39	*18.0 ± 3.2	2.5	*18.2 ± 3.2	2.2	6.17 ± 0.69	0.81	8.69 ± 0.81	0.86
MOJO-41	11.5 ± 1.8	0.69	5.40 ± 0.86	1.1	2.41 ± 0.57	0.80	3.75 ± 0.59	0.81
MOJO-42	10.6 ± 1.5	0.60	8.50 ± 1.3	0.53	2.37 ± 0.42	0.56	4.45 ± 0.65	0.85
MOJO-49	7.10 ± 3.2	3.7	8.90 ± 3.4	4.0	15.5 ± 1.5	1.6	14.0 ± 1.3	1.3
Understanding wells (5 wells sampled)								
MOJOU-01	—	2.1	2.44 ± 0.84	0.71	5.33 ± 0.76	0.99	6.70 ± 0.75	0.90
MOJOU-02	3.09 ± 0.82	0.63	4.58 ± 0.93	0.42	—	0.61	1.58 ± 0.43	0.62
MOJOU-03	*29.1 ± 4.3	2.3	*29.1 ± 4.3	2.0	4.48 ± 0.60	0.78	4.24 ± 0.88	1.3
MOJOU-04	— ⁽¹⁾	0.65	1.70 ± 1.0	1.0	— ⁽¹⁾	0.70	4.16 ± 0.98	1.4
MOJOU-05	—	0.67	—	0.58	—	0.70	—	0.64

¹72-hour holding time exceeded by 2 days.

Table 13C. Radon-222 detected in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[The five-digit U.S. Geological Survey (USGS) parameter code below the constituent name is used to uniquely identify a specific constituent or property. Samples from the twenty-four slow wells were analyzed. *Table 3I* contains additional information about the analytes. Two MCLs have been proposed for Radon-222. The proposed alternative MCL is in parentheses. **GAMA well identification No.:** MOJO, Mojave study unit grid well; MOJOU, Mojave study unit understanding well. Threshold type and threshold level as of April 2, 2008. **Threshold type:** Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists. MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** 2SCU, 2-sigma combined uncertainty; pCi/L, picocurie per liter; *, value above threshold level]

GAMA well identification No.	Radon-222 (pCi/L) (82303)
Threshold type	proposed MCL-US
Threshold level	2 300 (4,000)
result \pm 2SCU	
Grid wells (19 wells sampled)	
MOJO-12	*500 \pm 23
MOJO-13	*600 \pm 23
MOJO-14	*520 \pm 21
MOJO-15	*460 \pm 21
MOJO-16	*430 \pm 23
MOJO-17	*780 \pm 22
MOJO-18	*740 \pm 20
MOJO-19	*600 \pm 20
MOJO-25	*380 \pm 23
MOJO-27	*450 \pm 22
MOJO-29	*380 \pm 23
MOJO-30	300 \pm 21
MOJO-31	*350 \pm 23
MOJO-35	*560 \pm 28
MOJO-36	300 \pm 24
MOJO-39	*650 \pm 21
MOJO-41	*380 \pm 21
MOJO-42	*540 \pm 24
MOJO-49	*550 \pm 23
Understanding wells (5 wells sampled)	
MOJOU-01	*340 \pm 23
MOJOU-02	230 \pm 23
MOJOU-03	*570 \pm 24
MOJOU-04	*310 \pm 27
MOJOU-05	190 \pm 22

Appendix

Appendix

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

Sample Collection and Analysis

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

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 also located upstream of well-head treatment systems (if any) for all sites except for MOJO-22, which had a down-hole chlorination system that could not be turned off prior to groundwater sampling. For the fast (and fast plus DOC) schedules, samples were collected at the well head using a foot-long length of Teflon tubing. For the slow (and slow plus DOC) schedules, the samples were 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 fitted with a multi-probe meter that simultaneously measures the water-quality indicators (field parameters) —dissolved oxygen, temperature, pH, turbidity, and specific conductance. Turbidity was measured in the field with a calibrated turbidity meter. Field measurements were made in accordance with protocols in the USGS National Field Manual (Radtke and others, 2005; Wilde and Radtke, 2005; Lewis, 2006; Wilde, 2006; Wilde and others, 2006). All sensors on the multi-probe meter were calibrated daily. Measured temperature, dissolved oxygen, pH, specific conductance and turbidity values were recorded at 5-minute intervals for at least 30 minutes, and when these values remained stable for 20 minutes, samples for laboratory analyses then were collected.

Field measurements and instrument calibrations were recorded by hand on field record sheets and electronically in PCFF, a software package designed by the USGS with support from the GAMA program. Analytical service requests also were managed by PCFF. Information from PCFF was

uploaded directly into NWIS at the end of every week of sample collection.

For analyses requiring filtered water, groundwater was diverted through a 0.45- μm pore size vented capsule filter, a disk filter, or a baked glass-fiber filter depending on the protocol for the analysis (Wilde and others, 1999; 2004). Both perchlorate and chromium (abundance and speciation) samples required filtering using a small 0.45- μm pore sized disk filter attached to a syringe. Prior to sample collection, polyethylene sample bottles were pre-rinsed two times using deionized water, and then once with sample water before sample collection. Samples requiring acidification were acidified to a pH of 2 or less with the appropriate acids using ampoules of certified, traceable concentrated acids obtained from the NWQL.

Temperature-sensitive samples were stored on ice prior to, and during daily shipping to the various laboratories. The non-temperature sensitive samples for tritium, noble gases, chromium speciation, and stable isotopes of hydrogen and oxygen in water were shipped monthly, while temperature-sensitive samples for volatile organic compounds, pesticides, perchlorate, NDMA, dissolved organic carbon (DOC), radium isotopes, gross alpha and gross beta radioactivity, and radon-222 samples were shipped daily. The temperature-sensitive samples for stable isotopes of nitrogen and oxygen in nitrate and arsenic and iron speciation were stored on ice, archived in a laboratory freezer, and shipped after results for nitrate and the metal concentrations were received from the NWQL.

Detailed sampling protocols for individual analyses and groups of analytes are described in Koterba and others (1995), the USGS National Field Manual (Wilde and others, 1999; 2004), and in the references for analytical methods listed in *table A1*; only brief descriptions are given here. Volatile organic compounds (VOCs) samples were collected in 40-mL sample vials that were purged with three vial volumes of sample water before bottom filling to eliminate atmospheric contamination. Six normal (6-N) hydrochloric acid (HCl) was added as a preservative to the VOC samples. Each sample to be analyzed for perchlorate was collected in a 125-mL polystyrene bottle and then filtered in two or three 20-mL aliquots through a syringe-tip filter into a sterilized 125-mL bottle. Tritium samples were collected by bottom filling one 1-L polyethylene bottle and one 1-L glass bottle with unfiltered groundwater, after first overfilling the bottles with three volumes of water. Samples for analysis of stable isotopes of hydrogen and oxygen in water were collected in a 60-mL clear glass bottle filled with unfiltered water, sealed with a conical cap, and secured with electrical tape to prevent leakage and evaporation.

Pesticides and pesticide degradation products, pharmaceutical compounds, and NDMA samples were collected in 1-L baked amber bottles. Pesticide and pharmaceutical samples were filtered through a 0.3- μm nominal pore-size glass fiber filter during collection, whereas the NDMA samples were filtered at Weck Laboratories, Inc. prior to analysis. Samples of NDMA were collected in containers treated with 0.05 g of sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$).

Groundwater samples for major and minor ions, trace elements, alkalinity, and total dissolved solids (TDS) analyses required filling one 250-mL polyethylene bottle with untreated groundwater, and one 500-mL and one 250-mL polyethylene bottle with filtered groundwater (Wilde and others, 2004). Filtration was done using a 0.45- μm pore-size Whatman capsule filter. The 250-mL filtered sample then was preserved with 7.5-N nitric acid. Arsenic and iron speciation samples were filtered into a 250-mL polyethylene bottle that was covered with tape to prevent light exposure and preserved with 6-N hydrochloric acid. The nutrient and stable isotopes of nitrogen and oxygen in nitrate samples each were filtered into 125-mL brown polyethylene bottles. Radium isotopes and gross alpha and gross beta radiation samples were filtered into 1-L polyethylene bottles and acidified with nitric acid. Carbon isotope 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 a conical cap to avoid atmospheric contamination. Samples for alkalinity titrations were collected by filtering groundwater into 500-mL polyethylene bottles.

DOC, chromium, radon-222, and noble gases were collected from the hose bib at the well head, regardless of the sampling schedule (fast plus DOC, slow, or slow plus DOC). DOC was collected using a 50-mL syringe and 0.45- μm disk filter. For each sample, 50-mL of blank water and 50-mL of groundwater were filtered through the apparatus before filtering 100-mL of groundwater into a 125-mL baked glass bottle (Wilde and others, 2004). Each sample then was preserved immediately by lowering the pH to 2 with 4.5-N sulfuric acid.

Chromium speciation samples were collected using a 10-mL syringe with an attached 0.45- μm 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. Hexavalent 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- μL of 7.5-N nitric acid (Ball and McClesky, 2003a,b).

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

Noble gases were collected in $\frac{3}{8}$ -inch 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 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 noble gases (Weiss, 1968).

Alkalinity was measured in the mobile laboratory at the well site 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. Concentrations of HCO_3^- and CO_3^{2-} also were calculated from the laboratory alkalinity and pH measurements. Calculations were made in a spreadsheet using the advanced speciation method (<http://or.water.usgs.gov/alk/methods.html>) with $\text{pK}_1 = 6.35$, $\text{pK}_2 = 10.33$, and $\text{pK}_w = 14$.

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

Results from the USGS Branch of Quality Systems quality assurance program indicate that iron and manganese had negative analytical biases (of 16 and 6 percent, respectively); uranium and zinc had positive analytical biases (of "slight" and 11 percent, respectively) during the time that MOJO samples were analyzed at the NWQL (U.S. Geological Survey Branch of Quality Systems, 2008). The results suggest that iron and manganese concentrations may be slightly underestimated and uranium and zinc concentrations may be slightly overestimated.

Data Reporting

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

Reporting Limits

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

Detections between the LRL and the LT-MDL are reported as “estimated” concentrations (designated with an “E” before the values in the tables and text). For information-rich methods, detections below the LT-MDL have high certainty of detection, but the precise concentration is uncertain. Information-rich methods are those that utilize gas chromatography or high-performance liquid chromatography (HPLC) with mass spectrometry detection (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, for detections that did not meet all laboratory quality-control criteria, and for samples that were diluted prior to analysis (Childress and others, 1999).

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

Results for most constituents are presented using the LRL or MRL values provided by the analyzing laboratories. Results for some constituents are presented using raised study reporting limits (SRLs) derived from assessment of data from quality-control samples associated with groundwater samples collected as part of the GAMA project. The SRLs were determined by statistical assessment of results from the field blanks collected during the first 21 GAMA study units (May 2004 through January 2008) (L.D. Olsen and M.S. Fram, U.S. Geological Survey, unpub. data, 2009). The statistical analysis used order statistical and binomial probabilities to construct an upper confidence limit for the amount of contamination potentially present in field blanks, and by inference, in groundwater

samples (Hahn and Meeker, 1991). The upper confidence limit is the maximum concentration of a constituent for which there is a 90-percent confidence that no more than 10 percent of the groundwater samples might have a higher concentration of that constituent due solely to contamination of the groundwater sample during sample collection, handling, and analysis. This maximum concentration corresponds to the concentration in the field blank that is at the 95th percentile of the 86 field blanks used in the statistical assessment. For most constituents, this maximum concentration was below the LRL or MRL for the constituent. Data for such constituents are reported with the LRL or MRL. For some constituents, this maximum concentration was greater than the LRL or MRL. An SRL then was defined as equal to the concentration in the 95th percentile field blank. Detections of those constituents reported by the laboratory with concentrations greater than the LRL or MDL but less than the SRL are considered non-detections in this report, and are reported in the tables with a “less-than-or-equal-to” (\leq) sign preceding the reported value.

The methods used for analysis of radiochemical constituents (gross alpha radioactivity, gross beta radioactivity, and radium isotopes) 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, as well as being dependent on instrument background, counting times for the sample and background, and the characteristics of the instrument being used and the nuclide being measured. An ssL_c is calculated for each sample, and the measured activity in the sample is compared to the ssL_c associated with that sample. Measured activities less than the ssL_c are reported as non-detections.

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

Notation

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

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

where

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

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned $\delta^{18}\text{O}$ and $\delta^2\text{H}$ values of zero per mil (note that $\delta^2\text{H}$ is sometimes written as δD because the common name of the heavier isotope of hydrogen, hydrogen-2, is deuterium). The reference material for carbon is Vienna Pee Dee Belemnite (VPDB), which is assigned a $\delta^{13}\text{C}$ value of zero per mil. The reference material for nitrogen is atmospheric nitrogen gas, which is assigned a $\delta^{15}\text{N}$ value of zero per mil. Positive values indicate enrichment of the heavier isotope and negative values indicate depletion of the heavier isotope, compared to the ratios observed in the standard reference material.

Constituents on Multiple Analytical Schedules

Seven constituents targeted in this study were measured by more than one analytical schedule 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. Methods with full approval are preferred over those with provisional approval and approved methods are favored over research methods. The method with greater accuracy and precision and lower LRLs for the overlapping constituents is generally preferred. However, the method with higher LRLs may be selected as the preferred method to provide consistency with historical data analyzed by the same method.

Some of the water-quality indicators (field parameters)—pH, specific conductance, and alkalinity—were measured in the field and at the NWQL. The field measurements are the preferred method for all three constituents; however, both are reported because laboratory pH and alkalinity measurements were made on a greater number of samples.

Tritium also is measured at two laboratories: Lawrence Livermore National Laboratory (LLNL) and U.S. Geological Survey Stable Isotope and Tritium Laboratory (SITL), but only the data from SITL were available for reporting at the time of this publication.

For arsenic, chromium, and iron concentrations, the approved method, Schedule 1948, used by the NWQL is preferred over the research methods used by the USGS Trace Metal Laboratory. The concentrations measured by the Trace Metal Laboratory only are used to calculate ratios of redox

species for each element, $\frac{\text{As(V)}}{\text{As(III)}}$ for arsenic, $\frac{\text{Cr(VI)}}{\text{Cr(III)}}$ for chromium, and $\frac{\text{Fe(III)}}{\text{Fe(II)}}$ for iron. For example:

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

where

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

Quality Assurance

The purpose of quality assurance is to identify which data best represent environmental conditions and which may have been affected by contamination or bias during sample collection, processing, storage, transportation, or laboratory analysis. Four types of quality-control (QC) tests were used in this study: blank samples were collected to assess positive bias due to contamination during sample handling or analysis; replicate samples were collected to assess variability; matrix spike tests were done to assess positive or negative bias; and surrogate compounds were added to samples analyzed for organic constituents to assess bias of laboratory analytical methods. In this report, detections of organic constituents in groundwater samples that may have resulted from contamination were flagged with a “V” remark code, and were not considered detections for calculations of detection frequencies in water-quality assessments. Detections of inorganic constituents in groundwater samples that may have resulted from contamination during sample handling or analysis were flagged with a “≤” remark code to indicate that the amount of potential contamination may have been sufficient to change a non-detection into a detection relative to the stated reporting level. Because of the potential contamination, the actual concentration in the groundwater sample may be less than or equal to (≤) the measured concentration. The evaluation of QC data presented in this report was based on results for QC samples collected for the MOJO study unit and on results for QC samples for the 21 GAMA study units sampled from May 2004 through January 2008.

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

Blanks

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

Blank Collection and Analysis

Two types of blanks were collected: source-solution and field blanks. Source-solution blanks were collected to assess potential contamination of samples during transport and analysis, and potential contamination of the certified blank water obtained from the USGS NWQL. Field blanks were collected to assess potential contamination of samples during collection, processing, transport, and analysis. Blanks were collected using blank water certified by the NWQL to contain less than the LRL or MRL of the analytes investigated in the study. Nitrogen-purged, organic-free blank water was used for field blanks of organic constituents, and inorganic-free blank water was used for field blanks of other constituents. For MOJO, field blanks and source-solution blanks were collected at 8 percent of the wells sampled. Field blanks were analyzed for VOCs; pesticides; pharmaceuticals; perchlorate; NDMA; nutrients; dissolved organic carbon; major and minor ions; silica; TDS; trace elements; arsenic, chromium, and iron speciation; and radioactive constituents. Certified blank water was not available for tritium or noble gases, thus, field blanks were not collected for these constituents.

Source-solution blanks were collected at the sampling site by pouring blank water directly into sample containers that were preserved, stored, shipped, and analyzed in the same manner as the groundwater samples. For field blanks, blank water either was pumped or poured through the sampling equipment (fittings and tubing) used to collect groundwater, then processed and transported using the same protocols used for the groundwater samples. Eight to 12 liters of blank water were pumped or poured through the sampling equipment before each field blank was collected.

Assessment of Blank Results

Contamination in blanks may originate from several 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 field-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 field blank results from multiple studies, in addition to the results from field blanks collected during MOJO. The development of this approach and its methods are described by L.D. Olsen and M.S. Fram (U.S. Geological Survey, unpub. data, 2009).

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

The second potential mode evaluated is contamination from identifiable, known sources that are present at a specific field site. Contamination from specific sources may produce distinctive patterns of detections in field blanks and groundwater samples, particularly for the VOCs. Substances that may be encountered at the field site, such as cements used on PVC piping, the methanol used to clean sample lines, and the chlorinated tap-water used in the USGS standard cleaning procedure of submersible sampling pumps and sample lines, contain recognizable associations of VOC constituents. For example, cements used on PVC piping are primarily composed of tetrahydrofuran with lesser amounts of acetone and methyl ethyl ketone (2-butanone). Methanol, used to clean sample lines has the propensity to capture VOCs from the atmosphere. Chlorinated tap water used in large amounts during the cleaning of submersible pumps and Teflon sample lines at monitoring or observation well sites has known disinfection by-products in the water. These VOCs, called trihalomethanes (THMs), are composed of bromodichloromethane, bromoform (tribromomethane), chloroform (trichloromethane), and dibromochloromethane. 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, then the field notes and photographs from the site at which the sample was collected were examined for presence of conditions that may have resulted in contamination of the field blank or groundwater sample during sample collection. If the constituents were present in the field blank and groundwater sample from the same site at similar concentrations and the field notes or photographs indicated that the probable contaminant source was present, then the detections of those constituents in the groundwater sample were V-coded, and all other groundwater samples collected at sites where the same condition may have occurred were considered for V-coding. If the constituents were present in a groundwater sample and not the associated field blank, or a groundwater sample from a site where no blanks were collected, and the field notes or photographs indicated that the presence of conditions that may have resulted in contamination of the groundwater sample during sample collection, the data were considered for V-coding. If no conditions that may have resulted in contamination of the groundwater sample during sample collection were identified in the field notes or photographs, then V-codes were not applied.

The third potential mode of contamination that was evaluated was carry-over from the previous groundwater sample or field blank collected with the same equipment. Carry-over between samples is very rare because the procedures used to clean the equipment 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 field blank collected with the same equipment. If non-detections were reported in field 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 field blanks that could not be accounted for by impurities in the source-solution water, specific known conditions at field sites, or carry-over between samples were evaluated for random contamination. Random contamination in field and laboratory processes has an equal chance of affecting each groundwater sample, thus, strategies for flagging detections of constituents that are subject to random contamination in field and laboratory processes must be applied to all groundwater samples.

Different notation was used for flagging detections of organic and inorganic constituents that may have been subjected to contamination during sample collection, handling, and analysis. Inorganic constituents naturally are present in groundwater, and the concerns about inorganic constituents generally are related to concentration, rather than to detection (presence or absence). In contrast, concerns about organic

constituents generally are related to both detection and concentration. Therefore, different schema are used for assessing and flagging data for organic and inorganic constituents.

For organic constituents, V-codes were applied. The purpose of V-coding was to flag detections that have a greater chance of being false-positive detections. A false-positive detection is a detection that is caused by contamination during sample collection, handling, and analysis of a groundwater sample that would otherwise have a non-detection for that constituent. Results with V-codes were not considered detections of the constituent for this study and were not included in calculations of detection frequencies for organic constituents.

The V-coding level was defined as the highest concentration of the constituent detected in a field blank plus the LT-MDL (equal to $\frac{1}{2}$ the LRL) for that constituent. Detections of the constituent in groundwater samples at concentrations less than this V-coding level were flagged with a "V" in front of the reported value in the data tables. The highest concentration measured in a blank was assumed to represent the highest potential amount of contamination, thus, the V-code flags results that could have changed from non-detection to a detection relative to the LT-MDL, due to contamination. Results with V-codes were not considered detections of the constituent for this study and were not included in calculations of detection frequencies for organic constituents.

Inorganic constituents can be present naturally in groundwater, and the concerns about inorganic constituents generally are related to concentration, rather than to detection (presence or absence). In contrast, concerns about organic constituents generally are related to both detection and concentration. For inorganic constituents, a " \leq " symbol was applied to low-concentration detections of constituents that may have been affected by contamination. The \leq symbol means that the concentration of the constituent in the groundwater sample is less than or equal to the measured concentration (including the possibility that it may be less than the LT-MDL and, therefore, a non-detection). For select trace elements (aluminum, chromium, copper, lead, manganese, nickel, tungsten, vanadium, and zinc), the concentration cutoff, hereafter referred to as the study reporting limit, SRL, for applying the \leq symbol was determined from a statistical assessment of results for 86 field blanks collected between May 2004 and January 2008. The concentration threshold for applying the \leq symbol was equal to the concentration of the field blank ranked at the 90 percent confidence level for the 90th percentile of the binomial distribution of the 86 field blanks (L.D. Olsen and M.S. Fram, U.S. Geological Survey, unpub.data, 2009).

For all other inorganic constituents, the SRL for applying the \leq symbol was determined from assessment of the field blanks collected at MOJO sites only, and was defined as equal to the highest concentration measured in the five field blanks collected at MOJO sites (field blanks were collected at 8 percent of the wells sampled). In the data tables, a \leq symbol was put in front of measured values that were less than the threshold concentration. Future reports in this series will use

the approach of L.D. Olsen and M.S. Fram for all inorganic constituents.

Replicates

Sequential replicate samples were collected to assess variability that may result from the processing and analyses of inorganic and organic constituents. Relative standard deviation (RSD) of the measured values was used in determining the variability between replicate pairs for each compound (*table A4*). The RSD is defined as the standard deviation, divided by the mean concentration for each replicate pair, multiplied by 100 percent. If one value in a sample pair was reported as a non-detection and the other value was reported as an estimate below the LRL or MRL, the RSD was set to zero because the values were analytically identical. If one value in a sample pair was reported as a non-detection and the other value was greater than the LRL or MRL, then the non-detection value was set equal to one-quarter of the LRL and the RSD was calculated (Hamlin and others, 2002). Values of RSD less than 20 percent are considered acceptable in this study. High RSD values for a compound may indicate analytical uncertainty at low concentrations, particularly for concentrations within an order of magnitude of LT-MDL or MDL. Sequential replicate samples were collected at 7 percent of the wells sampled.

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. 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 MCL: a low recovery could result in a falsely measured concentration below the MCL, whereas, a high recovery could result in a falsely measured concentration above the MCL.

Acceptable ranges for matrix-spike recoveries are based on the acceptable ranges established for laboratory "set" spike recoveries. Laboratory set spikes are aliquots of laboratory blank water to which the same spike solution used for the matrix spikes has been added. One set spike is analyzed with

each set of samples. Acceptable ranges for set spike recoveries are 70 to 130 percent for NWQL Schedule 2020 (Connor and others, 1998), 60 to 120 percent for NWQL Schedule 2003 (Sandstrom and others, 2001), and 60 to 130 percent for Schedule 2080 (Kolpin and others, 2002). Based on these ranges, 70 to 130 percent was defined as the acceptable range for matrix-spike recoveries for organic compounds in this study.

Matrix spikes were performed for VOCs, pesticides, pharmaceuticals, perchlorate, and NDMA because the analytical methods for these constituents are chromatographic and may be susceptible to matrix interferences. Replicate samples for matrix-spike additions were collected at 7 percent of the wells sampled, although not all analyte classes were tested at every well (*tables A5A–C*).

Surrogates

Surrogate compounds are added to environmental samples in the laboratory prior to analysis to evaluate the recovery of similar constituents. Surrogate compounds were added to all groundwater and quality-control samples that were analyzed for VOCs and pesticides (*table A6*). Most of the surrogate compounds are deuterated analogs of compounds being analyzed. For example, the surrogate toluene-*d8* 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-*d8* 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-*d8* surrogate does not interfere with the analysis of toluene (Grob, 1995). Only 0.015 percent of hydrogen atoms are deuterium (Firestone and others, 1996), thus, deuterated compounds like toluene-*d8* do not occur naturally and are not found in environmental samples. Surrogates are used to identify general problems that may arise during sample analysis that could affect the analysis results for all compounds in that sample. Potential problems include matrix interferences (such as high levels of dissolved organic carbon) that produce a positive bias, or incomplete laboratory recovery (possibly due to improper maintenance and calibration of analytical equipment) that produces a negative bias. A 70- to 130-percent recovery of surrogates generally 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 and Source-Solution Blanks

Field blanks were collected at 8 percent of the sites sampled in MOJO. *Table A3* presents a summary of detections in field blanks. The only field blanks for which VOC detections were observed was the one associated with the monitoring wells (MOJOU-02 through MOJOU-05); therefore these four wells were examined more carefully. No VOCs were detected in the associated source-solution blank; therefore, the source blank water was not considered the source of the contamination. Toluene was the only VOC detected in the field blank that also was detected in monitoring well groundwater samples. Due to the detection of toluene in the field blank, toluene detections were subject to a V-coding level of 0.049 $\mu\text{g/L}$ (E0.04 $\mu\text{g/L}$ plus $\frac{1}{2}$ the LRL of 0.018 $\mu\text{g/L}$). Toluene was detected at a concentration of E0.04 $\mu\text{g/L}$ and 1.06 $\mu\text{g/L}$ in two monitoring well groundwater samples (MOJOU-03 and MOJOU-05); the former of these detections was V-coded as a non-detection. Detections of bromodichloromethane, chloroform (trichloromethane), and dibromochloromethane in the field blank may have been due to the large amounts of chlorinated tap-water used in the USGS cleaning procedure of the submersible sampling pump and Teflon sampling line before the VOC field blank was collected (Wilde, F.D., ed., 2004). It is theorized that the increased use of chlorinated tap-water in this cleaning procedure is substantially different than the cleaning procedure used for the standard MOJO sampling; therefore, only monitoring wells MOJOU-02 through MOJOU-05 were examined more carefully. No groundwater samples had measured levels of bromodichloromethane, chloroform (trichloromethane), and dibromochloromethane therefore, no values were V-coded as a result. Bromodichloromethane and methyl ethyl ketone (2-butanone) were the only other VOCs detected in the field blank, and these detections were considered to be random contamination, which has an equal chance of affecting each groundwater sample. Therefore, strategies for flagging detections of constituents that are subject to random contamination must be applied to all groundwater samples. No groundwater samples had measured levels of these two VOCs; therefore, no values were V-coded as a result (*table 5*).

Three field blanks were collected for analysis of nutrients in MOJO. Nitrite plus nitrate, as nitrogen ($\text{NO}_2 + \text{NO}_3$), was the only nutrient detected in one field blank, a study reporting limit, (SRL) of E0.02 mg/L. This blank detection was considered to be random contamination, which has an equal chance of affecting each groundwater sample, thus, strategies for flagging detections of constituents that are subject to random contamination must be applied to all groundwater samples. None of the corresponding environmental samples had measured levels of $\text{NO}_2 + \text{NO}_3$ at or below the SRL with

the exception of a monitoring well (MOJOU-05). This sample had $\text{NO}_2 + \text{NO}_3$ detected at a concentration of E0.02 mg/L; therefore, this value was flagged with a \leq symbol as a result of the blank detection (*table 8*).

One field blank was collected for analysis of dissolved organic carbon (DOC). DOC was detected at a concentration of E0.2 mg/L, and low concentrations of DOC were detected in field blanks collected in previous GAMA study units (Bennett and others, 2006; Kulongoski and Belitz, 2007). Thus, the data for all groundwater samples with concentrations at or below E0.4 mg/L (0.2 mg/L plus $\frac{1}{2}$ the LRL of 0.4 mg/L) were V-coded as non-detections (*table 8*).

Field blanks were collected at 3 of the 24 sites sampled for analysis of major and minor ions, silica, and TDS. Calcium was the only major or minor ion detected in the field blank, creating a study reporting limit (SRL) of 0.04 mg/L. This blank detection was considered to be random contamination, which has an equal chance of affecting each groundwater sample, thus, strategies for flagging detections of constituents that are subject to random contamination must be applied to all groundwater samples. No groundwater samples were below 0.04 mg/L, therefore, no values were marked with the \leq symbol (*table 9*).

Trace-element data were assessed for potential flagging of results using the GAMA study reporting limits (SRLs), which are based on results for 86 field blanks collected between May 2004 and January 2008, in conjunction with the three field blanks collected at MOJO sites. Aluminum, chromium, copper, lead, manganese, nickel, tungsten, vanadium, and zinc have SRLs. Measured values that are less than the SRL are flagged with a \leq symbol in *table 10*. Zinc was the only one of these trace elements detected at a concentration of E1.1 $\mu\text{g/L}$ in a field blank. All measured detections of zinc less than the SRL level of 4.8 $\mu\text{g/L}$ were flagged with a \leq symbol (*table 10*). Silver was the only other trace metal detected in the field blank, but there were no measurable detections of silver in any of the wells in MOJO, therefore, this detection was not of potential QC concern.

One field blank was collected for analysis of radioactive constituents. Radium-226 was measured at an activity of 0.033 ± 0.011 pCi/L in the field blank. Six detections of radium-226 had an activity less than 0.044 pCi/L, the upper confidence limit of the maximum activity measured in the blank; these data were flagged with a \leq symbol (*table 13A*).

No compounds were detected in any of the 10 source-solution blanks. Additionally, no constituents were detected in field blanks for the following analyte groups: pesticides and pesticide degradates (five field blanks), perchlorate (five field blanks), NDMA (three field blanks), arsenic, chromium, and iron species analysis at the USGS Trace Metal Laboratory (two field blanks).

Variability in Replicate Samples

Table A4 summarizes the results of replicate analyses for constituents detected in groundwater samples collected in the MOJO study. Concentrations or activities in the environmental and replicate samples are reported for all replicate analyses with RSD values greater than 20 percent. The majority of replicate sample pairs collected during the MOJO study had RSDs of less than 20 percent. Of the more than 700 replicate pairs of constituents analyzed, only five pairs had RSDs greater than 20 percent. One VOC (1,2,4-trimethylbenzene) had two replicate pairs with RSDs greater than 20 percent, these pairs both included one detection and one non-detection. At these low concentrations, small deviations in measured values result in large RSDs. The only other constituents with replicate pairs with a RSDs above 20 percent were; arsenic (total [analyzed by the USGS Trace Metal Laboratory]), oxygen isotopes in nitrate, gross alpha radioactivity 30-day count, radium-226 (two replicate pairs), and tritium. No replicate pairs had RSDs greater than 20 percent in the following analyte groups or constituents; pesticide and pesticide degradates, perchlorate, NDMA, nutrients, DOC, major and minor ions, silica, TDS, and trace elements. No environmental data were flagged as a result of variability in replicate analyses.

Matrix-Spike Recoveries

Tables A5A–C presents a summary of matrix-spike recoveries for the MOJO study. The addition of a spike or known concentration of a constituent to an environmental sample enables the analyzing laboratory to determine the effect of the matrix, in this case groundwater, on the analytical technique used to measure the constituent. Four environmental samples were spiked with VOCs to calculate matrix-spike recoveries (*table A5A*). All of the 85 VOC spike compounds had median matrix-spike recoveries within the acceptable range of 70 to 130 percent. Two VOC spike compounds, bromomethane (methyl bromide) and vinyl bromide (bromoethene) had one matrix-spike recovery greater than 130 percent; however, they were not detected in groundwater samples. VOC spike compounds that had at least one matrix-spike recovery below 70 percent were; acetone (one spike), dichlorodifluoromethane (two spikes), styrene (two spikes), and these compounds were not detected in groundwater samples (*table 3A*). [NOTE that low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations].

Four groundwater samples were spiked with pesticide and pesticide degradate compounds to calculate matrix-spike recoveries. Thirty-two of the 63 spike constituents had median matrix-spike recoveries within the acceptable range of 70 to 130 percent (*table A5B*). Seven of the 10 compounds detected in groundwater samples had median matrix-spike recoveries within the acceptable range. Median spike-matrix recoveries for three compounds detected in groundwater samples were below the acceptable range; deethylatrazine

(2-Chloro-4-isopropylamino-6-amino-s-triazine) (54 percent); fipronil (66 percent), and fipronil sulfide (64 percent). Two spike compounds, (fenamiphos and phorate oxon) had at least one recovery greater than 130 percent; however, they were not detected in groundwater samples. Fifty-three pesticide and pesticide degradate spike compounds had at least one recovery below 70 percent. Of these compounds; 3,4-dichloroaniline, deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine), fipronil, fipronil sulfide, metolachlor, prometon, and simazine were the only compounds also detected in groundwater samples (*table 3B*). None of the nine groundwater samples with environmental detections and unacceptable recoveries in matrix spikes were analyzed in the same batch, thus, none of the pesticide and pesticide degradate environmental detections were flagged (*table 6*). [NOTE that low recoveries may indicate that the compound might not have been detected in some samples if it was present at very low concentrations].

Four groundwater samples were spiked with perchlorate and two samples were spiked with NDMA at Weck Laboratories, Inc. For perchlorate, the median matrix-spike was used and for NDMA the median matrix-spike was calculated as the average of the recoveries for the two spike samples. All spike recoveries were within the acceptable range of 70 to 130 percent (*table A5C*).

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

Surrogate Compound Recoveries

Surrogate compounds were added to environmental samples in the laboratory and analyzed to evaluate the recovery of similar constituents. *Table A6* lists the surrogate, analytical schedule on which it was applied, the number of analyses for blank and environmental samples, the number of surrogate recoveries below 70 percent, and the number of surrogate recoveries above 130 percent for the blank and groundwater samples. Blank and environmental samples were considered separately to assess whether the matrices present in groundwater samples affect surrogate recoveries. No systematic differences between surrogate recoveries in blank and groundwater samples were observed.

In MOJO most surrogate recoveries were within acceptable range of 70 to 130 percent recovery. In total, 96 percent of the surrogate recoveries for VOC and 81 percent of the surrogate recoveries for pesticide analyses were within the acceptable range.

Appendix Tables

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 U.S. Geological Survey (USGS) National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names. UV, ultraviolet; VOC, volatile organic compounds]

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			
VOC	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; Madsen and others, 2003; Sandstrom and others, 2001
Pharmaceuticals	Solid-phase extraction and HPLC/mass spectrometry	NWQL, Schedule 2080	Kolpin and others, 2002; Furlong and others, 2008
Constituents of special interest			
Perchlorate	Liquid chromatography with mass spectrometry/mass spectrometry (USEPA Method 331.0)	Week Laboratories, Inc., 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 <i>modified</i>)	Week Laboratories, Inc., standard operating procedure ORG065.R10	U.S. Environmental Protection Agency, 1989; Plomley and others, 1994
Inorganic constituents			
Nutrients	Alkaline persulfate digestion, Kjeldahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
Dissolved organic carbon (DOC)	UV-promoted persulfate oxidation and infrared spectrometry	NWQL, laboratory code 2612	Brenton and Arnett, 1993
Major and minor ions, trace elements and nutrients	Atomic absorption spectrometry, colorimetry, ion-exchange chromatography, inductively-coupled plasma atomic emission spectrometry and mass spectrometry	NWQL, Schedule 1948	Fishman and Friedman, 1989; Fishman, 1993; Faires, 1993; McLain, 1993; Garbarino, 1999; Garbarino and Damrau, 2001; American Public Health Association, 1998; Garbarino and others, 2006
Chromium, arsenic and iron speciation	Various techniques of ultraviolet visible (UV-VIS) spectrophotometry and atomic absorbance spectroscopy	USGS Trace Metal Laboratory, Boulder, Colorado (USGSTMCO)	Stookey, 1970; To and others, 1998; Ball and McCleskey, 2003a and 2003b; McCleskey and others, 2003

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

[Laboratory entity codes in the U.S. Geological Survey (USGS) National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names. UV, ultraviolet; VOC, volatile organic compounds]

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
Nitrogen and oxygen isotopes of nitrate	Denitrifier method and mass spectrometry	USGS Stable Isotope Laboratory, Reston, Virginia (USGSSIVA), NWQL Lab Code 2900	Révész and Casciotti, 2007
Carbon isotopes	Accelerator mass spectrometry	University of Waterloo, Environmental Isotope Lab (CAN-UWIL); University of Arizona Accelerator Mass Spectrometry Lab (AZ-UAMSL), NWQL Schedule 2015	Donahue and others, 1990; Jull and others, 2004
		Radioactivity and gases	
Tritium	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA)	Thatcher and others, 1977
Tritium and noble gases	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory (CA-LLNL)	Moran and others, 2002; Eaton and others, 2004
Radon-222	Liquid scintillation counting	NWQL, Schedule 1369	American Society for Testing and Materials, 1998
Radium isotopes	Alpha activity counting	Eberline Analytical Services (CA-EB-ERL), NWQL Schedule 1262	Kreiger and Whittaker, 1980 (USEPA methods 903 and 904)
Gross alpha and gross beta radioactivity	Alpha and beta activity counting	Eberline Analytical Services, NWQL Schedule 1792	Kreiger and Whittaker, 1980 (USEPA method 900.0)

Table A2. Preferred analytical schedules for constituents appearing on multiple schedules for samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

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

Constituent	Primary constituent classification	Analytical schedules	Preferred analytical schedule
Results from both methods reported			
Alkalinity	Water-quality indicator	Field, 1948	Field
Arsenic, total	Trace element	1948, TML	1948
Chromium, total	Trace element	1948, TML	1948
Iron, total	Trace element	1948, TML	1948
pH	Water-quality indicator	Field, 1948	Field
Specific conductance	Water-quality indicator	Field, 1948	Field
Tritium	Inorganic tracer	LLNL, SITL	np

Table A3. Constituents detected in field blanks collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[V-coded data are reported but not used in summary statistics; CSU, combined standard uncertainty; E, estimated or having a higher degree of uncertainty; pCi/L, picocuries per liter; mg/L, milligrams per liter; ssL_c , sample-specific critical level; $\mu\text{g/L}$, micrograms per liter]

Constituent	Number of field blank detections/analyses	Concentrations detected in field blanks	Number of groundwater samples V-coded
Organic constituents ($\mu\text{g/L}$)			
Chloroform (Trichloromethane)	1/5	0.49	0
Bromochloromethane	1/5	E0.06	0
Bromodichloromethane	1/5	0.42	0
Dibromochloromethane	1/5	0.20	0
Methyl ethyl ketone (2-butanone, MEK)	1/5	2.29	0
Toluene	1/5	E0.04	1
Nutrients (mg/L)			
Dissolved organic carbon (DOC)	1/1	E0.2	10
Nitrite plus nitrate, as nitrogen	1/3	E0.02	1
Major and minor ions (mg/L)			
Calcium	1/3	0.04	0
Inorganic constituents ($\mu\text{g/L}$)			
Silver	1/3	0.19	0
Zinc	1/3	E1.1	0
Radioactive constituents (pCi/L)			
Radium-226 ¹	1/1	0.033 \pm 0.011 (0.015)	6

¹Radon-226 concentration is reported as the result \pm CSU (ssL_c).

Table A4. Quality-control summary of replicate analyses collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[E, estimated or having a higher degree of uncertainty; <, less than; mg/L, milligram per liter; µg/L, microgram per liter; —, not detected; RSD, relative standard deviation in percent; nv, no measured values with RSD greater than 20 percent]

Constituent	Number of relative standard deviations greater than 20 percent/number of replicate pairs	Maximum relative standard deviation (percent)	Measured values for pairs with RSD greater than 20 (environmental/replicate)
Volatile organic compounds (VOC) from Schedule 2020			
1,2,4-Trimethylbenzene	2/4	113	(E0.09; —)(—, E0.06)
All additional VOCs from Schedule 2020	0/4	<20	nv
Pesticides and pesticide degradates from Schedule 2003			
All pesticides and pesticide degradates from Schedule 2003	0/4	<20	nv
Constituents of special interest ¹			
Perchlorate	0/4	<20	nv
<i>N</i> -nitrosodimethylamine (NDMA)	0/2	<20	nv
Major ions, minor ions, trace elements, nutrients, and arsenic, chromium, and iron speciation			
Arsenic (total) (µg/L) ²	1/2	22	(0.65; 0.89)
Iron (total), iron(III), chromium (total), chromium(VI), arsenic(III) (µg/L) ²	0/2	<20	nv
All major ions, minor ions, trace elements from schedule 1948, nutrients from schedule 2755, and dissolved organic carbon (DOC) from lab code 2612	0/2	<20	nv
Isotopes and radioactivity			
Oxygen isotopes in nitrate	1/2	29	(1.26; 1.92)
Gross alpha 30-day radioactivity	1/2	43	(3.00; 5.60)
Radium-226	2/2	55	(0.072; 0.163)(0.133; 0.090)
Tritium	1/4	52	(0.6; 1.3)
All additional isotopes and radioactive constituents	0/2	<20	nv

¹Analyses performed at Weck Laboratories, Inc., City of Industry, California.

²Analyses performed at U.S. Geological Survey Trace Metal Laboratory, Boulder, Colorado.

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOC) in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetone	4	69	111	88
Acrylonitrile	4	102	112	106
<i>tert</i> -Amyl methyl ether (TAME)	4	100	113	107
Benzene	4	99	111	103
Bromobenzene	4	98	114	105
Bromochloromethane	4	103	109	107
Bromodichloromethane ¹	4	103	113	107
Bromoform (Tribromomethane) ¹	4	90	105	104
Bromomethane (Methyl bromide)	4	112	158	116
<i>n</i> -Butylbenzene	4	82	96	91
<i>sec</i> -Butylbenzene	4	92	108	102
<i>tert</i> -Butylbenzene	4	102	114	106
Carbon disulfide	4	76	92	84
Carbon tetrachloride (Tetrachloromethane) ¹	4	101	123	107
Chlorobenzene ¹	4	101	111	105
Chloroethane	4	100	115	102
Chloroform (Trichloromethane) ¹	4	103	120	113
Chloromethane	4	94	111	108
3-Chloropropene	4	110	121	116
2-Chlorotoluene	4	97	112	104
4-Chlorotoluene	4	96	104	100
Dibromochloromethane ¹	4	96	103	100
1,2-Dibromo-3-chloropropane (DBCP)	4	91	108	97
1,2-Dibromoethane (EDB)	4	101	115	104
Dibromomethane	4	98	114	110
1,2-Dichlorobenzene	4	99	110	104
1,3-Dichlorobenzene ¹	4	98	110	103
1,4-Dichlorobenzene	4	95	106	102
<i>trans</i> -1,4-Dichloro-2-butene	4	91	112	96
Dichlorodifluoromethane (CFC-12)	4	63	97	75
1,1-Dichloroethane (1,1-DCA) ¹	4	103	118	109
1,2-Dichloroethane (1,2-DCA) ¹	4	98	111	108
1,1-Dichloroethene (1,1-DCE) ¹	4	102	118	107
<i>cis</i> -1,2-Dichloroethene (<i>cis</i> -1,2-DCE) ¹	4	101	116	108
<i>trans</i> -1,2-Dichloroethene (<i>trans</i> -1,2-DCE) ¹	4	105	118	106
1,2-Dichloropropane	4	102	112	107
1,3-Dichloropropane	4	104	112	106
2,2-Dichloropropane	4	87	96	94
1,1-Dichloropropene	4	95	115	100
<i>cis</i> -1,3-Dichloropropene	4	88	100	99
<i>trans</i> -1,3-Dichloropropene	4	85	102	95
Diethyl ether	4	107	116	111
Diisopropyl ether (DIPE)	4	103	118	108
Ethylbenzene	4	97	107	105
Ethyl <i>tert</i> -butyl ether (ETBE)	4	100	115	108
Ethyl methacrylate	4	98	106	99
<i>o</i> -Ethyl toluene (1-Ethyl-2-methyl benzene)	4	90	104	100

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

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Hexachlorobutadiene	4	79	91	84
Hexachloroethane	4	90	112	100
2-Hexanone (<i>n</i> -Butyl methyl ketone)	4	91	103	96
Iodomethane (Methyl iodide)	4	81	123	113
Isopropylbenzene	4	95	108	104
4-Isopropyl-1-methyl benzene	4	90	102	101
Methyl acrylate	4	102	109	105
Methyl acrylonitrile	4	100	110	108
Methyl <i>tert</i> -butyl ether (MTBE) ¹	4	102	111	106
Methyl <i>iso</i> -butyl ketone (MIBK)	4	97	107	102
Methylene chloride (dichloromethane) ¹	4	98	108	104
Methyl ethyl ketone (2-butanone, MEK)	4	85	111	98
Methyl methacrylate	4	95	108	100
Naphthalene	4	97	113	105
Perchloroethene (PCE, tetrachloroethene)	4	98	112	104
<i>n</i> -Propylbenzene	4	88	104	98
Styrene	4	15	98	80
1,1,1,2-Tetrachloroethane	4	101	113	107
1,1,2,2-Tetrachloroethane	4	100	111	105
Tetrahydrofuran ¹	4	88	112	105
1,2,3,4-Tetramethylbenzene	4	92	107	102
1,2,3,5-Tetramethylbenzene	4	96	111	109
Toluene ¹	4	98	108	103
1,2,3-Trichlorobenzene	4	102	110	104
1,2,4-Trichlorobenzene	4	93	102	97
1,1,1-Trichloroethane (1,1,1-TCA)	4	99	120	109
1,1,2-Trichloroethane (1,1,2-TCA)	4	99	113	104
Trichloroethene (TCE) ¹	4	100	113	104
Trichlorofluoromethane (CFC-11) ¹	4	98	126	108
1,2,3-Trichloropropane (1,2,3-TCP)	4	98	108	103
Trichlorotrifluoroethane (CFC-113)	4	84	111	100
1,2,3-Trimethylbenzene	4	100	111	109
1,2,4-Trimethylbenzene ¹	4	80	103	96
1,3,5-Trimethylbenzene	4	90	103	101
Vinyl bromide (Bromoethene)	4	112	158	116
Vinyl chloride (Chloroethene)	4	102	124	108
<i>m</i> - and <i>p</i> -Xylene	4	93	105	102
<i>o</i> -Xylene	4	93	107	105

¹Constituents detected in groundwater samples.

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

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetochlor	4	59	92	82
Alachlor	4	64	94	86
Atrazine ¹	4	75	94	86
Azinphos-methyl	4	47	129	58
Azinphos-methyl oxon	4	20	50	29
Benfluralin	4	34	61	52
Carbaryl	4	60	110	70
2-Chloro-2,6-diethylacetanilide	4	58	96	83
4-Chloro-2-methylphenol	4	47	86	64
Chlorpyrifos	4	39	74	66
Chlorpyrifos oxon	4	10	55	17
Cyfluthrin	4	40	64	48
Cypermethrin	4	40	71	47
Dacthal (DCPA)	4	89	94	91
Deethylatrazine (2-Chloro-4-isopropylamino-6-amino-s-triazine) ¹	4	43	69	54
Desulfinylfipronil	4	70	100	78
Desulfinylfipronil amide	4	71	128	79
Diazinon	4	62	95	81
3,4-Dichloroaniline	4	64	90	76
Dichlorvos	4	7	19	13
Dicrotophos	4	15	37	28
Dieldrin	4	74	121	100
2,6-Diethylaniline	4	75	96	81
Dimethoate	4	27	51	38
Ethion	4	49	82	68
Ethion monoxon	4	48	82	68
2-Ethyl-6-methylaniline	4	78	104	82
Fenamiphos	4	71	148	89
Fenamiphos sulfone	4	56	112	74
Fenamiphos sulfoxide	4	7	40	24
Fipronil ¹	4	45	99	66
Fipronil sulfide ¹	4	48	101	64
Fipronil sulfone	4	45	71	59
Fonofos	4	58	86	76
Hexazinone	4	39	69	53
Iprodione	4	41	67	46
Isofenphos	4	48	102	74
Malaoxon	4	29	74	51
Malathion	4	43	92	71
Metalaxyl	4	65	96	83
Methidathion	4	63	90	83
Metolachlor	4	64	95	83
Metribuzin	4	50	87	73
Myclobutanil	4	56	91	80
1-Naphthol	4	17	30	21

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

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Paraoxon-methyl	4	24	50	33
Parathion-methyl	4	42	76	59
Pendimethalin	4	60	123	70
<i>cis</i> -Permethrin	4	34	64	50
Phorate	4	31	81	61
Phorate oxon	4	53	162	75
Phosmet	4	8	25	13
Phosmet oxon	4	0	51	14
Prometon ¹	4	50	83	70
Prometryn	4	61	91	82
Pronamide (Propyzamide)	4	57	95	80
Simazine ¹	4	63	92	79
Tebuthiuron	4	65	113	88
Terbufos	4	42	83	71
Terbufos oxon sulfone	4	29	85	49
Terbutylazine	4	73	102	88
Tribufos	4	35	66	53
Trifluralin	4	40	67	60

¹Constituents detected in groundwater samples.**Table A5C.** Quality-control summary for matrix-spike recoveries of perchlorate and *N*-nitrosodimethylamine (NDMA) in groundwater samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[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	4	99	110	103
<i>N</i> -nitrosodimethylamine (NDMA) ¹	2	95	127	² 111

¹Constituents detected in groundwater samples.² Median matrix-spike recovery was calculated as the average of the two recoveries for NDMA.

Table A6. Quality-control summary for surrogate recoveries of volatile organic compounds (VOCs), pesticides and pesticide degradates in samples collected for the Mojave Groundwater Ambient Monitoring and Assessment (GAMA) study, California, February to April 2008.

[VOC, volatile organic compound]

Surrogate	Analytical schedule	Constituent or constituent class analyzed	Number of blanks analyses	Median recovery in blanks (percent)	Number of surrogate recoveries below 70 percent in blanks	Number of surrogate recoveries above 130 percent in blanks	Number of sample analyses	Median recovery in samples (percent)	Number of surrogate recoveries below 70 percent in samples	Number of surrogate recoveries above 130 percent in samples
1-Bromo-4-fluorobenzene	2020	VOC	6	97	0	0	59	91	0	0
1,2-Dichloroethane- <i>d</i> 4	2020	VOC	6	108	0	0	59	114	0	7
Toluene- <i>d</i> 8	2020	VOC	6	99	0	0	59	98	0	0
Diazinon- <i>d</i> 10	2003	Pesticide	5	73	2	0	59	78	21	0
α -HCH- <i>d</i> 6	2003	Pesticide	5	85	0	0	59	84	1	0

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