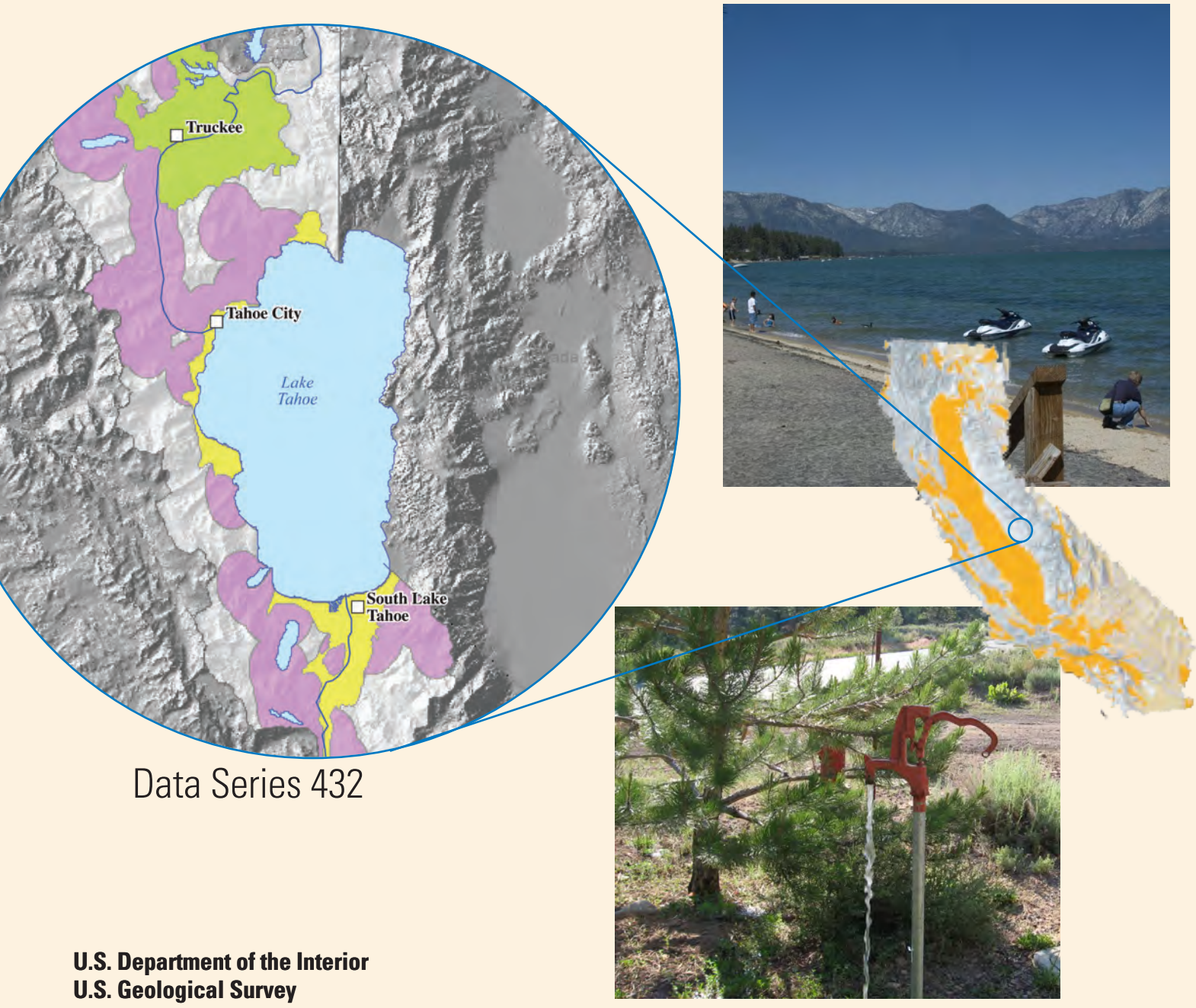
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Groundwater Quality Data for the Tahoe–Martis Study Unit, 2007: Results from the California GAMA Program



Data Series 432

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Cover Photographs:
Top: Lake Tahoe shoreline, 2007. (Photograph taken by Cathy M. Munday, U.S. Geological Survey.)
Bottom: Sampling point, 2007. (Photograph taken by Mike Judd, U.S. Geological Survey.)

Groundwater Quality Data for the Tahoe–Martis Study Unit, 2007: Results from the California GAMA Program

By Miranda S. Fram, Cathy Munday, and Kenneth Belitz

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Suggested citation:
Fram, M.S., Munday, Cathy, and Belitz, Kenneth, 2009, Groundwater quality data for the Tahoe–Martis study unit, 2007: Results from the California GAMA Program: U.S. Geological Survey Data Series 432, 88 p. Available at http://pubs.usgs.gov/ds/432/

Contents

Abstract 1
Introduction 2
    Purpose and Scope 4
    Hydrogeologic Setting 4
        Tahoe Study Area....7
        Martis Study Area....8
        Hard Rock Study Area....8
Methods 8
    Study Design....8
    Sample Collection and Analysis....9
    Data Reporting....10
    Quality Assurance....10
Water-Quality Results 10
    Quality-Control Results 10
    Comparison Thresholds....10
    Groundwater Quality Data....11
        Field Water-Quality Indicators....12
        Organic Constituents....12
        Inorganic Constituents....12
        Isotopic Tracers 13
        Radioactive Constituents....13
Future Work 14
Summary 14
Acknowledgments....15
References Cited....15
Tables 21
Appendix....60
Appendix Tables....73

Figures

Figure 1. Map of the 10 hydrogeologic provinces of California and the location of the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study unit 3
Figure 2. Map of the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study unit, and locations of groundwater basins, major cities, major hydrologic features, and the surface-water watershed area for Lake Tahoe and the Tahoe and Martis Valley groundwater basins, California 5
Figure 3. Map of the northern (*A*) and southern (*B*) parts of the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, and the distribution of the study area grid cells, and locations of the sampled grid wells and the understanding wells 6

Tables

Table 1. Well identification, and sampling and construction information for wells sampled for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September, 2007 22
Table 2. Classes of chemical and microbial constituents and water-quality indicators collected for the slow and intermediate sampling schedules for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September, 2007 24
Table 3A. Volatile organic compounds and gasoline additives, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2020 25
Table 3B. Gasoline oxygenates and degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 4024 28
Table 3C. 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 29
Table 3D. Pharmaceutical compounds, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory schedule 2080 31
Table 3E. Constituents of special interest, primary uses or sources, comparative thresholds, and reporting information for the Montgomery Watson Harza and Weck Laboratories 32
Table 3F. Nutrients and dissolved organic carbon, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 2755 32
Table 3G. Major and minor ions and trace elements, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 1948 33

Table 3H. Arsenic, chromium, and iron species, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) Trace Metal Laboratory, Boulder, Colorado 34
Table 3I. Isotopic and radioactive constituents, comparative thresholds, and reporting information for laboratories 35
Table 3J. Noble gases and tritium, comparison thresholds and reporting information for the Lawrence Livermore National Laboratory 36
Table 3K. Microbial constituents, comparison thresholds, and reporting information for the U.S. Geological Survey (USGS) Ohio Microbiology Laboratory parameter codes 99335 and 99332. 36
Table 4. Water-quality indicators in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 37
Table 5. Volatile organic compounds (VOC), and gasoline oxygenates and degradates detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 39
Table 6. Pesticides and pesticide degradates detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 40
Table 7. Nutrients detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 41
Table 8. Major and minor ions and dissolved solids detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 43
Table 9. Trace elements detected in groundwater samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 200. 47
Table 10. Species of inorganic arsenic, iron, and chromium detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 51
Table 11. Stable isotope and strontium isotope ratios and tritium and carbon–14 activities detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 53
Table 12A. Uranium isotopes and radon-222 detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 55
Table 12B. Gross alpha and gross beta particle activities detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June-September 2007 58
Table 12C. Radium isotopes detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 59

Appendix Tables

Table A1. Analytical methods used to measure organic, inorganic, and microbial constituents by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and other laboratories 74
Table A2. Preferred analytical schedules for constituents appearing on multiple schedules for samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 76
Table A3A. Constituents detected in field blanks collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 77
Table A3B. Volatile organic compounds (VOC) detected in a field blank analyzed in triplicate and determined to be affected by residual methanol from equipment cleaning 78
Table A4A. Quality-control summary of replicate analyses of organic constituents detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 79
Table A4B. Quality-control summary of replicate analyses of major and minor ions, nutrients, trace elements, and isotope tracers detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 80
Table A4C. Quality-control summary of replicate analyses of radiochemical constituents detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 82
Table A5A. Quality-control summary of matrix-spike recoveries of volatile organic compounds (VOC) and gasoline oxygenates and degradates in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 83
Table A5B. Quality-control summary of matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007 85

Abbreviations and Acronyms

AB	Assembly Bill (through the California State Assembly)
AL-US	action level (USEPA)
CAS	Chemical Abstract Service (American Chemical Society)
CSU	combined standard uncertainty
D	detected in groundwater samples
DBP	disinfection by-product
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 (USEPA)
HPLC	high-performance liquid chromatography
LRL	laboratory reporting level
LSD	land-surface datum
LT-MDL	long-term method detection level
MCL-US	maximum contaminant level (USEPA)
MCL-CA	maximum contaminant level (CDPH)
MDL	method detection limit
MRL	minimum reporting level
MU	method uncertainty
N	Normal (1 equivalent per liter of solution)
na	not available
nc	sample not collected
NL-CA	notification level (CDPH)
NWIS	National Water Information System (USGS)
PCFF-GAMA	portable computer field forms program designed for GAMA sampling
QC	quality control
RPD	relative percent difference
RSD	relative standard deviation
RSD5-US	risk-specific dose at 10^{-5} (USEPA)
SD	standard deviation
SMCL-CA	secondary maximum contaminant level (CDPH)
SMCL-US	secondary maximum contaminant level (USEPA)
SRL	study reporting limit
ssL_c	sample-specific critical level
TIC	tentatively identified compound
TMART	Martis study area grid well prefix
TMARTU	Martis study area understanding well prefix
TROCK	Hard Rock study area grid well prefix
TROCKU	Hard Rock study area understanding well prefix

TTAHO	Tahoe study area grid well prefix
TTAHOU	Tahoe study area understanding well prefix
TT-US	treatment technique (USEPA)
US	United States
V	constituent detected in blanks and therefore excluded from the dataset of groundwater quality results
VPDB	Vienna Pee Dee Belemnite
VSMOW	Vienna Standard Mean Ocean Water

Organizations

CDPH	California Department of Public Health
CDWR	California Department of Water Resources
USEPA	U.S. Environmental Protection Agency
LLNL	Lawrence Livermore National Laboratory
MWH	Montgomery Watson Harza
NAWQA	National Water Quality Assessment (USGS)
NWQL	National Water Quality Laboratory (USGS)
SWRCB	California State Water Resources Control Board
USGS	U. S. Geological Survey

Selected chemical names

$CaCO_3$	calcium carbonate
CO_3^{-2}	carbonate
CO_2	carbon dioxide
HCO_3-	bicarbonate
MEK	methyl ethyl ketone (2-butanone)
MTBE	methyl *tert*-butyl ether
NDMA	*N*-nitrosodimethylamine
PCE	perchloroethene
TCE	trichloroethene
TDS	total dissolved solids
THM	trihalomethane
VOC	volatile organic compound

Units of measurement

cm^3 STP/g	cubic centimeters of gas at standard temperature and pressure (0 degrees Celsius and 1 atmosphere of pressure) per gram of water
ft	foot (feet)
in	inch
ka	thousand years
L	liter
mg	milligram

mg/L	milligram per liter (parts per million)
mi	mile
mL	milliliter
Ma	million years
µg/L	microgram per liter (parts per billion)
µL	microliter
µm	micrometer
pCi/L	picocurie per liter
per mil	per thousand
°C	degrees Celsius
$\delta^{i}E$	delta notation, the ratio of a heavier isotope of an element (^{i}E) to the more common lighter isotope of that element, relative to a standard reference material, expressed as per mil

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

$$°F = (1.8 \times °C) + 32$$

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

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

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

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

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Groundwater Quality Data for the Tahoe–Martis Study Unit, 2007: Results from the California GAMA Program

By Miranda S. Fram, Cathy Munday, and Kenneth Belitz

Abstract

Groundwater quality in the approximately 460-square-mile Tahoe–Martis study unit was investigated in June through September 2007 as part of the Priority Basin Project of the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA Priority Basin Project was developed in response to the Groundwater Quality Monitoring Act of 2001 and is being conducted by the U.S. Geological Survey (USGS) in cooperation with the California State Water Resources Control Board (SWRCB).

The study was designed to provide a spatially unbiased assessment of the quality of raw groundwater used for public water supplies within the Tahoe–Martis study unit (Tahoe–Martis) and to facilitate statistically consistent comparisons of groundwater quality throughout California. Samples were collected from 52 wells in El Dorado, Placer, and Nevada Counties. Forty-one of the wells were selected using a spatially distributed, randomized grid-based method to provide statistical representation of the study area (grid wells), and 11 were selected to aid in evaluation of specific water-quality issues (understanding wells).

The groundwater samples were analyzed for a large number of synthetic organic constituents (volatile organic compounds [VOC], pesticides and pesticide degradates, and pharmaceutical compounds), constituents of special interest (perchlorate and *N*-nitrosodimethylamine [NDMA]), naturally occurring inorganic constituents (nutrients, major and minor ions, and trace elements), radioactive constituents, and microbial indicators. Naturally occurring isotopes (tritium, carbon-14, strontium isotope ratio, and stable isotopes of hydrogen and oxygen of water), and dissolved noble gases also were measured to help identify the sources and ages of the sampled groundwater. In total, 240 constituents and water-quality indicators were investigated.

Three types of quality-control samples (blanks, replicates, and samples for matrix spikes) each were collected at 12 percent of the wells, and the results obtained from 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 data for the groundwater samples were not compromised by possible contamination during sample collection, handling or analysis. Differences between replicate samples were within acceptable ranges. Matrix spike recoveries were within acceptable ranges for most compounds.

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

The concentrations of most constituents detected in groundwater samples from the Tahoe–Martis wells were below drinking-water thresholds. Organic compounds (VOCs and pesticides) were detected in about 40 percent of the samples from grid wells, and most concentrations were less than 1/100th of regulatory and nonregulatory health-based thresholds, although the conentration of perchloroethene in one sample was above the USEPA maximum contaminant level (MCL-US). Concentrations of all trace elements and nutrients in samples from grid wells were below regulatory and nonregulatory health-based thresholds, with five exceptions. Concentrations of arsenic were above the MCL-US in 20 percent of the samples from grid wells. Gross alpha particle activity (MCL-US), boron (CDPH notification level, NL-CA), and molybdenum (USEPA lifetime health advisory, HAL-US) were each detected above thresholds in two of the samples from grid wells, and radon (proposed alternative MCL-US) was detected above the threshold in one sample from a grid well. Most of the samples from Tahoe–Martis grid wells had concentrations of major elements, total dissolved solids, and trace elements below the CDPH secondary maximum contaminant levels, nonenforceable thresholds set for aesthetic and technical concerns. Fifteen percent of the samples from grid wells contained iron, manganese, or total dissolved solids at concentrations above these levels.

Introduction

Groundwater comprises nearly half of the water used for public supply in California (Hutson and others, 2004). To assess the quality of ambient groundwater in aquifers used for public supply and to establish a baseline groundwater quality monitoring program, the State Water Resources Control Board (SWRCB), in collaboration with the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL), implemented the Groundwater Ambient Monitoring and Assessment (GAMA) Program (*http://www.swrcb.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 interagency collaboration and cooperation with local water agencies and well owners. Local participation in the project is entirely voluntary.

The GAMA Priority Basin Project is unique in California because 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 a large number of chemical constituents using analytical methods that have much lower detection limits than those 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 when assessing 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 active and standby 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 fairly permeable, unconsolidated deposits of alluvial or volcanic origin (California Department of Water Resources, 2003). Groundwater basins were prioritized for sampling on the basis of the number of public-supply wells in the basin, with secondary consideration given to municipal groundwater use, agricultural pumping, the number of formerly leaking underground fuel tanks, and pesticide applications within the basins (Belitz and others, 2003). In addition, some groundwater basins or groups of adjacent similar basins with relatively few public-supply wells were assigned high priority so that all hydrogeologic provinces would be represented in the subset of basins sampled as part of the project. The 116 priority basins were grouped into 35 study units. Some areas outside of the defined groundwater basins were included to represent the 20 percent of public-supply wells not located in the groundwater basins. Of the 10 hydrogeologic provinces, the Sierra Nevada contains the largest number of public-supply wells outside of the mapped groundwater basins. About 97 percent of the total area and approximately 85 percent of the public-supply wells in the Sierra Nevada are outside of the mapped groundwater basins.

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

The Tahoe–Martis GAMA study unit, hereinafter referred to as Tahoe–Martis, consists of two groundwater basins and the areas outside of the basins corresponding to the surface-water watershed areas for the basins and Lake Tahoe. The Tahoe–Martis study was considered high priority to provide adequate representation of the Sierra Nevada hydrogeologic province (Belitz and others, 2003).



Figure 1. The 10 hydrogeologic provinces of California and the location of the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study unit (modified from Belitz and others, 2003).

Purpose and Scope

The purposes of this report are (1) to describe the study design and study methods, (2) to present the results of quality-control tests, and (3) to present the analytical results for groundwater samples collected in Tahoe–Martis. Groundwater samples were analyzed for organic, inorganic, and microbial constituents, field parameters, and isotopic tracers. The chemical and microbial data presented in this report were evaluated by comparing these data to State and Federal drinking-water regulatory and nonregulatory health-based standards that are applied to treated drinking water. Thresholds considered for this report were those established by the United States Environmental Protection Agency (USEPA) and CDPH. The data presented in this report are intended to characterize the quality of untreated, raw groundwater resources within the study unit, not the treated drinking water delivered to consumers by water purveyors. Discussion of the factors that influence the distribution and occurrence of the constituents detected in groundwater samples will be the subject of subsequent publications.

Hydrogeologic Setting

The Tahoe–Martis study unit (Tahoe–Martis) covers approximately 460 square miles in El Dorado, Placer, and Nevada Counties, California, in the northeast part of the Sierra Nevada hydrogeologic province (*figs. 1, 2*). The study unit includes two groundwater basins, as defined by CDWR (California Department of Water Resources, 2003). The Tahoe Valley groundwater basin is around the shores of Lake Tahoe (South, West, and North subbasins), and the Martis Valley groundwater basin is north of Lake Tahoe (*fig. 2*). The study unit area is defined by the boundaries of the surface-water watersheds of Lake Tahoe and of the Martis Valley groundwater basin, and by the California-Nevada state line. The headwaters of the Truckee River are at the southern end of the study unit, above the apex of the South Tahoe subbasin, and the river flows north into Lake Tahoe. The Truckee River exits Lake Tahoe at Tahoe City, flows north out of the Lake Tahoe watershed, and then crosses the Martis Valley basin.

Lake Tahoe and the Tahoe Valley and the Martis Valley groundwater basins lie in a structural valley between the Sierra Nevada crest to the west and the Carson Range to the east. The valley was formed by extensional faulting that resulted in approximately 5,000 ft of uplift of the Sierra Nevada crest and Carson Range relative to the valley in the graben between the two mountain ranges. Most of the uplift occurred in the Pliocene and early Pleistocene (2 to 5 million years [Ma]; Birkeland, 1963), although motion on faults around Lake Tahoe has continued through the late Pleistocene and Holocene to the present (Kent and others, 2005). The bedrock in the Lake Tahoe area is primarily composed of Mesozoic (80 to 120 Ma) granitic rocks, mostly granodiorites, of the Sierra Nevada batholith. Included within the granitic rocks are scattered remnants of the older metamorphic rocks into which the granitic plutons intruded. Uplift of the Sierra Nevada and Carson Range was accompanied by volcanic activity. Thick sequences of late Miocene to Pleistocene (1 to 10 Ma) volcanic rocks cover the granitic bedrock in the Martis basin and watershed area, and in the Lake Tahoe watershed north of approximately the Placer-El Dorado county line (*fig. 2*). The older volcanic rocks are dominated by andesite tuffs, breccias, and flows, and the younger rocks by basalt and latite flows and cinder cones. Lake Tahoe is impounded by a dam of lava flows.

The Lake Tahoe and Truckee areas preserve evidence of four major glacial advances during the Pleistocene (Birkeland, 1964). The topography of the Tahoe Valley subbasins and Martis Valley basin is dominated by glacial moraines and outwash plains, primarily from the Tahoe (70 to 150 thousand years [ka]) and Tioga (19 to 26 ka) glaciations. The glaciers also formed ice dams that episodically raised the level of the lake as much as 600 ft above the current lake level, as evidenced by wave-cut terraces high on the mountains around the lake.

The climate in Tahoe–Martis is characterized by warm, dry summers and cold, wet winters, although the temperatures and precipitation are strongly controlled by altitude and distance from the crest of the Sierra Nevada. The average surface altitude of Lake Tahoe is 6,225 ft and the lowest area in the Martis basin is 5,700 ft. The mountains bounding the South Tahoe subbasin rise to over 9,500 ft. Annual precipitation at stations in Truckee and on the California shores of Lake Tahoe averages 30–35 inches per year (note that snowfall has been converted to equivalent inches of rainfall) (California Department of Water Resources, 2008; Western Regional Climate Center, 2008), and precipitation increases to an average of over 80 inches per year at the highest elevations on the western side of the Lake Tahoe watershed (Crippen and Pavelka, 1970). At Lake Tahoe, approximately half of the precipitation falls as snow, and at the highest elevations, nearly all the precipitation falls as snow. Ninety percent of the precipitation falls in the winter, between October and April (California Department of Water Resources, 2008; Western Regional Climate Center, 2008).

Tahoe–Martis is divided into three study areas: the Martis study area, the Tahoe study area, and the Hard Rock study area (*fig. 3*). The boundary of the Martis study area corresponds to the CDWR Martis Valley basin (California Department of Water Resources, 2006), and the boundaries of the Tahoe study area correspond to the South, West, and North subbasins of the CDWR Tahoe Valley basin (California Department of Water Resources, 2004a,b,c). The Hard Rock study area corresponds to the surface-water watersheds surrounding the Martis and Tahoe Valley basins and Lake Tahoe.

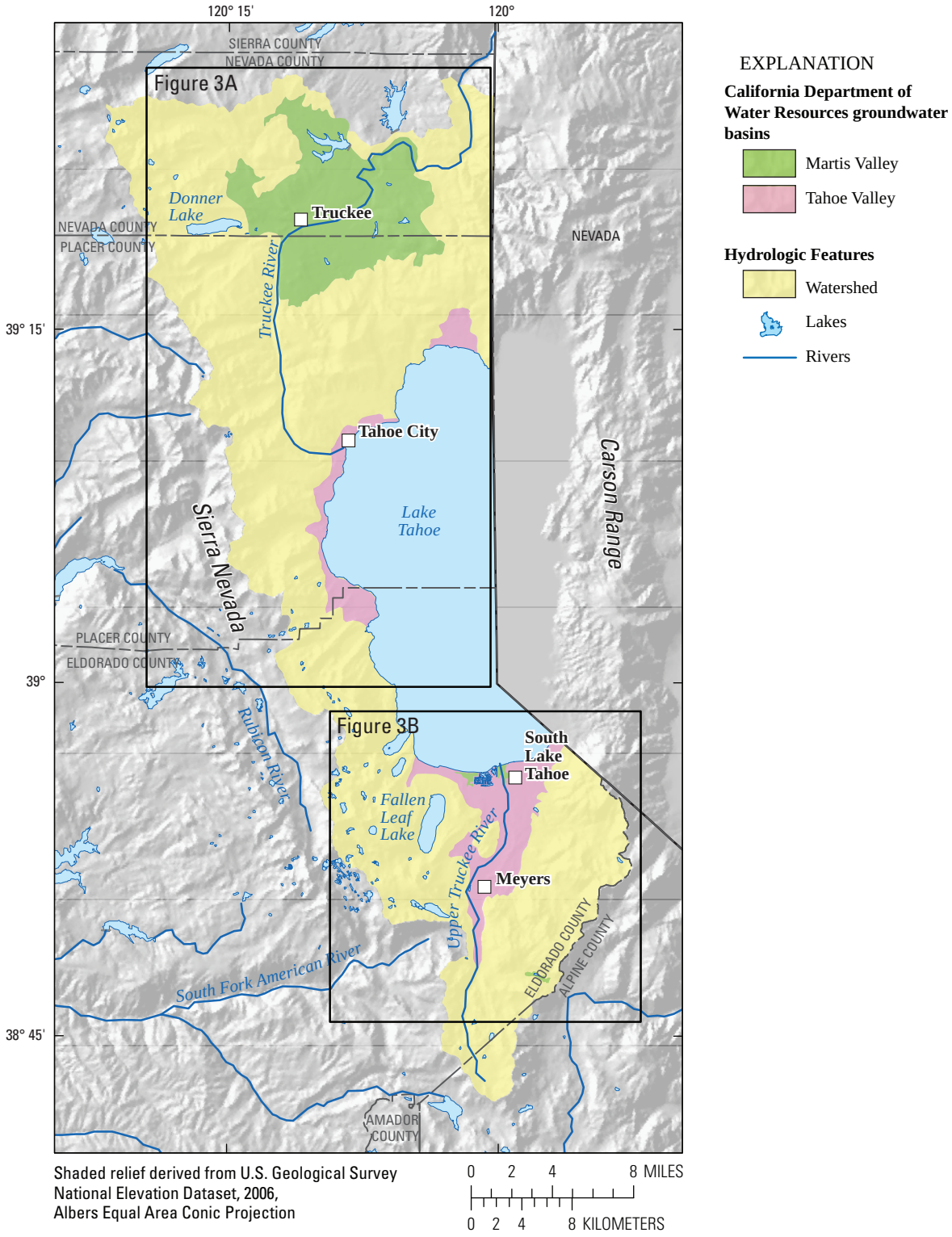


Figure 2. The Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study unit, and locations of groundwater basins, major cities, major hydrologic features, and the surface-water watershed area for Lake Tahoe and the Tahoe and Martis Valley groundwater basins, California.

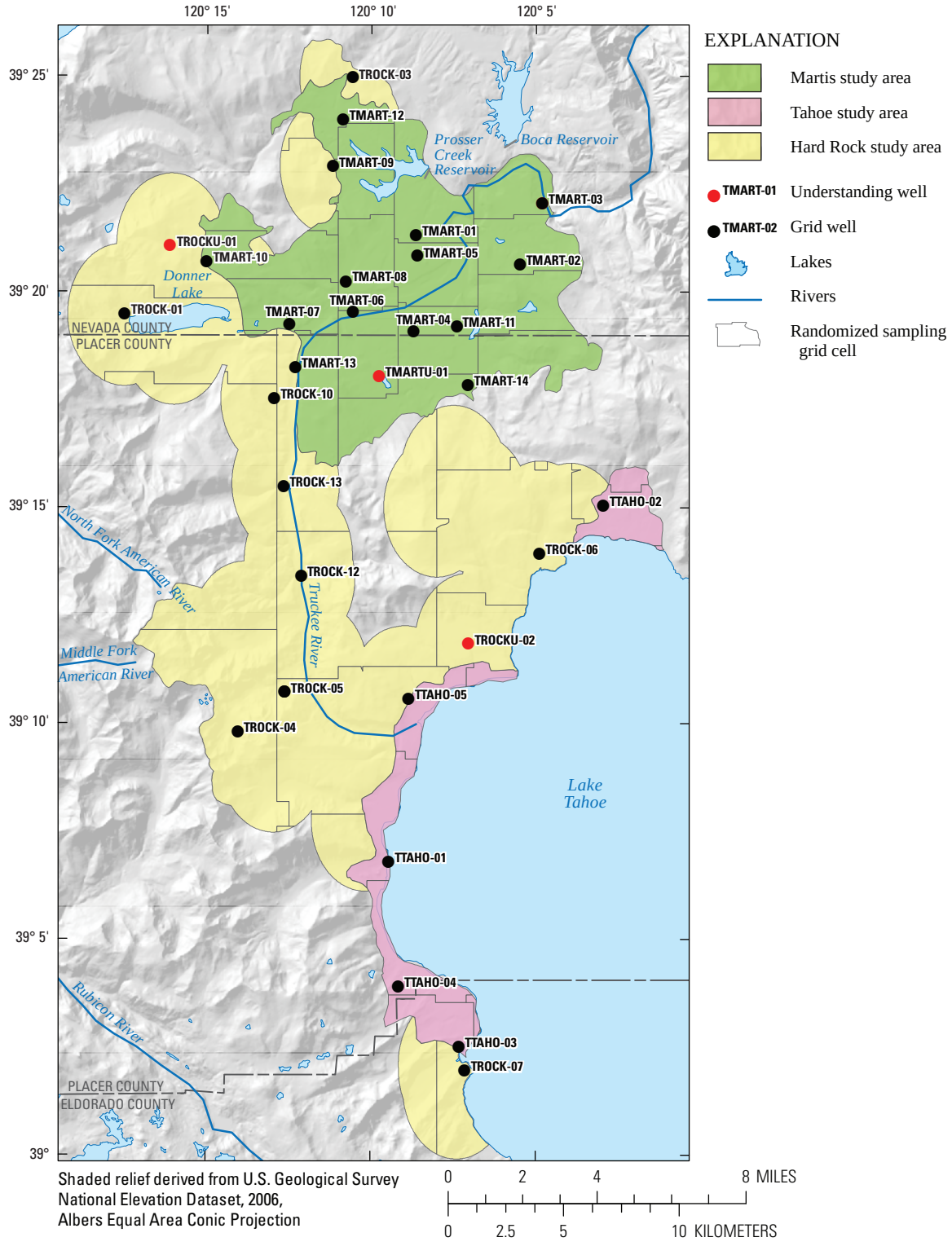


Figure 3. The northern (*A*) and southern (*B*) parts of the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study unit, California, and the distribution of the study area grid cells, and locations of the sampled grid wells and the understanding wells.

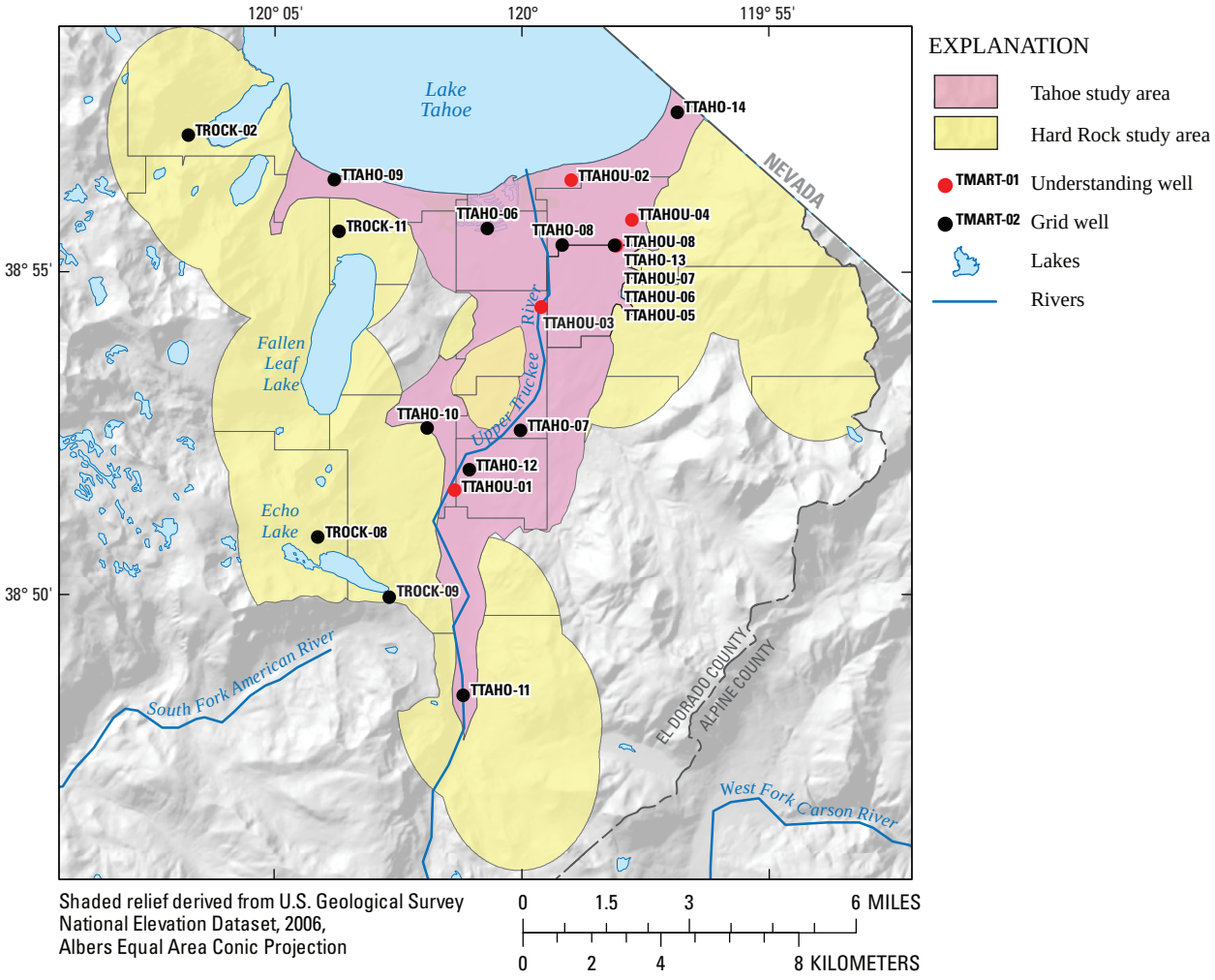


Figure 3. Continued.

Tahoe Study Area

The groundwater-bearing units in the South, West, and North subbasins of the Tahoe Valley basin consist of Pliocene to Recent glacial, lacustrine, and fluvial deposits, referred to as basin-fill deposits (Burnett, 1971; California Department of Water Resources, 2004a,b,c). The predominant sediments in the basins are glacial outwash sediments that were deposited on prograding deltas as the glaciers retreated. The outwash sediments are composed of sorted, stratified material; the grain size ranges from boulders to fine silt. Glacial tills were also deposited in lateral and terminal moraines. In the South Tahoe subbasin, the sediments were derived primarily from the granitic rocks in the surrounding Sierra Nevada and Carson Ranges. Fluctuations in the level of Lake Tahoe during the glacial period resulted in interbedding of lacustrine and glacial deposits. The lacustrine deposits range from beach sands to silt and clay layers. The fine-grained lacustrine deposits constitute discontinuous confining layers within the basin fill. The relatively thin Holocene fluvial deposits in the modern stream channels do not contribute significantly to groundwater storage in the basins.

The basin-fill deposits generally are 50 to 150 ft thick in the South Tahoe subbasin, but thicknesses up to 1,600 ft have been measured near the city of South Lake Tahoe (California Department of Water Resources, 2006a). Sediment thicknesses in the North and West Tahoe subbasins are less well known, but are thought to range from 20 to as much as 200 ft (California Department of Water Resources, 2006b,c). Groundwater conditions range from unconfined to semi-confined to confined.

Groundwater is recharged primarily by infiltration of rain and snow melt. Recharge occurs through the surface of the basin-fill deposits, and from higher elevations through fractures and faults in the bedrock and surface soils (Thodal, 1997). Stream-flow characteristics of the Upper Truckee River and Trout Creek in the South Tahoe subbasin suggests that these streams are net “gaining” streams, receiving groundwater discharge as they traverse the subbasin (Rowe and Allander, 2000).

Martis Study Area

The groundwater bearing units in the Martis Valley basin consist of interlayered volcanic and sedimentary deposits of late Miocene to late Pleistocene age (less than 1 to 7 Ma) (Nimbus Engineers, 2001; California Department of Water Resources, 2006). The sedimentary deposits are composed of glacial, lacustrine, and fluvial deposits with depositional characteristics similar to those of the basin-fill sedimentary deposits in the Tahoe Valley subbasins. The primary source of sediment deposited in the Martis Valley basin was the andesitic volcanic and volcaniclastic units located in and around the basin. The glacial outwash sediments that cover approximately half of the surface of the Martis Valley are up to 150 ft thick (Birkeland, 1964). The volcanic units include andesite lava, tuff, breccias, and volcaniclastic deposits.

The water-bearing sedimentary and volcanic units are up to 1,200 ft thick and are underlain by low-permeability Miocene volcanic rocks. The stratigraphy of the basin is complex, but it is generally separated into upper and lower aquifer systems that appear to have limited interconnection (Nimbus Engineers, 2001). Groundwater recharge occurs primarily by infiltration of rain and snow melt in the basin and in the mountains surrounding the basin.

Hard Rock Study Area

The groundwater bearing units in the Hard Rock study area are the Mesozoic granitic rocks in the mountains surrounding the South Tahoe subbasin and the southern half of the West Tahoe subbasin, and the Miocene to Pleistocene volcanic rocks in the mountains surrounding the Martis Valley, the North Tahoe subbasin, and the northern half of the West Tahoe subbasin. Extensive faulting associated with the uplift of the Sierra Nevada crest west and the Carson range east of the structural valley containing Lake Tahoe and the Tahoe and Martis Valley groundwater basins likely contributes to the permeability of the granitic and volcanic rocks.

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 statewide, (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-control design, and the results of analyses of quality-control samples.

Study Design

The wells selected for sampling in this study reflect the combination of two well-selection strategies. Forty-one wells were selected to provide a statistically unbiased, spatially distributed assessment of the quality of groundwater resources used for public drinking-water supply, and 11 additional wells were selected to provide greater sampling density in several areas to aid in the 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 Tahoe and the Martis study areas were each divided into 15 equal-area cells, approximately 2.5 mi^2 and 4 mi^2 in area, respectively (*fig. 3*). The Hard Rock study area had relatively few public-supply wells, and these wells were not evenly distributed. To minimize the number of cells without any wells, only the parts of the Hard Rock study area near public-supply wells were included in the gridded area. Locations of wells listed in the statewide database maintained by the CDPH were plotted, and 1.86-mi (3-kilometer) radius circles were drawn around each well. The collective area encompassed by the circles was then divided into 15 equal area cells, each approximately 12 mi^2 in area (*fig. 3*). The cell areas in the Tahoe and the Martis study areas were smaller than the GAMA design objective of 10-mi^2 grid cells in basins outside of the Central Valley hydrogeologic province (Belitz and others, 2003). The smaller cell sizes were necessary to provide a minimum of 15 cells in each study area for statistical confidence.

The objective was to select one public-supply well per grid cell. In the Hard Rock study area, approximately one-quarter of the public-supply wells listed in the CDPH databases were actually springs. For convenience, all sites will be referred to as wells unless the difference between a well and a spring is important to the discussion. Forty-one of the 45 grid cells were sampled; the other 4 grid cells did not contain accessible wells. If a grid cell contained more than one public-supply well, each well was randomly assigned a rank. The highest ranking well that met basic sampling criteria (for example, sampling point located before treatment, capability to pump for several hours, and available well-construction information) and for which permission to sample could be obtained was then sampled. If a grid cell contained no accessible public-supply wells, then domestic and irrigation wells were considered for sampling. An attempt was made to select domestic and irrigation wells with depths and screened intervals similar to those in public-supply wells in the area. Wells sampled as part of the spatially distributed, randomized grid-cell network are hereinafter referred to as grid wells. Grid wells in each study area were numbered in the order of sample collection, and prefixes were assigned to indicate the study area: TTAHO for the Tahoe study area, TMART for the Martis study area, and TROCK for the Hard Rock study area (*fig. 3*, *table 1*).

Additional wells were sampled to increase sampling density in selected areas and therefore aid in the understanding of changes in water chemistry along selected groundwater flow paths or between shallow and deep parts of the aquifers. These additional wells were not included in the statistical characterization of water quality in Tahoe–Martis because their inclusion would have caused some cells to be overrepresented. These additional, non-randomized wells were numbered in the order of sample collection and were assigned the prefixes TTAHOU, TMARTU, and TROCKU ("U" indicating "understanding") (*fig. 3*).

Table 1 provides the GAMA alphanumeric identification number for each well, along with the date sampled, sampling schedule, well elevation, well type, and well-construction information. Wells classified as production wells have pumps that pump the groundwater from the aquifer to a distribution system. Wells classified as monitoring wells included short-screen wells installed specifically as monitoring wells and wells that were once production wells, but no longer have pumps. Monitoring wells were sampled using a portable submersible pump. Wells were classified as springs if groundwater could flow from the aquifer into the distribution system without a pump, and the well was either drilled horizontally or had no drilled hole. The wells were sampled during June through September, 2007. The 41 grid wells included 37 sites classified by CDPH as public-supply wells (or springs). Public-supply wells are not identified in *table 1* because of security and confidentiality requirements; the number of public-supply wells in the grid-well network is reported to demonstrate that the network is representative of the parts of the aquifers in the study unit that are used for public supply. One short-screen monitoring well (TTAHO-13) was used as a grid well because the cell contained no other accessible wells, and the monitoring well was screened within the same depth zone as the public-supply wells in the area. The three remaining grid wells that were not public-supply wells were also screened within similar depth zones as public-supply wells in their vicinities. The 11 understanding wells included 4 short-screen monitoring wells, 6 wells classified as public-supply wells, and 1 irrigation well.

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

The wells in Tahoe–Martis were sampled using a tiered analytical approach. All wells were sampled for a standard set of constituents, including field water-quality parameters, organic constituents (VOCs and pesticides), perchlorate, inorganic constituents (nutrients, major ions, trace elements, and trace element species), radioactive constituents (uranium isotopes and radon), and geochemical and age dating tracers (stable isotopes of hydrogen and oxygen of water, strontium isotopes, carbon isotopes, dissolved noble gases, and tritium). The standard set of constituents was termed the *intermediate* schedule (*table 2*). Wells on the *slow* schedule were sampled for all the constituents on the intermediate schedule plus field alkalinity, pharmaceutical compounds, *N*-nitrosodimethylamine (NDMA), radium isotopes, gross alpha and gross beta particle activities, and microbial constituents. *Intermediate* and *slow* refer to the time required to sample the well for all the constituents on the schedule. In Tahoe–Martis, two wells could be sampled in one day. Many of the other GAMA study units have had a shorter list of standard constituents and have termed the standard set the *fast* schedule because three or four *fast* wells could be sampled in one day. In Tahoe–Martis, 42 of the groundwater wells were sampled on the *intermediate* schedule and 10 on the *slow* schedule.

Sample Collection and Analysis

Samples were collected in accordance with the protocols established by the USGS National Water Quality Assessment (NAWQA) program (Koterba and others, 1995) and the USGS National Field Manual (U.S. Geological Survey, variously dated). These sampling protocols ensure that a representative sample of groundwater is collected at each site and that potential contamination of samples during collection and handling is minimized. The methods used to collect samples are described in the *Appendix* section "Sample Collection and Analysis."

Tables 3A–K list the compounds analyzed in each constituent class. Groundwater samples were analyzed for 85 VOCs (*table 3A*); 8 gasoline oxygenates and degradates (Tahoe study area only, *table 3B*); 63 pesticides and pesticide degradates (*table 3C*); 14 pharmaceutical compounds (*table 3D*); 2 constituents of special interest (*table 3E*); 5 nutrients (*table 3F*); 10 major and minor ions, and total dissolved solids (*table 3G*); 24 trace elements (*table 3G*); arsenic, iron, and chromium species (*table 3H*); stable isotopes of hydrogen and oxygen of water, strontium isotopes, carbon isotopes, and 10 radioactive constituents, including tritium and carbon-14 (*table 3I*); 5 dissolved noble gases, and helium stable isotope ratios (*table 3J*); and 2 microbial constituents (*table 3K*). The methods used for sample 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*. Five VOCs analyzed in this study were measured by more than one method at the USGS National Water Quality Laboratory (NWQL), but only the results from the preferred method are reported (see *Appendix* section "Constituents on Multiple Analytical Schedules"). Arsenic, iron, and chromium concentrations and tritium activities were measured by more than one laboratory, and both sets of results are reported for these constituents.

Quality Assurance

The quality-assurance and quality-control procedures used for this study followed the protocols used by the USGS NAWQA program (Koterba and others, 1995) and described in the USGS National Field Manual (U.S. Geological Survey, variously dated). The quality assurance plan followed by the NWQL, the primary laboratory used to analyze samples for this study, is described by Maloney (2005) and Pirkey and Glodt (1998). Quality-control (QC) samples collected in the Tahoe–Martis study unit included source-solution blanks, field blanks, replicates, and matrix and surrogate spikes. QC samples were collected to evaluate potential contamination, bias, or variability of the data that may have resulted from collecting, processing, storing, transporting, and analyzing the samples. Quality-control procedures and quality-control sample 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 three organic compounds were considered suspect and therefore were removed from the set of groundwater quality data presented in this report (see *table A3A* and additional discussion in *Appendix*). Results from the replicates confirm that the procedures used to collect and analyze the samples were consistent. Ninety-seven percent of the replicate pairs analyzed for constituents detected in samples had variability between values within acceptable limits; additional discussion can be found in the *Appendix*. Median matrix-spike recoveries for 12 of the 166 organic constituents analyzed were lower than the acceptable limits (*table 3C*), which may indicate that these constituents might not have been detected in some samples if their concentrations in these samples had been 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 drinking-water regulatory and nonregulatory 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 and microbial data presented in this report are meant to characterize the quality of the untreated groundwater resources within Tahoe–Martis, and are not intended to represent the treated drinking water delivered to consumers by water purveyors. The chemical and microbial composition of treated drinking water may differ from that of untreated groundwater because treated drinking water may be disinfected, filtered, mixed with other waters, and exposed to the atmosphere before being delivered to consumers. Comparisons between concentrations of constituents in raw, untreated groundwater and drinking-water thresholds are for illustrative purposes only, and are not indicative of compliance or noncompliance with drinking-water regulations.

The following thresholds were used for comparisons:

- **MCL—Maximum Contaminant Level.** Legally enforceable standards that apply to public water systems and are designed to protect public health by limiting the levels of contaminants in drinking water. MCLs established by the USEPA are the minimum standards with which states are required to comply, and individual states may choose to set more stringent standards. CDPH has established MCLs for constituents not regulated by the USEPA, as well as lowered the threshold concentration for a number of constituents with MCLs established by the USEPA. In this report, a threshold set by the USEPA and adopted by CDPH is labeled "MCL-US", and one set by CDPH that is more stringent than the MCL-US is labeled "MCL-CA". CDPH is notified when constituents are detected at concentrations greater than an MCL-US or 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 at concentrations above the action-level thresholds trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and CDPH currently are the same; thus the thresholds are labeled "AL-US" in this report.

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

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

- **NL—Notification Level.** Health-based notification levels established by CDPH for some of the constituents in drinking water that lack MCLs (NL-CA). If a constituent is detected above its NL-CA, California state law requires timely notification of local governing bodies and recommends consumer notification.

- **HAL—Lifetime Health Advisory Level.** The maximum concentration of a constituent at which its presence in drinking water is not expected to cause any adverse carcinogenic effects for a lifetime of exposure. HALs are established by the USEPA (HAL-US) and are calculated assuming consumption of 2 liters (2.1 quarts) of water per day over a 70-year lifetime by a 70-kilogram (154-pound) adult and that 20 percent of a person's exposure comes from drinking water.

- **RSD5—Risk-Specific Dose.** The concentration of a constituent in drinking water corresponding to an excess estimated lifetime cancer risk of 1 in 100,000. RSD5 is an acronym for risk-specific dose at 10^{-5}. RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by ten (RSD5-US). USEPA generally only accepts cancer risk policies from the States that are based on risk-specific doses of 10^{-5} or smaller (Toccalino and others, 2003).

For constituents having MCLs, the concentrations 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; concentrations of these constituents in groundwater samples were compared with both levels. The SMCL-US values for these constituents correspond to the recommended SMCL-CA. Detected concentrations of constituents that lack an MCL or SMCL were compared to the NL-CA. For constituents that lack an MCL, SMCL, or NL-CA, detected concentrations were compared with the HAL-US. For constituents that lack an MCL, SMCL, NL-CA, or HAL-US, detected concentrations were compared with the RSD5-US. Note that if a constituent has more than one type of established threshold, using this hierarchy to select the comparison threshold will not necessarily result in selecting the threshold with the lowest concentration. For example, zinc has an SMCL-CA of 5,000 µg/L and a HAL-US of 2,000 µg/L, and the comparison threshold selected by this hierarchy is the SMCL-CA. The comparison thresholds used in this report are listed in *tables 3A-K* for all constituents and in *tables 4-12* for constituents detected in groundwater samples from Tahoe–Martis. One-hundred eight of the 240 constituents analyzed for this study have established thresholds. Detections of constituents at concentrations greater than the selected comparison thresholds are marked with asterisks in *tables 4–12*.

Groundwater Quality Data

Results from analyses of raw (untreated) groundwater samples from Tahoe–Martis are presented in tables 4 through 12. Groundwater samples collected in Tahoe–Martis were analyzed for up to 167 organic constituents, of which 156 were not detected in any of the samples (*tables 3A–E*). The samples were analyzed for up to 71 naturally-occurring inorganic constituents and isotopic tracers (*tables 3F–J*) and two microbial constituents (*table 3K*). The results tables present only the constituents that were detected and list only samples in which at least one constituent was detected. The tables containing organic constituent classes that were analyzed at all of the grid wells include the number of wells at which each constituent was detected, the percentage of grid wells in which each constituent was detected, and the total number of constituents detected at each well (*tables 5*, *6*). Results from the understanding wells are presented in the tables, but these results were excluded from the detection frequency calculations to avoid statistically over-representing the areas near the understanding wells.

Table 4 includes water-quality indicators measured in the field and at the NWQL, and *tables 5* through *12* present the results of groundwater analyses organized by constituent classes:

- Organic constituents
  - VOCs and gasoline oxygenates and degradates (*table 5*)
  - Pesticides and pesticide degradates (*table 6*)
- Inorganic constituents
  - Nutrients (*table 7*)

- Major and minor ions and dissolved solids (*table 8*)
- Trace elements (*table 9*)
- Arsenic, iron, and chromium species (*table 10*)

- Isotopic tracers (*table 11*)
- Radioactive constituents (*table 12A,B,C*)

The constituents of special interest and the microbial constituents have no summary tables because none of these constituents were detected in groundwater samples from Tahoe–Martis. Results for pharmaceutical compounds, and dissolved noble gases and tritium/helium age dates are not presented in this report; they will be included in subsequent publications.

Field Water-Quality Indicators

Field and laboratory measurements of dissolved oxygen, pH, specific conductance, alkalinity, and water temperature are given in *table 4*. Alkalinity and dissolved oxygen are used as indicators of natural processes that control water chemistry. Specific conductance is a measure of the electrical conductivity of water and is proportional to amount of total dissolved solids (TDS) in the water. Samples from 3 grid wells had field or laboratory specific-conductance values above the upper SMCL-CA, and specific-conductance values for samples from the other 38 wells were below the recommended SMCL-CA. The pH value indicates the acidity of the water. Low pH in water may contribute to corrosion and high pH in water may contribute to scaling. Samples from 10 grid wells had field pH values outside the SMCL-US range for pH (lower pH in 7 samples and higher pH in 3 samples). Laboratory pH values may differ from field pH values because the pH of groundwater may change upon exposure to the atmosphere (see *Appendix*).

Organic Constituents

Volatile organic compounds (VOC) are present in paints, solvents, fuels, fuel additives, refrigerants, fumigants, and disinfected water, and are characterized by their tendency to evaporate. VOCs generally persist longer in groundwater than in surface water because groundwater is isolated from the atmosphere. Of the 88 VOCs analyzed, 8 were detected in groundwater samples; all detections except for one detection of perchloroethene (PCE) had concentrations below health-based thresholds, and most had concentrations less than 1/100 of the threshold values (*table 5*). Chloroform, a byproduct of drinking-water disinfection, and PCE, a solvent used in dry-cleaning, were detected in more than 10 percent of the grid well samples. These two compounds are among the most commonly detected VOCs in groundwater nationally (Zogorski and others, 2006). One or more VOCs were detected in samples from 15 of the 41 grid 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, 3 were detected in groundwater samples; all concentrations were below health-based thresholds, and all were less than 1/100 of the threshold values (*table 6*). No compounds were detected in more than 10 percent of the grid well samples. Pesticide compounds were detected in samples from 2 of the 41 grid wells.

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.

Nutrients (nitrogen and phosphorus) in groundwater can affect biological activity in aquifers and in surface-water bodies that receive groundwater discharge. Nitrogen may be present in the form of ammonia, nitrite, or nitrate, depending on the oxidation-reduction state of the groundwater. High concentrations of nitrate can adversely affect human health, particularly the health of infants. All concentrations of nitrate, nitrite, and ammonia measured in samples from Tahoe–Martis wells were below health-based thresholds (*table 7*).

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

Samples from 3 grid wells had TDS contents above the upper SMCL-CA, but TDS concentrations in samples from the other 38 grid wells were below the recommended SMCL-CA (*table 8*). The concentrations of chloride and sulfate were each above the upper SMCL-CA in one well, but concentrations were below the recommended SMCL-CA in all of the other grid wells.

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. Samples from 6 of the 41 grid wells had concentrations of iron and (or) manganese above the SMCL-CA (*table 9*).

Seventeen of the 24 trace elements analyzed in this study have regulatory or nonregulatory health-based thresholds. Of the 17 trace elements with health-based thresholds, all detections of 13 trace elements in grid wells had concentrations below health-based thresholds (*table 9*). Samples from 8 of the 41 grid wells had arsenic concentrations above the MCL-US. Two of these samples also had boron concentrations above the NL-CA, and one of them had a strontium concentration above the HAL-US. Samples from two grid wells had concentrations of molybdenum above the HAL-US.

Arsenic, iron, and chromium occur as different species, depending on the oxidation-reduction state of the groundwater. The oxidized and reduced species have different solubilities in groundwater and may have different effects on human health. The relative proportions of the oxidized and reduced species of each element can be used to help interpret the oxidation–reduction state of the aquifer. Concentrations of total arsenic, total iron, and total chromium, and the concentrations of either the reduced or the oxidized species of each element are reported in *table 10*. The concentration of the other species can be calculated by the difference. The concentrations of arsenic, iron, and chromium reported in *table 10* may be different than those reported in *table 9* because different analytical methods were used (see *Appendix*). The concentrations reported in *table 9* are considered to be more accurate.

Isotopic Tracers

Isotopic ratios of oxygen and hydrogen of water, strontium isotopic ratios, tritium and carbon-14 activities, and concentrations of dissolved noble gases may be used as tracers of natural processes affecting groundwater composition. Stable isotope ratios of hydrogen and oxygen of water (*table 11*) aid in interpretation of the sources of groundwater recharge. The stable isotope ratios of water reflect the altitude, latitude, and temperature of precipitation, and also the extent of evaporation of water from 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 gases dissolve in water that is in contact with the atmosphere, and the solubilities of the different noble gas species vary with temperature. Noble gas analyses were not completed in time to be included in this report; results will be presented in a subsequent publication. The isotopic ratio of strontium in groundwater reflects the strontium isotope ratio in the aquifer materials contributing strontium (and other inorganic constituents) to the groundwater. In regions with diverse geology, strontium isotope ratios may aid in estimating groundwater flow paths.

Tritium and carbon-14 activities (*table 11*), and helium isotope ratios provide information about the age (time since recharge) of the groundwater. Tritium is a short-lived radioactive isotope of hydrogen that is incorporated into the water molecule. Low levels of tritium are continuously produced by interaction of cosmic radiation with the Earth's atmosphere, and a large amount of tritium was produced as a result atmospheric testing of nuclear weapons between 1952 and 1963. Thus, concentrations of tritium above background generally indicate the presence of water recharged since the early 1950s. Helium isotope ratios are used in conjunction with tritium concentrations to estimate ages of young groundwater. Helium isotope ratio analyses were not completed in time to be included in this report; results will be presented in a subsequent publication. Carbon-14 is a radioactive isotope of carbon. Low levels of carbon-14 are continuously produced by interaction of cosmic radiation with the Earth's atmosphere, and incorporated into atmospheric carbon dioxide. The carbon dioxide dissolves in precipitation, surface water, and groundwater exposed to the atmosphere, thereby entering the hydrologic cycle. Because carbon-14 has a half-life of approximately 5,700 years, low activities of carbon-14 relative to modern values generally indicate the presence of groundwater that is several thousand years old.

Of the isotopic tracer constituents analyzed for this study, tritium is the only one that has a health-based threshold. All measured tritium activities in samples from Tahoe–Martis wells were less than 1/1,000 of the MCL-CA (*table 11*).

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 (Soddy, 1913; Faure and Mensing, 2005). Radium-226, radium-228, and radon-222 are radioactive isotopes formed during the uranium or thorium decay series. In each step in the decay series, one radioactive element turns into a different radioactive element by emitting an alpha or a beta particle from its nucleus. For example, radium-226 emits an alpha particle and therefore turns into radon-222. Radium-228 decays to form actinium-228 by emission of a beta particle. The alpha and beta particles emitted during radioactive decay are hazardous to human health because these energetic particles may damage cells. Radiation damage to cell DNA may increase the risk of getting cancer.

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

Two MCL-USs have been proposed for radon-222. The higher, 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, 1999a). One of the 40 samples from grid wells analyzed for radon-222 had an activity above the alternative MCL-US (*table 12A*). Samples from 8 of the 41 grid wells were analyzed for radium and gross alpha and gross beta particle activities. Two samples from grid wells had activities of gross alpha particle activity above the MCL-US (*table 12B*), and none had activities of radium above the MCL-US (*table 12C*).

Future Work

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

Summary

Groundwater quality in the approximately 460-square-mile Tahoe–Martis study unit (Tahoe–Martis) was investigated in June through September 2007 as part of the Priority Basin Project of Groundwater Ambient Monitoring and Assessment (GAMA) Program. The California State Water Resources Control Board (SWRCB), in collaboration with the U.S. Geological Survey (USGS) and the Lawrence Livermore National Laboratory, is implementing the GAMA Program. The Priority Basin Project was designed by the USGS and the SWRCB in response to the State of California's Groundwater Quality Monitoring Act of 2001. The project is a comprehensive assessment of statewide groundwater quality designed to identify and characterize risks to groundwater resources, and to increase the availability of information about groundwater quality to the public. Tahoe–Martis was the nineteenth study unit sampled as part of the project.

Tahoe–Martis is in the northeast part of the Sierra Nevada hydrogeologic province and includes within it two groundwater basins defined by the California Department of Water Resources as wells as the watersheds surrounding these basins. The Tahoe–Martis study included an assessment of the groundwater quality in samples from 52 wells in El Dorado, Placer, and Nevada Counties. Forty-one of the wells were selected using a randomized grid approach to achieve a statistically unbiased representation of groundwater used for public drinking- water supplies. Eleven more wells were selected to provide additional sampling density to aid in understanding processes affecting groundwater quality.

Groundwater samples were analyzed for VOCs, pesticides and pesticide degradates, pharmaceutical compounds, nutrients, major and minor ions, trace elements, radioactivity, and microbial constituents. Naturally occurring isotopes (stable isotopes of hydrogen and oxygen of water, isotopes of carbon, strontium, and uranium, 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, 240 constituents and field water-quality indicators were investigated for this study. This report describes the sampling, analytical, and quality-control methods used in the study, and presents the results of the chemical analyses made of the groundwater samples collected during June through September 2007.

This study did not attempt to evaluate the quality of water delivered to consumers; after withdrawal from the ground, water typically is treated, disinfected, and blended with other waters to maintain acceptable water quality. Regulatory thresholds apply to treated water that is served to the consumer, not to raw groundwater. However, to provide some context for the results, concentrations of constituents measured in the raw groundwater were compared with regulatory and nonregulatory 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.

The concentrations of most constituents detected in groundwater samples from Tahoe–Martis wells were below regulatory and nonregulatory drinking-water thresholds. One or more organic compounds (VOCs and/or pesticides) were detected in about 40 percent of the grid wells and generally at less than 1/100 of a regulatory or nonregulatory health-based threshold, although the perchloroethene concentration in one sample was above USEPA maximum contaminant level (MCL-US). Perchlorate, NDMA, and microbial constituents were not detected in samples from any wells. The concentrations of trace elements and nutrients were below regulatory or nonregulatory health-based thresholds with the following exceptions: Arsenic was detected above the MCL-US in samples from 20 percent of the grid wells. Gross alpha particle activity (MCL-US), boron (CDPH notification level), and molybdenum (USEPA lifetime health advisory) were each detected above thresholds in samples from two of the 41 grid wells, and radon (proposed Alternative MCL-US) was detected above the threshold in a sample from one grid well. Fifteen percent of the samples from grid wells contained iron, manganese, or total dissolved solids at concentrations above the nonenforceable SMCL-CA thresholds set for aesthetic and technical concerns.

Subsequent reports will present evaluations of the data presented in this report using a variety of statistical, qualitative, and quantitative approaches to assess the natural and human factors affecting groundwater quality.

Acknowledgments

The authors thank the following cooperators for their support: the California SWRCB, CDPH, CDWR, and LLNL. We especially thank the well owners and water purveyors for their generosity in allowing the USGS to collect samples from their wells. Two reviewers, Jan Stepek (SWRCB) and Carmen Burton (USGS) provided comments to improve this work. Funding for this work was provided by State bonds authorized by Proposition 50 and administered by the SWRCB.

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Tables

Table 1. Well identification, and sampling and construction information for wells sampled for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September, 2007.

[GAMA well identification number: TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. **Other abbreviations:** ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

GAMA well identification number	Sampling information				Construction information		
	Date	Sampling schedule[1]	Elevation of LSD (ft above NAVD 88)[2]	Well type	Well depth (ft below LSD)	Top of opening (ft below LSD)	Bottom of opening (ft below LSD)
Grid wells							
TMART-01	06/25/07	Slow	5,847	Production	1,132	280	1,110
TMART-02	06/26/07	Intermediate	6,125	Production	690	65	680
TMART-03	06/26/07	Intermediate	5,596	Production	383	363	383
TMART-04	06/27/07	Intermediate	5,889	Production	1,026	100	1,026
TMART-05	06/27/07	Intermediate	5,968	Production	1,370	460	1,360
TMART-06	06/28/07	Slow	5,879	Production	900	40	900
TMART-07	07/10/07	Intermediate	5,884	Production	106	50	na
TMART-08	07/10/07	Intermediate	5,973	Production	612	125	612
TMART-09	09/20/07	Intermediate	5,940	Production	120	70	120
TMART-10	07/16/07	Intermediate	6,604	Production	600	500	600
TMART-11	07/18/07	Intermediate	5,914	Production	132	na	na
TMART-12	07/26/07	Intermediate	5,871	Production	250	175	250
TMART-13	09/11/07	Intermediate	5,857	Production	175	175	na
TMART-14	09/12/07	Intermediate	5,840	Production	800	217	800
TROCK-01	07/9/07	Intermediate	6,044	Production	270	na	na
TROCK-02	07/11/07	Intermediate	6,584	Spring	0	na	na
TROCK-03	07/16/07	Intermediate	6,064	Production	292	232	292
TROCK-04	07/17/07	Intermediate	7,209	Spring	0	na	na
TROCK-05	07/17/07	Intermediate	6,758	Spring	0	na	na
TROCK-06	07/18/07	Intermediate	6,314	Production	218	75	213
TROCK-07	07/24/07	Intermediate	6,319	Production	320	190	320
TROCK-08	07/30/07	Intermediate	8,107	Spring	0	na	na
TROCK-09	07/30/07	Intermediate	7,615	Spring	0	na	na
TROCK-10	07/31/07	Intermediate	6,316	Production	610	na	na
TROCK-11	08/01/07	Intermediate	6,354	Production	48	na	na
TROCK-12	09/12/07	Intermediate	6,056	Production	na	na	na
TROCK-13	09/13/07	Slow	5,984	Production	102	93	98
TTAHO-01	07/11/07	Intermediate	6,232	Production	50	45	50
TTAHO-02	07/19/07	Slow	6,443	Production	880	240	880
TTAHO-03	07/23/07	Intermediate	6,293	Production	152	124	144
TTAHO-04	07/24/07	Intermediate	6,405	Production	240	60	210
TTAHO-05	07/25/07	Intermediate	6,400	Production	482	228	452
TTAHO-06	08/02/07	Slow	6,232	Production	495	138	480
TTAHO-07	08/13/07	Intermediate	6,309	Production	266	108	160
TTAHO-08	08/14/07	Intermediate	6,254	Production	156	86	156
TTAHO-09	08/15/07	Intermediate	6,214	Production	100	70	100
TTAHO-10	08/16/07	Slow	6,319	Production	250	95	245
TTAHO-11	08/21/07	Slow	6,472	Monitoring	200	na	na
TTAHO-12	08/22/07	Intermediate	6,304	Monitoring	325	106	315
TTAHO-13	08/29/07	Slow	6,281	Monitoring	135	130	135
TTAHO-14	09/10/07	Intermediate	6,241	Production	250	135	245

Table 1. Well identification, and sampling and construction information for wells sampled for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September, 2007.—Continued

[GAMA well identification number: TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. **Other abbreviations:** ft, foot; LSD, land surface datum; NAVD 88, North American Vertical Datum 1988; na, not available]

GAMA well identification number	Sampling information				Construction information		
	Date	Sampling schedule[1]	Elevation of LSD (ft above NAVD 88)[2]	Well type	Well depth (ft below LSD)	Top of opening (ft below LSD)	Bottom of opening (ft below LSD)
Understanding Wells							
TMARTU-01	07/12/07	Slow	5,996	Production	900	140	900
TROCKU-01	07/09/07	Intermediate	6,984	Production	317	285	317
TROCKU-02	07/25/07	Intermediate	6,645	Production	860	380	800
TTAHOU-01	08/13/07	Intermediate	6,304	Production	330	130	310
TTAHOU-02	08/14/07	Intermediate	6,259	Production	418	110	400
TTAHOU-03	08/14/07	Intermediate	6,284	Production	380	186	366
TTAHOU-04	[3]08/23/07	Intermediate	6,263	Production	247	152	220
TTAHOU-05	08/27/07	Slow	6,281	Monitoring	335	325	335
TTAHOU-06	08/28/07	Intermediate	6,281	Monitoring	255	245	255
TTAHOU-07	08/28/07	Intermediate	6,281	Monitoring	163	158	163
TTAHOU-08	09/10/07	Intermediate	6,281	Monitoring	93	88	93

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

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

[3]Well was sampled for volatile organic compounds (VOC) on 04/03/08.

Table 2. Classes of chemical and microbial constituents and water-quality indicators collected for the slow and intermediate sampling schedules for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September, 2007.

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

Analyte classes	Slow schedule	Intermediate schedule	Analyte list table	Results table
Water-quality indicators				
Dissolved oxygen, temperature, specific conductance	X	X	—	*4*
pH, alkalinity	X	X	—	*4*
Organic constituents				
Volatile organic compounds	X	X	*3A*	*5*
Gasoline additives and oxygenates[1]	X	X	*3B*	*5*
Pesticides and pesticide degradates	X	X	*3C*	*6*
Pharmaceutical compounds	X	—	*3D*	(2)
Constituents of special interest				
Perchlorate	X	X	*3E*	(3)
N-Nitrosodimethylamine (NDMA)	X	—	*3E*	(3)
Inorganic constituents				
Nutrients	X	X	*3F*	*7*
Major and minor ions and total dissolved solids	X	X	*3G*	*8*
Trace elements	X	X	*3G*	*9*
Arsenic, iron, and chromium species	X	X	*3H*	*10*
Isotopic tracers				
Stable isotopes of hydrogen and oxygen of water	X	X	*3I*	*11*
Stable isotopes of carbon and carbon-14 activity	X	X	*3I*	*11*
Strontium isotope ratio	X	X	*3I*	*11*
Radioactivity and noble gases				
Tritium	X	X	*3I*	*11*
Tritium and noble gases	X	X	*3J*	(2)
Radium isotopes	X	—	*3I*	*12*
Radon-222	X	X	*3I*	*12*
Uranium isotopes	X	X	*3I*	*12*
Gross alpha and beta radiation	X	—	*3I*	*12*
Microbial constituents				
Viral indicators	X	—	*3K*	(3)

[1]Collected in the Tahoe study area only.

[2]Data will be presented in subsequent reports

[3]Constituents were not detected in any samples.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 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, microgram per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number[1]	LRL (µg/L)	Threshold type[2]	Threshold value (µg/L)	Detection
Acetone	Solvent	81552	67-64-1	6	na	na	—
Acrylonitrile	Organic synthesis	34215	107-13-1	0.4	RSD5-US	0.6	—
tert-Amyl methyl ether (TAME)	Gasoline oxygenate	50005	994-05-8	0.04	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	[3]80	D
Bromoform (tribromomethane)	Disinfection by-product (THM)	32104	75-25-2	0.08	MCL-US	[3]80	—
Bromomethane (methyl bromide)	Fumigant	34413	74-83-9	0.4	HAL-US	10	—
n-Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	0.14	NL-CA	260	—
sec-Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	0.04	NL-CA	260	—
tert-Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	0.08	NL-CA	260	—
Carbon disulfide	Organic synthesis, natural	77041	75-15-0	0.06	NL-CA	160	D
Carbon tetrachloride (tetrachloromethane)	Solvent	32102	56-23-5	0.08	MCL-CA	0.5	—
Chlorobenzene	Solvent	34301	108-90-7	0.02	MCL-CA	70	—
Chloroethane	Solvent	34311	75-00-3	0.10	na	na	—
Chloroform (trichloromethane)	Disinfection by-product (THM)	32106	67-66-3	0.04	MCL-US	[3]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	[3]80	—
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	0.04	MCL-CA	600	—
1,3-Dichlorobenzene	Solvent	34566	541-73-1	0.04	HAL-US	600	—
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	0.04	MCL-CA	5	—
trans-1,4-Dichloro-2-butene	Organic synthesis	73547	110-57-6	0.6	na	na	—
Dichlorodifluoromethane (CFC-12)	Refrigerant	34668	75-71-8	0.14	NL-CA	1,000	—
1,1-Dichloroethane (1,1-DCA)	Solvent	34496	75-34-3	0.06	MCL-CA	5	—
1,2-Dichloroethane (1,2-DCA)	Solvent	32103	107-06-2	0.10	MCL-CA	0.5	—
1,1-Dichloroethene (1,1-DCE)	Organic synthesis	34501	75-35-4	0.02	MCL-CA	6	—
cis-1,2-Dichloroethene (cis-1,2-DCE)	Solvent	77093	156-59-2	0.02	MCL-CA	6	—
trans-1,2-Dichloroethene (trans-1,2-DCE)	Solvent	34546	156-60-5	0.018	MCL-CA	10	—
1,2-Dichloropropane	Fumigant	34541	78-87-5	0.02	MCL-US	5	—
1,3-Dichloropropane	Fumigant	77173	142-28-9	0.06	na	na	—
2,2-Dichloropropane	Fumigant	77170	594-20-7	0.06	na	na	—
1,1-Dichloropropene	Organic synthesis	77168	563-58-6	0.04	na	na	—

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 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, microgram per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number[1]	LRL (µg/L)	Threshold type[2]	Threshold value (µg/L)	Detection
cis-1,3-Dichloropropene	Fumigant	34704	10061-01-5	0.06	RSD5-US	[4]4	—
trans-1,3-Dichloropropene	Fumigant	34699	10061-02-6	0.10	RSD5-US	[4]4	—
Diethyl ether	Solvent	81576	60-29-7	0.08	na	na	—
Diisopropyl ether (DIPE)	Gasoline oxygenate	81577	108-20-3	0.06	na	na	D
Ethylbenzene	Gasoline hydrocarbon	34371	100-41-4	0.02	MCL-CA	300	—
Ethyl *tert*-butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.04	na	na	—
Ethyl methacrylate	Organic synthesis	73570	97-63-2	0.14	na	na	—
o-Ethyl toluene (1-ethyl-2-methyl benzene)	Gasoline hydrocarbon	77220	611-14-3	0.04	na	na	—
Hexachlorobutadiene	Organic synthesis	39702	87-68-3	0.10	RSD5-US	9	—
Hexachloroethane	Solvent	34396	67-72-1	0.14	HAL-US	1	—
2-Hexanone (*n*-Butyl methyl ketone)	Solvent	77103	591-78-6	0.4	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	0.4	na	na	—
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	0.4	na	na	—
Methyl *tert*-butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.10	MCL-CA	13	D
Methyl *iso*-butyl ketone (MIBK)	Solvent	78133	108-10-1	0.2	NL-CA	120	—
Methylene chloride (dichloromethane)	Solvent	34423	75-09-2	0.04	MCL-US	5	—
Methyl ethyl ketone (2-butanone, MEK)	Solvent	81595	78-93-3	1.6	HAL-US	4,000	—
Methyl methacrylate	Organic synthesis	81597	80-62-6	0.20	na	na	—
Naphthalene	Gasoline hydrocarbon	34696	91-20-3	0.4	NL-CA	17	—
Perchloroethene (tetrachloroethene, PCE)	Solvent	34475	127-18-4	0.04	MCL-US	5	D
n-Propylbenzene	Solvent	77224	103-65-1	0.04	NL-CA	260	—
Styrene	Gasoline hydrocarbon	77128	100-42-5	0.04	MCL-US	100	—
1,1,1,2-Tetrachloroethane	Solvent	77562	630-20-6	0.04	HAL-US	70	—
1,1,2,2-Tetrachloroethane	Solvent	34516	79-34-5	0.10	MCL-CA	1	—
Tetrahydrofuran	Solvent	81607	109-99-9	1.0	na	na	—[5]
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	—[5]
1,2,3-Trichlorobenzene	Organic synthesis	77613	87-61-6	0.12	na	na	—
1,2,4-Trichlorobenzene	Solvent	34551	120-82-1	0.12	MCL-CA	5	—
1,1,1-Trichloroethane (1,1,1-TCA)	Solvent	34506	71-55-6	0.04	MCL-CA	200	D
1,1,2-Trichloroethane	Solvent	34511	79-00-5	0.04	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	—

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 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, microgram per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number[1]	LRL (µg/L)	Threshold type[2]	Threshold value (µg/L)	Detection
1,2,3-Trichloropropane (1,2,3-TCP)	Solvent/organic synthesis	77443	96-18-4	0.12	HAL-US[6]	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	—[5]
1,3,5-Trimethylbenzene	Organic synthesis	77226	108-67-8	0.04	NL-CA	330	—
Vinyl bromide (bromoethene)	Fire retardant	50002	593-60-2	0.12	na	na	—
Vinyl chloride (chloroethene)	Organic synthesis	39175	75-01-4	0.08	MCL-CA	0.5	—
m- and *p*-Xylene	Gasoline hydrocarbon	85795	108-38-3/ 106-42-3	0.08	MCL-CA	[7]1,750	—
o-Xylene	Gasoline hydrocarbon	77135	95-47-6	0.04	MCL-CA	[7]1,750	—

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

[2]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

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

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

[5]All detections of tetrahydrofuran, toluene, and 1,2,4-trimethylbenzene were V-coded because of detections in field blanks and were excluded from the dataset of groundwater quality results.

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

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

Table 3B. Gasoline oxygenates and degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey (USGS) National Water Quality Laboratory Schedule 4024.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 5*); na, not available; µg/L, microgram per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type[1]	Threshold value (µg/L)	Detection
Acetone	Degradate	81552	67-64-1	1.2	na	na	—
tert-Amyl alcohol	Oxygenate	77073	75-85-4	0.6	na	na	—
tert-Amyl methyl ether (TAME)	Oxygenate	50005	994-05-8	0.05	na	na	—
tert-Butyl alcohol (TBA)	Degradate	77035	75-65-0	2	NL-CA	12	—
Diisopropyl ether (DIPE)	Oxygenate	81577	108-20-3	0.06	na	na	D
Ethyl *tert*-butyl ether (ETBE)	Oxygenate	50004	637-92-3	0.04	na	na	—
Methyl acetate	Degradate	77032	79-20-9	0.4	na	na	—
Methyl *tert*-butyl ether (MTBE)	Oxygenate	78032	1634-04-4	0.04	MCL-CA	13	D

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

Table 3C. 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.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 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; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 6*); na, not available; µg/L, microgram per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type[1]	Threshold value (µg/L)	Detection
Acetochlor	Herbicide	49260	34256-82-1	0.006	na	na	—
Alachlor	Herbicide	46342	15972-60-8	0.005	MCL-US	2	—
Atrazine	Herbicide	39632	1912-24-9	0.007	MCL-CA	1	D
Azinphos-methyl	Insecticide	82686	86-50-0	0.08	na	na	—
Azinphos-methyl-oxon	Insecticide degradate	61635	961-22-8	0.042	na	na	—[2]
Benfluralin	Herbicide	82673	1861-40-1	0.01	na	na	—[2]
Carbaryl	Insecticide	82680	63-25-2	0.06	RSD5-US	400	—
2-Chloro-2,6-diethylacetanilide	Herbicide degradate	61618	6967-29-9	0.0065	na	na	—
4-Chloro-2-methylphenol	Herbicide degradate	61633	1570-64-5	0.005	na	na	—
Chlorpyrifos	Insecticide	38933	2921-88-2	0.005	HAL-US	2	—
Chlorpyrifos oxon	Insecticide degradate	61636	5598-15-2	0.0562	na	na	—[2]
Cyfluthrin	Insecticide	61585	68359-37-5	0.053	na	na	—
Cypermethrin	Insecticide	61586	52315-07-8	0.046	na	na	—
Dacthal (DCPA)	Herbicide	82682	1861-32-1	0.003	HAL-US	70	—
Deethylatrazine (2-chloro-4-isopropylamino-6-amino-*s*-triazine)	Herbicide degradate	04040	6190-65-4	0.014	na	na	D[2]
Desulfinylfipronil	Insecticide degradate	62170	na	0.012	na	na	—
Desulfinylfipronil amide	Insecticide degradate	62169	na	0.029	na	na	—
Diazinon	Insecticide	39572	333-41-5	0.005	HAL-US	1	—
3,4-Dichloroaniline	Herbicide degradate	61625	95-76-1	0.0045	na	na	—
Dichlorvos	Insecticide	38775	62-73-7	0.013	na	na	—[2]
Dicrotophos	Insecticide	38454	141-66-2	0.0843	na	na	D[2]
Dieldrin	Insecticide	39381	60-57-1	0.009	RSD5-US	0.02	—
2,6-Diethylaniline	Herbicide degradate	82660	579-66-8	0.006	na	na	—
Dimethoate	Insecticide	82662	60-51-5	0.0061	na	na	—[2]
Ethion	Insecticide	82346	563-12-2	0.016	na	na	—
Ethion monoxon	Insecticide degradate	61644	17356-42-2	0.021	na	na	—
2-Ethyl-6-methylaniline	Herbicide degradate	61620	24549-06-2	0.01	na	na	—
Fenamiphos	Insecticide	61591	22224-92-6	0.03	HAL-US	0.7	—
Fenamiphos sulfone	Insecticide degradate	61645	31972-44-8	0.053	na	na	—
Fenamiphos sulfoxide	Insecticide degradate	61646	31972-43-7	0.04	na	na	—[2]
Fipronil	Insecticide	62166	120068-37-3	0.016	na	na	—
Fipronil sulfide	Insecticide degradate	62167	120067-83-6	0.013	na	na	—
Fipronil sulfone	Insecticide degradate	62168	120068-36-2	0.024	na	na	—
Fonofos	Insecticide	04095	944-22-9	0.006	HAL-US	10	—
Hexazinone	Herbicide	04025	51235-04-2	0.026	HAL-US	400	—
Iprodione	Fungicide	61593	36734-19-7	0.026	na	na	—
Isofenphos	Insecticide	61594	25311-71-1	0.011	na	na	—

Table 3C. 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. Thresholds and threshold values as of June 1, 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; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5}. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 6*); na, not available; µg/L, microgram per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type[1]	Threshold value (µg/L)	Detection
Malaoxon	Insecticide degradate	61652	1634-78-2	0.039	na	na	—
Malathion	Insecticide	39532	121-75-5	0.016	HAL-US	100	—
Metalaxyl	Fungicide	61596	57837-19-1	0.0069	na	na	—
Methidathion	Insecticide	61598	950-37-8	0.0087	na	na	—
Metolachlor	Herbicide	39415	51218-45-2	0.01	HAL-US	700	—
Metribuzin	Herbicide	82630	21087-64-9	0.012	HAL-US	70	—
Myclobutanil	Fungicide	61599	88671-89-0	0.033	na	na	—
1-Naphthol	Insecticide degradate	49295	90-15-3	0.0882	na	na	—[2]
Paraoxon-methyl	Insecticide degradate	61664	950-35-6	0.019	na	na	—
Parathion-methyl	Insecticide	82667	298-00-0	0.008	HAL-US	1	—
Pendimethalin	Herbicide	82683	40487-42-1	0.02	na	na	—
cis-Permethrin	Insecticide	82687	54774-45-7	0.01	na	na	—
Phorate	Insecticide	82664	298-02-2	0.02	na	na	—[2]
Phorate oxon	Insecticide degradate	61666	2600-69-3	0.027	na	na	—
Phosmet	Insecticide	61601	732-11-6	0.0079	na	na	—[2]
Phosmet oxon	Insecticide degradate	61668	3735-33-9	0.0511	na	na	—[2]
Prometon	Herbicide	04037	1610-18-0	0.01	HAL-US	100	—
Prometryn	Herbicide	04036	7287-19-6	0.0059	na	na	—
Pronamide (propyzamide)	Herbicide	82676	23950-58-5	0.004	RSD5-US	20	—
Simazine	Herbicide	04035	122-34-9	0.006	MCL-US	4	—
Tebuthiuron	Herbicide	82670	34014-18-1	0.016	HAL-US	500	—
Terbufos	Insecticide	82675	13071-79-9	0.012	HAL-US	0.4	—
Terbufos oxon sulfone	Insecticide degradate	61674	56070-15-6	0.045	na	na	—
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]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 2008. **Abbreviations:** CAS, Chemical Abstract Service; na, not available; SRL, study reporting limit; µg/L, microgram per liter; —, not detected]

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

[1]The California Groundwater Ambient Monitoring and Assessment (GAMA) program uses reporting limits for the pharmaceutical compounds that are more conservative than those used by the USGS National Water Quality Laboratory (NWQL). The data for samples from this study unit were reported by the NWQL with interim laboratory reporting limits, and results below the interim method detection limits were included in the dataset. The GAMA program examined laboratory quality-control data and decided that the rate of false-positive detections was too high using the interim laboratory reporting limits. On the basis of our independent evaluation of the laboratory quality-control data, the GAMA program defined study reporting limits (SRL) for the pharmaceutical compounds. These SRLs have significantly higher concentrations than the interim laboratory reporting limits originally reported with the data, and GAMA does not report results below the SRLs. For albuterol, carbamazepine, codeine, cotinine, dehydronifedipine, diltiazem, 1,7-dimethylxanthine, sulfamethoxazole, thiabendazole, trimethoprim, and warfarin, the SRLs correspond to the long-term method detection limits determined by the USGS Branch of Quality Systems in October 2007 (LT-MDL). For acetaminophen, caffeine, and diphenhydramine, the SRLs correspond to the concentration above which there is less than a 1 percent probability of a false-positive detection determined from assessing laboratory quality-control data and field blanks associated with GAMA samples collected from May 2004 through September 2007. The SRLs for those compounds are higher than the BQS LT-MDLs. Detections reported by the USGS National Water Quality Laboratory with concentrations lower than the GAMA SRL are reported as non-detections by the GAMA program.

Table 3E. Constituents of special interest, primary uses or sources, comparative thresholds, and reporting information for the Montgomery Watson Harza and Weck Laboratories.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. Laboratories: MWH: Montgomery Watson Harza Laboratory; Weck, Weck Laboratory. **Other abbreviations:** CAS, Chemical Abstract Service; MRL, minimum reporting level; µg/L, microgram per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	MWH MRL (µg/L)	Weck MRL (µg/L)	Threshold type[1]	Threshold value (µg/L)	Detection
Perchlorate[2]	Rocket fuel, fireworks, natural	61209	14797-73-0	0.5	0.1	MCL-CA	6	—
N-Nitrosodimethylamine (NDMA)[3]	Rocket fuel, plasticizer, disinfection byproduct	64176	62-75-9	0.002	0.002	NL-CA	0.010	—

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2]All 52 samples were analyzed for perchlorate by MWH, and 15 samples collected after August 20, 2008, were also analyzed by Weck.

[3]All 10 samples on the slow schedule were analyzed for NDMA by MHW, and 3 samples on the slow schedule collected after August 20, 2008, were also analyzed by Weck.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 2008. **Threshold type:** HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*table 7*); na, not available; mg/L, milligram per liter]

Constituent	USGS parameter code	CAS number	LRL (mg/L)	Threshold type[1]	Threshold value (mg/L)	Detection
Ammonia, as nitrogen	00608	7664-41-7	0.010	HAL-US	[2]24.7	D
Nitrite, as nitrogen	00613	14797-65-0	0.002	MCL-US	1	D
Nitrite plus nitrate, as nitrogen	00631	na	0.060	MCL-US	10	D
Total nitrogen (ammonia, nitrite, nitrate, organic nitrogen)	62854	17778-88-0	0.06	na	na	D
Orthophosphate, as phosphorus	00671	14265-44-2	0.006	na	na	D

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 2008. **Threshold type:** AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; NL-CA, California Department of Public Health notification level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; LRL, laboratory reporting level; D, detected in groundwater samples (*tables 8, 9*); na, not available; mg/L, milligram per liter; µg/L, microgram per liter; —, not detected]

Constituent	USGS parameter code	CAS number	LRL	Threshold type[1]	Threshold value	Detection
Major and minor ions (mg/L)						
Bromide	71870	24959-67-9	0.02	na	na	D
Calcium	00915	7440-70-2	0.02	na	na	D
Chloride	00940	16887-00-6	0.12	SMCL-CA	[2]250 (500)	D
Fluoride	00950	16984-48-8	0.10	MCL-CA	2	D
Iodide	71865	7553-56-2	0.002	na	na	D
Magnesium	00925	7439-95-4	0.014	na	na	D
Potassium	00935	7440-09-7	0.04	na	na	D
Silica	00955	7631-86-9	0.018	na	na	D
Sodium	00930	7440-23-5	0.20	na	na	D
Sulfate	00945	14808-79-8	0.18	SMCL-CA	[2]250 (500)	D
Residue on evaporation (total dissolved solids, TDS)	70300	na	10	SMCL-US	[2]500 (1,000)	D
Trace elements (µg/L)						
Aluminum	01106	7429-90-5	1.6	MCL-CA	1,000	D
Antimony	01095	7440-36-0	0.06	MCL-US	6	D
Arsenic	01000	7440-38-2	0.12	MCL-US	10	D
Barium	01005	7440-39-3	0.08	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	0.06	MCL-US	4	D
Boron	01020	7440-42-8	8	NL-CA	1,000	D
Cadmium	01025	7440-43-9	0.04	MCL-US	5	D
Chromium	01030	7440-47-3	0.12	MCL-CA	50	D
Cobalt	01035	7440-48-4	0.04	na	na	D
Copper	01040	7440-50-8	0.4	AL-US	1,300	D
Iron	01046	7439-89-6	6	SMCL-CA	300	D
Lead	01049	7439-92-1	0.12	AL-US	15	D
Lithium	01130	7439-93-2	0.6	na	na	D
Manganese	01056	7439-96-5	0.2	SMCL-CA	50	D
Molybdenum	01060	7439-98-7	0.12	HAL-US	40	D
Nickel	01065	7440-02-0	0.06	MCL-CA	100	D
Selenium	01145	7782-49-2	0.08	MCL-US	50	D
Silver	01075	7440-22-4	0.10	SMCL-CA	100	—
Strontium	01080	7440-24-6	0.4	HAL-US	4,000	D
Thallium	01057	7440-28-0	0.04	MCL-US	2	D
Tungsten	01155	7440-33-7	0.06	na	na	D
Uranium	22703	7440-61-1	0.04	MCL-US	30	D
Vanadium	01085	7440-62-2	0.04	NL-CA	50	D
Zinc	01090	7440-66-6	0.6	SMCL-CA	5,000	D

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituents or property. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MDL, method detection limit; na, not available; µg/L, microgram per liter; D, detected in groundwater samples (*table 10*)]

Constituent (valence state)	USGS parameter code	CAS number	MDL (µg/L)	Threshold type[1]	Threshold level (µg/L)	Detection
Arsenic(III)	99034	22569-72-8	1	na	na	D
Arsenic(total)	99033	7440-38-2	0.5	MCL-US	10	D
Chromium(VI)	01032	18540-29-9	1	na	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-CA	300	D

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

Table 3I. Isotopic and radioactive constituents, comparative thresholds, and reporting information for laboratories.

[The five-digit U.S. Geological Survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 2008. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of the abundance of a heavier isotope to the more common lighter isotope of that element, relative to a standard reference material. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** H, hydrogen:, O, oxygen; C, carbon; Sr, strontium; CAS, Chemical Abstract Service; CSU, 1-sigma combined standard uncertainty; CV, critical value; MRL, minimum reporting level; MU, method uncertainty; na, not available; pCi/L, picocurie per liter; Prop., proposed; ssL_C, sample-specific critical level; D, detected in groundwater samples (*tables 11* and *12*)]

Constituent	USGS parameter code	CAS number	Reporting level type	Reporting level or uncertainty	Threshold type[1]	Threshold value	Detection
Stable isotope ratios (per mil)							
$\delta^{2}H$ of water[2]	82082	na	MU	2	na	na	D
$\delta^{18}O$ of water[2]	82085	na	MU	0.20	na	na	D
$\delta^{13}C$ of dissolved carbonates[3]	82081	na	1-sigma	0.05	na	na	D
Isotope ratios (atom ratio)							
Strontium isotope ratio ($^{87}Sr/^{86}Sr$)[4]	75978	na	MU	0.00005	na	na	D
Radioactive constituents (percent modern)							
Carbon-14[5]	49933	14762-75-5	MU	0.0015	na	na	D
Radioactive constituents (pCi/L)							
Radon-222[6]	82303	14859-67-7	na	CSU	Prop. MCL-US	[7]300 (4,000)	D
Tritium[8]	07000	10028-17-8	MRL	1	MCL-CA	20,000	D
Gross alpha particle activity, 72-hour and 30-day counts[9]	62636, 62639	12587-46-1	ssL_C	CSU	MCL-US	15	D
Gross beta particle activity, 72-hour and 30-day counts[9]	62642, 62645	12587-47-2	ssL_C	CSU	MCL-CA	50	D
Radium-226[9]	09511	13982-63-3	ssL_C	CSU	MCL-US	[10]5	D
Radium-228[9]	81366	15262-20-1	ssL_C	CSU	MCL-US	[10]5	D
Uranium-234[9]	22610	13966-29-5	ssL_C	CSU	MCL-CA	[11]20	D
Uranium-235[9]	22620	15117-96-1	ssL_C	CSU	MCL-CA	[11]20	D
Uranium-238[9]	22603	7440-61-1	ssL_C	CSU	MCL-CA	[11]20	D

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2]USGS Stable Isotope Laboratory, Reston, Virginia.

[3]University of Waterloo (contract laboratory).

[4]USGS Metals Isotope Research Laboratory, Menlo Park, California.

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

[6]USGS National Water Quality Laboratory.

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

[8]USGS Tritium Laboratory, Menlo Park, California.

[9]Eberline Analytical Services (contract laboratory).

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

[11]The MCL-CA threshold for uranium is the sum of uranium-234, uranium-235, and uranium-238.

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

[The five-digit U.S. Geological survey (USGS) parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level. **Other abbreviations:** CAS, Chemical Abstract Service; MU, method uncertainty; na, not available; cm^3 STP/g, cubic centimeter of gas at standard temperature and pressure per gram of water; pCi/L, picocurie per liter]

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

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Thresholds and threshold values as of June 1, 2008. **Threshold type:** TT-US, U.S. Environmental Protection Agency treatment technique - a required process intended to reduce the level of contamination in drinking water. **Other abbreviations:** MDL, method detection limit; na, not available; —, not detected]

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

Table 4. Water-quality indicators in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[The five digit number below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** A, average of two replicate values; °C, degrees Celsius; E, estimated value; RL, reporting limit; mg/L, milligram per liter; nc, sample not collected; na, not available; µS/cm, microsiemens per centimeter; $CaCO_3$, calcium carbonate; <, less than; >, greater than; *, value above threshold value or outside threshold range; **, value above upper threshold value]

GAMA well identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, lab (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as $CaCO_3$) (29802)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)
Threshold type	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**na**	**na**
Threshold level	**na**	**na**	**<6.5 or >8.5**	**<6.5 or >8.5**	**[1]900 (1,600)**	**[1]900 (1,600)**	**na**	**na**
[RL]	**[0.2]**	**[0.0–38.5]**	**[0–14]**	**[0–14]**	**[5]**	**[5]**	**[1]**	**[1]**
				Grid wells				
TMART-01	6.5	13.5	8.2	8.0	173	176	A77	82
TMART-02	6.6	17.5	8.4	8.3	162	162	nc	86
TMART-03	0.2	15.5	7.9	8.0	330	327	nc	155
TMART-04	E10	12.0	8.0	8.0	193	199	nc	89
TMART-05	7.2	18.0	7.9	7.8	314	329	nc	97
TMART-06	8.6	8.5	7.0	7.2	187	192	A83	88
TMART-07	4.1	13.0	6.7	*6.3	234	239	nc	58
TMART-08	6.0	17.0	8.2	8.0	332	338	nc	74
TMART-09	9.6	10.0	6.9	7.5	172	178	nc	94
TMART-10	6.1	12.5	8.0	8.2	167	181	nc	92
TMART-11	9.4	10.0	7.0	7.2	166	169	nc	57
TMART-12	8.8	11.0	8.1	8.1	133	142	nc	72
TMART-13	8.9	15.5	8.0	7.8	248	256	nc	105
TMART-14	3.9	18.5	7.5	7.8	260	267	nc	119
TROCK-01	6.2	12.5	7.4	7.6	277	289	nc	86
TROCK-02	2.8	7.5	*6.0	7.6	47	50	nc	26
TROCK-03	8.1	18.0	7.6	7.8	221	237	nc	126
TROCK-04	11.9	5.0	7.3	7.8	92	96	nc	50
TROCK-05	10.7	6.5	7.2	7.5	137	140	nc	75
TROCK-06	9.1	8.5	6.9	7.2	176	179	nc	96
TROCK-07	6.8	9.0	6.7	6.9	123	128	nc	52
TROCK-08	9.5	6.5	*5.5	7.0	15	18	nc	10
TROCK-09	8.1	14.5	*5.9	*6.4	31	34	nc	18
TROCK-10	7.6	12.5	7.4	7.7	169	175	nc	93
TROCK-11	6.0	9.0	6.5	6.8	131	135	nc	64
TROCK-12	0.5	12.5	*5.8	*6.1	**2,820	**2,900	nc	553
TROCK-13	12.6	12.5	7.3	7.5	*1,550	**1,660	A753	798

Table 4. Water-quality indicators in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five digit number below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** SMCL-US, U.S. Environmental Protection Agency secondary maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** A, average of two replicate values; °C, degrees Celsius; E, estimated value; RL, reporting limit; mg/L, milligram per liter; nc, sample not collected; na, not available; µS/cm, microsiemens per centimeter; $CaCO_3$, calcium carbonate; <, less than; >, greater than; *, value above threshold value or outside threshold range; **, value above upper threshold value]

GAMA well identification number	Dissolved oxygen, field (mg/L) (00300)	Water temperature, field (°C) (00010)	pH, field (standard units) (00400)	pH, lab (standard units) (00403)	Specific conductance, field (µS/cm at 25°C) (00095)	Specific conductance, lab (µS/cm at 25°C) (90095)	Alkalinity, field (mg/L as $CaCO_3$) (29802)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)
Threshold type	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**	**SMCL-CA**	**na**	**na**
Threshold level	**na**	**na**	**<6.5 or >8.5**	**<6.5 or >8.5**	**[1]900 (1,600)**	**[1]900 (1,600)**	**na**	**na**
[RL]	**[0.2]**	**[0.0–38.5]**	**[0–14]**	**[0–14]**	**[5]**	**[5]**	**[1]**	**[1]**
TTAHO-01	4.9	11.0	7.5	7.6	293	311	nc	114
TTAHO-02	7.6	14.5	8.1	8.1	199	206	A88	108
TTAHO-03	8.8	9.0	*6.1	6.7	71	76	nc	41
TTAHO-04	9.5	7.0	6.7	6.9	106	117	nc	61
TTAHO-05	6.9	9.0	7.6	7.8	135	138	nc	71
TTAHO-06	5.2	15.0	*9.0	*8.9	116	122	A39	50
TTAHO-07	8.4	9.0	8.0	8.1	73	76	nc	39
TTAHO-08	4.2	10.5	7.6	7.8	202	207	nc	70
TTAHO-09	5.7	10.5	8.1	8.2	118	123	nc	59
TTAHO-10	5.3	11.5	*8.6	*8.6	77	80	A35	40
TTAHO-11	0.2	15.0	*6.3	*6.4	**2,080	**1,910	A426	473
TTAHO-12	4.8	11.0	6.5	6.8	144	147	nc	37
TTAHO-13	0.8	12.5	*6.2	6.9	80	85	A5	39
TTAHO-14	9.6	11.5	*9.0	*9.1	64	70	nc	34
Understanding wells								
TMARTU-01	7.9	11.0	7.9	7.9	180	187	A87	95
TROCKU-01	16.2	8.0	7.3	7.7	105	109	nc	58
TROCKU-02	5.3	19.0	8.0	8.1	171	173	nc	90
TTAHOU-01	4.5	11.5	*8.8	*8.7	156	161	nc	61
TTAHOU-02	3.7	10.0	7.4	7.5	116	120	nc	55
TTAHOU-03	1.2	13.5	*9.0	*9.0	109	112	nc	46
TTAHOU-04	9.0	9.0	6.6	6.8	131	135	nc	52
TTAHOU-05	5.8	18.0	*9.2	*9.2	68	70	A28	33
TTAHOU-06	6.6	11.0	8.4	8.4	108	112	nc	46
TTAHOU-07	1.6	11.5	7.3	7.7	95	97	nc	48
TTAHOU-08	11.4	12.5	*6.1	7.7	62	68	nc	32

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

Table 5. Volatile organic compounds (VOC), and gasoline oxygenates and degradates detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed, but only samples with detections are listed. Analytes are grouped by primary use or source and listed in order of decreasing detection frequency in the 41 grid wells within each group. All analytes are listed in *tables 3A,B*. **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-US, U.S. Environmental Protection Agency maximum contaminant level; MCL-CA; California Department of Public Health maximum contaminant level; NL-CA, California Department of Public Health notification level. **Other abbreviations:** E, estimated value; V, analyte detected in blanks and excluded from the dataset of groundwater quality results; LRL, laboratory reporting level; DBP, disinfection by-product; na, not available; µg/L, microgram per liter; —, not detected; *, value greater than threshold value]

GAMA well identification number	DBP		Solvent			Gasoline oxygenate		Sulfide	VOC detections per well[1]
	Chloroform, (µg/L) (32106)	Bromodichloromethane, (µg/L) (32101)	Perchloroethene (PCE), (µg/L) (34475)	1,1,1-Trichloroethane, (µg/L) (34506)	Trichloroethene (TCE), (µg/L) (39180)	Methyl *tert*-butyl ether (MTBE), (µg/L) (78032)	Diisopropyl ether, (µg/L) (81577)	Carbon disulfide, (µg/L) (77041)	
[LRL]	**[0.04, 0.02]**	**[0.04]**	**[0.04]**	**[0.04, 0.02]**	**[0.02]**	**[0.1]**	**[0.06]**	**[0.06]**	
Threshold type[2]	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-CA**	**na**	**NL-CA**	
Threshold level	**[3]80**	**[3]80**	**5**	**200**	**5**	**13**	**na**	**160**	
Grid wells									
TMART-03[4]	0.28	0.11	—	—	—	—	—	—	2
TMART-04	E0.03	—	—	—	—	E0.04	—	—	1
TMART-06	E0.07	—	E0.03	—	—	—	—	—	2
TMART-09	1.12	E0.04	—	—	—	—	—	—	2
TMART-11	E0.03	—	—	—	—	—	—	—	1
TROCK-07	E0.01	—	—	—	—	—	0.1	—	2
TROCK-09[4]	E0.01	—	—	—	—	—	—	—	1
TROCK-13[4]	E0.03	—	—	—	—	—	—	—	1
TTAHO-02	—	—	E0.05	—	—	—	—	—	1
TTAHO-05	—	—	E0.02	—	—	—	—	—	1
TTAHO-06	E0.02	—	*19.5	—	E0.03	—	—	—	3
TTAHO-07	—	—	E0.03	—	—	—	—	—	1
TTAHO-08	0.1	—	0.24	E0.03	—	0.1	—	—	4
TTAHO-11	—	—	—	—	—	—	—	E0.35	1
TTAHO-12	0.28	E0.04	E0.04	—	—	0.8	—	—	4
Number of detections	11	3	7	1	1	3	1	1	
Detection frequency (percentage)	27	7	17	2	2	7	2	2	[5]37
Understanding wells									
TTAHOU-01	0.12	—	—	—	—	0.3	—	—	2
TTAHOU-02	E0.01	—	—	—	—	—	—	—	1
TTAHOU-04[6]	E0.05	—	—	—	—	0.1	—	—	2
TTAHOU-06	E0.07	—	E0.04	—	—	—	—	—	2
TTAHOU-07	—	—	E0.01	—	—	—	—	—	1

[1]All detections of the following three compounds were V-coded: tetrahydrofuran (TROCK-12, -13), toluene (TMART-10, TROCK-12), and 1,2,4-trimethylbenzene (TMART-10, -13; TMARTU-01; TROCK-08, -09, -10, -11; TTAHO-05, -07, -08, -09, -10, -12, -13, -14; TTAHOU-01, -02, -03, -06, -07).

[2]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

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

[4]The sampling point on the well was downstream of the point where hypochlorite disinfection solution was added. The disinfection system was shut off before the samples were collected.

[5]Frequency of detection of at least one volatile organic compound (VOC) in the grid wells. Detections assigned V remark codes are not included.

[6]Well was sampled for VOCs on 4/3/2008.

Table 6. Pesticides and pesticide degradates detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed, but only samples with detections are listed. Analytes are grouped by primary use or sources and listed in order of decreasing detection frequency in the 41 grid wells within each group. All analytes are listed in *table 3C*. **GAMA well identification number:** TMART, Martis study area grid well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level, na, not available; µg/L, microgram per liter; —, not detected]

GAMA well identification number	Herbicide	Herbicide degradate	Insecticide	Pesticide detections per well
	Atrazine (µg/L) (39632)	Deethylatrazine (µg/L) (04040)	Dicrotophos (µg/L) (38454)	
[LRL]	**[0.007]**	**[0.014]**	**[0.0843]**	
Threshold type[1]	**MCL-CA**	**na**	**na**	
Threshold level	**1**	**na**	**na**	
Grid wells				
TMART-07	0.012	E0.008	—	2
TMART-11	E0.004	E0.003	E0.03	3
Number of detections	2	2	1	
Detection frequency (percentage)	5	5	2	[2]5

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2]Frequency of detecting at least one pesticide in the grid wells.

Table 7. Nutrients detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed, but only samples with detections are listed. All analytes are listed in *table 3F*. Values less than the concentrations measured in field blanks (*table A3A*) are reported with a less than or equal to sign (≤). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US; U.S. Environmental Protection Agency maximum contaminant level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; na, not available; mg/L, milligram per liter; ≤, less than or equal to; —, not detected]

GAMA well identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-N), as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorus (mg/L) (00671)
[LRL]	**[0.02]**	**[0.06]**	**[0.002]**	**[0.06]**	**[0.006]**
Threshold type[1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Threshold level	**[2]24.7**	**10**	**1**	**na**	**na**
			Grid wells		
TMART-01	0.037	0.25	E0.001	0.28	0.216
TMART-02	—	0.14	—	0.15	0.029
TMART-03	0.141	—	—	0.14	0.140
TMART-04	—	0.44	—	0.49	0.070
TMART-05	—	0.07	—	0.13	0.325
TMART-06	—	0.90	—	0.89	0.043
TMART-07	—	0.22	—	0.25	0.026
TMART-08	—	0.19	—	0.21	0.023
TMART-09	—	0.33	—	0.33	≤0.004
TMART-10	—	E0.05	—	E0.05	0.045
TMART-11	—	1.14	E0.002	1.18	0.028
TMART-12	—	0.40	—	0.41	0.041
TMART-13	—	E0.06	E0.001	[3]E0.05	0.106
TMART-14	—	E0.04	E0.001	[3]E0.03	0.050
TROCK-01	—	0.08	—	[3]0.07	0.024
TROCK-02	—	—	—	—	≤0.006
TROCK-03	—	0.06	—	0.07	0.049
TROCK-04	—	E0.04	—	E0.04	0.048
TROCK-05	—	—	E0.001	E0.04	0.038
TROCK-06	—	E0.06	E0.001	0.08	0.029
TROCK-07	—	0.11	—	0.11	0.099
TROCK-08	—	—	—	—	0.010
TROCK-09	—	—	—	—	0.015
TROCK-10	—	0.07	—	[3]E0.05	0.020
TROCK-11	—	E0.06	—	0.07	0.014
TROCK-12	≤0.017	—	E0.002	—	0.011
TROCK-13	—	—	E0.001	—	0.036

Table 7. Nutrients detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed, but only samples with detections are listed. All analytes are listed in *table 3F*. Values less than the concentrations measured in field blanks (*table A3A*) are reported with a less than or equal to sign (≤). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US; U.S. Environmental Protection Agency maximum contaminant level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level; na, not available; mg/L, milligram per liter; ≤, less than or equal to; —, not detected]

GAMA well identification number	Ammonia, as nitrogen (mg/L) (00608)	Nitrite plus nitrate, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-N), as nitrogen (mg/L) (62854)	Orthophosphate, as phosphorus (mg/L) (00671)
[LRL]	**[0.02]**	**[0.06]**	**[0.002]**	**[0.06]**	**[0.006]**
Threshold type[1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**
Threshold level	**[2]24.7**	**10**	**1**	**na**	**na**
TTAHO-01	—	0.20	—	0.21	0.105
TTAHO-02	—	0.18	E0.001	0.20	0.077
TTAHO-03	—	—	—	—	0.032
TTAHO-04	—	E0.04	—	[3]E0.03	0.031
TTAHO-05	≤0.015	0.06	—	0.07	0.064
TTAHO-06	—	0.59	—	0.61	0.016
TTAHO-07	—	0.13	—	0.13	0.153
TTAHO-08	—	0.89	—	0.92	0.044
TTAHO-09	—	E0.06	—	0.07	0.090
TTAHO-10	—	E0.03	—	—	0.035
TTAHO-11	0.035	—	0.003	E0.03	0.034
TTAHO-12	—	0.30	E0.002	0.32	0.014
TTAHO-13	0.060	—	—	E0.05	0.024
TTAHO-14	—	E0.04	E0.001	—	0.009
			Understanding wells		
TMARTU-01	—	0.11	—	0.12	0.059
TROCKU-01	—	E0.05	—	[3]E0.04	0.031
TROCKU-02	—	E0.04	—	E0.04	0.066
TTAHOU-01	—	0.46	—	0.48	0.031
TTAHOU-02	—	0.27	—	0.31	0.042
TTAHOU-03	—	—	—	—	0.071
TTAHOU-04	—	0.75	E0.002	0.79	0.036
TTAHOU-05	—	E0.05	—	[3]E0.04	0.015
TTAHOU-06	—	0.96	—	0.96	0.022
TTAHOU-07	—	0.29	—	0.30	0.017
TTAHOU-08	≤0.021	0.24	0.003	0.26	0.037

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

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

[3]Total nitrogen in these samples is less than the sum of the filtered nitrogen analytes and falls outside the U.S. Geological Survey National Water Quality Laboratory acceptance criterion of a 10 percent relative percent difference. However, the absolute difference is ≤0.02 mg/L.

Table 8. Major and minor ions and dissolved solids detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3G* contains additional information about the analytes. **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level, na, not available; mg/L, milligram per liter; —, not detected; *, value above recommended threshold value; **, value above upper threshold value]

GAMA well identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Bicarbonate[1] (mg/L)	Carbonate[1] (mg/L)	Bromide (mg/L) (71870)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica (mg/L) (00955)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)
[LRL]	[0.02]	[0.014]	[0.04]	[0.2]	[1]	[1]	[0.02]	[0.12]	[0.1]	[0.002]	[0.018]	[0.18]	[10]
Threshold type[2]	na	na	na	na	na	na	na	SMCL-CA[3]	MCL-CA	na	na	SMCL-CA[3]	SMCL-CA[3]
Threshold level	na	na	na	na	na	na	na	250 (500)	2	na	na	250 (500)	500 (1,000)
Grid wells													
TMART-01	10.0	6.65	3.50	15.5	99	—	—	5.85	0.12	0.009	33.8	1.11	118
TMART-02	11.0	6.47	3.25	13.2	103	1	—	0.93	E0.06	—	36.2	0.90	125
TMART-03	10.1	7.71	4.62	52.2	187	1	E0.01	6.10	0.18	0.018	47.5	12.2	230
TMART-04	12.5	9.48	3.61	13.9	108	—	0.03	5.89	E0.06	E0.001	34.5	4.77	134
TMART-05	9.96	6.93	7.14	46.4	118	—	0.07	34.2	0.17	0.051	44.6	9.73	211
TMART-06	15.9	11.5	1.32	5.20	107	—	—	6.21	—	—	33.0	1.35	127
TMART-07	17.6	7.50	2.75	14.2	71	—	E0.02	35.4	—	E0.002	34.2	2.03	146
TMART-08	28.3	4.70	2.72	27.6	89	—	0.09	49.4	—	E0.001	27.8	14.8	202
TMART-09	21.0	6.94	1.21	5.30	114	—	—	0.42	—	—	35.8	E0.12	125
TMART-10	16.6	5.50	4.39	9.44	111	1	—	0.44	E0.05	—	40.9	2.79	147
TMART-11	15.6	7.45	1.22	5.36	69	—	E0.02	14.1	E0.06	—	33.0	0.50	133
TMART-12	12.9	4.52	3.22	7.49	87	1	—	0.38	E0.05	—	45.7	0.20	100
TMART-13	11.1	8.77	4.61	28.1	127	—	0.02	11.7	0.11	—	41.8	8.62	164
TMART-14	25.0	6.29	6.04	16.4	144	—	—	2.75	E0.09	—	59.9	15.0	201

Table 8. Major and minor ions and dissolved solids detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3G* contains additional information about the analytes. **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level, na, not available; mg/L, milligram per liter; —, not detected; *, value above recommended threshold value; **, value above upper threshold value]

GAMA well identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Bicarbonate[1] (mg/L)	Carbonate[1] (mg/L)	Bromide (mg/L) (71870)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica (mg/L) (00955)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)
[LRL]	[0.02]	[0.014]	[0.04]	[0.2]	[1]	[1]	[0.02]	[0.12]	[0.1]	[0.002]	[0.018]	[0.18]	[10]
Threshold type[2]	na	na	na	na	na	na	na	SMCL-CA[3]	MCL-CA	na	na	SMCL-CA[3]	SMCL-CA[3]
Threshold level	na	na	na	na	na	na	na	250 (500)	2	na	na	250 (500)	500 (1,000)
TROCK-01	32.7	5.73	3.98	9.47	105	—	E0.02	36.3	—	—	24.0	0.67	217
TROCK-02	5.19	1.11	1.63	2.32	32	—	—	0.23	—	—	16.3	0.47	40
TROCK-03	22.7	10.3	3.74	7.29	153	—	—	0.56	E0.05	—	51.3	0.40	188
TROCK-04	10.1	3.64	2.60	2.71	61	—	—	0.20	—	—	29.7	0.31	82
TROCK-05	16.1	5.07	3.30	4.50	91	—	—	0.19	—	—	37.2	0.19	117
TROCK-06	18.7	8.30	3.21	5.77	117	—	—	0.40	—	—	40.6	0.33	158
TROCK-07	12.8	2.54	1.67	7.22	63	—	—	7.76	—	—	34.8	0.29	81
TROCK-08	1.25	0.206	0.33	1.41	12	—	—	0.18	—	—	9.51	0.31	20
TROCK-09	3.45	0.307	0.66	2.34	22	—	—	0.29	—	—	17.6	0.22	40
TROCK-10	17.1	7.30	2.35	6.51	113	—	—	0.29	—	—	33.0	0.21	125
TROCK-11	17.8	2.85	2.27	3.31	78	—	—	0.55	—	—	28.1	5.17	102
TROCK-12	530	101	5.95	124	675	—	—	2.04	0.78	0.004	15.4	*1,390	**2,690
TROCK-13	21.7	10.3	12.7	348	971	1	—	13.0	0.61	0.016	31.8	123	**1,080

Table 8. Major and minor ions and dissolved solids detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3G* contains additional information about the analytes. **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level, na, not available; mg/L, milligram per liter; —, not detected; *, value above recommended threshold value; **, value above upper threshold value]

GAMA well identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Bicarbonate[1] (mg/L)	Carbonate[1] (mg/L)	Bromide (mg/L) (71870)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica (mg/L) (00955)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)
[LRL]	[0.02]	[0.014]	[0.04]	[0.2]	[1]	[1]	[0.02]	[0.12]	[0.1]	[0.002]	[0.018]	[0.18]	[10]
Threshold type[2]	na	na	na	na	na	na	na	SMCL-CA[3]	MCL-CA	na	na	SMCL-CA[3]	SMCL-CA[3]
Threshold level	na	na	na	na	na	na	na	250 (500)	2	na	na	250 (500)	500 (1,000)
TTAHO-01	27.9	15.9	4.89	6.20	139	—	—	27.4	—	—	42.9	1.20	187
TTAHO-02	20.4	6.82	4.60	11.0	130	1	—	0.66	—	—	43.3	0.24	173
TTAHO-03	8.06	1.07	0.94	6.12	50	—	—	0.23	—	—	32.9	E0.14	65
TTAHO-04	12.0	4.29	0.81	4.51	74	—	—	0.23	—	—	35.1	0.47	85
TTAHO-05	11.1	6.89	2.82	5.19	86	—	—	0.41	—	—	38.3	2.85	101
TTAHO-06	7.91	0.787	0.86	15.6	56	2	—	4.70	0.13	—	22.6	3.12	91
TTAHO-07	7.11	2.15	1.08	4.14	47	—	—	0.61	—	—	27.8	0.31	62
TTAHO-08	22.1	4.55	1.10	10.2	85	—	0.02	17.3	—	—	25.1	2.88	138
TTAHO-09	16.5	2.03	1.01	3.98	71	1	—	0.21	—	—	17.6	4.67	84
TTAHO-10	3.88	0.541	0.27	13.6	47	1	—	1.06	—	—	18.3	2.02	56
TTAHO-11	95.7	38.7	7.83	284	577	—	0.63	*425	0.52	0.635	49.8	34.2	**1,310
TTAHO-12	14.8	2.91	1.31	6.60	45	—	—	19.0	—	—	20.9	2.49	118
TTAHO-13	8.28	1.76	1.00	5.16	48	—	—	2.68	—	—	32.8	—	75
TTAHO-14	6.45	0.014	0.84	7.92	36	2	—	0.39	0.11	—	11.8	1.52	44

Table 8. Major and minor ions and dissolved solids detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3G* contains additional information about the analytes. **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** E, estimated value; LRL, laboratory reporting level, na, not available; mg/L, milligram per liter; —, not detected; *, value above recommended threshold value; **, value above upper threshold value]

GAMA well identification number	Calcium (mg/L) (00915)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Sodium (mg/L) (00930)	Bicarbonate[1] (mg/L)	Carbonate[1] (mg/L)	Bromide (mg/L) (71870)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Silica (mg/L) (00955)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70300)
[LRL]	[0.02]	[0.014]	[0.04]	[0.2]	[1]	[1]	[0.02]	[0.12]	[0.1]	[0.002]	[0.018]	[0.18]	[10]
Threshold type[2]	na	na	na	na	na	na	na	SMCL-CA[3]	MCL-CA	na	na	SMCL-CA[3]	SMCL-CA[3]
Threshold level	na	na	na	na	na	na	na	250 (500)	2	na	na	250 (500)	500 (1,000)
Understanding wells													
TMARTU-01	11.6	8.84	4.45	12.2	115	—	—	1.70	—	—	39.5	1.54	130
TROCKU-01	10.8	3.83	2.48	4.03	70	—	—	0.28	—	—	36.7	0.20	96
TROCKU-02	7.95	6.49	7.42	14.8	108	1	—	0.42	E0.06	—	62.1	1.29	144
TTAHOU-01	14.1	0.912	1.96	17.0	71	2	—	10.3	E0.08	—	23.8	2.44	106
TTAHOU-02	12.9	2.67	0.52	6.83	67	—	—	2.98	—	—	25.7	1.44	90
TTAHOU-03	4.94	0.178	0.44	19.2	51	2	—	2.57	0.26	E0.002	18.7	6.96	75
TTAHOU-04	14.5	2.62	1.51	7.38	63	—	—	5.82	—	—	25.2	3.69	98
TTAHOU-05	6.28	E0.013	0.54	8.23	34	2	—	0.35	0.10	—	11.7	1.98	42
TTAHOU-06	14.6	0.30	0.70	7.01	55	1	—	3.29	—	—	19.6	2.21	78
TTAHOU-07	11.1	1.78	0.77	5.62	58	—	—	1.19	—	—	25.7	0.50	81
TTAHOU-08	6.02	1.16	1.13	5.28	39	—	—	1.44	E0.05	—	31.3	0.46	66

[1]Bicarbonate and carbonate concentrations were calculated from the laboratory alkalinity and pH values (*table 4*) using the advanced speciation method (*http://or.water.usgs.gov/alk/methods.html*) with $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_W = 14$. pK_a, pK_2, and pK_W are the minus logarithms of the equilibrium constants for the first ionization of carbonic acid, the second ionization of carbonic acid, and the first ionization of water, respectively.

[2]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

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

Table 9. Trace elements detected in groundwater samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3G* contains additional information about the analytes. Values less than the study reporting limit are reported with a less than or equal to sign (≤). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** 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; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** NWQL, U.S. Geological Survey National Water Quality Laboratory; BQS, U.S. Geological Survey Office of Water Quality Branch of Quality Systems; NWIS, U.S. Geological Survey National Water Information System database; E, estimated value; LRL, laboratory reporting level; SRL, study reporting limit; na, not available; µg/L, microgram per liter; —, not detected; *, value above threshold value; ≤, less than or equal to]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
[LRL] or [SRL][1]	[2][1.6]	[0.06]	[0.12]	[2][0.36]	[0.06]	[8]	[0.04]	[2][0.42]	[0.04]	[2][1.7]	[2][6]	[2][0.65]
Threshold type[3]	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
						Grid wells						
TMART-01	2.5	E0.03	2.4	8	—	128	—	0.65	0.1	≤1.2	14	≤0.11
TMART-02	4.2	E0.04	0.8	7	—	13	—	2.1	—	≤0.22	—	≤0.23
TMART-03	—	—	*30.8	53	—	401	—	—	—	≤1.6	120	—
TMART-04	≤1.1	0.07	*11.5	25	—	91	—	1.2	—	≤0.41	—	≤0.27
TMART-05	2.4	0.07	*16.7	23	—	654	—	0.58	—	2.2	20	≤0.27
TMART-06	1.7	—	1.6	12	—	24	—	1.0	—	≤0.89	—	≤0.14
TMART-07	—	—	0.38	25	—	9	—	≤0.19	E0.02	≤0.58	—	≤0.24
TMART-08	1.9	0.06	8.1	6	—	334	—	0.54	—	≤0.22	6	—
TMART-09	≤0.9	—	—	12	—	—	—	≤0.30	—	≤1.1	—	≤0.12
TMART-10	—	E0.03	1.0	55	—	E5	—	≤0.38	—	—	—	≤0.16
TMART-11	≤1.0	—	0.66	14	—	—	—	0.69	—	≤0.63	7	≤0.16
TMART-12	≤1.4	E0.04	0.52	29	—	E8	—	0.48	—	—	6	—
TMART-13	5.4	0.06	*48	31	—	279	—	0.56	—	≤1.5	8	≤0.39
TMART-14	2.1	E0.05	1.6	88	—	36	—	≤0.23	—	≤1.4	—	≤0.51
TROCK-01	—	0.10	0.21	2	—	—	—	—	—	≤0.69	14	≤0.47
TROCK-02	5.7	E0.05	E0.08	4	—	—	—	≤0.17	—	3.1	—	≤0.22
TROCK-03	—	—	0.31	101	—	—	—	≤0.11	—	≤0.54	—	≤0.24
TROCK-04	—	—	0.15	30	—	—	—	≤0.23	—	≤0.57	—	≤0.20
TROCK-05	≤0.8	—	E0.07	39	—	—	—	0.51	—	≤0.59	—	≤0.34
TROCK-06	8.3	—	E0.09	25	—	—	—	1.2	—	≤0.77	≤3	≤0.45
TROCK-07	—	—	1.7	17	—	—	—	≤0.17	—	4.0	—	≤0.18
TROCK-08	3.3	E0.03	—	5	—	—	E0.02	—	—	11.3	—	≤0.64
TROCK-09	≤1.2	—	—	E0.9	—	—	—	≤0.10	—	5.4	≤3	≤0.45
TROCK-10	≤1.0	E0.03	0.59	9	—	8	—	≤0.31	—	2.3	—	≤0.25
TROCK-11	—	0.07	2.5	4	—	E4	0.08	≤0.14	—	10.9	≤5	1.03
TROCK-12	32.1	—	*14.9	8	0.82	84	E0.05	≤0.28	0.95	5.1	*4,560	1.16
TROCK-13	1.9	0.07	*31.1	13	—	*1,830	0.08	≤0.07	E0.03	2.5	≤4	≤0.17
TTAHO-01	2.0	E0.04	0.24	56	—	E6	—	≤0.24	E0.02	≤0.70	86	≤0.07
TTAHO-02	2.0	E0.05	0.53	52	—	9	E0.02	≤0.21	—	≤0.32	—	≤0.44
TTAHO-03	—	—	0.25	14	—	—	—	≤0.34	—	2.2	—	≤0.55
TTAHO-04	—	E0.04	1.6	6	—	—	—	1.6	—	≤1.0	—	≤0.34
TTAHO-05	≤1.5	—	2	11	—	E7	—	0.45	—	≤0.76	≤5	≤0.20
TTAHO-06	4.3	0.26	7.2	3	—	35	—	0.96	—	—	—	≤0.35

Table 9. Trace elements detected in groundwater samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3G* contains additional information about the analytes. Values less than the study reporting limit are reported with a less than or equal to sign (≤). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** 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; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** NWQL, U.S. Geological Survey National Water Quality Laboratory; BQS, U.S. Geological Survey Office of Water Quality Branch of Quality Systems; NWIS, U.S. Geological Survey National Water Information System database; E, estimated value; LRL, laboratory reporting level; SRL, study reporting limit; na, not available; µg/L, microgram per liter; —, not detected; *, value above threshold value; ≤, less than or equal to]

GAMA well identification number	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	Beryllium (µg/L) (01010)	Boron (µg/L) (01020)	Cadmium (µg/L) (01025)	Chromium (µg/L) (01030)	Cobalt (µg/L) (01035)	Copper (µg/L) (01040)	Iron (µg/L) (01046)	Lead (µg/L) (01049)
[LRL] or [SRL][1]	[2][1.6]	[0.06]	[0.12]	[2][0.36]	[0.06]	[8]	[0.04]	[2][0.42]	[0.04]	[2][1.7]	[2][6]	[2][0.65]
Threshold type[3]	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
TTAHO-07	≤1.3	E0.04	1.5	4	—	E4	—	1.2	—	≤0.41	—	≤0.06
TTAHO-08	≤1.1	E0.05	0.84	18	—	11	—	0.54	—	≤1.0	—	≤0.18
TTAHO-09	≤1.5	0.14	*13.8	3	—	—	—	1.7	—	≤0.25	21	≤0.26
TTAHO-10	6.6	0.11	7.8	3	—	E5	—	0.42	—	≤0.47	7	≤0.06
TTAHO-11	6.2	E0.04	*142	39	E0.03	*5,120	—	1.2	0.98	≤0.24	*15,400	—
TTAHO-12	—	—	E0.1	15	—	E5	—	≤0.17	0.07	—	*350	—
TTAHO-13	4.6	—	E0.07	8	—	—	0.04	0.78	0.3	—	11	—
TTAHO-14	8.5	0.17	1.2	3	—	15	0.06	≤0.22	—	—	—	≤0.09
Understanding wells												
TMARTU-01	≤0.9	0.06	7.3	17	—	65	—	1.2	—	≤0.45	—	≤0.08
TROCKU-01	≤1.2	—	0.16	32	—	—	—	≤0.10	—	≤0.61	—	≤0.16
TROCKU-02	1.8	0.11	3.9	8	—	26	—	0.71	—	≤0.31	≤4	≤0.07
TTAHOU-01	10.9	0.13	7.4	3	—	41	—	≤0.29	—	≤0.33	—	≤0.06
TTAHOU-02	≤1.4	—	0.88	13	—	E7	E0.02	0.62	—	≤1.0	11	≤0.18
TTAHOU-03	4.9	0.25	*10.2	2	—	84	0.06	≤0.13	—	≤0.21	7	—
TTAHOU-04	—	E0.03	0.12	16	—	E5	E0.02	0.43	—	≤1.6	—	≤0.25
TTAHOU-05	16.1	0.22	0.82	2	—	10	0.13	≤0.21	—	—	—	—
TTAHOU-06	4.0	0.14	0.38	4	—	8	—	0.51	E0.02	—	—	—
TTAHOU-07	≤1.5	0.10	0.65	8	—	—	—	≤0.12	—	≤0.32	—	—
TTAHOU-08	5.8	0.07	0.31	14	—	—	0.08	≤0.18	0.09	≤1.4	E6	—

Table 9. Trace elements detected in groundwater samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3G* contains additional information about the analytes. Values less than the study reporting limit are reported with a less than or equal to sign (≤). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** 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; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** NWQL, U.S. Geological Survey National Water Quality Laboratory; BQS, U.S. Geological Survey Office of Water Quality Branch of Quality Systems; NWIS, U.S. Geological Survey National Water Information System database; E, estimated value; LRL, laboratory reporting level; SRL, study reporting limit; na, not available; µg/L, microgram per liter; —, not detected; *, value above threshold value; ≤, less than or equal to]

GAMA well identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
[LRL] or [SRL][1]	[0.6]	[2][0.2]	[0.12]	[2][0.36]	[0.08]	[0.4]	[0.04]	[2][0.11]	[0.04]	[2][0.11]	[2][4.8]2
Threshold type[3]	na	SMCL-CA	HAL-US	MCL-CA	MCL-US	HAL-US	MCL-US	na	MCL-US	NL-CA	SMCL-CA
Threshold level	na	50	40	100	50	4,000	2	na	30	50	5,000
					Grid wells						
TMART-01	12.6	4.4	1.5	0.52	—	117	—	0.25	0.51	2.6	—
TMART-02	2.1	—	0.9	—	0.11	149	—	≤0.16	0.92	5.7	≤3.8
TMART-03	15.3	*124	5.1	—	—	134	—	0.56	E0.02	0.11	≤1.4
TMART-04	13.3	≤0.1	0.7	—	—	132	—	≤0.20	0.71	7.3	—
TMART-05	43.6	7.8	7.0	0.51	—	97.3	—	0.72	0.63	3.4	≤1.5
TMART-06	3.8	—	0.2	≤0.04	—	394	—	—	0.13	1.5	≤0.32
TMART-07	1.5	1.1	0.3	≤0.04	—	240	—	E0.05	0.31	2.2	≤0.47
TMART-08	21.5	≤0.1	0.9	—	—	199	—	0.86	0.47	2.1	≤0.96
TMART-09	—	—	—	≤0.12	—	254	—	—	0.23	1.1	12.5
TMART-10	0.8	—	0.3	—	0.12	192	—	1.4	0.96	4.4	9.6
TMART-11	1.9	0.2	E0.1	—	E0.05	174	—	—	0.09	1.8	64.0
TMART-12	5.8	≤0.1	0.1	—	—	137	—	≤0.08	0.68	6.4	≤0.85
TMART-13	16.7	0.9	0.7	≤0.07	—	158	—	0.26	0.61	12.9	28.3
TMART-14	5.2	0.2	1.0	≤0.17	E0.06	319	—	≤0.09	1.14	8.1	≤2.6
TROCK-01	4.5	1.4	2.9	≤0.07	E0.04	245	—	0.33	9.83	0.86	5.5
TROCK-02	—	0.5	0.2	≤0.09	—	30.1	—	—	1.21	1.2	10.4
TROCK-03	2.6	—	0.2	—	—	278	—	E0.03	1.14	5.0	10.4
TROCK-04	—	—	—	≤0.04	—	70.4	—	—	0.18	1.7	≤1.6
TROCK-05	1.3	—	—	≤0.04	—	155	—	—	0.24	0.92	≤1.5
TROCK-06	1.3	0.3	0.1	—	—	240	—	—	0.51	1.5	5.6
TROCK-07	4.0	—	0.3	≤0.04	—	102	—	≤0.07	0.31	2.7	5.7
TROCK-08	—	E0.2	—	≤0.24	—	14.1	—	—	0.13	≤0.10	12.4
TROCK-09	E0.6	0.5	—	≤0.12	—	37.3	—	—	0.05	0.27	≤2.1
TROCK-10	4.2	—	—	≤0.09	—	207	—	—	0.38	1.5	42.1
TROCK-11	2.1	0.2	1.4	0.53	0.47	51.4	—	≤0.06	0.14	1.3	16.5
TROCK-12	86.3	*1,340	0.4	3.0	—	*5,600	—	—	—	≤0.06	66.9
TROCK-13	388	*87.4	*47.2	≤0.26	—	659	E0.02	E0.04	0.8	0.08	49.1
TTAHO-01	E0.5	2.8	0.1	≤0.07	—	274	—	≤0.06	0.87	3.3	13.0
TTAHO-02	3.3	—	0.5	—	—	247	—	E0.05	1.39	5.4	≤1.1
TTAHO-03	1.8	≤0.1	—	—	—	93	—	—	E0.03	1.1	6.5
TTAHO-04	E0.4	—	E0.1	—	E0.05	115	—	—	0.06	2.6	≤1.6
TTAHO-05	4.6	9.9	0.5	—	—	138	—	≤0.21	0.18	1.2	6.5

Table 9. Trace elements detected in groundwater samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3G* contains additional information about the analytes. Values less than the study reporting limit are reported with a less than or equal to sign (≤). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** 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; AL-US, U.S. Environmental Protection Agency action level; HAL-US, U.S. Environmental Protection Agency lifetime health advisory level; SMCL-CA, California Department of Public Health secondary maximum contaminant level. **Other abbreviations:** NWQL, U.S. Geological Survey National Water Quality Laboratory; BQS, U.S. Geological Survey Office of Water Quality Branch of Quality Systems; NWIS, U.S. Geological Survey National Water Information System database; E, estimated value; LRL, laboratory reporting level; SRL, study reporting limit; na, not available; µg/L, microgram per liter; —, not detected; *, value above threshold value; ≤, less than or equal to]

GAMA well identification number	Lithium (µg/L) (01130)	Manganese (µg/L) (01056)	Molybdenum (µg/L) (01060)	Nickel (µg/L) (01065)	Selenium (µg/L) (01145)	Strontium (µg/L) (01080)	Thallium (µg/L) (01057)	Tungsten (µg/L) (01155)	Uranium (µg/L) (22703)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)
[LRL] or [SRL][1]	[0.6]	[2][0.2]	[0.12]	[2][0.36]	[0.08]	[0.4]	[0.04]	[2][0.11]	[0.04]	[2][0.11]	[2][4.8]2
Threshold type[3]	na	SMCL-CA	HAL-US	MCL-CA	MCL-US	HAL-US	MCL-US	na	MCL-US	NL-CA	SMCL-CA
Threshold level	na	50	40	100	50	4,000	2	na	30	50	5,000
TTAHO-06	2.9	≤0.1	10.5	—	0.09	37.2	—	9.2	25.3	3.0	—
TTAHO-07	1.8	E0.2	1.3	≤0.10	E0.05	75	—	0.59	1.59	2.1	≤0.73
TTAHO-08	5.4	—	6.4	≤0.08	E0.04	207	—	1.4	14.2	2.2	≤2.4
TTAHO-09	1.1	—	1.9	≤0.10	0.72	66.3	—	0.91	1.63	7.0	≤3.6
TTAHO-10	—	0.4	3.2	≤0.03	E0.05	26.7	—	1.1	2.43	2.3	≤1.5
TTAHO-11	474	*398	6.2	0.87	0.09	815	—	0.56	9.53	0.58	4.9
TTAHO-12	1.3	23.1	0.3	0.40	—	194	—	—	0.1	0.34	≤2.1
TTAHO-13	1.2	*70	0.4	0.80	—	147	—	0.38	0.07	0.52	5.0
TTAHO-14	—	—	*46.4	—	E0.07	28.7	—	10.2	22.4	4.8	≤1.3
Understanding wells											
TMARTU-01	18.7	—	0.3	≤0.03	—	137	—	≤0.11	0.74	6.8	≤1.3
TROCKU-01	—	—	0.1	—	—	133	—	—	0.3	1.5	≤2.4
TROCKU-02	13.9	0.3	0.8	—	0.13	54.5	—	0.22	0.7	6.2	≤3.9
TTAHOU-01	7.2	—	2.6	≤0.06	—	52.6	—	2.8	14.4	1.8	—
TTAHOU-02	1.2	1.2	9.0	≤0.06	E0.04	139	—	3.0	1.29	4.3	≤1.7
TTAHOU-03	11.1	3.2	38.9	≤0.04	E0.04	15.5	—	27.8	25.6	3.6	≤0.75
TTAHOU-04	1.4	—	17.2	≤0.05	E0.05	188	—	2.2	9.17	1.1	≤2.2
TTAHOU-05	E0.5	E0.2	*85.3	0.59	0.09	39.2	—	15.4	*30.9	3.5	≤1.2
TTAHOU-06	1.5	E0.2	1.3	≤0.26	E0.05	97.1	—	1.7	*52.8	1.4	—
TTAHOU-07	1.0	1.7	1.0	≤0.10	E0.06	139	—	2.5	3.88	2.3	≤0.37
TTAHOU-08	2.1	15.9	0.3	1.2	—	102	—	≤0.18	0.06	0.68	14.2

[1]Study reporting limits (SRL) were defined on the basis of the examination of field blanks collected in GAMA study units from May 2004 through January 2008 (L.D. Olsen and M.S. Fram, U.S. Geological Survey, unpublished data, 2008).

[2]Values equal to or less than the SRL are reported as less than or equal to the value reported by the laboratory (≤). Values reported with a ≤ symbol in this table have the following field comment included in the USGS NWIS database: Result is < or = reported value, based on quality control data (including but not limited to field blanks, source-solution blanks, trip blanks, NWQL set blanks, NWQL blank water certificates, and BQS Blind Blank Program data).

[3]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

Table 10. Species of inorganic arsenic, iron, and chromium detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[Data in this table were analyzed at U.S. Geological Survey (USGS) Trace Metal Laboratory in Boulder, Colorado using research methods and are not stored in the USGS National Water Information System database. Samples from all 52 wells were analyzed. *Table 3H* contains additional information about the analytes. Values less than the concentrations measured in field blanks (*table A3A*) are reported with a less than or equal to sign (≤). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency 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 value]

GAMA well identification number	Iron (total) (µg/L)	Iron(II) (µg/L)	Arsenic (total) (µg/L)	Arsenic(III) (µg/L)	Chromium (total) (µg/L)	Chromium(VI) (µg/L)
Threshold type[1]	**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			
TMART-01	18	9	2.2	—	—	—
TMART-02	—	—	0.54	—	2	2
TMART-03	117	60	*25	6.3	—	—
TMART-04	—	—	9.8	—	1	—
TMART-05	18	14	*15	—	—	—
TMART-06	—	—	1.3	—	—	—
TMART-07	—	—	—	—	—	—
TMART-08	5	—	9.0	—	—	—
TMART-09	—	—	—	—	—	—
TMART-10	—	—	0.88	—	—	—
TMART-11	4	3	≤0.56	—	—	—
TMART-12	—	—	—	—	—	—
TMART-13	5	—	*36	—	—	—
TMART-14	≤2	—	1.0	—	—	—
TROCK-01	12	—	—	—	—	—
TROCK-02	—	—	—	—	—	—
TROCK-03	—	—	—	—	—	—
TROCK-04	—	—	—	—	—	—
TROCK-05	4	—	—	—	—	—
TROCK-06	≤2	—	—	—	—	—
TROCK-07	—	—	1.4	—	—	—
TROCK-08	—	—	—	—	—	—
TROCK-09	—	—	—	—	—	—
TROCK-10	—	—	—	—	—	—
TROCK-11	7	4	2.0	—	—	—
TROCK-12	*3,740	3,740	*14	9.2	—	—
TROCK-13	4	—	*41	—	—	—
TTAHO-01	80	20	—	—	—	—
TTAHO-02	—	—	—	—	—	—
TTAHO-03	—	—	—	—	—	—
TTAHO-04	—	—	1.2	—	1	1
TTAHO-05	5	3	1.6	1	—	—
TTAHO-06	—	—	5.9	—	—	—
TTAHO-07	—	—	1.2	—	1	1
TTAHO-08	—	—	≤0.53	—	—	—

Table 10. Species of inorganic arsenic, iron, and chromium detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[Data in this table were analyzed at U.S. Geological Survey (USGS) Trace Metal Laboratory in Boulder, Colorado using research methods and are not stored in the USGS National Water Information System database. Samples from all 52 wells were analyzed. *Table 3H* contains additional information about the analytes. Values less than the concentrations measured in field blanks (*table A3A*) are reported with a less than or equal to sign (≤). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency 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 value]

GAMA well identification number	Iron (total) (µg/L)	Iron(II) (µg/L)	Arsenic (total) (µg/L)	Arsenic(III) (µg/L)	Chromium (total) (µg/L)	Chromium(VI) (µg/L)
Threshold type[1]	**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]**
TTAHO-09	≤2	—	4.2	—	2	1
TTAHO-10	—	—	2.7	—	—	—
TTAHO-11	*12,900	12,800	*150	110	—	—
TTAHO-12	298	290	—	—	—	—
TTAHO-13	9	5	—	—	—	—
TTAHO-14	—	—	0.97	1.1	—	—
Understanding wells						
TMARTU-01	—	—	6.5	—	—	—
TROCKU-01	—	—	—	—	—	—
TROCKU-02	—	—	3.2	—	—	—
TTAHOU-01	—	—	2.1	—	—	—
TTAHOU-02	—	—	—	—	—	—
TTAHOU-03	5	3	5.6	—	—	—
TTAHOU-04	—	—	—	—	—	—
TTAHOU-05	—	—	1.0	—	—	—
TTAHOU-06	—	—	—	—	—	—
TTAHOU-07	—	—	0.77	—	—	—
TTAHOU-08	—	—	—	—	—	—

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

Table 11. Stable isotope and strontium isotope ratios and tritium and carbon–14 activities detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 31* contains additional information about the analytes. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to the more common lighter isotope of that element, relative to a standard reference material. **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** H, hydrogen; O, oxygen; C, carbon; Sr, strontium; nc, sample not collected; pCi/L, picocurie per liter; <, less than]

GAMA well identification number	δ^{2}H of water (per mil) (82082)	δ^{18}O of water (per mil) (82085)	Tritium (pCi/L) (07000)	δ^{13}C of dissolved carbonates (per mil) (82081)	Carbon-14 (percent modern)[1] (49933)	$^{87}Sr/^{86}Sr$ (atom ratio) (75978)
Threshold type[2]	**na**	**na**	**MCL-CA**	**na**	**na**	**na**
Threshold level	**na**	**na**	**20,000**	**na**	**na**	**na**
			Grid wells			
TMART-01	–109	–14.89	4.2	–15.49	70	0.70524
TMART-02	–115	–15.44	1.6	–15.63	75	0.70501
TMART-03	–117	–15.53	<1	–15.29	29	0.70491
TMART-04	–108	–14.75	3.5	–16.32	72	0.70523
TMART-05	–111	–15.09	1.0	–13.29	40	0.70526
TMART-06	–105	–14.36	9.0	–16.88	97	0.70559
TMART-07	–92.3	–12.73	9.6	–17.53	101	0.70538
TMART-08	–107	–14.62	3.2	–17.16	82	0.70533
TMART-09	–105	–14.41	15.4	–16.45	100	0.70448
TMART-10	–105	–14.56	<1	–18.41	72	0.70488
TMART-11	–102	–13.86	12.8	–18.71	82	0.70532
TMART-12	–109	–14.77	<1	–17.27	85	0.70481
TMART-13	–110	–15.15	<1	–14.80	42	0.70524
TMART-14	–112	–14.98	<1	–16.65	71	0.70458
TROCK-01	–96.9	–13.61	12.5	–19.83	104	0.70563
TROCK-02	–95.8	–13.33	11.2	–18.05	106	0.70788
TROCK-03	–110	–15.02	<1	–16.06	81	0.70478
TROCK-04	–98.5	–13.85	9.0	–18.11	98	0.70527
TROCK-05	–101	–14.20	7.0	–18.04	97	0.70539
TROCK-06	–110	–15.07	5.1	–17.05	98	0.70532
TROCK-07	–99.7	–13.73	11.5	–18.04	98	0.70840
TROCK-08	–93.9	–13.25	9.3	–17.21	nc	0.70805
TROCK-09	–94.4	–13.44	9.0	–19.30	112	0.70902
TROCK-10	–106	–14.53	6.4	–18.46	87	0.70548
TROCK-11	–98.7	–13.46	10.2	–17.81	109	0.70863
TROCK-12	–104	–14.52	<1	–7.44	2	0.70548
TROCK-13	–112	–15.44	<1	–7.60	1	0.70545
TTAHO-01	–98.5	–13.66	10.2	–19.34	103	0.70533
TTAHO-02	–111	–15.32	<1	–16.77	82	0.70517
TTAHO-03	–100	–13.90	18.9	–17.86	100	0.70777
TTAHO-04	–97.5	–13.66	12.8	–18.74	96	0.70653
TTAHO-05	–106	–14.65	6.7	–17.40	88	0.70528
TTAHO-06	–109	–14.86	2.9	–19.24	83	0.70604
TTAHO-07	–106	–14.54	3.5	–18.67	91	0.70600
TTAHO-08	–107	–14.59	7.7	–19.56	91	0.70590

Table 11. Stable isotope and strontium isotope ratios and tritium and carbon–14 activities detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 31* contains additional information about the analytes. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to the more common lighter isotope of that element, relative to a standard reference material. **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA; California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** H, hydrogen; O, oxygen; C, carbon; Sr, strontium; nc, sample not collected; pCi/L, picocurie per liter; <, less than]

GAMA well identification number	δ^{2}H of water (per mil) (82082)	δ^{18}O of water (per mil) (82085)	Tritium (pCi/L) (07000)	δ^{13}C of dissolved carbonates (per mil) (82081)	Carbon-14 (percent modern)[1] (49933)	^{87}Sr/^{86}Sr (atom ratio) (75978)
Threshold type[2]	**na**	**na**	**MCL-CA**	**na**	**na**	**na**
Threshold level	**na**	**na**	**20,000**	**na**	**na**	**na**
TTAHO-09	–108	–14.72	<1	–19.09	76	0.70733
TTAHO-10	–105	–14.64	<1	–20.37	68	0.70667
TTAHO–11	–108	–14.82	4.5	–6.31	2	0.70646
TTAHO–12	–99.3	–13.86	6.7	–20.01	107	0.70568
TTAHO–13	–110	–14.98	4.8	–19.68	89	0.70590
TTAHO–14	–114	–15.57	<1	–17.98	84	0.70575
Understanding wells						
TROCKU-01	–102	–14.31	5.1	–18.39	92	0.70490
TMARTU-01	–108	–15.01	1.6	–15.87	74	0.70532
TROCKU-02	–108	–14.92	<1	–16.41	71	0.70514
TTAHOU-01	–101	–13.92	9.0	–20.19	101	0.70766
TTAHOU-02	–111	–15.04	2.2	–19.02	87	0.70567
TTAHOU-03	–111	–15.13	<1	–17.66	57	0.70631
TTAHOU-04	–107	–14.59	9.9	–19.63	106	0.70595
TTAHOU-05	–111	–15.31	<1	–19.59	81	0.70620
TTAHOU-06	–113	–15.18	7.7	–17.90	97	0.70632
TTAHOU-07	–110	–15.15	13.1	–18.54	87	0.70626
TTAHOU-08	–104	–14.10	18.9	nc	nc	0.70627

[1]100-percent modern carbon is referenced to atmospheric carbon-14 production rates in 1950. Values of percent modern carbon can be greater than 100 percent because the atmospheric production rate was much higher during the period of above-ground nuclear testing in the 1950s and 1960s.

[2]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

Table 12A. Uranium isotopes and radon-222 detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 31* contains additional information about the analytes. Measured values less than the sample-specific critical level (ssL_C) are reported as nondetections (—). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocurie per liter; nc, sample not collected; *, result above threshold value; ±, plus or minus]

GAMA well identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)		Radon-222 (pCi/L) (82303)
Threshold type[1]	MCL-CA		MCL-CA		MCL-CA		Proposed MCL-US
Threshold value	[2]20		[2]20		[2]20		[3]300 (4,000)
	Result ± CSU	ssL_c	Result ± CSU	ssL_c	Result ± CSU	ssL_c	Result ± CSU[4]
				Grid wells			
TMART-01	0.343 ± 0.034	0.011	0.039 ± 0.013	0.011	0.170 ± 0.022	0.0089	1,020 ± 16
TMART-02	0.754 ± 0.052	0.0097	0.043 ± 0.015	0.0083	0.294 ± 0.030	0.0069	480 ± 11
TMART-03	0.021 ± 0.011	0.0088	0.0162 ± 0.0065	0.0076	0.0134 ± 0.0080	0.0063	810 ± 13
TMART-04	0.408 ± 0.036	0.0066	—	0.0079	0.203 ± 0.026	0.0066	1,740 ± 18
TMART-05	0.464 ± 0.040	0.0096	0.018 ± 0.011	0.0082	0.236 ± 0.027	0.0096	760 ± 14
TMART-06	0.068 ± 0.020	0.011	—	0.014	0.034 ± 0.015	0.011	870 ± 14
TMART-07	0.170 ± 0.026	0.0084	—	0.010	0.130 ± 0.022	0.0084	750 ± 13
TMART-08	0.541 ± 0.050	0.016	0.028 ± 0.014	0.011	0.149 ± 0.028	0.013	1,520 ± 17
TMART-09	0.160 ± 0.023	0.015	0.021 ± 0.011	0.0080	0.106 ± 0.017	0.0066	660 ± 13
TMART-10	0.663 ± 0.053	0.0084	0.0174 ± 0.0085	0.010	0.353 ± 0.038	0.0084	370 ± 11
TMART-11	0.069 ± 0.017	0.0076	—	0.0092	0.042 ± 0.013	0.0076	1,030 ± 14
TMART-12	0.659 ± 0.077	0.017	—	0.021	0.252 ± 0.045	0.017	540 ± 12
TMART-13	0.346 ± 0.032	0.0091	0.020 ± 0.010	0.0078	0.216 ± 0.026	0.0091	1,360 ± 19
TMART-14	0.937 ± 0.060	0.011	0.020 ± 0.010	0.0079	0.374 ± 0.035	0.0065	660 ± 14
TROCK-01	4.59 ± 0.18	0.019	0.171 ± 0.028	0.0093	3.11 ± 0.13	0.015	1,950 ± 20
TROCK-02	0.525 ± 0.038	0.0055	0.0115 ± 0.0060	0.0067	0.408 ± 0.033	0.0055	nc
TROCK-03	1.109 ± 0.066	0.0078	0.0202 ± 0.0080	0.0094	0.533 ± 0.046	0.013	140 ± 9
TROCK-04	0.197 ± 0.025	0.0065	0.0168 ± 0.0065	0.0078	0.053 ± 0.014	0.0091	810 ± 14
TROCK-05	0.178 ± 0.028	0.014	—	0.0097	0.055 ± 0.014	0.0080	820 ± 14
TROCK-06	0.306 ± 0.031	0.011	0.0149 ± 0.0060	0.0070	0.182 ± 0.023	0.0057	350 ± 10
TROCK-07	0.156 ± 0.044	0.020	0.042 ± 0.021	0.024	0.139 ± 0.035	0.020	650 ± 12
TROCK-08	0.051 ± 0.015	0.0085	—	0.010	0.084 ± 0.019	0.0085	2,090 ± 23
TROCK-09	0.019 ± 0.013	0.010	—	0.0090	0.0350 ± 0.0095	0.0074	2,910 ± 26

Table 12A. Uranium isotopes and radon-222 detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3I* contains additional information about the analytes. Measured values less than the sample-specific critical level (ssL_C) are reported as nondetections (—). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocurie per liter; nc, sample not collected; *, result above threshold value; ±, plus or minus]

GAMA well identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)		Radon-222 (pCi/L) (82303)
Threshold type[1]	MCL-CA		MCL-CA		MCL-CA		Proposed MCL-US
Threshold value	[2]20		[2]20		[2]20		[3]300 (4,000)
	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU	ssL_C	Result ± CSU[4]
TROCK-10	0.285 ± 0.033	0.013	0.031 ± 0.012	0.0089	0.136 ± 0.022	0.0074	870 ± 14
TROCK-11	0.061 ± 0.017	0.014	—	0.013	0.051 ± 0.014	0.0079	660 ± 14
TROCK-12	0.139 ± 0.021	0.0095	0.014 ± 0.011	0.0082	0.0203 ± 0.0085	0.0068	620 ± 13
TROCK-13	5.13 ± 0.25	0.016	0.042 ± 0.017	0.020	0.203 ± 0.042	0.016	420 ± 12
TTAHO-01	0.776 ± 0.051	0.011	0.023 ± 0.010	0.0077	0.265 ± 0.028	0.0090	350 ± 10
TTAHO-02	1.068 ± 0.061	0.0095	0.049 ± 0.014	0.0081	0.470 ± 0.040	0.0067	270 ± 9
TTAHO-03	0.035 ± 0.014	0.016	—	0.020	—	0.016	820 ± 14
TTAHO-04	0.030 ± 0.023	0.017	—	0.021	—	0.017	500 ± 11
TTAHO-05	0.026 ± 0.017	0.020	—	0.024	0.076 ± 0.026	0.020	1,590 ± 20
TTAHO-06	9.72 ± 0.35	0.029	0.367 ± 0.044	0.011	7.88 ± 0.29	0.026	1,530 ± 18
TTAHO-07	0.539 ± 0.042	0.012	0.0314 ± 0.0095	0.0073	0.515 ± 0.039	0.0060	1,280 ± 18
TTAHO-08	5.86 ± 0.21	0.017	0.203 ± 0.027	0.0079	4.63 ± 0.17	0.016	1,220 ± 16
TTAHO-09	0.536 ± 0.043	0.013	0.017 ± 0.011	0.0080	0.519 ± 0.043	0.0094	830 ± 14
TTAHO-10	0.734 ± 0.058	0.016	0.033 ± 0.014	0.011	0.640 ± 0.052	0.0091	2,340 ± 28
TTAHO-11	5.69 ± 0.20	0.017	0.183 ± 0.024	0.0069	2.74 ± 0.11	0.015	520 ± 12
TTAHO-12	0.087 ± 0.033	0.025	—	0.031	0.065 ± 0.033	0.025	640 ± 12
TTAHO-13	0.032 ± 0.016	0.021	—	0.011	0.024 ± 0.012	0.0094	1,930 ± 20
TTAHO-14	7.70 ± 0.26	0.022	0.283 ± 0.031	0.0077	6.97 ± 0.24	0.019	*10,800 ± 48

Table 12A. Uranium isotopes and radon-222 detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from all 52 wells were analyzed. *Table 3I* contains additional information about the analytes. Measured values less than the sample-specific critical level (ssL_c) are reported as nondetections (—). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TROCKU, Hard Rock study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, 1-sigma combined standard uncertainty; pCi/L, picocurie per liter; nc, sample not collected; *, result above threshold value; ±, plus or minus]

GAMA well identification number	Uranium-234 (pCi/L) (22610)		Uranium-235 (pCi/L) (22620)		Uranium-238 (pCi/L) (22603)		Radon-222 (pCi/L) (82303)
Threshold type[1]	MCL-CA		MCL-CA		MCL-CA		Proposed MCL-US
Threshold value	[2]20		[2]20		[2]20		[3]300 (4,000)
	Result ± CSU	ssL_c	Result ± CSU	ssL_c	Result ± CSU	ssL_c	Result ± CSU[4]
				Understanding wells			
TMARTU-01	0.96 ± 0.13	0.033	0.051 ± 0.034	0.039	0.280 ± 0.070	0.033	1,440 ± 15
TROCKU-01	0.164 ± 0.025	0.0081	—	0.0099	0.098 ± 0.018	0.0081	820 ± 14
TROCKU-02	0.567 ± 0.081	0.026	—	0.031	0.156 ± 0.045	0.026	1,600 ± 19
TTAHOU-01	5.83 ± 0.20	0.020	0.248 ± 0.028	0.0070	4.72 ± 0.17	0.017	290 ± 11
TTAHOU-02	0.474 ± 0.038	0.0091	0.020 ± 0.010	0.0078	0.405 ± 0.035	0.0091	1,100 ± 16
TTAHOU-03	7.74 ± 0.26	0.020	0.280 ± 0.031	0.0098	6.66 ± 0.22	0.017	*4,530 ± 31
TTAHOU-04	3.36 ± 0.14	0.017	0.151 ± 0.022	0.0086	2.88 ± 0.12	0.016	*4,220 ± 28
TTAHOU-05	*11.72 ± 0.40	0.036	*0.526 ± 0.052	0.011	*9.24 ± 0.33	0.031	*9,620 ± 49
TTAHOU-06	*21.10 ± 0.65	0.036	*0.827 ± 0.059	0.0082	*17.26 ± 0.54	0.033	1,610 ± 20
TTAHOU-07	1.369 ± 0.078	0.012	0.041 ± 0.015	0.0087	1.242 ± 0.072	0.012	*5,330 ± 35
TTAHOU-08	0.077 ± 0.017	0.0078	0.0122 ± 0.0080	0.0094	0.057 ± 0.014	0.0078	1,610 ± 18

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2]The MCL-US threshold for uranium is the sum of those for uranium-234, uranium-235, and uranium-238.

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

[4]The 2-sigma combined standard uncertainties reported for radon-222 in the U.S. Geological Survey National Water Information System (NWIS) database have been divided by two and reported here as 1-sigma combined standard uncertainties for consistency with reporting of the other radiochemical constituents.

Table 12B. Gross alpha and gross beta particle activities detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June-September 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from the 10 slow wells were analyzed (*table 2*). *Table 3I* contains additional information about the analytes. The reference nuclide for measurement of gross alpha particle activity is thorium-230 and the reference nuclide for measurement of gross beta particle activity is cesium-137. Measured values less than the sample-specific critical level (ssL_c) are reported as nondetections (—). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, combined standard uncertainty; pCi/L, picocurie per liter; *, result above threshold value; ±, plus or minus]

GAMA well identification number	Gross alpha particle activity, 72-hour count (pCi/L) (62636)		Gross alpha particle activity, 30-day count (pCi/L) (62639)		Gross beta particle activity, 72-hour count (pCi/L) (62642)		Gross beta particle activity, 30-day count (pCi/L) (62645)	
Threshold type[1]	**MCL-US**		**MCL-US**		**MCL-CA**		**MCL-CA**	
Threshold value	**15**		**15**		**50**		**50**	
	Result ± CSU	**ssL_c**	**Result ± CSU**	**ssL_c**	**Result ± CSU**	**ssL_c**	**Result ± CSU**	**ssL_c**
Grid wells								
TMART-01	1.04 ± 0.71	0.77	—	1.1	3.19 ± 0.72	0.86	2.94 ± 0.55	0.66
TMART-06	—	0.89	—	1.2	1.75 ± 0.62	0.92	—	1.4
TROCK-13	—	4.2	—	3.8	11.5 ± 1.4	1.1	11.8 ± 1.4	0.97
TTAHO-02	1.21 ± 0.91	1.2	—	0.92	5.8 ± 1.1	1.4	4.77 ± 0.89	0.96
TTAHO-06	*25.9 ± 3.3	0.56	*26.1 ± 3.3	0.84	—	0.98	8.6 ± 1.2	0.85
TTAHO-10	2.98 ± 0.95	0.95	2.99 ± 0.81	0.67	2.75 ± 0.75	0.99	1.28 ± 0.56	0.84
TTAHO-11	[2],*26.2 ± 4.6	3.5	8.9 ± 3.7	4.6	[3]13.0 ± 1.6	1.1	13.8 ± 1.8	1.7
TTAHO-13	—	0.88	—	1.2	—	0.97	1.94 ± 0.87	1.3
Understanding wells								
TMARTU-01	1.86 ± 0.82	0.82	—	1.0	5.17 ± 0.87	0.89	3.12 ± 0.72	0.90
TTAHOU-05	[2],*36.1 ± 4.2	0.48	*32.4 ± 3.9	1.1	[3]—	0.86	8.6 ± 1.4	1.4

[1] Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

[2] 72-hour holding time exceeded by 1 day.

[3] 72-hour holding time exceeded by 3 days.

Table 12C. Radium isotopes detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. Samples from the 10 slow wells were analyzed (*table 2*). *Table 31* contains additional information about the analytes. Values less than the sample-specific critical level (ssL_c) are reported as nondetections (—). Values less than the activities measured in field blanks (*table A3A*) are reported with a less than or equal to sign (≤). **GAMA well identification number:** TMART, Martis study area grid well; TROCK, Hard Rock study area grid well; TTAHO, Tahoe study area grid well; TMARTU, Martis study area understanding well; TTAHOU, Tahoe study area understanding well. Thresholds and threshold values as of June 1, 2008. **Threshold type:** MCL-CA, California Department of Public Health maximum contaminant level; MCL-US, U.S. Environmental Protection Agency maximum contaminant level. **Other abbreviations:** CSU, combined standard uncertainty; pCi/L, picocurie per liter; ±, plus or minus]

GAMA well identification number	Radium-226 (pCi/L) (09511)		Radium-228 (pCi/L) (81366)	
Threshold type[1]	**MCL-US**		**MCL-US**	
Threshold value	**[2]5**		**[2]5**	
	Result ± CSU	**ssL_c**	**Result ± CSU**	**ssL_c**
		Grid wells		
TMART-01	≤ 0.0147 ± 0.0080	0.011	—	0.19
TMART-06	≤ 0.0187 ± 0.0090	0.012	—	0.17
TROCK-13	0.115 ± 0.016	0.013	—	0.17
TTAHO-02	≤ 0.018 ± 0.010	0.014	—	0.18
TTAHO-06	≤ 0.021 ± 0.011	0.016	—	0.18
TTAHO-10	≤ 0.018 ± 0.012	0.017	—	0.24
TTAHO-11	0.251 ± 0.020	0.013	3.04 ± 0.15	0.19
TTAHO-13	0.046 ± 0.012	0.014	—	0.25
		Understanding wells		
TMARTU-01	≤ 0.0171 ± 0.0090	0.013	—	0.21
TTAHOU-05	—	0.016	—	0.25

[1]Maximum contaminant level thresholds are listed as MCL-US when the MCL-US and MCL-CA are identical, and as MCL-CA when the MCL-CA is lower than the MCL-US or no MCL-US exists.

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

Appendix

This appendix includes discussions of the methods used to collect and analyze groundwater samples, the conventions used in reporting the resulting water-quality data, the methods used for quality assurance, and the results of quality-control assessments.

Sample Collection and Analysis

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

Samples were collected from three types of sites: production wells, monitoring wells, and springs (also called horizontal wells). Before sampling, each well was pumped continuously in order to purge at least three casing-volumes of water from the well (Wilde and others, 1999). For production wells, the existing pump on the well was used, and for monitoring wells, water was pumped using a portable, 2-inch diameter submersible pump (Grundfos RediFlo2 pump) attached to reels of approximately 300 feet of Teflon tubing. No pumping was required for springs.

Groundwater samples were collected through Teflon tubing attached to a sampling point on the well (or spring) discharge pipe with brass and stainless-steel fittings. The sampling point was located as close as possible to the well-head or point where the spring issued from the ground, and upstream of any water-storage tanks. The sampling point was also located upstream of well-head treatment systems (if any) for all sites except seven: TMART-02, -03, -09, and -14 and TROCK-12 and -13 had chlorination systems upstream of the sampling points that were turned off before sampling, and TTAHO-14 had a filter upstream of the sampling point. Most samples were collected inside an enclosed chamber located inside a mobile laboratory and connected to the sampling point by a 10- to 50-foot length of Teflon tubing (Lane and others, 2003). At all of the springs and several of the wells, the mobile laboratory could not be driven within 50 feet of the sampling point. At these sites, samples were collected outdoors in a portable enclosed chamber connected to the sampling point by a 1- to 2-foot length of Teflon tubing. All fittings and lengths of tubing were cleaned after each sample was collected (Wilde, 2004).

For the field water-quality indicator measurements, groundwater was pumped through a flow-through chamber fitted with a multi-probe meter that simultaneously measured the field water-quality indicators—dissolved oxygen, temperature, pH, and specific conductance. Field measurements were made in accordance with protocols in the USGS National Field Manual (Radtke and others, 2005; Wilde and Radtke, 2005; Lewis, 2006; Wilde, 2006; Wilde and others, 2006). All sensors on the multi-probe meter were calibrated daily. Measured temperature, dissolved oxygen, pH, and specific conductance values were recorded at 5-minute intervals for at least 30 minutes, and after these values remained stable for 20 minutes, samples to be analyzed in laboratories were collected. At monitoring wells, turbidity also was measured. Turbidity was measured in the mobile laboratory using a calibrated turbidity meter. Field measurements and instrument calibrations were recorded by hand on field record sheets and electronically in PCFF-GAMA, a software package designed by the USGS with support from the GAMA program. Analytical service requests also were managed by PCFF-GAMA. Information from PCFF-GAMA was uploaded directly into NWIS after samples were collected each week.

For analyses requiring filtered water, groundwater was diverted through a 0.45-µm pore size vented capsule filter, a disk filter, or a baked glass-fiber filter, depending on the protocol for the analysis (Wilde and others, 1999; Wilde and others, 2004). Before samples were collected, polyethylene sample bottles were pre-rinsed three 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 USGS National Water Quality Laboratory (NWQL).

Samples collected to be analyzed for VOCs, pesticides, pharmaceuticals, nutrients, major ions, and trace elements were stored on ice, and shipped overnight in coolers with ice to the NWQL within three days of sample collection (samples were shipped daily whenever possible). Samples to be analyzed for radium isotopes, gross alpha and gross beta particle activities, uranium isotopes, and radon-222 were shipped overnight within two days of sample collection (samples were shipped daily whenever possible). Samples to be analyzed for perchlorate and NDMA were stored on ice and shipped in coolers with ice overnight at the end of each week. Samples to be analyzed for tritium, noble gases, chromium speciation, and stable isotopes of hydrogen and oxygen of water were shipped in batches after the last sample was collected in the study unit.

Detailed sampling protocols for individual analyses and groups of constituents are described by Koterba and others (2005) and the USGS National Field Manual (Wilde and others, 1999; Wilde and others, 2004) and in the references for analytical methods listed in *table A1*. The brief descriptions given here are organized in the order that samples were collected at each well. Volatile organic compounds (VOC) and gasoline oxygenate and degradate samples were collected in 40-mL sample vials that were bottom-filled and purged with three vial volumes of sample water before being filled to eliminate entrainment of ambient air. Six normal (6 N) hydrochloric acid was added as a preservative to the VOC samples, but not to the gasoline oxygenate and degradate samples. Perchlorate samples to be analyzed at the Montgomery Watson Harza laboratory were collected in 125-mL polyethylene bottles. Tritium samples were collected by bottom filling two 1-L polyethylene bottles with unfiltered groundwater after first overfilling the bottle with three volumes of water. Samples to be analyzed for stable isotopes of hydrogen and oxygen of water were collected in 60-mL clear glass bottles filled with unfiltered water, sealed with conical caps, and secured with electrical tape to prevent leakage and evaporation.

Samples to be analyzed for pesticides and pesticide degradation products, pharmaceutical compounds, and *N*-nitrosodimethylamine (NDMA) were collected in 1-L baked amber bottles. Pesticide and pharmaceutical samples were filtered through a 0.3-µm nominal pore-size glass fiber during collection, whereas the NDMA samples were filtered at the Montgomery Watson Harza and Weck laboratories before analysis. Each sample to be analyzed for perchlorate at the Weck laboratory was collected in a plastic bottle and then filtered in two or three 20-mL aliquots through a syringe-tip filter into a sterilized 125-mL bottle.

Groundwater samples to be analyzed for inorganic and radioactive constituents were filtered through a 0.45-µm pore-size Whatman capsule filter. Two 250-mL polyethylene bottles were filled for each sample to be analyzed for major and minor ions, trace elements, and total dissolved solids, one with filtered groundwater and the other with unfiltered groundwater (Wilde and others, 2004). The 250-mL filtered sample was then preserved with 7.5 N nitric acid. Samples to be used for field and laboratory alkalinity titrations were filtered into 500-mL polyethylene bottles. Samples to be analyzed for species of arsenic and iron were filtered into 250-mL polyethylene bottles that were covered with tape to prevent light exposure, and preserved with 6 N hydrochloric acid. Samples to be analyzed for nutrients were filtered into 125-mL brown polyethylene bottles. Samples to be analyzed for radium isotopes, uranium isotopes, and gross alpha and gross beta particle activities were filtered into 1-L polyethylene bottles and acidified with nitric acid. Carbon isotope samples were filtered and bottom filled into two 500-mL glass bottles that were first overfilled with three bottle volumes of groundwater. These samples had no headspace and were sealed with a conical cap to prevent interaction between the sample and ambient air.

Samples to be analyzed for chromium species, radon-222, and noble gases were collected from the sampling point on the well discharge pipe. Samples to be analyzed for chromium species were collected using a 10-mL syringe with an attached 0.45-µm disk filter. After the syringe was thoroughly rinsed and filled with groundwater, 4 mL of groundwater was forced through the disk filter; the next 2 mL were slowly filtered into a small centrifuge vial for analysis of total chromium. A second small centrifuge vial was filled for analysis of hexavalent chromium, Cr(VI). A small cation exchange column was attached to the disk filter, and after conditioning the column with 2 mL of groundwater, 2 mL was collected in the second centrifuge vial. Both vials were preserved with 10 µL of 7.5 N nitric acid (Ball and McClesky, 2003a,b).

To collect samples for analysis 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 partially closed to create back pressure, and a 10-mL sample was collected through a Teflon septum on the valve assembly using a glass syringe affixed with a stainless-steel needle. The sample was then injected into a 25-mL vial partially filled with scintillation mixture (mineral oil) and shaken. The vial was then placed in a cardboard tube in order to shield it from light during shipping.

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

Alkalinity of filtered samples was measured in the mobile laboratory ("field" alkalinity) using Gran's titration method (Gran, 1952; Stumm and Morgan, 1996; Rounds, 2006). Titration data were entered directly into PCFF-GAMA, and the concentrations of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) were automatically calculated from the titration data using the advanced speciation method. Concentrations of HCO_3^- and CO_3^{2-} were also 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 $pK_1 = 6.35$, $pK_2 = 10.33$, and $pK_W = 14$.

Eleven laboratories did chemical and microbial analyses for this study (*table A1*), although most of the analyses were done at the NWQL or by laboratories contracted by the NWQL. The NWQL maintains a rigorous quality-assurance program (Pirkey and Glodt, 1998; Maloney, 2005). Laboratory quality-control samples, including method blanks, continuing calibration verification standards, standard reference samples, reagent spikes, external certified reference materials, and external blind proficiency samples, are analyzed regularly. Method detection limits are continuously tested and laboratory reporting levels updated accordingly. NWQL maintains National Environmental Laboratory Accreditation Program (NELAP) and other certifications (*http://qadata.cr.usgs.gov/nfqa*). 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. In addition, the Branch of Quality Systems runs the National Field Quality Assurance program that includes annual testing of all USGS field personnel for proficiency in making field water-quality measurements (*http://bqs.usgs.gov/nfqa/*). Results of analyses made at the NWQL or by laboratories contracted by the NWQL are uploaded from the laboratory directly into NWIS from the laboratory. Results of analyses made at other laboratories are compiled in a project Access (Microsoft, Redmond, Washington) database and uploaded from there into NWIS.

Data Reporting

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

Reporting Limits

The USGS NWQL uses the laboratory reporting level (LRL) as a threshold for reporting analytical results. The LRL is set to reduce the chance of reporting a false negative (not detecting a compound when it is actually present in a sample) to less than 1 percent (Childress and others, 1999). The LRL is usually set at two times the long-term method detection level (LT-MDL). The LT-MDL is derived from the standard deviation for at least 24 MDL determinations made over an extended period of time. The method detection limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the concentration is greater than zero (at the MDL there is less than 1 percent chance of a false positive) (Childress and others, 1999; U.S. Environmental Protection Agency, 2002). The USGS NWQL updates LRL values regularly and the values listed in this report were in effect when groundwater samples from the Tahoe–Martis study unit (June–October 2007) were analyzed.

Concentrations between the LRL and the LT-MDL are reported as estimated concentrations (designated with an "E" before the values in the tables and text). In rare cases, concentrations above the LRL may be reported as E-coded values. These cases may occur if the concentration was outside the range of the calibration standards, if the sample was diluted before analysis, or if the result did not meet all laboratory quality-control criteria (Childress and others, 1999).

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

Results for most constituents are presented using the LRL or MRL values provided by the analyzing laboratories. Results for some constituents are presented using study reporting levels (SRL) derived from assessing data from quality-control samples associated with groundwater samples collected as part of the GAMA project. The SRLs for trace elements were determined by statistical assessment of results from the field blanks collected in the first 20 GAMA study units (May 2004 through January 2008) (L.D. Olsen and M.S. Fram, U.S. Geological Survey, unpub. data, 2008). The assessment used order statistics and binomial probabilities to construct an upper confidence limit (Hahn and Meeker, 1991) for the maximum concentration of constituents potentially introduced while groundwater samples were collected, handled, transported, and analyzed. The resulting SRLs for trace elements were set at concentrations representing the upper 90 percent confidence limit for the 90th percentile of the 86 field blanks used in the assessment.

The SRLs for major and minor ions, nutrients, species of arsenic, iron, and chromium, and radioactive constituents were determined by assessment of results from field blanks collected in the Tahoe–Martis study unit. The maximum concentration of a constituent potentially introduced while groundwater samples were collected, handled, transported, and analyzed was defined as the maximum concentration of the constituent measured in blanks collected in the Tahoe–Martis study unit.

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, and therefore was defined as the SRL. Detections of those constituents reported by the laboratory with concentrations greater than the LRL or MDL but less than the SRL are given in *tables 7–10* and *12* with a less-than-or-equal-to (≤) sign preceding the reported value.

The methods used to analyze radiochemical constituents (gross alpha particle activity, gross beta particle activity, radium isotopes, and uranium isotopes) measure activities by using counting techniques (*table A1*). The reporting limits for radiochemical constituents are based on sample-specific critical levels (ssL_C) (McCurdy and others, 2008). The critical level is analogous to the LT-MDL used for reporting analytical results for organic and non-radioactive inorganic constituents. In this report, the critical level is defined as the minimum measured activity that indicates a positive detection of the radionuclide in the sample with less than a 5-percent probability of a false positive detection. The critical level depends on instrument background, counting times for the sample and background, and the characteristics of the instrument being used and the nuclide being measured. Sample-specific critical levels are used because the critical level also depends on sample size and sample yield during analytical processing. An ssL_C is calculated for each sample, and the measured activity in the sample is compared to the ssL_C associated with that sample. Measured activities less than the ssL_C are reported as nondetections.

The analytical uncertainties associated with measuring activities are sensitive to sample-specific parameters also, including sample size, sample yield during analytical processing, and time elapsed between sample collection and various steps in the analytical procedure, as well as parameters associated with the instrumentation. Therefore, measured activities of radioactive constituents are reported with sample-specific uncertainties. Activities of uranium isotopes, radium isotopes, and gross alpha and gross beta particle activities are reported with sample-specific 1-sigma combined standard uncertainties (CSU). Radon activities are reported with 2-sigma combined standard uncertainties in the USGS NWIS database and are reported here with 1-sigma combined standard uncertainties to be consistent with reporting of the other radiochemical constituents.

Notation

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

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

where

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

E is the element (O for oxygen, C for carbon, or H for hydrogen),

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

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

The reference material for oxygen and hydrogen is Vienna Standard Mean Ocean Water (VSMOW), which is assigned $\delta^{18}O$ and $\delta^{2}H$ values of 0 per mil (note than $\delta^{2}H$ is sometimes referred to as δD because the common name of the heavier isotope of hydrogen, hydrogen-2, is deuterium). The reference material for carbon is Vienna Peedee Belemnite (VPDB), which is assigned a $\delta^{13}C$ value of 0 per mil. Positive values indicate enrichment of the heavier isotope and negative values indicate depletion of the heavier isotope, compared to the ratios observed in the standard reference material.

Constituents on Multiple Analytical Schedules

Fourteen constituents targeted in this study were measured by more than one analytical schedule or more than one laboratory (*table A2*). The preferred methods for these constituents were selected on the basis of the procedure recommended by the NWQL (*http://wwwnwql.cr.usgs.gov/USGS/Preferred_method_selection_procedure.html*). Methods with full approval are preferred over those with provisional approval and approved methods are favored over research methods. The method having greater accuracy and precision and lower LRLs for the overlapping constituents is usually preferred. However, the method having higher LRLs may be selected as the preferred method to provide consistency with the historical data analyzed by the same method.

For the five constituents on NWQL Schedules 2020 (VOCs; *table 3A*) and 4024 (gasoline oxygenates; *table 3B*), the preferred method was Schedule 2020 to provide historical consistency (all samples collected for the GAMA Priority Basin Project are analyzed using Schedule 2020). Only the results from the preferred method are reported.

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

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

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).

Constituents Analyzed in the Field and the Laboratory

The field water-quality indicators—pH, specific conductance, and alkalinity—were measured in the field and at the NWQL. The field measurements are the preferred method for all three constituents, although results from field and laboratory measurements were reported. The field and laboratory results were compared statistically to assess potential bias in datasets consisting of field values for some samples and laboratory values for other samples.

The field and laboratory data were compared using the Wilcoxon signed-rank test, a nonparametric statistical test that is analogous to the parametric statistical test the paired t-test (Helsel and Hirsch, 2002). A nonparametric test was used because the data were not normally distributed. The Wilcoxon signed-rank test evaluates the null hypothesis that the median of the paired differences between the two data sets is zero. Results are reported as the probability, P, of obtaining the observed distribution of data, or one even less likely, when the null hypothesis is true. Therefore, a P value of 0.01 indicates 99 percent confidence that the two data sets are different.

Specific conductance in all 52 samples was measured in both the field and the laboratory. The median difference between field and laboratory measurements on the same sample was 4 percent higher values for the laboratory result ($P = 0.002$). The reason for this discrepancy is unknown. The values for specific conductance measured in the field were used to describe and assess groundwater quality because field values were available for all samples, and field conditions are considered more representative of groundwater conditions (Hem, 1985).

Both laboratory and field pH measurements were made for all 52 samples, and the two data sets were systematically different ($P < 0.001$). Laboratory pH values ranged from 0.3 pH units lower to 1.6 pH units higher than field pH values for the same sample; the median difference was 0.2 pH units higher. The discrepancy may be due to difficulties inherent in measuring pH in natural waters, particularly in waters with low concentrations of dissolved solids. It is difficult to measure pH in water samples having a specific conductance less than 100 µS/cm because of the high diffusion potential between the water sample and the reference electrolyte in the pH probe and the high resistance of the water sample to the propagation of electrical current (Galster, 1991). There were 12 groundwater samples having a specific conductance less than 100 µS/cm, and the median difference between laboratory and field pH values for the same sample was laboratory value higher by 0.48 pH unit. In comparison, there were 40 groundwater samples having a specific conductance greater than 100 µS/cm, and the median difference between laboratory and field pH values for the same sample was laboratory value higher by only 0.15 pH units. The conditions of the field pH measurements are more likely to give an accurate pH reading than the conditions of the laboratory pH measurements, particularly because of the use of a flow-through chamber and the longer contact time between the pH probe and groundwater in the field. Because most of the groundwater samples that have a specific conductance less than 100 µS/cm also have pH values less than 7, insufficient contact time would result in pH values biased high (towards the pH of the buffer solution in which the probe is stored when not in use in the laboratory). In addition, pH values of groundwater samples with low dissolved solids content will generally increase if the samples are inadvertently contaminated by contact with pH buffer solutions or other sources of ions (Galster, 1991).

The increase in pH of the groundwater samples between field and laboratory measurements also may be explained by equilibration of the sample with the atmosphere after collection. The partial pressure of CO_2 in groundwater is often greater than the atmospheric partial pressure (Appelo and Postma, 2005), thus CO_2 degasses from the groundwater when it is brought in contact with the atmosphere. CO_2 loss results in increased pH. The field values for pH were used to describe and assess groundwater quality because field values are available for all samples, and field values are preferred because field conditions are considered more representative of groundwater conditions (Hem, 1985) and because analytical issues may introduce bias in the laboratory values, as discussed above.

Alkalinities of 10 samples were measured in the field and in the laboratory. The median difference between the laboratory and field measurements on the same sample was 11 percent higher alkalinity measured in the laboratory ($P < 0.002$). This 11 percent difference is greater than the error associated with replicate alkalinity measurements (Rounds, 2006). Alkalinity does not change with loss or gain of CO_2 from the water (Stumm and Morgan, 1996); thus, the increase in alkalinity was not likely caused by equilibration between the sample and the atmosphere during the time between the field and the laboratory measurements. Part of the discrepancy may be due to the difference between the Gran's titration method used in the field and the fixed-endpoint (pH = 4.5) titration used in the

laboratory. The fixed-endpoint method systematically yields higher alkalinity values, particularly for samples containing low concentrations of dissolved inorganic carbon, because the titration equivalence point shifts to higher pH values as the dissolved inorganic carbon content of the sample decreases. For the ten samples in which alkalinity was measured in both the field and the laboratory, the median cation-anion imbalance was –1.3 percent if the laboratory alkalinity values were used to calculate bicarbonate and carbonate concentrations and +3.7 percent if the field alkalinity values were used. Because the laboratory alkalinity values usually yielded better cation-anion balances than the field alkalinity values, the laboratory alkalinity values were used in the assessments of groundwater quality.

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, and (or) laboratory analysis. Four types of quality-control (QC) tests were used in this study: blanks were collected to assess contamination during sample collection, handling or analysis; replicate samples were collected to assess reproducibility; matrix spike tests were done to assess accuracy of laboratory analytical methods; and surrogate compounds were added to samples analyzed for organic constituents to assess bias of laboratory analytical methods.

In this report, detections of organic constituents in groundwater samples that may have resulted from contamination during sample collection, handling, or analysis were flagged with "V" remark codes in the results tables (*tables 5*, *6*) 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 collection, handling, or analysis were flagged to indicate that the amount of potential contamination may have been sufficient to give a false positive relative to the stated reporting level. Because of the possible contamination, the actual concentration in the groundwater sample may be less than or equal to (≤) the measured concentration. The evaluation of QC data presented in this report was based on results for QC samples collected for the Tahoe–Martis study unit and on results for QC samples for the 20 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 by Maloney (2005) and Pirkey and Glodt (1998).

Blanks

The primary purposes of collecting blanks are to evaluate the magnitude of potential contamination of samples by constituents of interest during sample collection, handling, or analysis, and to identify and mitigate sources of this contamination.

Blank Collection and Analysis

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

For Tahoe–Martis, blanks were collected at 12 percent of the wells sampled. Field blanks were analyzed for VOCs; gasoline oxygenates and degradates; pesticides; pharmaceuticals; perchlorate; NDMA; nutrients; major and minor ions; trace elements; iron, arsenic, and chromium speciation; and radioactive constituents (*table A3A*). Blank water certified to be free of tritium and noble gases was not available, thus field blanks were not collected and analyzed for these constituents. The concept of blank samples does not apply to analyses of stable isotope ratios because the constituents (oxygen and hydrogen in water, and carbon in dissolved inorganic carbon) are in all samples.

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

Assessment of Blanks

Contamination in blanks may originate from several different types of sources that require different strategies to assess potential contamination of groundwater samples during sample collection, handling, or analysis. Four primary modes of contamination are assessed in the event of detections in field-blanks or unusual 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 from one sample to the next sample collected with the same sampling equipment, and (4) systematic and random contamination from field and laboratory equipment and processes. The fourth source of contamination (systematic and random) was addressed using a larger set of field blank results from multiple studies, in addition to the results from field blanks collected during the Tahoe–Martis study. The development of this approach and its methods are described by L.D. Olsen and M.S. Fram (U.S. Geological Survey, unpub. data, 2008)

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

The second potential mode evaluated was contamination from identifiable, known sources at a specific field site. Contamination from specific sources may produce distinctive patterns of detections (particularly of VOC constituents) in field blanks and groundwater samples. Substances that may be encountered at the field site, such as lubricants (for example, WD-40), cements used on PVC-piping, exhaust fumes from pump engines, and the methanol used to clean sample lines, contain recognizable associations of VOC constituents. For example, cements used on PVC-piping are composed primarily of tetrahydrofuran, acetone, methyl ethyl ketone (MEK), and cyclohexanone (not analyzed in this study). However, detecting these recognizable associations of VOC constituents in groundwater samples does not necessarily indicate contamination during sample collection because these VOC constituents may also occur together in groundwater.

If a recognizable association of VOC constituents was detected in a field blank or in a groundwater sample, the field notes and photographs from the site at which the sample was collected were examined for conditions that may have caused the field blank or the groundwater sample to be contaminated. If the constituents were present in the field blank and the groundwater sample from the same site at similar concentrations and the field notes or photographs indicated that the probable contaminant source was present, the detections of 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 detected in a groundwater sample and not the in associated field blank, or a in groundwater sample from a site where no blanks were collected, and the field notes or photographs indicated 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, V-codes were not applied on this basis.

The third potential mode of contamination 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 after each use have been developed and extensively tested to assure that carry-over does not occur. 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 nondetections were reported for a constituent in field blanks or groundwater samples collected after groundwater samples containing high concentrations of the constituent, then carry-over was ruled out as a mode of contamination for that constituent.

The fourth potential mode of contamination evaluated was random or systematic contamination from field or laboratory equipment or processes. All detections in field blanks which 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 subject to random contamination in field and laboratory processes must be applied to all groundwater samples.

Different notation was used for flagging results for organic and inorganic constituents that may have been affected by contamination during sample collection, handling, or analysis. Inorganic constituents are naturally present in groundwater, and the concerns about inorganic constituents usually are related to concentration, rather than detection (presence or absence). In contrast, concerns about organic constituents usually are related to both detection and concentration. Therefore, different schema are used for assessing and flagging data for organic and inorganic constituents.

Results for organic constituents that may have been affected by contamination during sample collection, handling, or analysis were flagged with V-codes. The purpose of V-coding was to flag detections that have a greater than acceptable probability of being false-positive detections. A false-positive detection of a constituent is an apparent detection that is caused by contamination during the sample collection, handling, or analysis of a groundwater sample that would otherwise not have a detection for of that constituent. Results labeled with V-codes were not considered to be 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 one-half the LRL) for that constituent. The following example illustrates why the V-coding level is defined in this way. In this example, the LT-MDL for the constituent is 0.10 µg/L, the true concentration in the groundwater sample is 0.05 µg/L, and the highest concentration detected in a field blank is 0.20 µg/L. It is assumed that the highest concentration measured in a field blank represents the maximum amount of contamination that groundwater samples may receive during collection, handling, transport, or analysis. If the groundwater sample is not affected by contamination during collection, handling, transport, or analysis, the measured concentration will be reported as a nondetection (0.05 µg/L is less than the LT-MDL of 0.10 µg/L). If the maximum amount of contamination (0.20 µg/L) occurs, then the measured concentration will be 0.25 µg/L, which is reported as a detection of the constituent. Therefore, by setting the V-coding level at 0.30 µg/L (the LT-MDL of 0.10 µg/L plus the potential maximum amount of contamination of 0.20 µg/L), detections that might be false-positive detections are removed from of the dataset.

Results for inorganic constituents that may have been affected by contamination during sample collection, handling, transport, or analysis were flagged with a less than or equal to symbol (≤). The ≤ symbol means that the true 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 nondetection). For trace elements, the concentration cutoff, hereinafter referred to as the study reporting limit (SRL), for assigning the ≤ symbol was determined from a statistical assessment of results for 86 field blanks collected between May 2004 and January 2008 (L.D. Olsen and M.S. Fram, U.S. Geological Survey, unpub. data, 2008). For all other inorganic constituents, the SRL for assigning the ≤ symbol was determined from assessing the field blanks collected at Tahoe–Martis sites only. The SRL was defined as equaling the highest concentration measured in the six field blanks collected at Tahoe–Martis sites (field blanks were collected at 12 percent of the wells sampled).

Replicates

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

Two methods for measuring variability were needed to adequately assess precision over the broad range of measured concentrations of most constituents. The variability between measured concentrations in the pairs of sequential replicate samples was represented by the standard deviation (SD) for low concentrations and by relative standard deviation (RSD) for high concentrations (Anderson, 1987; Mueller and Titus, 2005). The RSD is defined as the SD divided by the mean concentration for each replicate pair of samples, expressed as a percentage. The boundary between concentrations for which variability is assessed with SD and concentrations for which variability is assessed with RSD was defined as 5 times the LRL for each constituent.

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

- For concentrations less than 5 times the LRL (< 5 LRL), an SD of less than ½ LRL is acceptable
- For concentrations greater than (or equal to) 5 times the LRL (> 5 LRL), an RSD of less than 10 percent is acceptable. For comparison, an RSD of 10 percent is equivalent to a relative percent difference (RPD) of 14 percent.
- For activities of radiochemical constituents, the presence of overlap between the results (value ± 1-sigma CSU) is acceptable

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

For organic and inorganic constituents (except for radiochemical constituents), if both values for a replicate sample pair were reported as detections, the SD was calculated if the mean concentration was <5 LRL for the constituent or the RSD was calculated if the mean concentration was ≥5 LRL for the constituent. If both values were reported as nondetections, the variability was set to zero by definition. Cases other than two detections or two nondetections were treated as follows:

- For organic constituents, if one or both values were assigned a V-code, neither SD nor RSD was calculated. A V-code indicates that the constituent was detected in blanks and was excluded from the dataset of groundwater quality results. The data might not represent the concentration of the constituent in the groundwater sample.
- For organic and inorganic constituents, if one value was reported as a nondetection, and the other value was reported as a detection below the LRL, a value of zero was substituted for the nondetection and the SD calculated. Substituting zero for the nondetection yields the maximum estimate of variability for the replicate pair.
- For inorganic constituents, if one value for a sample pair was reported as a nondetection and the other value was reported as a ≤-coded value less than the SRL, or if both values were reported as ≤-coded values less than the SRL, neither SD nor RSD was calculated, because the values may be analytically identical. The ≤-code indicates that the value is a maximum potential concentration, and that concentration may be low enough to be reported as a nondetection.
- For organic and inorganic constituents, if one value was reported as a nondetection and the other value was reported as a detection greater than the LRL, the variability for the pair was considered unacceptable.

Matrix Spikes

Adding a known concentration of a constituent ('spike') to a replicate environmental sample enables the analyzing laboratory to determine the effect of the matrix, in this case 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 at the laboratory doing the analysis. Low matrix-spike recovery may indicate that the compound might not be detected in some samples if it was present at very low concentrations. Low and high matrix-spike recoveries may be a concern if the concentration of a compound in a groundwater sample is close to the MCL: a low recovery could falsely result in a measured concentration below the MCL, whereas a high recovery could falsely result in a measured concentration above the MCL.

The GAMA program defined the data quality objective for acceptable matrix-spike recoveries as 70 to 130 percent. Constituents with matrix-spike recoveries outside of this range were flagged as having unacceptable recoveries in table 3C (none of the constituents listed in tables 3A,B,E had unacceptable matrix-spike recoveries). For many constituents, an acceptable range of 70 to 130 percent for matrix spike recovery was more restrictive than the acceptable control limits for laboratory "set" spike recoveries. Laboratory set spikes are aliquots of laboratory blank water to which the same spike solution used for the matrix spikes has been added. One set spike is analyzed with each set of samples. Acceptable control limits for set spikes are defined relative to the long-term variability in recovery. For example, for many NWQL schedules acceptable set spike recovery is within plus or minus three F-pseudosigma of the median recovery for at least 30 set spikes (Conner and others, 1998; Rose and Sandstrom, 2003). For NWQL schedule 2080, acceptable set spike recovery is within plus or minus two standard deviations of the long-term mean recovery (Furlong and others, 2008).

Matrix spike recovery tests were done for VOCs, gasoline oxygenates and degradates, pesticides, pharmaceuticals, and NDMA because the analytical methods for these constituents are chromatographic methods that may be susceptible to matrix interferences. Replicate samples for matrix-spike recovery tests were collected at 12 percent of the wells sampled.

Surrogates

Surrogate compounds are added to environmental samples in the laboratory before analysis in order to evaluate the recovery of similar constituents. Surrogate compounds were added in the laboratory to groundwater and quality-control samples that were analyzed for VOCs, gasoline oxygenates and degradates, pesticides, pharmaceuticals, and wastewater-indicators by the NWQL, and for NDMA by the MWH laboratory. Most of the surrogate compounds are deuterated analogs of compounds being analyzed. For example, the surrogate toluene-*d*8 used for the VOC analytical method has the same chemical structure as toluene, except that the eight hydrogen-1 atoms on the molecule have been replaced by deuterium (hydrogen-2). Toluene-*d*8 and toluene behave very similarly in the analytical procedure, but the small mass difference between the two results in slightly different chromatographic retention times thus the use of a toluene-*d*8 surrogate does not interfere with the analysis of toluene (Grob, 1995). Only 0.015 percent of hydrogen atoms are deuterium (Firestone and others, 1996) thus deuterated compounds like toluene-*d*8 do not exist 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 because of improper maintenance and calibration of analytical equipment) that produces a negative bias. A 70- to 130-percent recovery of surrogates is generally considered acceptable; values outside this range indicate possible problems with the processing and analyzing samples (Connor and others, 1998; Sandstrom and others, 2001).

Quality-Control Results

Detections in Field and Source-Solution Blanks

Six field blanks and three source-solution blanks were collected for analysis of VOCs, and three VOCs were detected: toluene, 1,2,4-trimethylbenzene, and methyl ethyl ketone (MEK). Toluene was detected in two field blanks at a concentration of E0.02 µg/L. Concentrations of toluene between E0.01 µg/L and E0.08 µg/L were detected in approximately 40 percent of the field and source-solution blanks in other study units (Wright and others, 2005; Bennett and others, 2006; Kulongoski and others, 2006; Fram and Belitz, 2007; Kulongoski and Belitz, 2007; Dawson and others, 2008; Ferrari and others, 2008; and Landon and Belitz, 2008). Because the certificates of analysis stated that no toluene was detected in the lots of nitrogen-purged, organic-free blank water used when the Tahoe–Martis samples were collected, the source blank water was not considered to be the source of the contamination. The source of the toluene is not known. Because toluene is detected frequently in both source-solution and field blanks, all toluene detections in groundwater samples collected in GAMA study units are subject to V-coding at a level based on the concentrations detected in the blanks. The concentration of toluene detected in two Tahoe–Martis groundwater samples was E0.02 µg/L in two groundwater samples; both of these detections were V-coded and excluded from the dataset of groundwater quality results (*tables 5, A3*).

1,2,4-Trimethylbenzene was detected in 3 of the 6 field blanks at concentrations of E0.05, E0.05, and 0.12 µg/L, and in 1 source-solution blank at a concentration of E0.03 µg/L. Because the certificates of analysis stated that no 1,2,4-trimethylbenzene was detected in the lots of nitrogen-purged, organic-free blank water used when the Tahoe–Martis samples were collected, the source blank water was not considered to be the source of the contamination. 1,2,4-Trimethylbenzene was detected in 20 of the 52 groundwater samples at concentrations ranging from E0.02 to 0.13 µg/L (median E0.05 µg/L). The frequency and the concentrations at which 1,2,4-trimethylbenzene was detected in both the groundwater samples and the blanks suggest that groundwater samples and blanks were randomly contaminated with 1,2,4-trimethylbenzene from an unknown source while being collected, handled, transported, or analyzed. All detections of 1,2,4-trimethylbenzene in groundwater samples were V-coded and excluded from the dataset of groundwater quality results (*tables 5* and *A3*).

The pattern of VOC detections observed in one of the field blanks led to an unusual opportunity to demonstrate the importance of the rigorous procedures for cleaning equipment after samples are collected. Three vials are filled in the field for each VOC sample or blank, and the laboratory (the NWQL) randomly selects one to be analyzed for VOCs and reserves the other two for reruns that may be necessary if there are problems with the analysis of the first vial or if the project (GAMA) requests a rerun to verify a detection. Under normal circumstances, the three vials collected for a sample or a blank would yield the same results. Highly unusual conditions occurred when one of the field blanks was being collected and resulted in the three vials having markedly different VOC results.

The normal procedure for cleaning equipment after collecting a sample entails flushing the equipment with soapy water followed by rinsing it with clean water, then flushing it with methanol followed by rinsing it with clean water. In the field notes for the site at which the unusual field blank was collected, the field crew recorded that they thought they might not have rinsed the peristaltic pump used to pump the blank water from the source bottles through the sampling equipment and into the sample vials with clean water after the methanol flush. The three VOC vials are the first sample containers to be filled during sample collection, and therefore the VOC results would be the most affected by any contaminants from the methanol. The collection order is not marked on the three vials. The NWQL randomly selects one of the three vials collected for analysis and only uses the other vials if the analysis of the first vial was not successful.

The NWQL notified us immediately upon noticing a high number of VOC detections and an unusual chromatogram for our field blank (even before releasing the data to us). Information in the field notes led us to suspect that residual methanol may have been the source, and we requested that the remaining two vials be analyzed to test our hypothesis. Methanol is a polar organic solvent and would be expected to dissolve large amounts of polar organic compounds, such as acetone and MEK, as well as lesser amounts of less polar and nonpolar organic compounds. The methanol used for cleaning is not certified as being free of other organic constituents and may be exposed to airborne contaminants while being transferred into the containers used to transport it safely in the mobile laboratories, while being stored in the mobile laboratories, and while being used for cleaning. Thus, the methanol likely had many opportunities to accumulate organic contaminants.

The laboratory analyzed all three vials for VOCs and the three vials yielded different results. For the purposes of discussion, the vials are numbered based on the size of an unusual peak present on the chromatograms for all three vials from this field blank; this peak is not present on chromatograms for groundwater or surface-water samples (Donna Rose, U.S. Geological Survey, written commun., 2007). The chromatogram for the first vial had a large, broad peak near the beginning of the chromatogram. On the basis of comparison between retention times for identified VOCs on the chromatogram and retention times for a larger suite of VOCs (J&W Scientific, 1998), this large, broad peak was inferred to correspond to methanol. The size of the methanol peak systematically decreased from the first to the second to the third vial.

The analytical results for the first, second, and third vials also showed a progressive decrease in the number and concentration of VOCs detected (*table A3B*). In addition, the laboratory reported an unusually high number of tentatively identified compounds (TIC) in the chromatogram of the first vial, and fewer TICs in the chromatograms for the second and third vials (*table A3B*). TICs are constituents not included in the 85 VOCs analyzed on NWQL schedule 2020. TICs are tentatively identified on the basis on their retention times and their mass spectra. The presence of a large number of TICs suggests some VOCs in the sample may have come from a source that usually does not contribute VOCs to groundwater or surface-water samples (NWQL schedule 2020 was designed to include most VOCs encountered in groundwater or surface-water samples [Connor and others, 1998]).

On the basis of these results, residual methanol from cleaning of equipment was inferred to be the source of the VOC detections in the three vials of this field blank. The progressive changes in the size of the inferred methanol peak, the number of TICs, and the number and concentration of VOCs detected from the first to the second to the third vial are inferred to reflect the progressive decrease in the amount of methanol in the blank water as the pump was flushed with more blank water. Results from the third vial were used to represent the field blank and are included in *table A3A*. Results from the third vial indicated detections of MEK and toluene in the field blank (*table A3A,B*). MEK was not detected in any groundwater samples from the Tahoe–Martis study unit (*table 5*); thus it is unlikely that methanol used for the cleaning procedures contaminated any of the groundwater samples.

Tetrahydrofuran was not detected in any field blanks or source-solution blanks, but it was detected in two groundwater samples at concentrations of 1 and 9 µg/L. Tetrahydrofuran was the only solvent detected in either groundwater sample, which is unusual. The field notes and photographs showed that in both sites, the groundwater passed through fairly new PVC piping between the well-head and the sampling point, and the piping had several joints sealed with PVC cement. Tetrahydrofuran is a main ingredient in PVC cement; thus, it is likely that the tetrahydrofuran in the groundwater samples came from the cement. Both detections of tetrahydrofuran were V-coded and excluded from the dataset of groundwater quality results (*tables 5* and *A3A*).

Six field blanks were analyzed for pesticide compounds and there were no detections.

Two laboratories analyzed field blanks for NDMA and perchlorate, Montgomery Watson Harza laboratory (MWH) and Weck laboratory (Weck). NDMA was detected in one of the four field blanks analyzed by MWH at a concentration of 0.0033 µg/L and was not detected in either of the two field blanks analyzed by Weck (*table A3A*). NDMA was not detected in any of the 10 groundwater samples analyzed. Six field blanks were analyzed for perchlorate by MWH and two field blanks were analyzed for perchlorate Weck laboratory; perchlorate was not detected in any of the field blanks.

Of the six field blanks analyzed for nutrients, one contained E0.013 mg/L of ammonia and another contained E0.003 mg/L of orthophosphate (*table A3A*). Two groundwater samples had orthophosphate concentrations less than or equal to 0.006 mg/L (E0.003 mg/L plus one-half the LRL of 0.006 mg/L) and were flagged with a ≤ symbol. (*table 7*). Three groundwater samples had ammonia concentrations less than 0.023 mg/L (E0.013 mg/L plus one-half the LRL of 0.02 mg/L) and were flagged with a ≤ symbol. The ≤ flag indicates that the true concentration in the groundwater sample is less than or equal to the measured concentration, including the possibility that the true concentration may have been less than the LRL and thus reported as a nondetection.

Six field blanks and six source-solution blanks were analyzed for major ions. One field blank had a total dissolved solids (TDS) concentration of 10 mg/L (*table A3A*). However, the only other constituents detected in this field blank were silica (0.02 mg/L), MEK (4.1 µg/L), and radium-226 (0.042 + 0.013 pCi/L), which together account for less than 1 percent of the measured TDS. No TDS results for groundwater samples were flagged. Five field blanks had concentrations of silica ranging from 0.02 to 0.43 mg/L (*table A3A*). The lowest concentration measured in groundwater was 9.51 mg/L (*table 8*), which is greater than 0.044 mg/L (0.43 mg/L plus one-half the LRL of 0.018 mg/L), thus no groundwater data were flagged.

The GAMA study reporting limits (SRL), instead of the results for the six field blanks collected at Tahoe–Martis sites, were used to determine which trace element data should be flagged; SRLs are based on the results for 86 field blanks collected between May 2004 and January 2008 (L.D. Olsen and M.S. Fram, U.S. Geological Survey, unpub. data, 2008). Aluminum, barium, chromium, copper, iron, lead, manganese, nickel, tungsten, vanadium, and zinc have SRLs. Measured values that are less than the SRL are flagged with a ≤ symbol in *table 9*. Of these 11 trace elements, only aluminum and nickel were detected in field blanks collected at Tahoe–Martis sites (*table A3A*). Nickel was detected in one field blank at a concentration of E0.04 µg/L, which is less than the SRL of 0.36 µg/L. Aluminum was detected in one field blank at a concentration of 4 µg/L, which is greater than the SRL of 1.6 µg/L. Aluminum was detected in the associated source-solution blank also at a concentration of 4.2 µg/L. Although concentrations of aluminum detected in 9 groundwater samples are less than 4 µg/L but greater than 1.6 µg/L, these detections have not been flagged with a ≤ symbol because the SRL was used to determine which data should be flagged.

Six field blanks were analyzed for arsenic, iron, and chromium by the USGS Trace Metals laboratory in Boulder, Colorado. One field blank contained 0.79 µg/L of arsenic and another contained 3 µg/L of iron (*table A3A*). Two concentrations of arsenic detected in groundwater samples and three of iron were less than the concentration detected in the field blank and were flagged with a ≤ symbol (*table 10*).

Four field blanks and four source-solution blanks were analyzed for radioactive constituents. Three field blanks and their associated source solution blanks had detections of radium-226; the maximum activity was 0.042 ± 0.013 pCi/L (*table A3A*). Seven groundwater samples had radium-226 activities less than 0.055 pCi/L, the upper confidence limit of the maximum activity measured in a blank. These data were flagged with a ≤ symbol (*table 12*). One field blank had a gross alpha particle activity (72-hour count) of 0.54 ± 0.33 pCi/L. The lowest gross alpha particle activity (72-hour count) measured in groundwater was 1.04 + 0.71 pCi/L; thus no data were flagged (*table 12B*).

Variability in Replicate Samples

Tables A4A-C summarize the results of replicate analyses for constituents detected in groundwater samples collected in the Tahoe–Martis study. Replicate analyses were made on 12 percent of the samples collected. Of the 1,320 replicate pairs analyzed (counted by constituent), 414 were analyzed for constituents detected in at least one groundwater sample. Of these 414 pairs, 12 had results outside the limits for acceptable precision. Results for replicate analyses for constituents that were not detected are not reported in tables *A4A–C*.

Six replicate pairs of samples were analyzed for organic constituents and nearly all pairs yielded two values reported as nondetections (*table A4A*). One replicate pair for 1,2,4-trimethylbenzene and one for tetrahydrofuran each yielded two V-coded values. Variability was not assessed for pairs with V-coded data because the data are not considered representative of the composition of the groundwater. One replicate pair for carbon disulfide yielded two detections, and the SD of the concentrations was 0.15 µg/L, which was greater than one-half the LRL of 0.06 µg/L for carbon disulfide. An E-code was assigned to the one carbon disulfide detection in a groundwater sample to indicate greater uncertainty in the magnitude of the reported concentration (*table 5*).

Six replicate pairs of samples were analyzed for major and minor ions, nutrients, trace elements, trace element species, and isotopic tracers. Over 97 percent of the pairs yielded two concentrations with an SD value of less than ½ the LRL (for concentrations <5 LRL), an RSD value of less than 10 percent (for concentrations ≥5 LRL), or two nondetections (*table A4B*). These results indicated data for groundwater samples from the Tahoe–Martis study unit had variability within acceptable ranges.

One replicate pair analyzed for boron yielded concentrations with an RSD value greater than 10 percent; this sample (TROCK-12) was diluted during analysis to reduce matrix interferences. Diluting a sample requires mixing measured aliquots of blank water and sample water and measurement error may have increased variability between results for the replicate pair. One replicate pair analyzed for iron yielded one detection and one nondetection (TTAHOU-02). However, the concentration detected in the replicate was 10 µg/L, which was less than one-tenth of the SMCL-CA for iron. The less-than-acceptable precision at this low concentration will not affect the assessments of groundwater quality being made by the GAMA Priority Basin Project.

Four replicate pairs were analyzed for species of iron and arsenic by the USGS Trace Metals Laboratory in Boulder, Colorado. One replicate pair analyzed for species of iron yielded a detection and a nondetection for both total iron and iron(II) (*table A4B*). The USGS NWQL reported that iron was not detected in this sample (TTAHO-02; *table 9*), and USGS NWQL results are preferred (*table A2*).

Six replicate pairs of samples were analyzed for uranium isotopes, tritium, and radon, and two pairs were analyzed for radium isotopes and gross alpha and gross beta particle activities (*table A4C*). Eighty-three percent of the replicate pairs yielded overlapping values and were therefore considered acceptable. One replicate pair each analyzed for uranium-234, uranium-235, radium-228 and gross alpha particle activity (72-hour count) and two replicate pairs for radon and gross alpha particle activity (72-hour count) yielded non-overlapping values. However, the activities were less than one-third of the activities of the corresponding MCL-CA, MCL-US, and proposed AMCL-US values (*table 3I*). The less-than-acceptable precision for these constituents at these low activities will not affect the assessments of groundwater quality being made by the GAMA Priority Basin Project.

One replicate pair analyzed for radium-228 yielded non-overlapping values, and had one activity that was more than half of the activity of the corresponding MCL-US. However, this sample (TTAHO-11) was the only sample in which radium-228 was detected (*table 12C*); thus no samples were incorrectly reported as having activities above the MCL-US. One replicate pair analyzed for gross alpha particle activity (72-hour count) yielded non-overlapping values; the sample had an activity greater than the MCL-US and the replicate had an activity less than the MCL-US (*table A4C*). However, the groundwater sample (TTAHO-11) was analyzed 1 day beyond the 72-hour holding time (*table 12B*), and the replicate sample was analyzed 4 days beyond the 72-hour holding time. Decay of alpha-emitting species with short half-lives may account for the decrease in gross alpha particle activity between the time the groundwater sample and the replicate sample were analyzed.

Perchlorate was analyzed in quadruplicate at one Tahoe–Martis site. Perchlorate was not detected in the groundwater and replicate samples analyzed by Weck nor was it detected in the replicate sample analyzed by MWH. However, perchlorate was detected at a concentration of 11 µg/L in the groundwater sample analyzed by MWH. Because perchlorate was not detected in three analyses and was detected at a high concentration in only one analysis, the detection was V-coded and excluded from the dataset of groundwater quality results.

Fourteen additional samples were analyzed for perchlorate by both MWH and Weck. Both laboratories reported the no perchlorate was detected in 13 of the 14 samples. In one sample (TTAHOU-04), Weck detected perchlorate and MWH did not. However, the concentration of perchlorate reported by Weck, 0.13 µg/L, was less than the detection limit of 0.5 µg/L used by MWH.

Matrix-Spike Recoveries

Tables A5A,B summarize the results of matrix-spike recovery tests for the Tahoe–Martis study. Adding a spike (a known concentration of a compound) 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 compound. Six groundwater samples were spiked with VOCs to calculate matrix-spike recoveries (*table A5A*). Acceptable results for matrix-spike recovery tests were defined as recoveries between 70 and 130 percent. The median recoveries for all 88 VOC compounds were within this acceptable range. Three VOC compounds yielded a least one matrix-spike recovery greater than 130 percent. Of these three compounds, only 1,2,4-trimethylbenzene was detected in groundwater samples, and all detections of 1,2,4-trimethylbenzene were V-coded because it was detected in the field and source-solution blanks. One compound, hexachlorobutadiene, had at least one matrix-spike recovery less than 70 percent, but was not detected in groundwater samples. [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].

Six groundwater samples were spiked with pesticide and pesticide degradate compounds in order to calculate matrix-spike recoveries (*table A5B*). Acceptable results for matrix-spike recovery tests were defined as recoveries between 70 and 130 percent. The median recoveries for 40 of the 62 compounds were within this acceptable range. All 62 compounds had at least one matrix-spike recovery less than 70 percent, and 11 compounds had median recoveries less than 70 percent. For nine compounds all six matrix-spike recovery tests yielded recoveries less than 70 percent. Two of those compounds, deethyatrazine and dicrotofos, were detected in groundwater samples (*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]. Ten compounds had at least one matrix-spike recovery greater than 130 percent, but none of these compounds were detected in groundwater samples.

Two groundwater samples were spiked with NDMA in order to calculate matrix-spike recovery. Acceptable results for matrix-spike recovery tests were defined as recoveries between 70 and 130 percent, and the tests yielded spike recoveries of 98 and 112 percent.

Surrogate Compound Recoveries

Surrogate compounds were added to samples in the laboratory and analyzed to evaluate the recovery of similar constituents. *Table A6* lists the surrogate, the analytical schedule on which it was applied, the number of analyses of blanks and of groundwater samples (environmental samples, replicates, and matrix-spike samples), the number of surrogate recoveries below 70 percent and the number of surrogate recoveries above 130 percent for the blanks and the groundwater samples. Blank and groundwater samples were considered separately to assess whether the matrices present in groundwater samples affect surrogate recoveries. The results suggest that the presence of sample matrices may decrease the recovery of 1-bromo-4-fluorobenzene and increase the recovery of 1,2-dichloroethane-*d*4 (*table A6*). However, because the median matrix-spike recoveries of all VOC compounds were within acceptable ranges, this change in surrogate recovery apparently did not have a noticeable effect on the data. Eighty-two percent of the surrogate recoveries for VOC and gasoline oxygenate and degradate compounds, and 95 percent of the surrogate recoveries for pesticide compounds were in the acceptable ranges.

Appendix Tables

Table A1. Analytical methods used to measure organic, inorganic, and microbial constituents by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and other laboratories.

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names. VOC, volatile organic compound; HPLC, high-performance liquid chromatography]

Analyte	Analytical method	Laboratory and analytical schedule	Citation(s)
		Water-quality indicators	
Field parameters	Calibrated field meters and test kits	USGS field measurement	U.S. Geological Survey, variously dated
		Organic constituents	
VOCs	Purge and trap capillary gas chromatography/mass spectrometry	NWQL, Schedule 2020	Connor and others, 1998
Pesticides and degradates	Solid-phase extraction and gas chromatography/mass spectrometry	NWQL, Schedule 2003	Zaugg and others, 1995; Lindley and others, 1996; Madsen and others, 2003; Sandstrom and others, 2001
Gasoline oxygenates	Heated purge and trap/gas chromatography/mass spectrometry	NWQL, Schedule 4024	Rose and Sandstrom, 2003
Pharmaceuticals	Solid-phase extraction and HPLC/mass spectrometry	NWQL, Schedule 2080	Furlong and others, 2008
		Constituents of special interest	
Perchlorate	Ion chromatography and mass spectrometry	Montgomery Watson Harza Laboratory (CA-MWHL)	Hautman and others, 1999
N-Nitrosodimethylamine (NDMA)	Gas chromatography and mass spectrometry	Montgomery Watson Harza Laboratory (CA-MWHL)	U.S. Environmental Protection Agency, 2004; U.S. Environmental Protection Agency, 1999b
Perchlorate	Liquid chromatography electrospray ionization mass spectrometry	Weck Laboratory	U.S. Environmental Protection Agency, 2005
N-Nitrosodimethylamine (NDMA)	Gas chromatography and mass spectrometry	Weck Laboratory	U.S. Environmental Protection Agency, 2004; Plomley and others, 1994
		Inorganic constituents	
Nutrients	Alkaline persulfate digestion, Kjedahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
Major and minor ions, trace elements and nutrients	Atomic absorbance spectroscopy, 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,b; McCleskey and others, 2003

Table A1. Analytical methods used to measure organic, inorganic, and microbial constituents by the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) and other laboratories.—Continued

[Laboratory entity codes in the USGS National Water Information System (NWIS) for laboratories other than the USGS National Water Quality Laboratory (NWQL) are given in parentheses after the laboratory names. VOC, volatile organic compound; HPLC, high-performance liquid chromatography]

Analyte	Analytical method	Laboratory and analytical schedule	Citation(s)
		Isotope tracers	
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
Strontium isotopes	Chemical separations and thermal-ionization mass spectrometry	USGS Radiogenic Isotope Laboratory, Menlo Park, California	Bullen and others, 1996
Carbon isotopes	Accelerator mass spectrometry	University of Waterloo, Environmental Isotope Laboratory (CAN-UWIL); University of Arizona Accelerator Mass Spectrometry Laboratory (AZ-UAMSL), NWQL Schedule 2015	Donahue and others, 1990; Jull and others, 2004
		Radioactivity and gases	
Tritium	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California (USGSH3CA)	Thatcher and others, 1977
Tritium and noble gases	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory (CA-LLNL)	Moran and others, 2002; Eaton and others, 2004
Radon-222	Liquid scintillation counting	NWQL, Schedule 1369	American Society for Testing and Materials, 1998
Radium isotopes	Alpha activity counting	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1262	Kreiger and Whittaker, 1980 (USEPA methods 903.0 and 903.1)
Uranium isotopes	Chemical separations and alpha-particle spectrometry	Eberline Analytical Services (CA-EBERL), NWQL Schedule 1130	American Society for Testing and Materials, 2002
Gross alpha and beta radioactivity	Alpha and beta activity counting	Eberline Analytical Services, NWQL Schedule 1792	Kreiger and Whittaker, 1980 (USEPA method 900.0)
		Microbial constituents	
F-specific and somatic coliphage	Single-agar layer (SAL) and two-step enrichment methods	USGS Ohio Water Microbiology Laboratory (USGSOHML)	U.S. Environmental Protection Agency, 2001

Table A2. Preferred analytical schedules for constituents appearing on multiple schedules for samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[Of the methods used to analyze the compound in question, analytical schedules that are the most accurate and precise usually are preferred except when consistency with historic data analyzed using the same method is preferred. **Laboratory:** LLNL, Lawrence Livermore National Laboratory; MWH, Montgomery Watson Harza Laboratory; SITL, U.S. Geological Survey Stable Isotope and Tritium Laboratory; TML, U.S. Geological Survey Trace Metal Laboratory, Boulder, Colorado; Weck, Weck Laboratory. **Other abbreviations:** VOC, volatile organic compound; —, no preference]

Constituent	Primary constituent classification	Analytical schedules	Preferred analytical schedule
Results from preferred method reported			
Acetone	VOC, gasoline additive degradate	2020, 4024	2020
tert-Amyl methyl ether (TAME)	VOC, gasoline oxygenate	2020, 4024	2020
Diisopropyl ether (DIPE)	VOC, gasoline oxygenate	2020, 4024	2020
Ethyl *tert*-butyl ether (ETBE)	VOC, gasoline oxygenate	2020, 4024	2020
Methyl *tert*-butyl ether (MTBE)	VOC, gasoline oxygenate	2020, 4024	2020
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
Perchlorate	Special interest	MWH, Weck	MWH
N-Nitrosodimethylamine	Special interest	MWH, Weck	MWH
Tritium	Isotope tracer	LLNL, SITL	—

Table A3A. Constituents detected in field blanks collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[V-coded data for groundwater samples are excluded from the dataset of groundwater quality results because the constituents were detected in blanks at similar concentrations or were determined to be a result of contamination during sample collection. **Abbreviations:** E, estimated value; pCi/L, picocurie per liter; mg/L, milligram per liter; µg/L, microgram per liter; —, not detected; ≤, less than or equal to; ±, plus or minus]

Constituent	Number of field blank detections/analyses	Concentrations detected in field blanks	Number of groundwater samples V-coded or ≤-coded
Organic constituents (µg/L)			
Toluene	2/6	E0.02, E0.02	2
Methyl ethyl ketone (2-butanone, MEK)	1/6	E4.1	0
Tetrahydrofuran	0/6	—	2
1,2,4-Trimethylbenzene[1]	3/6	E0.05, E0.05, 0.12	20
NDMA	1/4	0.0033	0
Nutrients and major ions (mg/L)			
Ammonia, as nitrogen	1/6	E0.013	3
Orthophosphate, as phosphorus	1/6	E0.003	2
Silica	5/6	0.02, 0.04, 0.43, 0.03, 0.03	0
Total dissolved solids (TDS)	1/6	10	0
Trace elements (µg/L)			
Aluminum[2,3]	1/6	4	15
Chromium[3]	0/6	—	24
Copper[3]	0/6	—	34
Lead[3]	0/6	—	39
Manganese[3]	0/6	—	5
Nickel[3]	1/6	E0.04	26
Tungsten[3]	0/6	—	10
Vanadium[3]	0/6	—	2
Zinc[3]	0/6	—	27
Arsenic (total)[4]	1/6	0.79	3
Iron (total)[4]	1/6	3	3
Radioactivity (pCi/L)			
Gross alpha, 72-hour count	1/4	0.54 ± 0.33	0
Radium-226[5]	3/4	0.0013 ± 0.0070, 0.017 ± 0.011, 0.042 ± 0.013	7

[1]1,2,4-Trimethylbenzene was also detected in 1 of 3 source-solution blanks at a concentration of E0.03 µg/L.

[2]Aluminum was detected in the associated source-solution blank at a concentration of 4.2 µg/L. Calcium was detected in the same source-solution blank at a concentration of E0.01 mg/L.

[3]Constituents have a study 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, 2008).

[4]Constituents analyzed by the USGS Trace Metal Laboratory in Boulder, Colorado using research methods.

[5]Radium-226 was detected in 3 of 4 source-solution blanks at concentrations of 0.023 ± 0.010, 0.029 ± 0.012, 0.030 ± 0.011 pCi/L, respectively.

Table A3B. Volatile organic compounds (VOC) detected in a field blank analyzed in triplicate and determined to be affected by residual methanol from equipment cleaning.

[The three vials were collected sequentially. TICs, tentatively identified compounds; E, estimated value; µg/L, microgram per liter; —, not detected]

Constituent	Concentration (µg/L)		
	Vial #1	Vial #2	Vial #3
Acetone	30.3	E3.4	—
Methyl ethyl ketone (MEK)	155	16.4	E4.1
Tetrahydrofuran	4.36	E0.64	—
Toluene	0.12	E0.02	E0.02
Ethylbenzene	E0.07	E0.01	—
m- and *p*-Xylenes	E0.20	E0.06	—
o-Xylene	E0.08	E0.02	—
Styrene	E0.05	—	—
1,2,4-Trimethylbenzene	E0.02	—	—
TICs	13	0	1

Table A4A. Quality-control summary of replicate analyses of organic constituents detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[SD, standard deviation; RSD, percent relative standard deviation; LRL, laboratory reporting limit; µg/L, microgram per liter; V, analyte detected in samples and blanks thus result is not considered a detection for groundwater quality assessment; —, none in category; nv, no values in category]

Constituent	Number of nondetects/number of replicates	Number of V-coded replicates	Number of SDs greater than ½ LRL/number of replicates with concentration less than 5 times the LRL	Concentrations of replicates with SDs greater than ½ LRL (environmental, replicate)	Number of RSDs greater than ten percent/ number of replicates with concentration greater than 5 times the LRL
Volatile organic compounds and gasoline oxygenates (Schedules 2020 and 4204)					
Chloroform	6/6	—	—	nv	—
Perchloroethene	6/6	—	—	nv	—
Bromodichloromethane	6/6	—	—	nv	—
Methyl *tert*-butyl ether	6/6	—	—	nv	—
Trichloroethene	6/6	—	—	nv	—
1,1,1-Trichloroethane	6/6	—	—	nv	—
Diisopropyl ether	6/6	—	—	nv	—
Carbon disulfide	5/6	—	1/6	0.35, 0.14	—
1,2,4-Trimethylbenzene	5/6	1	—	nv	—
Tetrahydrofuran	5/6	1	—	nv	—
Toluene	6/6	—	—	nv	—
Pesticides and pesticide degradates (Schedule 2003)					
Atrazine	6/6	—	—	nv	—
Deethylatrazine	6/6	—	—	nv	—
Dicrotophos	6/6	—	—	nv	—

Table A4B. Quality-control summary of replicate analyses of major and minor ions, nutrients, trace elements, and isotope tracers detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[SD, percent standard deviation; RSD, percent relative standard deviation in percent; LRL, laboratory reporting limit; USGS, U.S. Geological Survey; δ^2H, delta hydrogen; $\delta^{18}O$, delta oxygen; $\delta^{13}C$, delta carbon; Sr, strontium. µg/L, microgram per liter; mg/L, milligram per liter; per mil, per thousand; nv, no measured values in category; —, none in category; <, less than]

Constituent	Number of non-detected or ≤-coded replicates	Number of SDs greater than ½ LRL/number of replicates with concentration less than 5 times the LRL	Concentrations of replicates with SDs greater than ½ LRL (environmental, replicate)	Number of RSDs greater than ten percent/number of replicates with concentration greater than 5 times the LRL	Concentrations of replicates with RSDs greater than ten percent (environmental, replicate)
Major and minor Ions (mg/L)					
Alkalinity	—	—	nv	0/6	nv
Calcium	—	—	nv	0/6	nv
Magnesium	—	—	nv	0/6	nv
Potassium	—	0/1	nv	0/5	nv
Sodium	—	—	nv	0/6	nv
Bromide	4	0/1	nv	0/1	nv
Chloride	—	0/2	nv	0/4	nv
Fluoride	3	0/1	nv	0/2	nv
Iodide	3	0/1	nv	0/2	nv
Sulfate	—	0/2	nv	0/4	nv
Silica	—	—	nv	0/6	nv
Total dissolved solids	—	—	nv	0/6	nv
Nutrients (mg/L)					
Phosphorus	—	0/1	nv	0/5	nv
Total nitrogen	2	0/4	nv	—	nv
Nitrate plus nitrite	4	0/2	nv	—	nv
Ammonia	3	0/3	nv	—	nv
Nitrite	3	0/3	nv	—	nv
Trace elements (µg/L)					
Aluminum	3	0/2	nv	0/1	nv
Antimony	4	0/2	nv	—	nv
Arsenic	—	0/2	nv	0/4	nv
Barium	—	—	nv	0/6	nv
Beryllium	4	0/1	nv	0/1	nv
Boron	1	1/2	nv	1/3	(84, 152)
Cadmium	4	0/2	nv	—	nv
Chromium	4	0/1	nv	0/1	nv
Cobalt	—	0/4	nv	0/2	nv
Copper	4	1/1	nv	0/1	nv
Iron	2	1/1	(<6, 10)	0/3	nv
Lead	5	—	nv	0/1	nv
Lithium	—	1/2	nv	0/4	nv
Manganese	2	—	nv	0/4	nv
Molybdenum	1	0/2	nv	0/3	nv
Nickel	4	—	nv	0/2	nv
Selenium	4	0/2	nv	—	nv
Strontium	—	—	nv	0/6	nv

Table A4B. Quality-control summary of replicate analyses of major and minor ions, nutrients, trace elements, and isotope tracers detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[SD, percent standard deviation; RSD, percent relative standard deviation in percent; LRL, laboratory reporting limit; USGS, U.S. Geological Survey; $\delta^{2}H$, delta hydrogen; $\delta^{18}O$, delta oxygen; $\delta^{13}C$, delta carbon; Sr, strontium. µg/L, microgram per liter; mg/L, milligram per liter; per mil, per thousand; nv, no measured values in category; —, none in category; <, less than]

Constituent	Number of non-detected or ≤-coded replicates	Number of SDs greater than ½ LRL/number of replicates with concentration less than 5 times the LRL	Concentrations of replicates with SDs greater than ½ LRL (environmental, replicate)	Number of RSDs greater than ten percent/number of replicates with concentration greater than 5 times the LRL	Concentrations of replicates with RSDs greater than ten percent (environmental, replicate)
Thallium	6	—	nv	—	nv
Tungsten	3	—	nv	0/3	nv
Uranium	1	0/2	nv	0/3	nv
Vanadium	2	—	nv	0/4	nv
Zinc	3	—	nv	0/3	nv
USGS Boulder, Colorado, Trace Metals Laboratory (µg/L)					
Iron(total)	2	—	nv	1/2	(<2, 16)
Iron(II)	2	1/1	(<2, 5)	0/1	nv
Arsenic(total)	2	—	nv	0/2	nv
Arsenic(III)	2	—	nv	0/2	nv
Isotope tracers					
$\delta^{2}H$ (per mil)	—	—	nv	0/6	nv
$\delta^{18}O$ (per mil)	—	—	nv	0/6	nv
$\delta^{13}C$ (per mil)	—	—	nv	0/6	nv
Carbon-14 (percent modern)	—	—	nv	0/6	nv
$^{87}Sr/^{86}Sr$ (atom ratio)	—	—	nv	0/6	nv

Table A4C. Quality-control summary of replicate analyses of radiochemical constituents detected in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[pCi/L, picocurie per liter; nv, no values with non-overlapping ranges]

Constituent	Number of non-overlapping values/number of replicates	Activities for replicates with non-overlapping values (environmental, replicate) (pCi/L)
Uranium-234	1/6	(0.474 ± 0.014, 0.366 ± 0.033)
Uranium-235	1/6	(0.049 ± 0.014, 0.020 ± 0.012)
Uranium-238	0/6	nv
Radon-222	2/6	(780 ± 13, 820 ±14), (1210 ± 17, 1100 ± 16)
Radium-226	0/2	nv
Radium-228	1/2	(3.04 ± 0.15, 2.68 ± 0.14)
Gross alpha particle activity, 72-hr count	2/2	(1.21 ± 0.91, 3.4 ± 1.1), (26.2 ± 4.6, 10.0 ± 3.4)
Gross alpha particle activity, 30-day count	1/2	nv
Gross beta particle activity, 72-hr count	0/2	nv
Gross beta particle activity, 30-day count	0/2	nv
Tritium	0/6	nv

Table A5A. Quality-control summary of matrix-spike recoveries of volatile organic compounds (VOC) and gasoline oxygenates and degradates in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetone[1]	6	95	115	109
Acrylonitrile	6	95	112	104
tert-Amyl alcohol	3	94	98	97
tert-Amyl ethyl ether (TAME)[1]	6	84	106	101
Benzene	6	97	112	100
Bromobenzene	6	96	113	103
Bromochloromethane	6	94	109	103
Bromodichloromethane[2]	6	94	117	105
Bromoform (tribromomethane)	6	94	122	102
Bromomethane (Methyl bromide)	6	80	143	103
tert-Butyl alcohol (TBA)	3	92	98	97
n-Butylbenzene	6	80	121	93
sec-Butylbenzene	6	93	111	102
tert-Butylbenzene	6	100	120	107
Carbon disulfide[2]	6	70	86	78
Carbon tetrachloride (tetrachloromethane)	6	98	122	110
Chlorobenzene	6	94	113	103
Chloroethane	6	83	120	105
Chloroform (trichloromethane)[2]	6	98	123	110
Chloromethane	6	88	109	91
3-Chloropropene	6	103	126	117
2-Chlorotoluene	6	96	113	101
4-Chlorotoluene	6	93	109	101
Dibromochloromethane	6	93	108	100
1,2-Dibromo-3-chloropropane (DBCP)	6	84	113	103
1,2-Dibromoethane (EDB)	6	97	118	103
Dibromomethane	6	94	110	102
1,2-Dichlorobenzene	6	94	113	99
1,3-Dichlorobenzene	6	92	111	98
1,4-Dichlorobenzene	6	93	108	96
trans-1,4-Dichloro-2-butene	6	92	124	98
Dichlorodifluoromethane (CFC-12)	6	79	99	87
1,1-Dichloroethane (1,1-DCA)	6	96	121	105
1,2-Dichloroethane (1,2-DCA)	6	91	116	106
1,1-Dichloroethene (1,1-DCE)	6	95	112	99
cis-1,2-Dichloroethene (*cis*-1,2-DCE)	6	96	117	108
trans-1,2-Dichloroethene (*trans*-1,2-DCE)	6	98	117	105
1,3-Dichloropropane	6	100	114	107
1,2-Dichloropropane	6	94	115	104
2,2-Dichloropropane	6	76	106	94
1,1-Dichloropropene	6	95	112	99
cis-1,3-Dichloropropene	6	82	109	92
trans-1,3-Dichloropropene	6	86	110	93
Diethyl ether	6	101	115	104
Diisopropyl ether (DIPE)[1,2]	6	96	113	103
Ethylbenzene	6	97	111	103
Ethyl *tert*-butyl ether (ETBE)[1]	6	91	125	101
Ethyl methacrylate	6	88	103	96
o-Ethyl toluene (1-ethyl-2-methyl benzene)	6	91	103	98
Hexachlorobutadiene	6	69	97	87
Hexachloroethane	6	90	113	102

Table A5A. Quality-control summary of matrix-spike recoveries of volatile organic compounds (VOC) and gasoline oxygenates and degradates in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
2-Hexanone (*n*-Butyl methyl ketone)	6	101	118	107
Iodomethane (Methyl iodide)	6	74	114	103
Isopropylbenzene	6	96	111	101
4-Isopropyl-1-methyl benzene	6	88	114	100
Methyl acetate	3	100	113	101
Methyl acrylate	6	95	110	105
Methyl acrylonitrile	6	97	116	108
Methyl *tert*-butyl ether (MTBE)[1,2]	6	91	120	104
Methyl *iso*-butyl ketone (MIBK)	6	93	115	105
Methylene chloride (dichloromethane)	6	89	111	97
Methyl ethyl ketone (2-butanone, MEK)[3]	6	93	113	106
Methyl methacrylate	6	80	115	96
Naphthalene	6	94	104	100
Perchloroethene (PCE)[2]	5	98	119	104
n-Propylbenzene	6	89	108	98
Styrene	6	95	105	102
1,1,1,2-Tetrachloroethane	6	93	113	105
1,1,2,2-Tetrachloroethane	6	90	110	106
Tetrahydrofuran[3]	6	101	126	108
1,2,3,4-Tetramethylbenzene	6	88	107	103
1,2,3,5-Tetramethylbenzene	6	92	125	106
Toluene[3]	6	96	114	98
1,2,3-Trichlorobenzene	6	97	109	100
1,2,4-Trichlorobenzene	6	85	101	94
1,1,1-Trichloroethane (1,1,1-TCA)[2]	6	100	124	111
1,1,2-Trichloroethane	6	93	113	100
Trichloroethene (TCE)[2]	6	92	115	97
Trichlorofluoromethane (CFC-11)	6	89	112	105
1,2,3-Trichloropropane (1,2,3-TCP)	6	99	131	107
Trichlorotrifluoroethane (CFC-113)	6	78	103	86
1,2,3-Trimethylbenzene	6	99	114	105
1,2,4-Trimethylbenzene[3]	6	97	139	105
1,3,5-Trimethylbenzene	6	93	111	101
Vinyl bromide (Bromoethene)	6	81	121	104
Vinyl chloride (Chloroethene)	6	95	121	104
m- and *p*-Xylene	6	99	111	105
o-Xylene	6	97	109	105

[1]Constituents on schedules 2020 and 4024; only values from schedule 2020 are reported because it is the preferred analytical schedule.

[2]Constituents detected in groundwater samples.

[3]Constituents detected in groundwater samples that were V-coded and excluded from the dataset of groundwater quality results because they were also detected in blanks.

Table A5B. Quality-control summary of matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetochlor	6	55	133	107
Alachlor	6	56	132	107
Atrazine[1]	6	55	117	103
Azinphos-methyl	6	41	106	104
Azinphos-methyl-oxon	6	23	69	51
Benfluralin	6	34	90	66
Carbaryl	6	57	134	115
2-Chloro-2,6-diethylacetanilide	6	50	123	103
4-Chloro-2-methylphenol	6	57	93	74
Chlorpyrifos	6	43	119	97
Chlorpyrifos oxon	6	15	45	20
Cyfluthrin	6	28	108	71
Cypermethrin	6	30	88	70
Dacthal (DCPA)	6	49	127	102
Deethylatrazine[1]	6	35	67	58
Desulfinyl fipronil	6	43	122	90
Desulfinyl fipronil amide	6	45	126	98
Diazinon	6	51	109	98
3,4-Dichloroaniline	6	50	108	91
Dichlorvos	6	27	53	32
Dicrotophos[1]	6	31	64	44
Dieldrin	6	55	139	85
2,6-Diethylaniline	6	53	105	101
Dimethoate	6	24	49	41
Ethion	6	35	111	96
Ethion monoxon	6	40	111	103
2-Ethyl-6-methylaniline	6	57	100	97
Fenamiphos	6	43	109	101
Fenamiphos sulfone	6	37	106	84
Fipronil	6	49	139	105
Fipronil sulfide	6	37	127	94
Fipronil sulfone	6	31	90	75
Fonofos	6	49	108	92
Hexazinone	6	30	103	84
Iprodione	6	34	102	74
Isofenphos	6	51	119	109
Malaoxon	6	51	107	98
Malathion	6	50	139	109
Metalaxyl	6	60	127	108
Methidathion	6	42	117	101
Metolachlor	6	57	124	105

Table A5B. Quality-control summary of matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Metribuzin	6	49	105	92
Myclobutanil	6	46	117	111
1-Naphthol	6	20	45	38
Paraoxon-methyl	6	43	78	71
Parathion-methyl	6	52	117	90
Pendimethalin	6	48	125	92
cis-Permethrin	6	32	95	81
Phorate	6	43	87	67
Phorate oxon	6	55	149	96
Phosmet	6	7	47	25
Phosmet oxon	6	5	33	18
Prometon	6	52	128	103
Prometryn	6	58	135	111
Propyzamide	6	49	126	102
Simazine	6	57	120	107
Tebuthiuron	6	68	173	126
Terbufos	6	43	172	131
Terbufos oxon sulfone	6	49	113	92
Terbuthylazine	6	56	130	107
Tribufos	6	25	82	75
Trifluralin	6	40	100	75

[1]Constituents detected in groundwater samples.

Table A6. Quality-control summary for surrogate recoveries of volatile organic compounds, gasoline oxygenates and degradates, pesticides and pesticide degradates, and constituents of special interest in samples collected for the Tahoe–Martis Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June–September 2007.

[MWH, Montgomery Watson Harza Laboratory; VOC, volatile organic compound; NDMA, *N*-nitrosodimethylamine]

Surrogate	Analytical schedule	Constituent class analyzed	Number of analyses	Median recovery (percent)	Number of surrogate recoveries below 70 percent	Number of surrogate recoveries above 130 percent
Blanks						
1-Bromo-4-fluorobenzene	2020, 4024	VOC, gasoline	9	88	0	0
1,2-Dichloroethane-*d*4	2020, 4024	VOC, gasoline	9	121	0	2
Isobutyl alcohol-*d*6	4024	Gasoline	2	105	0	0
Toluene-*d*8	2020, 4024	VOC, gasoline	9	100	0	0
Diazinon-*d*10	2003	Pesticide	6	90	1	0
α-HCH-*d*6	2003	Pesticide	6	87	1	0
NDMA-d6	MWH	Special interest	6	82	0	2
Groundwater, replicate, and matrix-spike test samples						
1-Bromo-4-fluorobenzene	2020, 4024	VOC, gasoline	65	77	12	0
1,2-Dichloroethane-*d*4	2020, 4024	VOC, gasoline	65	130	0	32
Isobutyl alcohol-*d*6	4024	Gasoline	26	95	0	0
Toluene-*d*8	2020, 4024	VOC, gasoline	65	98	0	0
Diazinon-*d*10	2003	Pesticide	64	95	2	0
α-HCH-*d*6	2003	Pesticide	64	86	3	0
NDMA-*d*6	MWH	Special interest	13	85	2	0

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Manuscript approved for publication, February 25, 2009
Prepared by the USGS Publishing Network,
Publishing Service Center, Sacramento, California

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