conjunctive use program. Today SSWD encompasses a total gross area of nearly 64,000 acres, including 57,012 acres that are authorized to receive surface water. According to the District,41,946 acres have actually been irrigated in recent years using a combination of surface and groundwater supplies. By far the majority of those acres grow rice (roughly 34,834 acres, or 83%), while the balance is apportioned between orchards (2,881 acres, or 5%), irrigated pasture (2,088 acres, or 5%), row and field crops (1,742 acres, or 4%) and the remaining 3%, which is fallowed in certain years.

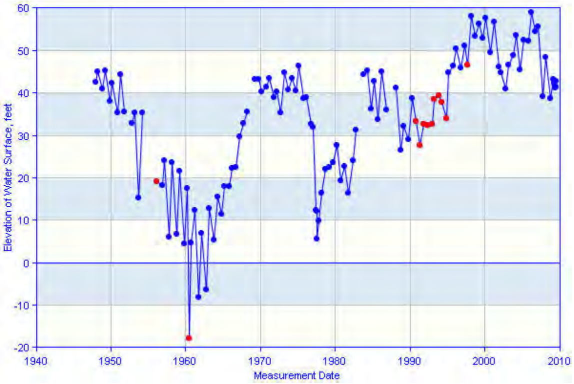

Figure 4 - Hydrograph for Well 13N/4E-13R1M

The enlarged New Camp Far West (NCFW) Reservoir was completed in 1964 with a storage capacity of 104,400 acre-feet (AF). SSWD and Camp Far West Irrigation District (CFWID), formed in 1924, holds the water rights for operating the reservoir. Surface supplies are managed conjunctively with groundwater supplies. The seven (7) megawatts of power generated by the NCFW powerhouse is wholesaled to Sacramento Municipal Utility District. The Federal Energy Commission (FERC) license for NCFW was issued on July 2, 1981.

One and a quarter miles downstream of NCFW Dam (and about 15 miles above the confluence with the Feather River), water is diverted by a diversion dam designed to move 30 cubic feet per second (cfs) north into the CFWID and 380 cfs south into the SSWD. In 1994, SSWD, CFWID, and the Department of Water Resources entered into a settlement agreement to meet the District's obligations under the State Water Resources Control Board's (SWRCB) Water Quality Control Plan for the Bay-Delta. Under the agreement, SSWD agreed to release up to 4,400 AF of water from NCFW, when requested by DWR, in all dry and critical year types. The present water rights require minimum in stream flows below the diversion works of 25 cfs from April 1 through June 30 and 10 cfs from July 1 through March 30. Under the new agreement, SSWD would increase the flow releases to the lower Bear up to 37 cfs in dry and critical years for up to sixty days in July through September.

SSWD receives anywhere from 5,000-20,000 AF of surplus water from Nevada Irrigation District (NID) annually. That water is currently conveyed to SSWD from Rollins Reservoir via the Bear River/Wise Canal system. When completed, SSWD's Canal Expansion project, including related conveyance system improvements, could

> *well provide previously-unforeseen opportunities for delivering a portion of surplus NID supplies to SSWD directly via the Bear River and NCFW Reservoir."*

1.5.4. Will there be taxes or fees for groundwater use?

Concerns have been expressed about the sources of funding for the GMP and other groundwater programs in the County. Funding would be necessary should staff be required to perform new monitoring and evaluation activities or to undertake groundwater investigations. Funding for the latter may be available from DWR and other grant programs, under which this GMP maintains eligibility for the County. Currently, the County assesses fees only for exploratory drilling, well construction, and well destructions, as shown in the following table (Table 1).

Table 1
Current **Sutter County Fee Assessments (as of January 1, 2012)**

Well Permit	***Fee***
Well Construction	$470.00
Well Destruction	$376.00
Water Exploration and Test Holes	$376.00
Permit Extension (1 year)	$47.00

There is concern about the potential for taxes and fees on groundwater use, and metering of pumps. This GMP does not contain any recommendation to meter groundwater pumping or to enact use-based fees or taxes, although they are considerations and are used in other areas. State law affords property owners the right to make beneficial use of groundwater on their land.

1.5.5. How can we obtain good quality water?

Water quality problems are significant within the County and concerns have been expressed about water quality with regard to salinity, arsenic, and manganese. The hydrogeology of the County as it relates to water quality is not well-understood, and further study will be necessary to develop guidelines for how to obtain good-quality water in different areas of the County, and to determine how to manage groundwater without causing water quality deterioration in areas with otherwise good quality water. As discussed in Section 4.4, this GMP illustrates water quality in different areas of the

County, and shows the geographic areas (and depths) where poorer quality groundwater can be anticipated. As more data becomes available, the County will be able to incorporate it into the existing understanding of the groundwater subbasins.

1.5.6. Is this going to generate new regulations on groundwater?

Concern has been expressed about the potential for additional layers of bureaucracy and regulations on groundwater use. In general, stakeholders recognize a need to better understand and manage groundwater in the County, but have expressed a desire for a "balance" between achieving this objective and minimizing bureaucracy and regulations.

To implement the GMP, an institutional framework (not yet determined) will be needed; however, the intent of this GMP is to minimize the bureaucracy and regulations needed to achieve the goals and objectives of the GMP. The GMP provides a framework and a forum for studying, discussing, and managing groundwater within the County. Ideally, management will be accomplished cooperatively amongst the groundwater users in the County.

2. THE COUNTY

2.1. Physical Setting

Sutter County encompasses approximately 607 square miles (389,443 acres) in the central portion of the Sacramento Valley. As shown in Figure 5, Sutter County is bound by Butte County to the north, Colusa and Yolo Counties to the west, Yuba and Placer Counties to the east, and Sacramento County to the south. The County seat, Yuba City, is located approximately 50 miles north of Sacramento. The 2010 U.S. Census reported that the population of the County in 2010 was 94,737, with the majority of the population residing in Yuba City and Live Oak, and about 25 percent of the population in the rural communities. Land use within the County is principally agricultural, with approximately 318,701 acres in production (Sutter 2010a).

The two main population centers in the County are Yuba City, with 67 percent of the population, and the City of Live Oak, approximately 10 percent of the population (U.S. Census 2010). The remaining County residents live within the small communities of Tierra Buena, Meridian, Rio Oso, Trowbridge, Sutter, Pleasant Grove, Nicolaus, East Nicolaus, Riego, Robbins, or in the vast rural agricultural areas which make up Sutter County. Future major growth areas planned for Sutter County include Sutter Pointe (Measure M). The Sutter Pointe Specific Plan details a large-scale development project that is currently on file with and being processed by Sutter County. This plan area is located in the southern most portion of the County adjacent to the Sacramento County border and a portion of the Placer County border. The plan area includes the development of approximately 7,500 acres into mixed use and residential properties and has been structured to facilitate future incorporation as an independent city (Sutter 2010).

The main transportation routes connecting the County with the region are Highway 99, which runs north-south through the County, California State Route 20, which runs east-west through the County and Highway 113, which runs from the south-west portion of the County and terminates at Highway 99 (connecting Woodland with the County).

Land elevations range between 80 and 20 feet above sea level throughout the County with the exception of the Sutter Buttes, where elevations are more than 2,100 feet above sea level. The lowest land elevations are located towards the southern portion of the County.

Sutter County has abundant surface water, including the Sacramento, Feather, and Bear Rivers, as shown in Figure 5. A number of the water districts in the County (Figure 2) divert and transfer surface water.

2.2. Water Purveyors and Users

Water resources in the County are managed by water purveyors and individual water users who have “hands on” control of both surface water and groundwater for agricultural, urban, environmental, and domestic uses. These water managers represent a complex mix of organized water purveyors, non-organized areas, and areas within National Wildlife Refuges. A brief discussion of each category is presented below.

2.2.1. Water Purveyors

There are 48 water purveyors in Sutter County which provide water service to their customers (Figure 2). These water purveyors include water districts, irrigation districts, reclamation districts, mutual water companies, public utilities districts, and incorporated cities. Additionally, there are many private water users including community service districts (CSD’s) and farming interests.

Six water purveyors provide water service not only in Sutter County, but in the counties that share borders with Sutter. They are:

- Reclamation District No. 1004 (Colusa County)
- Biggs-West Gridley Water District (Butte County)
- Butte Water District (Butte County)
- Dry Creek Mutual Water Company (Yuba County)
- South Sutter Water District (Placer County)
- Natomas Central Mutual Water Company (Sacramento County)

2.2.2. Non-Organized Areas

The non-organized areas within the County are not within the boundaries or service area of established water purveyors.

2.2.3. National Wildlife Refuges

The Sacramento National Wildlife Refuge Complex consists of five national wildlife refuges and three wildlife management areas. Portions of Sutter County have been dedicated, both through public and private efforts, as wildlife refuges. Exclusively in Sutter County, the Sutter National Wildlife Refuge has 2,591 total acres, with the majority (83%) located inside the Sutter Bypass. According to U.S. Fish and Wildlife

Service, the refuge "consists of approximately 1,881 acres of seasonal and summer wetlands and approximately 674 acres of unmanaged wetlands, grasslands, and riparian habitats" (USFW 2009).

The Natomas Basin Conservancy also owns nearly 1,000 acres of wildlife habitat/mitigation lands within the southern portion of the County.

2.3. Land Use

The predominant land use within the County is agriculture. The 2008 Sutter County General Plan Technical Background Report estimates that 322,240 acres (83%) of Sutter County is agricultural land. An estimated 44,581 acres (11%) is designated as open space. The remaining 6% of the County is designated as residential, public and vacant, commercial, industrial, and transportation and utilities. As stated above, agriculture dominates land uses within Sutter County. Figure 6 shows the distribution of land uses, with regard to crop type and water source, for the entire County. It is apparent that permanent crops dominate the eastern portion of the County, along the Feather River, while rice and other non-permanent crops dominate the central and western portion of the County.

2.4. Water Use

The amount of water applied for agricultural production and urban or community use has been estimated using information from DWR with respect to unit crop, consumptive use, and applied water, with corresponding losses included and accounted for. Water use within cities and communities was estimated using limited production data from some water purveyors from 2008 to 2010.

2.4.1. Agricultural Water Use

Water use during the 2009 growing season was calculated based on the Sutter County 2009 Crop Report. Estimates of applied water for irrigated agriculture are 1,122,018 AF.

Sutter County's agricultural water usage is approximately 60 percent surface water, 20 percent groundwater, and 20 percent that is irrigated by both surface water and groundwater. Figure 6 illustrates the source of water for crops grown in the County. The predominant source of water for permanent crops is groundwater.

2.4.2. Urban/Community Water Use

Water for urban and community use is from groundwater and surface water. From available DWR records, the minimum urban water use was 1,770 AF in 2010 (records for all urban water suppliers was not available). Yuba City provides mostly surface water (15,682 AF in 2008) while smaller communities rely exclusively on groundwater.

3. HYDROLOGY AND SURFACE WATER

3.1. Seasonal and Long-Term Hydrology

Annual fluctuations in northern California precipitation directly influence the volume of water flowing in the Sacramento River. Precipitation and climate data from the Western Regional Climate Center (WRCC) suggest the average annual precipitation for the west side of the County (Colusa Station) is 16.40 inches per year and on the east side of the County (Marysville Station), it is 20.96 inches per year. In Nicolaus, the average annual precipitation is 18.27 inches per year. Collectively, average annual precipitation is 18.54 inches per year. Snow-fall within Sutter County is rare, measuring on average 0.01 inches per year. Precipitation is highly variable throughout the State, from year to year. Precipitation usually takes place from October to May and on average no precipitation occurs from June to September. The water year, defined as starting on October 1 and ending September 30, is classified as one of five water year types: critical, dry, below normal, above normal, or wet[2]. Within the past ten years, only two water years were classified as wet and one year was classified above normal. The remaining years were either dry, critical, or below normal. The average annual temperature is approximately 62° F, with an average high of 95.7° F in July and an average low of 37.4° F in January.

Precipitation in the Sierra Nevada, Coast Range, Klamath, and Cascade Mountains contribute to surface water flow and groundwater recharge in the Sacramento River Basin. The general direction of surface water flow is toward the center of the valley, flowing south. Water diversions, evaporation, and groundwater recharge reduce flows as the Sacramento River approaches the Delta.

3.2. Surface Water

Sutter County is located in the Sacramento River Basin, with the Sacramento River on the west and the Feather River on the east. The Sacramento River is the largest river in northern California and drains the northern central part of California. The watershed for the Sacramento River includes tributaries originating in the Sierra Nevada, the Coast Range, and the Cascade Mountains. The main tributaries in Sutter County include the Feather River, Bear River, Dry Creek, Pleasant Grove Creek, Auburn Ravine, and Coon Creek.

During periods of heavy precipitation and runoff, a portion of the flow within the Sacramento River is diverted through the Sutter Bypass. The Sutter Bypass is a man-made feature in Sutter County and was designed to alleviate the flood control system along the Sacramento

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[2] http://cdec.water.ca.gov/cgi-progs/iodir/wsihist

River. Aside from the major rivers and tributaries within Sutter County, there are no significant surface water storage reservoirs within Sutter County.

It is important to note that flows in all the major rivers in northern California are managed by dams, e.g. the Feather River by Lake Oroville and the Sacramento River by Lake Shasta. The reservoirs are managed to provide flood protection while collecting runoff from the watershed. Releases from the reservoirs occur from spring through summer to provide irrigation water for agriculture as well as to provide drinking water downstream.

The following discussion provides information on the location, ownership, infrastructure, and an overview of the operational practices of the major water bodies that relate to or are within Sutter County.

3.2.1. The Sacramento River

The Sacramento River is the major surface water feature in Sutter County. Running north-south along the western part of the County, the Sacramento River is the main drainage for the Sacramento Valley Basin on its way to the Delta and the San Francisco Bay. The Sacramento River supports many beneficial uses including recreational, agricultural, and wildlife. The river is currently not used for municipal or domestic water supplies in the County. There are, however, future plans to utilize the Sacramento River, in conjunction with groundwater, to provide municipal water supply to the Measure M Sutter Pointe development (Sutter 2011).

Many tributary streams flow from the mountains on both sides of the valley into the Sacramento River. According to a 2005 report by the Glenn County Department of Agriculture (GCDA), flows in the Sacramento River near Grimes in Southern Colusa County range from 6,500 cfs to 16,900 cfs for the period of record of 1946-2003 (GCDA 2005).

3.2.2. The Feather River

The Feather River is a major tributary of the Sacramento River and outlines a major portion of Sutter County's eastern boundary. The river trends north-south along the northern and central portions of the County to the convergence with the Bear River, where it changes course and flows southwest through the south-central portion of the County until it intersects the Sutter Bypass and the Sacramento River. Like the Sacramento River, the Feather River provides beneficial uses including recreation, agricultural, and wildlife. Yuba City obtains a large portion of its annual water supplies for municipal and domestic use from the Feather River.

3.2.3. The Bear River

The Bear River is a tributary of the Feather River and enters Sutter County from Placer County near the City of Wheatland in Yuba County. It forms the boundary between Sutter and Yuba Counties up to the convergence with the Feather River. The Bear River generally flows west until it converges with the Feather River, approximately one mile upstream from the rural community of Nicolaus. Although smaller than the Sacramento and Feather Rivers, the Bear River also provides beneficial uses that include recreation, agricultural, and wildlife. Discharges within the river are partially controlled by several upstream reservoirs. The Camp Far West Reservoir (located in the counties of Yuba, Placer and Nevada) is the last downstream reservoir on the river and subsequently regulates surface water discharges to downstream users, which has been the source of surface water for a very successful conjunctive water use program for the South Sutter Water District.

3.2.4. The Sutter Bypass

The Sutter Bypass (Bypass) is an artificial flood corridor constructed in the 1930's. As described by the Army Corp of Engineers, "the Sutter Bypass, which began operation in the 1930's, is a leveed portion of the natural floodway in the Sutter Basin. The bypass is south of the Sutter Buttes from Colusa to Verona between the Sacramento and Feather rivers. Flows enter the Sutter Bypass from the Butte Basin at its upper end near Colusa at the Butte Slough. Other flows enter from Wadsworth Canal, interior drainage from pumping plants, and the Sacramento River by way of the Tisdale Weir and Bypass. Flows exit the Sutter Bypass and combine with the Sacramento River, Feather River, Natomas Cross Canal, and Yolo Bypass upstream from the Fremont Weir near the town of Verona"(USACE).

3.3. Seasonal and Long-Term Water Quality

Under the USGS National Water Quality Assessment (NAWQA) Program, the USGS conducted an intensive study of the Sacramento River Basin and collected data between 1995 and 1998. Through the sampling process, the USGS selected indicator streams that were based upon the characterization that "they drain small to intermediate sized watersheds with relatively homogeneous land use and geology" (USGS 1998). The Colusa Basin Drain is located entirely in the Sacramento Valley and was chosen as an indicator stream to determine the impacts of agriculture on stream-water quality (USGS 1998). At the indicator water quality station, Colusa Basin Drain at Road 99E near Knights Landing, it was determined that pH levels were generally on the higher end, with declining suspended sediment concentrations over the two-year sampling period. The higher concentrations of mercury correlate with suspended sediment because much of the load of total mercury is transported with the suspended material.

The findings of the USGS study also indicated that the water of the Sacramento River and its major tributaries is generally of good quality. As stated in the U.S. Geological Survey Circular 1215:

> "the amount of dissolved solids in the Sacramento River and its major tributaries (Yuba, Feather, and American rivers) was low at all of the sampled locations. Higher median concentrations of dissolved solids occurred at agricultural sites such as the Sacramento Slough and Colusa Basin Drain, but those are diluted upon mixing with Sacramento River water. Nutrient concentrations such as nitrate also were low throughout the Sacramento River Basin, and drinking-water standards for nitrate were not exceeded during the course of this study. The concentrations of Molinate and other pesticides (used in rice farming) measured during this study in the Colusa Basin Drain or in the Sacramento River, represent a significant improvement over concentrations measured in previous years".

3.4. Surface Water Supply Contracts

3.4.1. Settlement Contracts

USBR currently contracts with approximately 145 water districts, water purveyors, or private users for water rights to the Sacramento River. The total amount of water under the settlement contracts is approximately 2.2 million acre-feet and cover a total of almost 440,000 acres of land bordering the Sacramento River and its tributaries between Redding and Sacramento. The Settlement Contracts were originally executed in 1964 with a term not to exceed 40 years. New contracts have been executed with approximately 145 existing Sacramento River Settlement Contracts.

The Settlement Contracts include a Base Supply and Project Water. The Base Supply is the amount that reflects the agreed-upon water right of the respective entity. This is generally regarded as pre-1914 water rights and also water rights perfected after 1914 and reflect water that would be available to the respective entities under "natural" conditions. Project Water represents the amount of water the Bureau of Reclamation agrees to provide from its Central Valley Project (CVP) yield. Under the provisions of the Settlement Contracts both the Base Supply and Project Supply could be reduced by 25 percent of the total contract amount, but only in certain water year types.

3.4.2. Long-Term Renewal Contracts

In accordance with the CVP Improvement Act (CVPIA), the USBR negotiated long-term water service contracts in 2007. According to Section 3404c of the CVPIA, Renewal of Existing Long-Term Contracts requires the USBR to renew any existing long-term repayment or water service contract for the delivery of water from the CVP for a period of 25 years and may renew such contracts for successive periods of up to 25 years each. The USBR anticipates that, "as many as 113 CVP water service contracts, located within the Central Valley of California, may be renewed during this negotiation process" (USBR 2007a).

The long-term renewal contracts, unlike the Settlement Contracts, have no specified reduction in delivery; during critically dry or water-short years, the water supply available from the Project will be allocated among the contractors.

Also, the long-term renewal contracts contain a tiered pricing provision. The Base Supply is 80 percent of the total contract amount, and Tier 1 and Tier 2 supplies represent 10 percent each of the remaining contract amount. Each tier has an incrementally higher water cost. The Tier 1 and Tier 2 water, which is available in most years, is not used due to the incremental higher cost of water.

4. GROUNDWATER

4.1. Groundwater Basins and Subbasins

Sutter County is underlain by the Sacramento Valley Groundwater Basin. The Sacramento Valley Groundwater Basin covers a vast area and encompasses the alluvial deposits under the valley floor from the Sierra Nevada Mountains to the east, the Coast Range mountains to the west, the Sacramento-San Joaquin Delta to the south, and the Klamath and Cascade Ranges to the north. The Sacramento Valley Groundwater Basin covers over 5,900 square miles and 10 counties, and has been divided into 18 subbasins. The GMP area is underlain by three groundwater subbasins (Figure 1) as defined by the California Department of Water Resources (DWR) in “California’s Groundwater, Bulletin 118 – Update 2003”. These subbasins are: the East Butte Subbasin, the Sutter Subbasin, and the North American Subbasin. According to DWR,

“A groundwater basin is defined as an alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined […] features that significantly impede groundwater flow such as rock or sediments with very low permeability or a geologic structure such as a fault. […]

“A subbasin is created by dividing a groundwater basin into smaller units using geologic and hydrologic barriers or, more commonly, institutional boundaries […]. These subbasins are created for the purpose of collecting and analyzing data, managing water resources, and managing adjudicated basins.”

4.2. Hydrogeology

4.2.1. Overview of Groundwater and Geology

Groundwater is water that is underground and below the water table (saturated zone), as opposed to surface water, which flows across the ground surface. There are three main types of subsurface geology where groundwater can exist:

- Hard Rock – Groundwater can be present in cracks or fractures in the rocks.
- Underground Caverns – Groundwater can fill these underground voids.
- Porous Sediments – Groundwater can fill the pore spaces between grains of sand and gravel.

In Sutter County, groundwater exists in porous sediments, alluvial aquifers, or fractured volcanic rock such as in the vicinity of the Sutter Buttes. Figure 7 shows a simplified surface geologic map with the major faults in the County. Sutter County is situated along the axial portion of the Sacramento Valley Groundwater Basin. The subsurface aquifers consist generally of layers of gravel, sand, clay, and in some cases volcanic ash. The characteristics of different aquifers, and zones within each aquifer, are related to the aquifer materials (sands, gravels, clays, etc.). Within a single aquifer zone, nearby wells with similar construction can have very similar well yields and water quality. It should be noted that many of the geologic formations that make up the alluvial aquifers are continuous units that are also present in other counties as discussed.

In the northern portion of Sutter County, the geologic setting changes rapidly from the stratigraphic succession observed in the rest of the County. A thick sequence of volcaniclastic sediments derived from the Sutter Buttes volcanic epoch form a volcanic fan apron of alluvial deposits around its perimeter. These deposits have been characterized recently by DWR as consisting largely of gravel, sand, silt, and clay. These deposits are observed at ground surface around the Buttes, and may extend up to a 15 mile radius in the subsurface (Springhorn 2008). Sediments deposited under marine sedimentary processes are also observed at ground surface and at shallow depths in the subsurface around the Buttes. These deposits were elevated from depth to their current position during the emplacement of the volcanic intrusion which formed the Sutter Buttes. Water quality in these sediments is generally poor and deteriorates with depth.

There is a large amount of hydrogeologic data available in the Sacramento Valley which has been widely studied, and groundwater is continuous within specific aquifer zones (although discontinuous between different aquifer zones) over large areas within the Sacramento Valley.

4.2.2. Status of Understanding of Regional and Local Geology

The geology of the Sacramento Valley has been studied for at least 95 years, and much has been learned over this time. However, there are still many areas of active study and debate. In Sutter County, areas that are not well-understood and/or are actively being studied include:

- The connection between the Coast Range-sourced Tehama Formation and the analogous Sierra Nevada-sourced deposits, and where this interaction occurs.
- The possible existence of subsurface barriers to groundwater flow within the County.
- The source of poor water quality in parts of the County.

4.2.3. Regional Geology and Structure

The Sacramento Valley Groundwater Basin is a north-south trending structural trough which is filled with layers of sediments. The stratigraphic succession of the basin deposits, from oldest to youngest (deep to shallow), depict a regional change in depositional environment from one dominated by marine sedimentary processes to that of continental (alluvial) processes. The deepest portions of the basin generally consist of marine sedimentary rocks, ranging in age from Late Jurassic to early Miocene (160 million years ago to 24 million years ago). These marine deposits are overlain by younger alluvial and locally prominent volcanic rocks of early Miocene to Holocene age (Harwood and Helley 1987). Within the Basin, these deposits are disrupted by deformational stresses derived from east-west compressional forces associated with regional uplift along the western margin of the valley and extensional forces to the east, within the Basin and Range Provenance (Harwood and Helley 1987). Over time, these forces have applied great stresses and strain on valley deposits, creating complex and diversely-oriented fold and fault structures.

The prominent fault system that occurs in Sutter County is the Willows Fault. The Willows Fault is an active northwest-trending fault that dips steeply to the east and shows reverse displacement, meaning the ground east of the fault has moved up relative to the west side. The Willows Fault enters into the County from Colusa County southwest of the Sutter Buttes and extends to the southeast portion of the County towards Sacramento.

The most prominent and recognizable geologic feature in Sutter County are the Sutter Buttes. The Sutter Buttes are composed of late Cenozoic volcanic rocks that rise over 2,000 feet above the Sacramento Valley floor. The Sutter Buttes formed between 2.4 and 1.4 million years ago as magma at depth was injected into the overlying Cretaceous and Tertiary rocks, causing deformation in the form of faulting, folding, and uparching (Harwood and Helley 1987).

4.2.4. Regional Stratigraphy

The prominent non-marine, fresh water-bearing stratigraphic units found within the East Butte, Sutter, and North American Subbasins include (from youngest to oldest):

- Recent Alluvial Deposits (stream channel, basin, and flood plain);
- the Modesto Formation;
- the Riverbank Formation;

- the Sutter Buttes Rampart;
- the Victor Formation;
- the contiguous Laguna, Tuscan, and the Tehama Formations;
- the Mehrten Formation; and
- the informally named Sutter Formation (Springhorn 2008).

Except for the Sutter Formation, the stratigraphic descriptions presented herein are based upon the California Department of Water Resources "Bulletin 118 – California's Groundwater" and are shown in the geologic cross-sections (Figure 8). The location of the cross-section is shown in Figure 7.

Locally, the stratigraphic succession observed in each subbasin differs slightly; therefore, each subbasin and its associated geologic setting are described separately with regard to their relative positions and occurrences in the specific subbasin.

4.2.4.1. East Butte Subbasin (Basin Number 5-21.59)

The northern section of Sutter County is underlain by the East Butte Subbasin. The East Butte Subbasin is bounded by the Sutter Buttes to the south, Butte Creek to the west and northwest, the Cascade Mountain range to the northeast, and the Feather River to the southeast. The East Butte Subbasin aquifer system consists of late Tertiary to Quaternary aged deposits comprised of Sierra and Cascade sourced material, and in the southern portion of the subbasin around the Sutter Buttes, by volcanic and volcaniclastic rocks. The geologic formations that comprise the East Butte Subbasin are (from youngest to oldest):

- Recent Alluvial Deposits;
- the Pleistocene aged Modesto and Riverbank Formations;
- the Sutter Buttes Rampart; and
- the Tertiary aged Laguna and Tuscan Formations.

Recent Alluvial Deposits

Stream channel deposits are Holocene in age and were deposited between 11,000 years ago and present day. The stream channel deposits occur along the current and ancestral paths of streams and rivers in Sutter County. Where present, the stream channel deposits extend from ground surface up to a depth of 80 feet below ground surface (Helley and Harwood 1985). The stream channel deposits consist of unconsolidated gravels, sand, silt, and clay, derived from the erosion and reworking of the Modesto and Riverbank Formations (described below). This unit is moderately to highly permeable, but because of its shallow depth and limited thickness, it possesses limited water-bearing capacity.

Basin deposits are Holocene in age and, like the stream channel deposits, were deposited between 11,000 years ago and present day. Basin deposits occur where sediment-laden floodwaters breached natural stream and river levees and spread across lower-lying topography. Where present, the basin deposits extend from ground surface up to a depth of 150 feet. The basin deposits consist mainly of silt and clay. These units have low permeability and generally yield small quantities of water to wells.

The Modesto Formation

The Modesto Formation is Pleistocene in age and is a stream terrace deposit that was deposited between 12,000 to 50,000 years ago (Helley and Harwood, 1985). Within this subbasin, the Modesto Formation consists of poorly indurated gravel and cobbles, sand, and clay and is derived from the reworking and deposition of the Riverbank Formation, Laguna Formation, and Tuscan Formation (DWR 2004). The Modesto Formation was likely deposited by the same stream and river systems that flow today, because it generally borders existing channels (Blake et. al. 1999). This formation may extend across the entire subbasin and where present, may range in thicknesses from 50 to 150 feet (DWR 2000). The sediments of the Modesto Formation are moderately to highly permeable and can yield moderate quantities of water to wells.

The Riverbank Formation

The Riverbank Formation is Pleistocene in age and was deposited between 120,000 and 500,000 years ago (Helley and Harwood, 1985). The Riverbank Formation consists of gravel and small cobbles, and is interbedded with reddish-clay, sand and silt. Like the Modesto Formation, the Riverbank Formation is a stream terrace deposit. However, the Riverbank Formation is older than the Modesto Formation. The

Riverbank Formation may extend across the entire subbasin, underlying the Modesto Formation, with thicknesses ranging from 50 to 200 feet. The Riverbank Formation is poorly to highly permeable and can yield moderate quantities of water to wells.

Sutter Buttes Rampart

The Sutter Buttes Rampart was deposited during the Middle to Lower Pleistocene period and is encountered in the southern portion of the subbasin. This unit is up to 600 feet thick in the subsurface (DWR 2000). In several studies (William and Curtis 1977, Springhorn 2008) the Sutter Buttes Rampart has been separated into two distinct units: the Rhyolitic Rampart and the Andesitic Rampart. The Andesitic Rampart phase of volcanism was much larger than the Rhyolitic phase. All the large peaks of the Sutter Buttes are andesitic domes and comprise the majority of the Rampart on the surface and the subsurface. The Sutter Buttes Rampart consists largely of gravel, sand, silt, and clay sediments which were deposited circumferentially around the Buttes as a geologic apron. These sediments may extend up to 15 miles north of the Sutter Buttes and west beyond the Sacramento River. Certain zones within these units yield large quantities of water (DWR 2004).

Laguna Formation

The Laguna Formation is Plio-Pleistocene in age and was deposited between 4 million and 2 million years ago. The Laguna Formation is comprised of Sierra Nevada sourced sediments, consisting of consolidated alluvial gravel, sand, and silt, comprised of granitic, metamorphic, and volcanic material. Estimates of the thickness of the Laguna Formation range from 180 feet (Helley and Harwood 1985) to 1,000 feet (Olmstead and Davis 1961). The Laguna Formation is characterized as being moderately consolidated and poorly to moderately cemented. Because of this, the permeability of formation is generally low to moderate. Wells completed in this formation have been observed to yield only moderate quantities of water (DWR 2003).

Tuscan Formation

The Tuscan Formation has been the subject of much interest in recent years. The Tuscan Formation is a regional aquifer system wholly or in parts of Tehama, Butte, Glenn, Colusa, and Sutter County. Within Sutter County, there has been limited analysis done on the subsurface extent of the Tuscan Formation. It is likely that the Tuscan Formation is only present in the northern portion of the County and consequently is not a major water resource for the County.

The Tuscan Formation is Plio-Pleistocene in age and was deposited between 4 million and 2 million years ago. The Tuscan Formation was derived by alluvial deposition associated with the erosion of volcanic material derived from Cascade volcanism. The formation outcrops from Red Bluff, in the northern part of the Sacramento Valley, to Oroville, southeast of Chico, and has been recognized in the subsurface at a distance of about 15 miles west of the Sacramento River (DWR 2003a). The deposits of the Tuscan Formation thin from east to west, from about 1,600 feet thick in the foothills of the Sierra Nevada to about 300 feet thick in the subsurface of the Sacramento Valley (Lydon 1969). In surface outcrops, the exposures of the Tuscan Formation are described as four separate, but lithologically similar units: Units A through D (Helley and Harwood 1985). Units A, B, and C are found within the subsurface in the northern part of the subbasin and units A and B are found in the southern part of the subbasin (DWR 2004). All of the units of the Tuscan Formation contain stratigraphic sequences of volcanic mudflows, volcanic conglomerates, volcanic sandstones, siltstones, and tuff deposits. In the subsurface, the Tuscan Formation consists largely of black volcanic sand and gravel, with interbedded layers of tuff breccias and tuffaceous clays (Ferriz, H. 2001). Unit A is the oldest (deepest) water-bearing unit and is distinguished from Units B and C by the presence of metamorphic clasts. Unit B contains equal distributions of volcanic mudflows, conglomerates, and tuffaceous sandstones. Units A and B are referred to as the “Lower Tuscan Formation”. Unit C is capped by massive volcanic mudflows with some interbedded conglomerates and sandstones. In the subsurface, the volcanic mudflows of Unit C act as a confining layer to groundwater flow, separating the more permeable deposits of the Lower Tuscan Formation (Helley and Harwood 1985).

4.2.4.2. Sutter Subbasin (Basin Number 5-21.62)

The Sutter Subbasin underlies the central portion of Sutter County and is wholly within the boundaries of the County. The subbasin is bound by the confluence of Butte Creek with the Sacramento River and the Sutter Buttes to the north, by the Feather River to the east, by the confluence of the Sutter Bypass and Sacramento River to the south, and by the Sacramento River to the west. The Sutter Subbasin aquifer system consists of late Tertiary to Quaternary aged deposits comprised of Sierra-sourced (Sierra Nevada) detritus and volcanic and clastic rocks in the northern portion of the subbasin around the Sutter Buttes. The identified geologic formations that comprise the Sutter Subbasin are (from youngest to oldest):

- Recent Alluvial Deposits;
- the Pleistocene aged Sutter Buttes Rampart and Victor Formation;
- the Pliocene Laguna Formation; and
- the informally named Sutter Formation.

Recent Alluvial Deposits

The Holocene aged stream channel and flood plain deposits occur along the current and ancestral paths of streams and rivers in Sutter County. The stream channel and flood plain deposits consist of unconsolidated gravel, sand, silt, and clay. Both thickness and grain size decrease as the distance increases from their source. Where present, the stream channel and flood plain deposits extend from ground surface to an estimated depth of 100 feet (Helley and Harwood 1985). These units are highly permeable and provide for large amounts of groundwater recharge within the subbasin. This unit is highly permeable, and yields significant quantities of water to wells (DWR 2000).

Sutter Buttes Rampart

The Sutter Buttes Rampart is Middle to Lower Pleistocene aged alluvial deposit that is encountered in the northern portion of the subbasin. This unit can be up to 600 feet thick in the subsurface (DWR 2000). In several studies (William and Curtis 1977, Springhorn 2008), the Sutter Buttes Rampart has been separated into two distinct units: The Sutter Buttes Rhyolitic Rampart and the Sutter Buttes Andesitic Rampart. The deposition and composition of Rhyolitic Rampart reflects the initial stages of volcanism and deposition around the Sutter Buttes, while the Andesitic Rampart reflects the later stages. These fan deposits form an apron around the Buttes and consist largely of gravel, sand, silt, and clay, and may extend up to 15 miles north of the Sutter Buttes and west beyond the Sacramento River. Certain zones within these units yield large quantities of water (DWR 2004).

Victor Formation

The Pleistocene aged Victor Formation is comprised of alluvial fan deposits composed of Sierra-sourced loosely consolidated gravel, sand, and silt. The Victor Formation has an estimated thickness of 100 feet (DWR 2004). This unit is observed to have an impermeable surface due to the presence of hardpan and clay pan soils (DWR 2003). At its base, the Victor Formation has been observed to have moderate permeability and provides most of the groundwater for domestic and shallow irrigation wells in Sutter County (DWR 2003). Wells completed in this unit have been reported to have yields as high as 1,000 gpm.

Laguna Formation

The Laguna Formation is comprised of Sierra sourced, consolidated alluvial gravel, sand, and silt, which consist of granitic, metamorphic, and volcanic material. Estimates of the formations thickness range from 180 feet (Helley and Harwood 1985) to 1,000 feet (Olmstead and Davis 1961). The Laguna Formation is characterized as being moderately consolidated and being poorly-to-moderately cemented, because of this, the formation generally has a low to moderate permeability. Wells completed in this formation have been observed to yield only moderate quantities of water (DWR 2003).

Sutter Formation

The Mio-Pliocene aged Sutter Formation is an informally named stratigraphic unit that underlies the area around the Sutter Buttes and the central portion of Sutter County. The extent of the deposits have been characterized on a local to sub-regional scale and have been generally classified as volcanic and epiclastic[3] sediments derived from volcanic sources located to the east in the Sierra Nevada, western Nevada, and the southern Cascade Volcanic Province (Springhorn 2008). Due to the complexity of identifying distinguishable characteristics within these deposits, informal and formal stratigraphic units within this region have been grouped together. Some of the major regional stratigraphic units that have been included in the Sutter Formation (from youngest to oldest) are the Tuscan, Mehrten, and Princeton Valley fill deposits.

4.2.4.3. North American Subbasin (Basin Number 5-21.65)

A portion of the North American Subbasin underlies the southeastern section of Sutter County. The North American subbasin is bound by the Bear River to the north, the Feather River to the west, the Sacramento River to the south, and in the east by a north-south trending line that represents the approximate edge of the alluvial basin (DWR 2004). The North American Subbasin is dominated by late Tertiary to Quaternary aged deposits consisting of Sierra-sourced volcanic sediments and alluvial derived sediments. The identified geologic formations that comprise the North American Subbasin are (from youngest to oldest):

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[3] Consisting of fragments of preexisting rocks

- Recent Alluvial Deposits;
- Older alluvial deposits (the Pleistocene aged Modesto, Riverbank, Victor, and Laguna Formations); and
- the Mio-Pliocene aged Mehrten Formation.

Recent Alluvial Deposits

Stream channel deposits are Holocene in age and were deposited between 11,000 years ago and present day. The stream channel deposits occur along the current and ancestral paths of streams and rivers in Sutter County. The stream channel deposits consist of unconsolidated gravels, sand, silt, and clay, derived from active stream deposition, overbank sedimentation, and the erosion and deposition of existing Quaternary stream terrace deposits such as the Modesto and Riverbank Formations. Where present, the stream channel deposits extend from ground surface to a depth of 100 feet (Helley and Harwood 1985). This unit is highly permeable, and yields significant quantities of water to wells (DWR 2000).

The flood plain deposits consist primarily of silt and clay size sediments, with intermittent lenses of stream channel deposits. These deposits are generally observed along the flanks of existing and ancestral stream and river systems. These deposits have an estimated thickness up to 100 feet. Being that this unit is primarily comprised of finer-grained material, permeability is generally poor and generally yields low quantities of water. Brackish water is commonly encountered within this unit (DWR 2000).

Older Alluvial Deposits

Within this subbasin, a number of geologic formations have been assigned to the category “older alluvium” including: the Modesto, Riverbank, Victor, and Laguna Formations (DWR 2004). These deposits generally underlie the Recent Alluvial Deposits and consist of loosely to moderately compacted gravel, sand, silt, and clay size sediments that were derived and deposited under alluvial conditions. The thickness of these units ranges from approximately 100 to 650 feet (DWR 2004).

Mehrten Formation

The Mehrten Formation is Mio-Pliocene in age and consists of a sequence of volcaniclastic and volcanic rocks. In the subsurface, the Mehrten Formation ranges in thickness from 200 feet to 1,000 feet along the axis of the Sacramento Valley (DWR

2003). The Mehrten Formation is comprised of two distinct geologic units. The first unit consists of sediments deposited under alluvial and fluvial conditions and are comprised of gravel, sand, silt, and clay size sediments. This unit is highly permeable and wells constructed within this unit have been observed to produce yields exceeding 1,000 gpm (DWR 2003). The second unit consists of dense volcanic flows of tuff breccias with some interbedded conglomerates and sandstones. This unit acts as a confining layer between sand intervals and has a thickness that ranges from 200 to 1,200 feet in the subsurface (DWR 2003).

4.2.5. Areas Outside a Designated Groundwater Basin

The only part of the County that is not within a designated groundwater basin is the area consisting of the Sutter Buttes. Groundwater is likely found in the subsurface in fractures of the volcanic rock; however, historic groundwater levels and water quality were not reviewed in the preparation of this GMP. There are no local entities, aside from private domestic water users, that utilize groundwater resources in this area.

4.3. Groundwater Levels

DWR does not currently consider any of the groundwater subbasins underlying the County to be in overdraft. Overdraft is characterized by a declining trend in groundwater levels over multiple years without recovery during recharge events. Historic groundwater level data were reviewed for each of the subbasins within the County. DWR maintains a publicly available on-line database, which includes groundwater level data for the County. The DWR Water Data Library (WDL) website can be found at http://www.wdl.water.ca.gov. Wells monitored by DWR and cooperating agencies are identified by the State Well Number (SWN). Data can be obtained for specific wells by means of a map interface, by groundwater basin, or by the assigned SWN.

A 79-year period of record for water level measurements in Sutter County depicts a groundwater system that has experienced changing conditions over time. A number of DWR monitored wells were selected throughout the County to represent these changes. The locations of these wells, along with their associated hydrographs illustrating the historic groundwater levels, are shown in Figure 9. Groundwater level data from well 10N/4E-12A1, a 290-foot-deep well located in the southeast portion of Sutter County, and well 13N/3E-32N1, a shallow (less than 100 feet deep) well located in the southern portion of the County show the groundwater levels typical of different areas of the County. Groundwater levels in well 10N/4E-12A1 are characteristic of areas of high groundwater use and differing water conditions. Water levels fluctuate, sometimes dramatically, in response to changes in groundwater use and hydrologic conditions. This well is located in an area where agricultural demands are supplied entirely with groundwater. The Sacramento County Department of Water Resources website includes published groundwater elevation maps and indicates that this well is in close proximity to a large pumping depression in northern Sacramento County. Groundwater levels in well 13N/3E-32N1 are characteristic of areas with lower groundwater use and more stable water conditions, and as such, water levels have not exhibited significant fluctuations over times. This well is located in an area where agricultural demands have been met almost entirely with surface water and groundwater demands have consequently been small.

Groundwater levels in well 10N/4E-12A1 have varied from 20 to 80 feet below ground surface over time. The combination of high groundwater use, the close proximity to a pumping depression, and changing climatic conditions has led to significant declines in groundwater levels from the early 1950' through the late 1970's. In the middle to late 1970's, drought conditions increased the rate of decline of groundwater levels on an even larger scale. In the mid 1980's and early 1990's, private and municipal water agencies in a collaborative effort started to implement conjunctive water use programs. With the availability of surface water, and the decrease in groundwater pumpage, groundwater levels have been steadily recovering from the early 1980's through present. Groundwater levels in this well are currently about 35 to 40 feet higher than they were in the late 1970's.

Groundwater measurements in well 13N/3E-32N1 shows very stable groundwater levels since measurements began in 1942. Groundwater levels have remained virtually unchanged, with water levels within 5 to 6 feet of ground surface and seasonal fluctuations of less than 10 feet.

The direction of groundwater flow during the fall season within the County has not changed significantly from 1912-1913 (Bryan 1923) to 2007; with the exception of the southeastern portion of the County. Contours of equal groundwater levels from fall 1912-1913 and fall 2007 were compared to identify changes over the 95 year period. Figure 10 depicts changes in groundwater levels over the aforementioned period. In most areas within the County, groundwater levels were not dramatically different in 2007 than they were in 1912-1913. In the central portion of the County, an increase in groundwater levels is observed in the data, which may be likely due to applied surface water for irrigation. In the southeastern portion of the County, a significant decline in groundwater levels is observed, which can be related to the high usage of ground water for irrigation of crops, and the influence of the large pumping depression in the northern portion of Sacramento County.

Fall and spring contour maps of equal groundwater elevation for 2007, 2008, 2009, and spring 2010 were reviewed (Figures 11 through 17) to determine groundwater gradient and flow direction. The fall 2009 and spring 2009 groundwater contours generally follow the topography of the County and indicate that groundwater flows from the Sierra Nevada toward the Sacramento Valley (east to west), and north to south within the Valley. The fall 2007 contour map of equal groundwater elevations indicates a few locations where small pumping depressions are present, but in general, suggests the same direction of groundwater flow as seen in the spring 2007 groundwater contour map. Differences in groundwater levels between fall and spring appear to be a result of normal fluctuations in groundwater conditions from seasonal pumping and from wet and dry climatic cycles.

Data from the nested monitoring well at the extensometer site in the southern portion of the County indicates that, for the 14 years of available data, the spring groundwater levels in the monitored aquifer zones have been very similar, within a few feet of one another; except for the deepest completion where groundwater levels are approximately 10 feet lower than the shallower completions.

4.4. Groundwater Quality

The quality of groundwater is a product of the material through which it flows, or that flows into it. Local variations in the quality of the County's groundwater can limit its use for either potable water supply and/or agricultural applications. Groundwater contamination is a result of naturally occurring, point source contamination, and/or regional contamination. Naturally occurring contaminants of concern include dissolved salts [as measured by the specific conductance or electrical conductance (EC)], boron, nitrate, manganese, arsenic, and mercury. Point source contamination typically involves solvent releases originating mostly from gas stations and dry cleaners. Regional sources of contamination include applied fertilizers, salts, and leaky septic systems (nitrate and salt loading).

Historic and current water quality data (collected by the DWR, USGS, and local water purveyors) for wells located within the County were analyzed to characterize spatial and depth dependent water quality trends within the County's groundwater subbasins. The data was separated by well depth into the following three categories: less than 150 feet deep, 150 to 400 feet deep and more than 400 feet deep, as shown in Figures 18 through 23. The categories were chosen based on the occurrence at which certain stratigraphic units are observed in the subsurface in Sutter County.

4.4.1. Specific Conductance

Specific conductance was selected as an indicator of overall water quality. Specific conductance is a property of groundwater that is relatively simple to collect in the field at the well head and can help identify and characterize the condition of the non-marine fresh water bearing aquifer system. Specific conductance is a measure of how effectively water will conduct electricity and is reported in micro Siemens (µS/cm) per centimeter and provides for the indirect measurement of the amount of dissolved solids (salts) in the groundwater. Lower specific conductance generally indicates better water quality (fresh water) while higher specific conductance generally indicates poorer water quality (brackish to saline water).

Applied irrigation and fertilizers can add salts to the water that percolate into the hydrogeologic system, increasing the specific conductance of the groundwater. Increased specific conductance values of the groundwater can also be attributed to naturally occurring brackish or saline water, such as geologic formations (aquifers) which are, or have been in the past, directly connected to a salt water body or where geologic formations were deposited under marine (salt water) conditions and which have inherently high dissolved salt concentrations. As shown in Figures 18 and 19, specific conductance values within the County are generally acceptable for agricultural and domestic use east of Highway 99 and in the northern half of the County. Elevated values for specific conductance are near to and/or exceed the recommended maximum contaminant level (MCL)[4] for domestic use in the shallow aquifers near the Sacramento River and in the aquifers below 900 feet. The elevated specific conductance could potentially be problematic for agricultural use. It is unclear why there is elevated specific conductance in this area.

4.4.2. Boron

Boron is a naturally occurring element. As shown in Figure 20, boron concentrations in the County are generally acceptable. Some deeper wells, which likely encounter more marine sediments, do contain elevated boron concentrations. Boron is a necessary element for agriculture, but may become toxic to crops above 500 micrograms per liter (µg/L). For public drinking water systems, the California Department of Public Health (CDPH) has established a notification level of 1,000 µg/L for boron. Increased concentrations of boron are observed in wells greater than 400 feet as well as in the southwestern portion of the County.

4.4.3. Nitrate

Nitrate is a contaminant which does not naturally occur in the subsurface. Elevated concentrations of nitrate are widespread in the Sacramento Valley. As shown in Figure 21, concentrations of nitrate in the populated areas of Sutter County are near or above the MCL for nitrate (as NO_3). The CDPH has established a primary MCL of 45 milligrams per liter (mg/L) for nitrate (as NO_3). Near the Sutter Buttes and Yuba City, nitrate concentrations in several wells (less than 150 feet) exceed the MCL. Where present, elevated concentrations of

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[4] Recommended CDPH MCL for Specific Conductance is 900 µS/cm; upper limit is 1,600 µS/cm; short term is 2,200 µS/cm

nitrate are likely a result of overlying land uses, such as septic systems, animal enclosures, or applied fertilizers.

4.4.4. Manganese

Manganese is a naturally occurring element found in rocks and minerals. Its presence in groundwater is a result of the dissolution of the naturally occurring element in sediments containing minerals composed of manganese. As illustrated in Figure 22, manganese concentrations are elevated in all portions of the County, at levels that may cause aesthetic problems (odor or staining) for domestic and municipal uses, but generally below levels that could represent a health risk. There are, however, a few locations where manganese concentrations are near or exceed the CDPH established Notification Level of 50 µg/L, and may pose a health risk.

4.4.5. Arsenic

Arsenic is a naturally occurring element commonly found in alluvial sediments. Its presence in groundwater is a result of the dissolution of the element in sediments containing minerals containing arsenic. The CDPH has established a primary MCL of 10 µg/L for arsenic. As illustrated in Figures 19 and 23, arsenic concentrations are near to or above the CDPH MCL throughout the County in each of the aquifer zones assessed; conversely, concentrations of arsenic below the CDPH MCL are also present throughout the County in each of the aquifer zones assessed. Countywide, arsenic concentrations do not appear to be isolated to any one specific aquifer zone in the subsurface. However, recent data analysis suggests a possible correlation between elevated arsenic concentrations and the presence of volcaniclastic material of the Sutter Buttes Rampart formation. Concentrations of arsenic in the stratigraphic units that occur above and below the Rampart are generally less than 10 µg/L, whereas concentrations of arsenic within the Rampart material are between 10 to 370 µg/L (Springhorn, 2008). Concentrations of arsenic tend to be under the CDPH MCL southeast of Highway 99 and in the shallow aquifers.

4.4.6. Mercury

Historic gold mining processes and operations introduced toxic mercury into the surface water system throughout Northern California in the late 1800's. Due to the proximity of these operations to Sutter County, the PAG requested an assessment of the concentrations of mercury in the groundwater. A limited number of wells have been sampled within Sutter County for mercury, and as such, concentrations of mercury in the groundwater within Sutter County can not be well characterized. The few wells that have been sampled for mercury indicate that mercury concentrations were low. In most cases, the concentrations were below the analytical detection limit (not detectable by the laboratory method used at the time).

4.5. Land Subsidence

Land subsidence is the gradual or sudden lowering of the land surface due to compaction of the underlying sediments. Two types of land subsidence are observed within alluvial sediments: inelastic and elastic. Inelastic land subsidence is a result of the compression of geologic formations and is irreversible. Inelastic land subsidence can be caused by excessive extractions of groundwater, oil, or natural gas. In discussing land subsidence, it is important to note that elastic (reversible) land subsidence is a normal occurrence, whereas inelastic land subsidence has associated negative impacts.

Although there are several causes of inelastic land subsidence, the compression of clay as a result of groundwater extraction is considered the most likely cause of subsidence north of the Sacramento-San Joaquin Delta (Page 1998). Once water is removed (mined) from compressible clay, the clay compresses and cannot accept water again, thus resulting in the permanent lowering of the overlying land surface (inelastic land subsidence). Clay compression has occurred in several locations in California, including the San Joaquin Valley. Compressible clay, such as the Corcoran Clay member of the Tulare Lake Formation, has been mapped over much of the western side of the San Joaquin Valley and can be over 130 feet thick. The subsidence documented in the San Joaquin Valley extends over a very large area, with over 30 feet of subsidence recorded in some areas.

North of the Sacramento-San Joaquin Delta in the Sacramento Valley, inelastic land subsidence, which has been directly related to clay compression as a result of groundwater extraction, has occurred in portions of Solano, Yolo, and Colusa Counties (Page 1998). Recorded land subsidence of more than two feet, and possibly as much as five feet, has occurred in this area. Subsidence in the Sacramento Valley appears to extend from Davis to Arbuckle. The area of subsidence appears to follow a local geologic feature known as the Zamora Syncline. A syncline is a structural fold that is formed by compressional forces which cause the sedimentary layers to have a concave, or a bowl-like geometry. Lakebeds are often associated with structural lows such as synclines. Lakebed deposits typically consist of fine-grained, clayey sediments, which settle out to the bottom of standing bodies of water and of which can include large volumes of freshwater diatoms[5]. Along with sediments, the microscopic diatoms settle and collect on the bottom of a lakebed. In Yolo County, diatomaceous (diatom rich) clay sediments have been identified within the geologic formations of Zamora Syncline. These diatomaceous clay sediments were identified to be

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[5] Diatoms are unicellular aquatic algae, typically 20 to 200 microns (Prothero, 1998)

highly compressible (Page 1998). Although diatomaceous clay has been identified in numerous boreholes drilled in Sutter County, there have not been any recorded land subsidence issues.

Elastic land subsidence is observed to be cyclical and does not result in permanent compaction of subsurface materials. One example of elastic land subsidence is seasonal fluctuations in ground surface elevations that coincide with fluctuations in groundwater levels (and associated aquifer pressure). In elastic land subsidence, the subsurface pressures acting on the aquifer do not decrease enough so that subsurface materials permanently compact.

The DWR, in cooperation with federal, state and local agencies, installed and surveyed Global Positioning System (GPS) monuments to be able to measure and monitor ground surface elevations over time in the Sacramento Valley. The project, titled "The Sacramento Height-Modernization Project", consists of 339 monuments, spaced approximately 7 kilometers apart, in 10 counties. There are 32 monuments located in Sutter County. The GPS monuments will augment the existing network of extensometers which DWR currently monitors for land subsidence. In total, there are 13 extensometers located in Glenn, Colusa, Butte, Yolo, and Sutter Counties. The land subsidence monitoring network is shown in Figure 24. Only one of these extensometers, State Well Number 11N/4E-04, is located within Sutter County. It is located in the south-central part of the County along Highway 99, and extends to a depth of 1,003 feet, extending over a large portion of the fresh-water formations. The extensometer is installed in a dedicated monitoring well and is designed to measure any change in distance between the bottom of the well and the ground surface. DWR reports the accuracy of the extensometer to be ±0.001 feet. The extensometer provides for ongoing, real-time data collection, of land surface elevation changes. The Sutter County extensometer has been recording data since early 1994. In the 14 years since it began recording, the extensometer in Sutter County has recorded seasonal (cyclic) elastic land subsidence of approximately 0.03 feet (approximately one-third inch). There has been no indication over the period of record that any inelastic subsidence has occurred.

4.6. Groundwater-Surface Water Interaction

Several clustered monitoring wells located throughout the county adjacent are used to monitor changes in surface flow or quality that directly affect the groundwater system (levels or quality), and/or to monitor changes in surface flow or quality that are caused by groundwater pumping. These monitoring wells are adjacent to surface water bodies, and have a river stage gage located in the immediate vicinity.

Several of the network wells are located along the banks of the Sacramento, Feather, and Bear Rivers, as shown in Figure 25. The relationship between the volume of water flowing in the major rivers/streams and the influence the surface water imparts on groundwater elevation are being monitored with a combination of nested monitoring wells and river stage gages. Four stations exist in the County for observing this interaction: on the Sacramento River below Wilkins Slough (WLK), on the Bear River at Pleasant Grove Road (BPG), on the Sutter Bypass at RD 1500 pump (SBP), and along the Feather River above Star Bend (FSB). Sutter County also monitors a river stage gage at Boyd’s Landing (FBL). At stations BPG and FBL, observations of water surface/groundwater elevations trend closely during high flow/stage events in the rivers, suggesting a significant hydrologic connection between the groundwater in the shallow aquifers and the surface water.

4.7. Groundwater Recharge

Groundwater recharge is the process in which groundwater is replenished. The geologic formations that comprise the aquifer system underlying the County extend well beyond the County’s jurisdictional boundaries. Several processes are responsible for recharge of the groundwater basin. On a regional scale, surface water flowing over the surface expression of the geologic formations (surface outcrops) allows for direct infiltration into the hydrogeologic system. Figure 26 depicts contours of equal groundwater elevations, superimposed over the surface geology, for the Sacramento Valley Groundwater Basin. Groundwater flow is perpendicular and down gradient to the contour interval. On the east side of the Sacramento Valley Groundwater Basin, the groundwater contours become parallel to and follow the margin of the valley, indicating groundwater is moving through the subsurface from the east to the west. Locally, groundwater recharge occurs where surface water flows over permeable sediments (gravel and sand) in the river channels, allowing for the direct infiltration of surface water. Deep percolation of applied irrigation water also recharges the groundwater basin. Additionally, surface water deliveries have increased the quantity of water flowing down the river, adding available water to recharge the underlying aquifers helping to improve groundwater elevations.

The amount of groundwater recharge is dependent on the available storage space within the aquifer(s). Depending on the degree of separation between the elevation of the bottom of the river or stream and that of the groundwater, streams can either “lose” water into the underlying aquifer(s) or “gain” water. Where groundwater levels are at or above the elevation of surface water, groundwater will discharge into the stream (gaining stream). Where there is a separation between the groundwater and surface water, water flowing downstream will recharge into (losing stream) the groundwater basin (although the contribution has not been studied). Conversely, if groundwater levels are at land surface, there will be refusal of any "new" water into the subsurface.

The State Water Resources Control Board has identified hydrogeological vulnerable areas, meaning vulnerable to groundwater contamination, where geologic conditions allow recharge to the underlying aquifers. Generally, these areas include the coarse deposits associated with the Feather River.

4.8. Groundwater Infrastructure

According to DWR records, 6,742 well completion reports have been filed for wells constructed in Sutter County. Well completion reports are not always filed with DWR, even though they are required by law, so the number of reports likely under-represent the actual total for the County. Of the wells for which well completion reports have been filed:

- 3,344 are domestic wells
- 1,167 are irrigation wells
- 854 have unknown or other uses
- 308 are monitoring wells
- 75 are municipal wells
- 34 are industrial wells
- 13 are test wells
- Seven (7) are stock-watering wells
- 12 are fire or frost protection wells
- Two (2) are cathodic protection wells

Figure 27 shows the number of DWR well completion reports filed for Sutter County from 1928 through 2007. The figure only illustrates wells that were classified as either: domestic, irrigation, or public supply. Domestic wells were constructed at a rate of approximately five per year from 1941 through 1950, but have been constructed at a rate of approximately 59 per year since then. Irrigation wells tend to be constructed more frequently during drought periods, in the mid-1970's and early 1990's. On average, 16 irrigation wells are constructed per year; however, significantly more wells are constructed during droughts. Municipal well construction has averaged two-and-a-half per year. Of the wells for which records exist, approximately 700 wells are classified as either abandoned or destroyed.

Figure 28 shows the average depth of wells constructed from 1950 through 2005. The average depth of domestic wells has fluctuated since the 1930's, but has generally been about 100 feet deep. The average depth of irrigation wells has fluctuated significantly, but has been about 160 feet deeper than the average depth of domestic wells in any give year, or an average of about 260 feet deep. Municipal well depths are inconsistent and vary widely in depth, from about 50 to 700 feet deep. Combined with the small number constructed annually, calculation of an average depth of new municipal wells would not be meaningful.

5. GROUNDWATER MANAGEMENT PLAN REQUIRED, VOLUNTARY, AND RECOMMENDED COMPONENTS

California Water Code §10750 et seq., as amended by Senate Bill (SB) 1938, defines the required and voluntary components of a GMP and establishes procedures by which they must be developed. DWR recommends additional elements to include in a GMP in Bulletin 118 Update 2003, Appendix C. The Sutter County GMP includes the components required in the Water Code and has been developed in accordance with the required procedures. This GMP also includes many of the voluntary and recommended GMP components. This GMP also includes components designed to address the requirements of California Water Code §10920 et seq., which establish requirements for groundwater monitoring that affect eligibility for grant funding.

5.1. California Water Code Requirements

Section 10750 et seq. of the California Water Code, as amended by SB 1938, requires GMPs to include six mandatory components to be eligible for the award of funds administered by DWR for the construction of groundwater projects or groundwater quality projects. These components are listed below.

Description	***GMP Section***
Make available to the public a written statement describing the manner in which interested parties would be allowed to participate in the development of the GMP.	1.4
Include Basin Management Objectives (BMOs), including components relating to the monitoring and management of groundwater levels, groundwater quality degradation, inelastic land subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping.	6.2
Prepare a plan that involves other agencies that enables Sutter County to work cooperatively with other public entities whose service area or boundary overlies the groundwater basin.	7.1.5
Prepare a map that details the area of the groundwater basins, Sutter County's boundaries, and other local agencies within the groundwater basins.	Figure 1

Description	*GMP Section*
Adopt monitoring protocols to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence, and flow and quality of surface water that directly affects groundwater levels or quality or are caused by groundwater pumping.	7.1
For areas outside the groundwater basins, use geologic and hydrologic principles appropriate to those areas.	4.2.5;7.1.4

5.2. DWR Bulletin 118 Recommended Components

DWR's Bulletin 118 recommends other components that may voluntarily be included in a GMP. These are listed below.

Description	*GMP Section*
Establish an advisory committee of stakeholders to help guide the development and implementation of the plan and provide a forum for resolution of controversial issues.	1.4
Describe the area to be managed under the GMP.	1.3
Describe how meeting each BMO will contribute to a more reliable long-term groundwater supply, and describe management actions to achieve each BMO.	6.2
Describe GMP monitoring program.	7.1
Describe integrated water management planning efforts.	7.1.5
Periodically report groundwater basin conditions and management activities.	7.1.6
Evaluate GMP periodically.	7.1.6

5.3. California Water Code Voluntary Requirements

California Water Code §10753.8 lists twelve issues of groundwater management which may voluntarily be included in a groundwater management plan.

Description	*GMP Section*
Control of saline water intrusion.	6.1.3
Identification and management of wellhead protection areas and recharge areas.	4.7; 6.1.3
Regulation of the migration of contaminated groundwater.	N/A
Administration of well abandonment and well destruction program.	6.1.3
Mitigation of conditions of overdraft.	4.3
Replenishment of groundwater extracted by water producers.	N/A
Monitoring of groundwater levels and storage.	4.3; 5.4
Facilitating conjunctive use operations.	6.1.3
Identification of well construction policies.	6.1.3
The construction and operation of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.	N/A
The development of relationships with state and federal regulatory agencies.	7.1.5
Review of land use plans and coordination with land use planning agencies to assess activities which create a reasonable risk of groundwater contamination.	7.1.6

5.4. California Water Code Groundwater Monitoring Components

On November 4, 2009 the State Legislature amended the Water Code with Senate Bill SBx7-6, which mandates a statewide groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. To achieve that goal, the amendment requires collaboration between local monitoring entities and DWR to collect groundwater elevation data. Collection and evaluation of such data on a statewide scale is an important fundamental step toward improving management of California's groundwater resources.

In accordance with this amendment to the Water Code, DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program. The intent of the CASGEM program is to establish a permanent, locally-managed program of regular and systematic monitoring in all of California's alluvial groundwater basins. The CASGEM program will rely and build on the many, established local long-term groundwater monitoring and management programs. DWR's role is to coordinate the CASGEM program, to work cooperatively with local entities, and to maintain the collected elevation data in a readily and widely available public database. DWR will also continue its current network of groundwater monitoring as funding allows.

The law anticipates that the monitoring of groundwater elevations required by the enacted legislation will be done by local entities. The law requires local entities to notify DWR in writing by January 1, 2011 if the local agency or party seeks to assume groundwater monitoring functions in accordance with the law (Water Code §10928).

Additionally, on or before January 1, 2012, the law requires that Monitoring Entities shall begin reporting seasonal groundwater elevation measurements to DWR (Water Code §10932).

Local entities in Sutter County that have submitted official notifications to DWR to be considered for CASGEM Monitoring Entities include:

- Sutter Extension Water District
- Feather Water District
- Reclamation District 1500 (including RD 1500, Pelger Mutual Water Company and Sutter Mutual Water Company)
- Natomas Central Mutual Water Company
- South Sutter Water District

Garden Highway Mutual Water Company has shown interest in participating in CASGEM but has not yet completed the official notification submittal process include.

Local entities that submit complete Monitoring Entity notifications and adequate groundwater monitoring plans and well networks will be officially designated by DWR to be the Monitoring Entities for their respective subbasin or portion of a subbasin for the purposes of the CASGEM Program. However, if no local monitoring entity volunteers or is identified for a particular area or groundwater basin, DWR may assume the monitoring and reporting duties and certain entities in the basin may not be eligible for water grants or loans administered by the state.

Sutter County is severely limited in its ability to take a lead in groundwater monitoring because of budget and staff shortages. Furthermore, the County does not own any groundwater monitoring wells and does not conduct any groundwater monitoring on its own. For this reason, Sutter County does not seek to assume groundwater monitoring functions under California Water Code §10920 et seq. However, the County does promote the coordinated collection of groundwater elevation data through its Groundwater Monitoring Program, discussed in Section 7.1 of this GMP.

6. GROUNDWATER MANAGEMENT GOALS AND BASIN MANAGEMENT OBJECTIVES

6.1. Groundwater Management Goals

Sutter County's groundwater management goals represent the overarching intent of the County with regard to groundwater management. Basin Management Objectives (BMOs) and Management Actions must be consistent with these Groundwater Management Goals, and must contribute to achieving the goals. Sutter County's goals for groundwater management (as developed with input from the public through PAG meetings and workshops) are:

- To promote responsible groundwater use in Sutter County so groundwater is available to meet present and future demands.
- To provide groundwater users with information and guidance to help them be responsible stewards of the groundwater resources in Sutter County.
- To discourage activities that could reduce the long-term availability of high-quality groundwater in Sutter County.

Each of the Groundwater Management Goals is discussed below.

6.1.1. To Promote Responsible Groundwater Use in Sutter County So Groundwater is Available to Meet Present and Future Demands.

One of Sutter County's main goals for groundwater management is to ensure that a reliable water supply is available so that water users in the County can be confident that water will be available to meet domestic, irrigation, and other demands on an ongoing basis.

The goal to promote responsible groundwater use in Sutter County is intended to provide the County with useable groundwater resources now and in the future. This is important because the socio-economic well being of the County could be adversely affected if the groundwater supply becomes less useable from a supply or quality standpoint. Ensuring responsible groundwater use will help protect groundwater rights and maintain local control because adjudication of the groundwater basin will not be warranted if long-term groundwater sustainability can be achieved.

6.1.2. To Provide Groundwater Users with Information and Guidance to Help Them Be Responsible Stewards of the Groundwater Resources in Sutter County.

It is important to understand that in order to responsibly manage groundwater to ensure long-term groundwater sustainability, it is necessary to thoroughly understand the groundwater system underlying the County, along with its capabilities and limitations. Sutter County's water resources should be viewed as a dynamic system with the amount of available surface water and groundwater varying over time with fluctuations in hydrologic and climatic conditions. The implementation of a surface/groundwater monitoring program to observe and document the County's resources is essential to provide the community with the necessary information to accomplish this management objective.

6.1.3. To Discourage Activities that Could Reduce Long-Term Availability of High-Quality Groundwater in Sutter County.

It is important to recognize that this management objective is not intended to restrict the users within the community from exercising their legal rights to groundwater. Groundwater is a resource that should remain available for the people of the County to use beneficially on their property. The intent of this objective is for groundwater management to be accomplished in a way that minimizes activities that could potentially reduce the long-term availability of high-quality groundwater in Sutter County. There are a number of management practices that can be utilized to accomplish this goal. Two of the main practices that should be considered are conjunctive use programs and improving County well standards.

The goal of optimizing the conjunctive use of surface water and groundwater will enhance the County's water supply reliability and maximize the available water supply. The term "conjunctive use" basically means using surface water and groundwater together to meet water demands, using different proportions of each depending upon availability. For example, in years of reduced surface water availability, more groundwater would be used and groundwater levels might decline. Conversely, in years of full surface water availability, less groundwater would be used and groundwater levels would be allowed to recover. Optimizing conjunctive use generally means that, whenever possible, surface water is used to the fullest extent with groundwater serving as a "back-up" supply. This maximizes the available water supply because unused surface water generally flows downstream and is lost, but unused groundwater remains in the ground and would be available for later use.

On the other hand, the potential may exist in some areas of the County where groundwater levels are (and have historically been) high, to utilize more groundwater and thus induce more recharge (by creating additional storage space within the aquifer) thereby increasing the total water supply available in the County.

A related goal is to “even out” water availability in the County. There are cases when surplus water is available in some areas of the County, but other areas have inadequate supplies. For example, an area with high groundwater levels may have adequate or excess surface water, while another area may have low groundwater levels and inadequate surface water. In this case, groundwater could be pumped in the area with high groundwater levels, and their surface water could be transferred to the area with low groundwater levels so that area does not have to rely as much on groundwater. If possible, undertaking such projects will help improve the overall water supply reliability in the County.

The goal for updating the County’s well standards is to add additional levels of protection to ensure that the design of new well structures prohibit the downward migration of surface/shallow contaminants or cross contamination of aquifers. The County has adopted standards as set forth in Chapter II of the State Department of Water Resources Bulletin 74-81, and as supplemented by Bulletin 74-90, entitled “Water Well Standards: State of California”, except as otherwise provided in Section 700, Chapter 765 “Water Wells” of the Sutter County Municipal Code[6]. Some amendments that could be made to the existing well standards are: (1) require the use of geophysical surveys for all new well projects, (2) increase the required minimum sanitary seal depths, (3) institute water quality sampling during cable tool well drilling, (4) institute well restriction zones where poor water quality is known, and (5) improve/implement well destruction programs.

Requiring the use of geophysical surveys (spontaneous potential, 16- and 64-inch resistivity) in all new boreholes can help to enhance groundwater protection by identifying the zone(s) of poor water quality, as well as the depths of confining layers, which can be used to design adequate sanitary/annular seals. With this data, future wells can be designed to effectively seal against poor water quality while providing adequate measures for aquifer protection.

Increasing the minimum sanitary seal depth required for new wells is a proactive measure that can effectively increase aquifer protection. Increasing the required sanitary seal to a minimum depth of 50 feet for all new wells can seal off shallower aquifers with poorer water quality from the deeper aquifers with better water quality, as well as impede the

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[6] http://www.co.sutter.ca.us/doc/government/bos/ordinance

downward migration of surface contaminants. Currently, the standards in force require a minimum 50-foot sanitary seal for municipal supply wells and 20-foot sanitary seal for all other wells (Bulletin 74-90).

Many wells in Sutter County have been drilled and constructed utilizing the cable tool drilling method. One of the main troubles with cable tool wells is that they usually are constructed across, and connect, multiple aquifer zones. Some of these well structures likely have become conduits for the downward migration and cross contamination of aquifer zones. Water quality sampling during the drilling of these wells (field tests for TDS or specific conductance) would delineate between problematic and non-problematic aquifer zones. If an existing well is deemed problematic (i.e. poor water quality), corrective measures through well modification or even well destruction could help mitigate the movement of poorer water quality between aquifer zones.

Implementing well restriction zones where water quality contamination is known to exist in specific aquifers can aide in protecting aquifers with acceptable water quality. Restricting the construction of wells or requiring specific seal intervals can provide an additional level of aquifer protection. Certain areas within Sutter County have localities of poorer water quality. It may be beneficial to assess the risk of drilling and constructing new wells within these areas. If adequate aquifer protection can not be achieved during construction activities, it may be warranted to designate well exclusion zones.

Unused, unsecured, abandoned, or improperly destroyed wells can act as a direct conduit for surface water infiltration or degradation of one or more aquifers, if they are connected by the well structure. Well destruction requirements adopted by the County currently require abandoned wells to be destroyed. Currently, these requirements require the uppermost 20 feet of the well/borehole be filled with impervious material. Special situations, in the case where vertical movement of poor water quality could contaminate an aquifer with good water quality, require impervious sealing material to be placed adjacent to confining layers. Increasing oversight of the permitting process during the planning and design of well destruction programs can ensure added protection against the vertical migration of poor water quality.

6.2. Basin Management Objectives

Basin Management Objectives (BMOs) are guidelines established to ensure that the County’s basin management goals are being fulfilled. BMOs create a systematic method for collecting and monitoring data for specific components of the groundwater system and to provide for the dissemination of such information to the public. The objective of the BMOs is not to assign a fixed value, or level, to each parameter, but to allow for the early identification of potential problems with sufficient time for the County and its groundwater users to formulate an action plan to mitigate adverse effects to its groundwater resource.

Sutter County's BMOs address the following parameters:

- Groundwater levels
- Groundwater quality
- Inelastic land subsidence
- Surface water
- Coordination

6.2.1. Groundwater Levels BMO

There are three BMOs for groundwater levels:

- *Avoid ongoing declines in groundwater levels during water year types identified by DWR to be "above normal" or "wet" for the Sacramento Valley.*
- *Avoid problematically high groundwater levels.*
- *Provide assistance with assessing problems and resolve disputes related to groundwater levels.*

Groundwater levels are to be managed to ensure adequate water supplies while avoiding adverse impacts and mitigating them if and when they do occur. Adverse impacts related to groundwater levels can occur from excessively high or low groundwater levels. What constitutes an excessively high or low groundwater level may change over time, and will also vary by land use and hydrologic and climatic conditions.

Excessively high groundwater levels are problematic in some areas of the County. High groundwater levels in Sutter County are often naturally occurring. However, groundwater levels can be raised by application of water to the ground surface through irrigation, surface storage, or recharge projects. When groundwater levels are high, there is no storage capacity available in the underlying aquifer for groundwater recharge from precipitation, stream flow, or excess applied irrigation water. This represents a lost opportunity to capture recharge and increase the overall water supply for the County. Adverse impacts related to high groundwater levels include:

- Damage to foundations, roads, and other infrastructure.

- Water-logging the root zone of certain crops.

Groundwater levels decline when pumping exceeds recharge and rise when recharge exceeds pumping. It is important to note that periodic short-term declines in groundwater levels (during drought periods and/or increased pumping), which are then followed by recovery to at or near historic highs (during wet periods and/or decreased pumping), are normal and do not represent overdraft. Excessively low groundwater levels that are caused by long-term declines without recovery, thus overdraft, can be avoided by reducing pumpage. This can be accomplished by expanding the conjunctive use with surface water. Adverse impacts related to low groundwater levels include:

- Infrastructure problems when lowered groundwater levels dewater pumps or wells, so groundwater cannot be extracted using existing infrastructure even though it is available at greater depths.
- Depleted available groundwater supply.
- Inelastic land subsidence.
- Riparian and/or native vegetation destroyed.
- Reduced surface water flow due to increases in streambed infiltration, or increases in the capture of groundwater that otherwise would have contributed to increasing the base flow of a surface water system.

6.2.2. Groundwater Quality BMO

The BMO for groundwater quality is to:

- *Improve the understanding of groundwater quality in Sutter County.*
- *Maintain or improve groundwater quality.*

Adverse impacts to groundwater quality most commonly occur when degradation of groundwater renders groundwater unsuitable for intended uses. Accordingly, what constitutes a significant adverse impact to groundwater quality is related to the purposes for which groundwater is used, and may change over time as land uses and water quality regulations change. Groundwater quality degradation can occur when groundwater pumping causes poor quality water (surface water or groundwater) to migrate into areas with good quality groundwater. It can also occur when surface contaminants migrate into groundwater. As a consequence, it is important to coordinate land use planning and resource management activities in order not to create opportunities for water quality deterioration. Adverse impacts related to groundwater quality include:

- Degradation of groundwater quality so that yields are reduced for crops irrigated with groundwater.
- Degradation of groundwater quality so that it does not comply with drinking water quality standards.
- Degradation of groundwater quality so that it is no longer suitable for beneficial uses.

There are some areas in Sutter County that currently have problems with groundwater quality (particularly arsenic and salinity) that appear to be naturally-occurring. The BMO of maintaining or improving groundwater quality reflects the County's desire to improve the quality of naturally-occurring groundwater where possible, so that it is more useful as a water supply.

6.2.3. Inelastic Land Subsidence BMO

The BMO for inelastic land subsidence is to:

- *Avoid inelastic land subsidence that is linked to declines in groundwater levels.*

Inelastic land subsidence is the permanent compaction of the subsurface. In Sutter County, the activities that have the most potential to cause inelastic land subsidence are withdrawals of groundwater or natural gas from the subsurface. Adverse impacts related to inelastic land subsidence include:

- Reduction in the volume of the subsurface that results in a permanent loss in aquifer storage.
- Damage to foundations, roads, bridges, and/or other infrastructure.
- Change in surface topography that reverses the gradients in canals and ditches, and/or changes floodplains.

6.2.4. Surface Water

There are three BMOs for surface water:

- *To improve the understanding of the relationship between surface water and groundwater.*

- *To avoid changes in surface water flow and surface water quality that adversely affect groundwater levels or are caused by groundwater pumping.*

- *Avoid changes in surface water flow and water quality that adversely affect groundwater quality.*

Pumping from very shallow aquifer zones or poorly sealed wells has the potential to affect surface water or wetlands. Adverse impacts related to surface water or wetlands include:

- Depletion of surface flows and/or degradation of water quality.

- Destroying riparian and/or native vegetation and habitat.

6.2.5. Coordination

This BMO for coordination is to:

- *Coordinate County groundwater management efforts with other groundwater management efforts within and surrounding Sutter County.*

This BMO establishes the importance of local coordination of groundwater management and sharing of hydrogeologic data. To make effective and relevant decisions, the County must rely on current data regarding the quality and quantity of the underlying groundwater.

7. PLAN IMPLEMENTATION

Sutter County intends to implement this GMP through a Groundwater Monitoring Program and an Action Plan. In order to recognize and mitigate adverse impacts to the underlying groundwater system, a system is required to collect and disseminate information to the appropriate groundwater users and agencies.

7.1. Groundwater Monitoring Program

The role of monitoring is essential to implementing the BMOs. Monitoring is the process of collecting data that is used to better understand the groundwater basin underlying the County, evaluate groundwater conditions, facilitate groundwater management, and other related activities. In order for the County to promote sustainable groundwater management, as well as for groundwater users to make effective and relevant decisions, the data needs to be made publicly available.

7.1.1. Groundwater Level Monitoring

There is an extensive network of DWR monitored wells, both dedicated monitoring wells and wells with other uses, within Sutter County. Additionally, several water purveyors within the County monitor groundwater levels within their service areas by means of dedicated monitoring wells and production wells. There is an extensive inventory of wells with groundwater measurements within Sutter County. Historically, DWR and its partners have monitored 172 wells in Sutter County, including 15 dedicated monitoring wells. The earliest recorded DWR water level measurement in Sutter County took place in 1929. Wells accessible to DWR are typically agricultural or domestic wells in which the land owners have previous agreements with DWR to allow access for measurements. Overall, the County has adequate spatial distribution of its current network to obtain groundwater level measurements. For this GMP, DWR utilized 122 of the 172 wells to produce groundwater contour maps of equal elevation.

Water level measurements are generally made two times each year, in spring and fall. Measurements have been made at some monitoring wells on an almost-monthly basis. Twice-annual (spring/fall) water level measurements are generally sufficient for the purpose of determining changes in overall groundwater conditions over time. However, these measurements should reflect the annual high (spring) and low (fall) water levels. More frequent (i.e. at most monthly) measurements are necessary to confirm that the months chosen for spring and fall measurements reflect the months with the highest and lowest groundwater elevations, on average. Water level data is currently available from DWR’s Water Data Library, at: http://well.water.ca.gov.

7.1.1.1. Vertical Groundwater Gradients – Nested and/or Clustered Monitoring Wells

The vertical gradients between aquifer zones are important because they give an indication of the direction (up or down) that groundwater will migrate if a pathway, such as a well that connects multiple aquifer zones, is present. To evaluate the vertical gradient between aquifer zones, data for the different aquifer zones at a single location is needed. The preferred way to obtain this data is with nested and/or clustered monitoring wells. Nested monitoring wells have multiple wells within a single borehole, with each well isolated from the others by annular seals. Clustered monitoring wells have a single well in each borehole, with the boreholes in close proximity to one another. Figure 19 shows the locations of the 15 nested and/or clustered monitoring wells in Sutter County. Eleven of these wells are in the DWR monitoring network with measurements taken twice a year, in spring and fall. The remaining four nested monitoring wells are pending inclusion into the network because they were constructed by private parties. All of these wells are dedicated monitoring wells.

7.1.1.2. Groundwater Flow Direction – Contour Maps

The direction of groundwater flow is evaluated with groundwater level contour maps. Groundwater contours are created which connect surfaces of equal elevation (or levels). Figure 17 illustrates the contours of equal groundwater elevation for measurements taken in the spring of 2010.

The current water level monitoring network spacing is suitable for contouring groundwater elevations. Additionally, it would be beneficial to include data from nearby monitored wells in Butte, Yolo, Sacramento, and Yuba Counties to better characterize the groundwater flow direction at the County lines.

7.1.2. Water Quality

Water quality samples from wells within the County have, in the past, been obtained either by local water purveyors, the DWR, or the USGS. Currently, the County only samples groundwater in Robbins, its only public water supply system. Groundwater samples have been collected for analysis in a total of 133 wells. The DWR has sampled 34 of these wells in Sutter County, fifteen of which are nested multiple-completion monitoring wells, as shown in Figure 19. The USGS has sampled 94 of these wells, and the remaining wells were sampled by water purveyors which have shared their data. The DWR expects to conduct water quality sampling of these wells every three years, or as funds are available. The water quality data is disseminated on the DWR WDL.

The results for the USGS water quality sampling are available on the National Water Information System (NWIS) website[7]. The USGS sampled these wells as part of a larger investigation to document the condition of the groundwater throughout the valley. It is not expected that the USGS will routinely sample these wells.

The current water quality monitoring network consists of DWR owned multiple-completion monitoring wells with a sparse distribution covering the entire County. Routine sampling of these wells will allow for water quality trends to be identified. As stated within this GMP, the County does not own any dedicated monitoring wells. In conjunction with DWRs efforts to collect and distribute water quality information of the groundwater resource, the County encourages private water purveyors to disseminate their water quality data to aid in documenting depth specific and County-wide water quality trends.

7.1.3. Land Subsidence

Land subsidence has not been historically reported or documented within Sutter County. Nevertheless, DWR installed an extensometer and began monitoring for ground surface displacement in 1994. Measurements are recorded on a daily basis, offering real-time and site specific measurements. On a more regional scale, DWR and its cooperating agencies, have implemented the Sacramento Valley GPS Height Modernization Project which will provide significant enhancements to a Sacramento Valley subsidence monitoring program. It is reported by DWR that the GPS monuments will be re-surveyed approximately every three years. The monitoring of land surface elevations will allow for periodic measurements of permanent land subsidence induced by groundwater pumping and/or natural processes. The surveys will be conducted in accordance with the National Geodetic Survey Standards for two centimeter accuracy.

When used in conjunction with surface subsidence survey data (GPS), the extensometer data could aide in identifying whether subsidence is occurring over the total depth of the monitoring well.

7.1.4. Future Groundwater Monitoring

The County's existing monitoring network is described above. Groundwater monitoring within the County is currently conducted by DWR and local water purveyors. The County will continue to cooperate with DWR and encourage the local water purveyors to continue to monitor groundwater levels. Under the voluntary guidelines of SBx7-6, selected local water purveyors will continue to monitor groundwater elevations for their

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[7] http://waterdata.usgs.gov/nwis

respective service area(s), along with the DWR, under protocols established by DWR. The possibility exists that in the future, DWR may cease their monitoring if they lose funding for groundwater level measurements, and the responsibility of groundwater level monitoring will be entirely upon the local water purveyors.

All new wells should be sampled for basic water chemistry (i.e. specific conductance, arsenic, manganese, and nitrate). Although not required, the County may, in the future, consider requesting copies of laboratory reports to be submitted through the permit process. Water quality results from wells sampled by DWR are routinely placed on the WDL, and are often sampled every three years, or as funding allows.

The overall subsidence monitoring program should continue to be monitored by the extensometer and GPS monuments throughout the County. The Sacramento Valley GPS Network incorporates existing GPS networks and monuments to create a regional network that covers part or all of Colusa, Sutter, Glenn, Butte, Yolo, Yuba, Tehama, and Placer Counties.

For the area encompassing the Sutter Buttes, which is outside of a DWR delineated groundwater basin, groundwater is likely contained in the fractures of the volcanic rock as well as in the marine sands that compromise the Sutter Buttes. The area encompassing the Sutter Buttes is primarily privately owned and groundwater use is unknown but is likely limited to domestic wells or stock watering wells. It is suggested that private well owners monitor groundwater levels at least twice a year (fall and spring) in order to realize changing conditions. It is also good practice to test the quality of the groundwater for health based constituents.

7.1.5. Local and Regional Groundwater Management Coordination

Coordinating local and regional groundwater management is important to meeting Sutter County's Groundwater Management Goals because groundwater, like other resources, does not respect administrative/jurisdictional boundaries, and actions outside the County can affect groundwater in the County. Further, in order to achieve the Groundwater Management Goals, the County needs to be an "effective participant" in local and regional management efforts and work cooperatively with water managers to conduct effective groundwater management. To be an "effective participant", the County needs to be informed of its groundwater conditions and activities underway or planned, which may affect the resources positively or negatively. With time and appropriate documentation of water management activities and monitoring, an understanding of the resources can be obtained so that groundwater conditions can be the result of deliberate water management choices.

Coordinating groundwater management across local and regional jurisdictions will contribute to ensuring a reliable water supply by working towards management of entire groundwater basins, not just the portions underlying the County. Involvement in regional activities will help ensure that activities outside of Sutter County that affect the reliability of the groundwater supply in the County can be addressed through regional management actions. This involvement will also help protect water rights because the County's involvement with regional groundwater management will allow it to be part of a larger group that can exert more influence in preserving water rights north of the Delta. Finally, regional coordination will help the County maintain local control by ensuring that the County's interests are represented in regional groundwater management activities.

Sutter County recognizes the importance of regional coordination, collaboration, and communication and is signatory to the "Four-County Group," which has evolved into the "Northern Sacramento Valley – Integrated Regional Water Management Group", consisting of Butte, Glenn, Colusa, Tehama, Shasta, and Sutter Counties.

In addition to the water management coordination addressed above, which is more at a technical and operational level, it is important that coordination occur at the policy level as well. This is especially important for effective and consistent operations within water purveyors whose geographic jurisdiction extends beyond Sutter County. The processes to addressing water transfers, in particular, are different in each of the three counties. It would be important, as the GMP is implemented and the institutional structure and management processes become solidified, that a dialogue be established with the neighboring counties to address the need for developing consistency in processes that affect the management and operation of the respective water purveyors.

7.1.6. State of the Basin Report - Groundwater Condition and Groundwater Management Plan Evaluation

In the future, Sutter County and local water purveyors may benefit from preparing an annual report of the conditions of its groundwater basin. However, the present County staffing and funding levels are unable to accommodate this work effort. Groundwater elevation data for the County will be available through the CASGEM program and continued DWR monitoring. Additionally, new and/or current water quality data is periodically submitted and is available through the DWR Water Data Library. The County encourages cooperation among all groundwater users to share data (groundwater level and/or quality) which is not reported or what is readily available through the Water Data Library. Water quality data is also accessible through the Department of Public Health for permitted public water systems. Through this report, the County will encourage its groundwater users to be responsible stewards of the County's resources.

This GMP prepared by the County is not intended to be a static document. As conditions change, such as population, land uses, or climate, it may be warranted to revisit the County's goals and BMOs to ensure that the overall goals of sustaining its groundwater resources to meet current and future demands for the County are being satisfied. The County encourages cooperation among its groundwater users to keep these goals in mind. It is not Sutter County's intent of this GMP to be an enforcer with regards to groundwater use; however, as climatic and groundwater usage change in the future, it may be necessary to "check in" and adjust or expand this GMP.

7.2. Action Plan

7.2.1. Actions for Groundwater Levels BMO

To avoid ongoing declines in groundwater, to avoid abnormally high groundwater levels, the County has taken and will take the following actions:

Action	*Frequency*	*Status*
Participation in the "Northern Sacramento Valley – Integrated Regional Water Management Group"	As needed	2008 - Present
Maintain relationships with state and federal agencies	Annual	1850 - Present
Promote conjunctive use through public outreach	Annual	2008 - Present
Coordination with local and regional jurisdictions on groundwater.	Annual	2008 - Present
Ensure compliance with adopted policies in 2008 General Plan (Goal ER 6)	Annual	2008 - Present
Review groundwater contour maps prepared by DWR	Annual	2008 - Present
Disseminate groundwater level data on County's website	As needed	2010 - Present

7.2.2. Actions for Groundwater Quality BMO

To improve the understanding of groundwater quality, the County has taken and will take the following actions:

Action	*Frequency*	*Status*
Cooperate with DWR in its monitoring efforts	Annual	2010 - Present
Maintain relationships with neighboring counties	Annual	1850 - Present
Ensure compliance with adopted policies in 2008 General Plan (Goal ER 6)	Annual	2008 - Present
Ongoing coordination with local and regional jurisdictions on groundwater	Annual	unknown - Present

7.2.3. Actions for Inelastic Land Subsidence BMO

To avoid inelastic land subsidence that is linked to declines in groundwater levels, the County has taken and will take the following actions:

Action	*Frequency*	*Status*
Cooperate with DWRs monitoring efforts	Annual	2010 - Present
Participate in the "Northern Sacramento Valley – Integrated Regional Water Management Group"	Annual	2008 - Present
Establish and update a groundwater management plan website	Annual	2008 - Present
Review data from the extensometer installed in Sutter County	6 months	2010 - Present
Maintain relationships with state and federal agencies	Annual	1850 - Present

7.2.4. Actions for Surface Water BMO

To improve the understanding of the relationship between surface water and groundwater; to avoid changes in surface water flow and surface water quality that directly affect groundwater levels or are caused by groundwater pumping; and to avoid changes in surface flow and surface water quality that directly affect groundwater quality, the County has taken and will take the following actions:

Action	*Frequency*	*Status*
Engage in the "Northern Sacramento Valley – Integrated Regional Water Management Group"	Annual	2008 - Present
Establish a groundwater management plan website	Annual	2008 - Present
Maintain relationships with state and federal agencies	Annual	1850 - Present
Ensure compliance with adopted policies in 2008 General Plan (Goal ER 5)	Annual	2008 - Present

7.2.5. Actions for Coordination BMO

To coordinate County groundwater management efforts with other groundwater management efforts within and surrounding Sutter County, the County has taken and will take the following actions:

Action	*Frequency*	*Status*
Engage in the "Northern Sacramento Valley – Integrated Regional Water Management Group"	Annual	2008 - Present
Maintain relationships with state and federal agencies	Annual	1850 - Present
Establish and update a groundwater management plan website	As needed	2008 - Present

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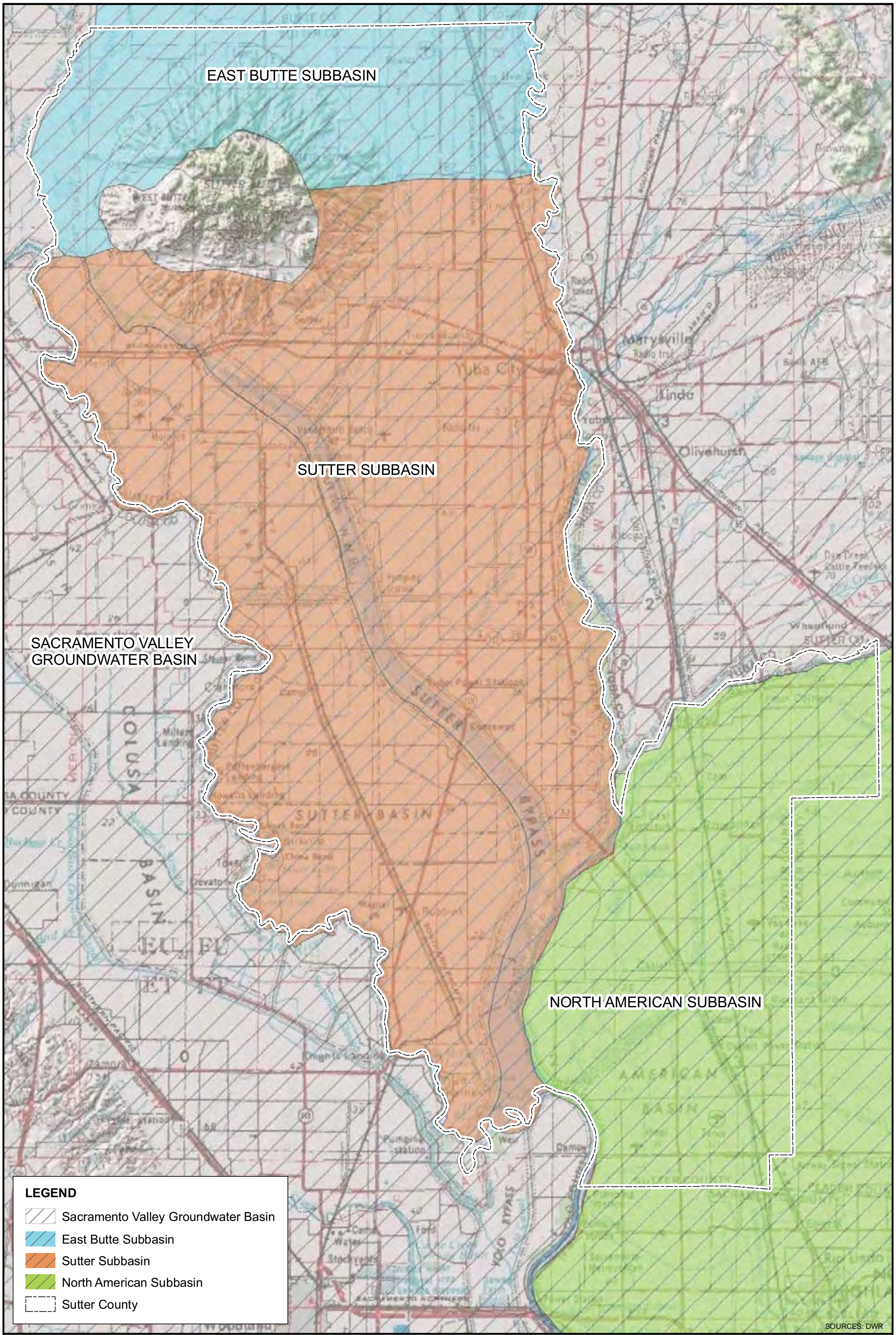

FIGURE 1

GROUNDWATER BASIN AND SUBBASINS

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH
0 1.5 3
MILES

SUTTER COUNTY CALIFORNIA

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J:\Jobs\8337_SutterCounty\GIS\Tasks\20120201 Final Draft Figure Comments\Figure 1 Groundwater Subbasins.mxd 2/7/2012 12:50:01 PM bdemucha

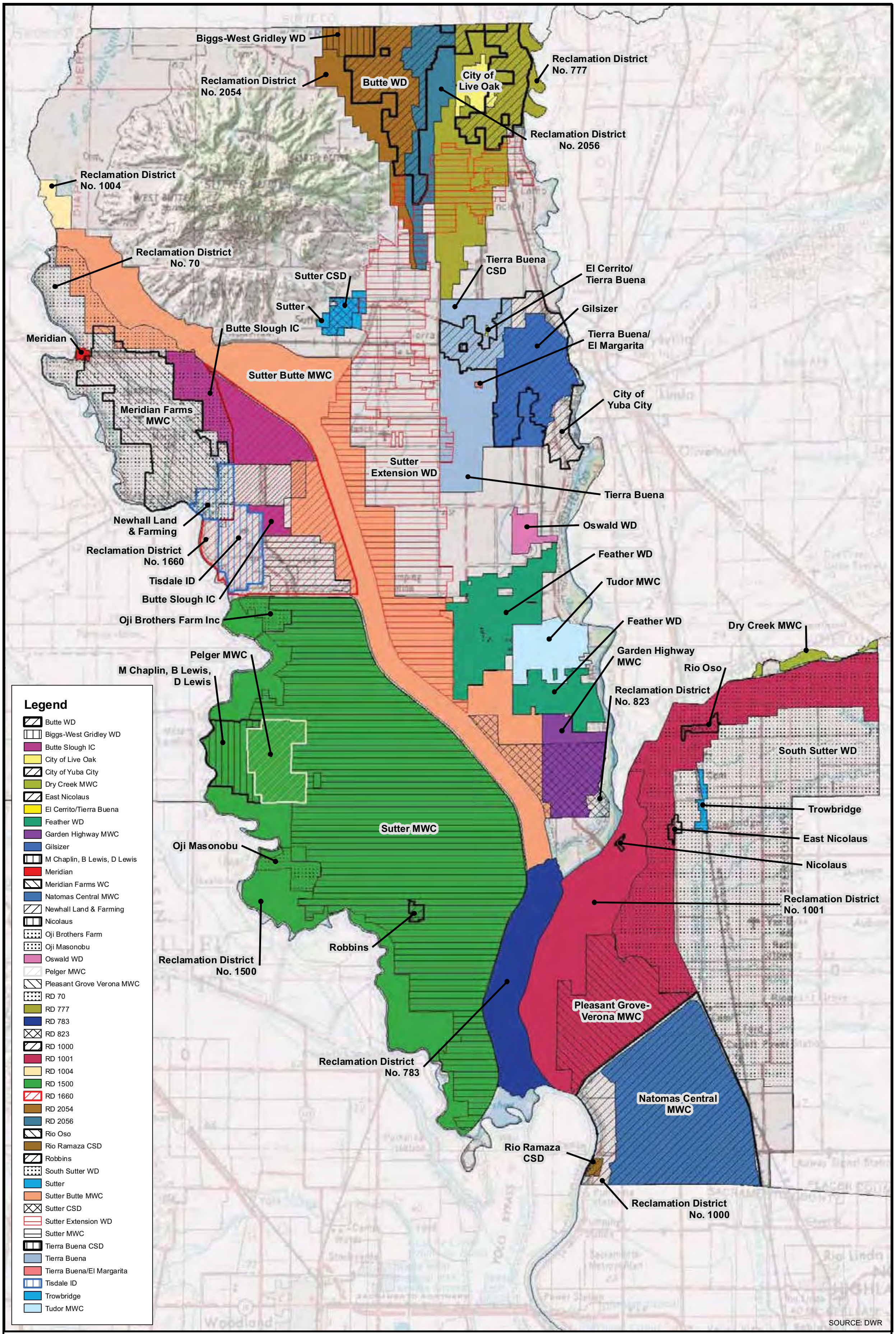

FIGURE 2
WATER DISTRICTS, PURVEYORS, AND
WATER COMPANIES
SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

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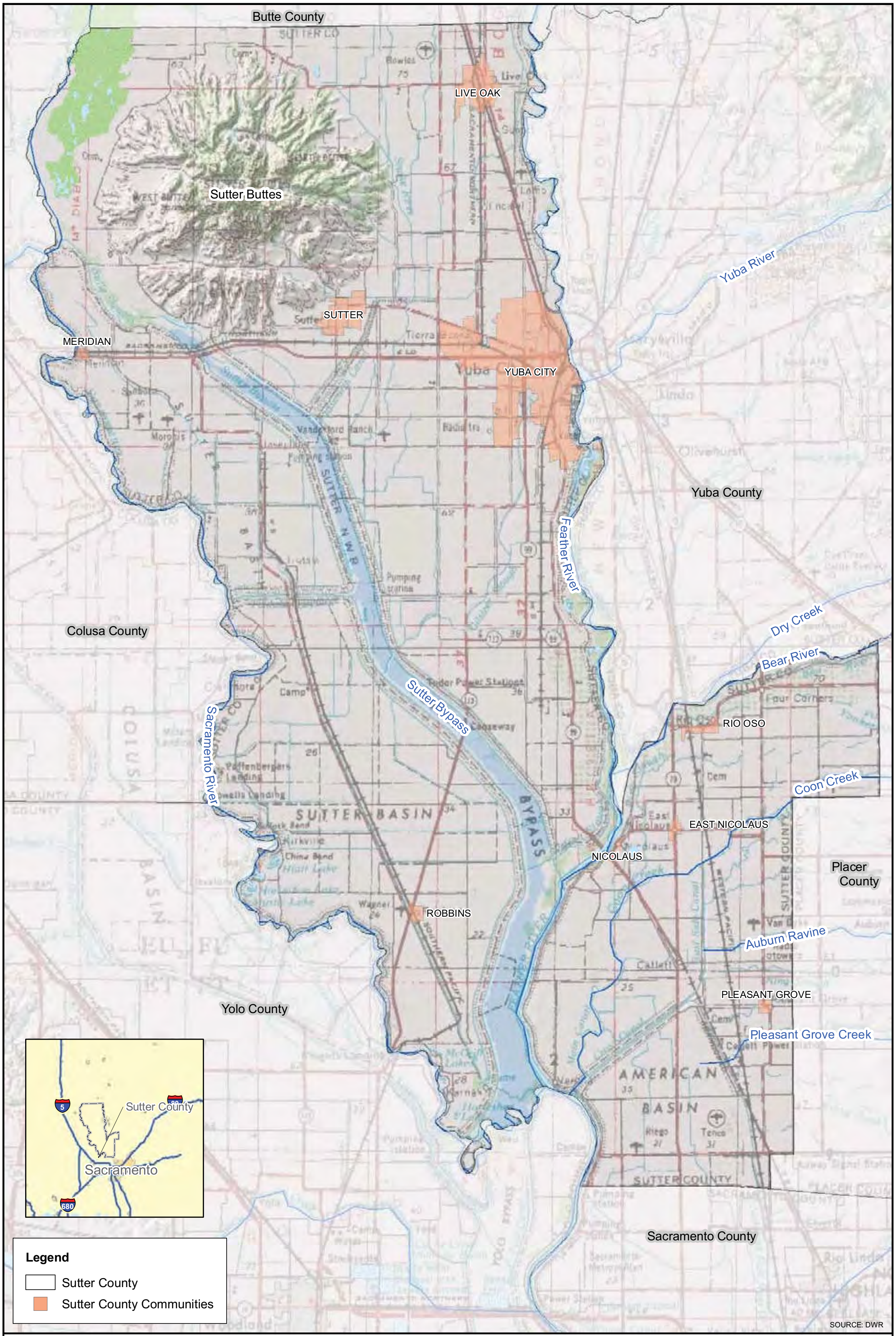
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 2 Water_District_Poster.mxd 2/7/2012 12:39:44 PM bdemucha



SOURCE: DWR

FIGURE 5
PHYSICAL FEATURES
SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 1.5 3
MILES

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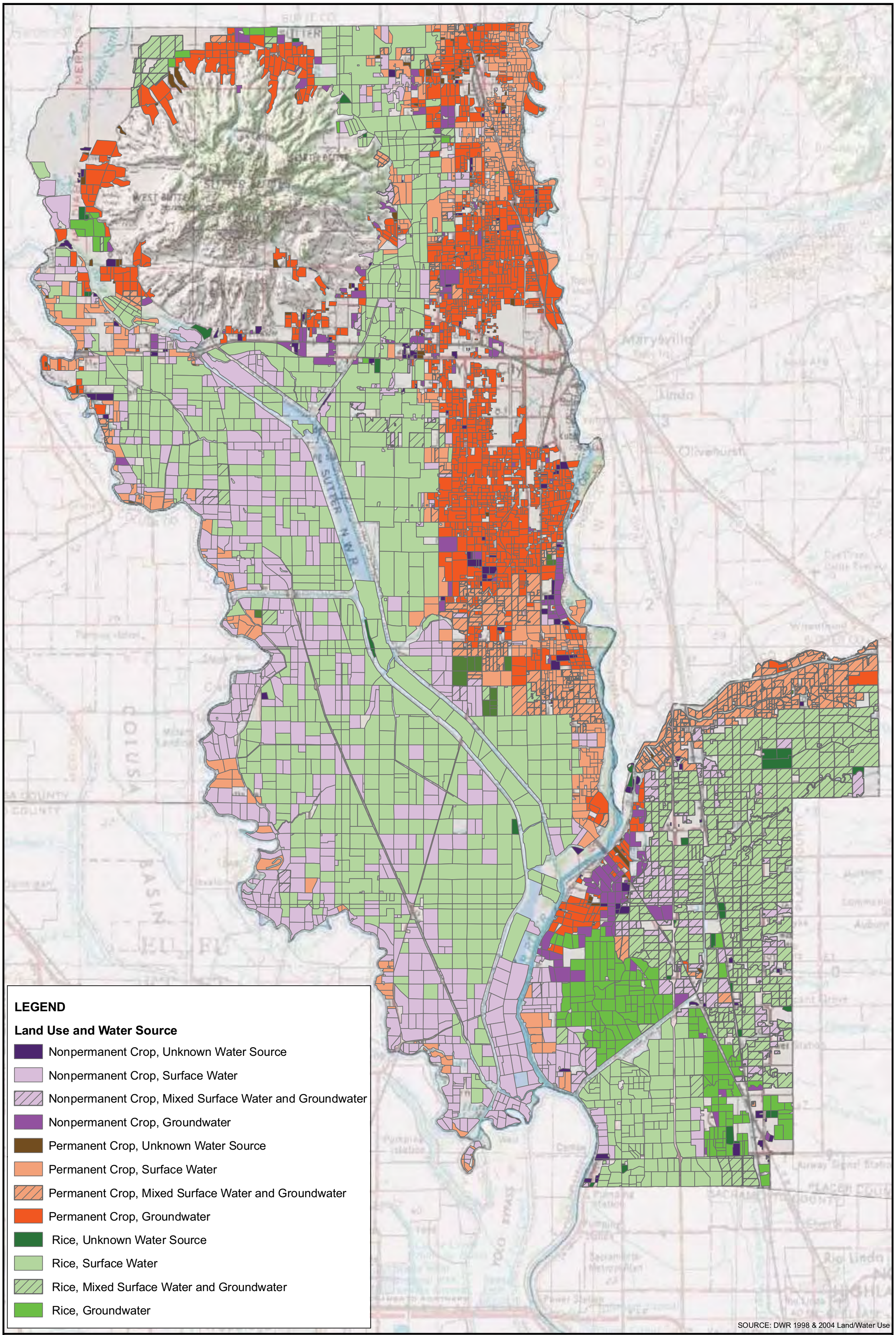
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 5 Sutter County Physical Features.mxd 2/7/2012 12:47:54 PM bdemucha



LEGEND

Land Use and Water Source

- 🟪 Nonpermanent Crop, Unknown Water Source
- 🟪 Nonpermanent Crop, Surface Water
- ▨ Nonpermanent Crop, Mixed Surface Water and Groundwater
- 🟪 Nonpermanent Crop, Groundwater
- 🟫 Permanent Crop, Unknown Water Source
- 🟧 Permanent Crop, Surface Water
- ▨ Permanent Crop, Mixed Surface Water and Groundwater
- 🟥 Permanent Crop, Groundwater
- 🟩 Rice, Unknown Water Source
- 🟩 Rice, Surface Water
- ▨ Rice, Mixed Surface Water and Groundwater
- 🟩 Rice, Groundwater

SOURCE: DWR 1998 & 2004 Land/Water Use

FIGURE 6
WATER SOURCES FOR IRRIGATED CROPS
SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
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J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 6 Water_Source_IRR_Crops_.mxd 2/7/2012 12:52:19 PM bdemucha

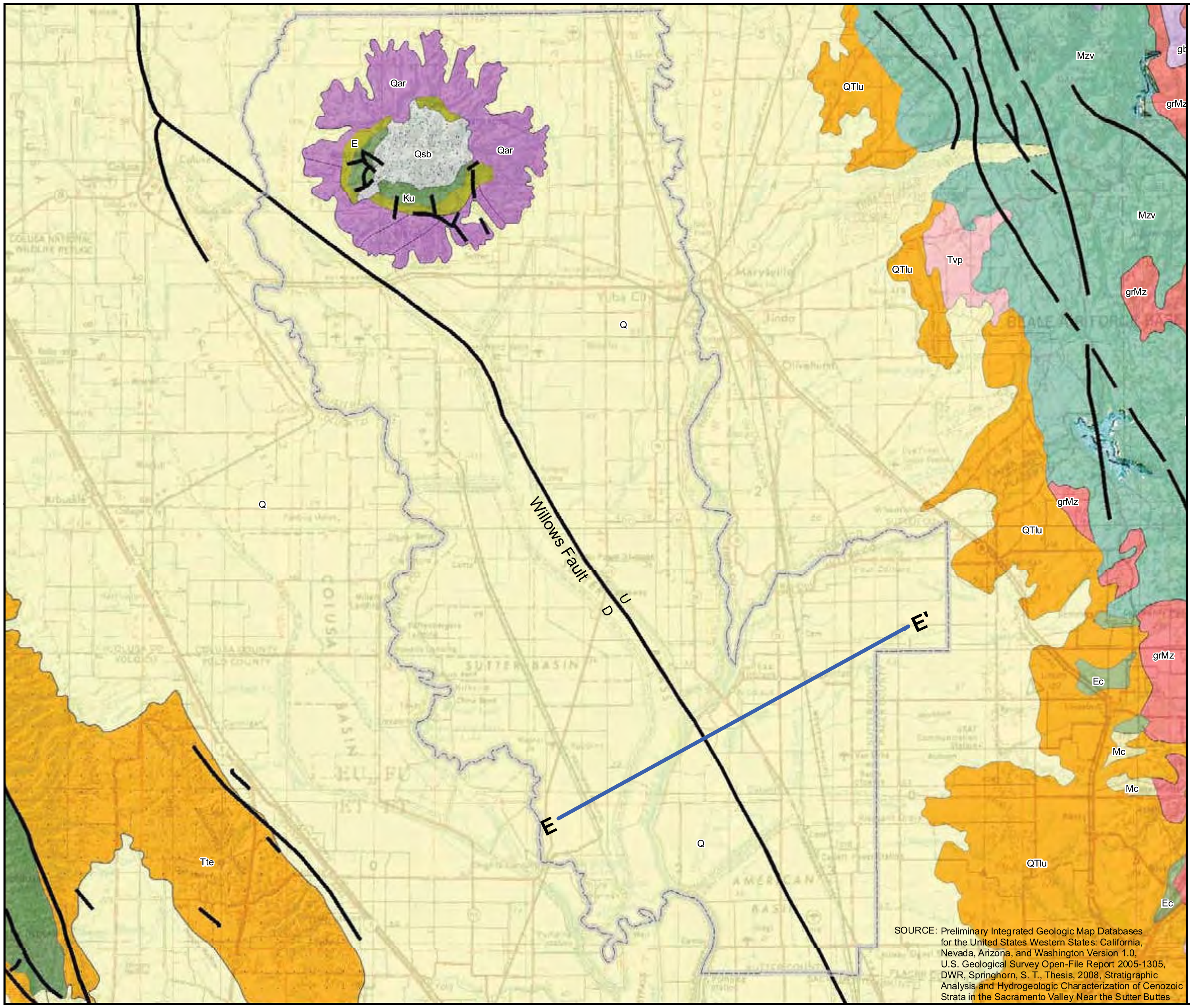

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FIGURE 7

SIMPLIFIED SURFACE GEOLOGY AND FAULTS

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH
0 2 4
MILES

LEGEND

- 🟨 Q - Recent Deposits
  - Qb - Basin Deposits
  - Qm - Modesto Formation
  - Qr - Riverbank Formation
- ▨ Qsb - Sutter Buttes Igneous Rocks
- 🟪 Qar - Sutter Buttes Andesitic Rampart
- 🟧 QTlu - Laguna Formation
- ▨ Tte - Tehama Formation
- 🟥 Tvp - Andesite, Rhyolite
- 🟨 Mc - Sandstone, Conglomerate
- 🟩 Ec - Conglomerate, Sandstone
- 🟩 E - Mudstone, Sandstone
- 🟩 Ku - Sandstone, Mudstone
- 🟩 J - Mudstone, Sandstone, & Slate
- 🟦 um - Serpentinite
- 🟩 Mzv - Volcanic, Metavolcanic
- 🟪 gb - Gabbro, Diorite
- 🟥 grMz - Granodiorite
- — Fault
- — Fault Displacement - U, upthrown side; D, downthrown side
- ☐ Counties
- — Simplified Conceptual Geologic Cross Section Line (See Figure 8)

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J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 7 Simplified Surface Geology and Faults.mxd 2/7/2012 12:54:14 PM bdemucha

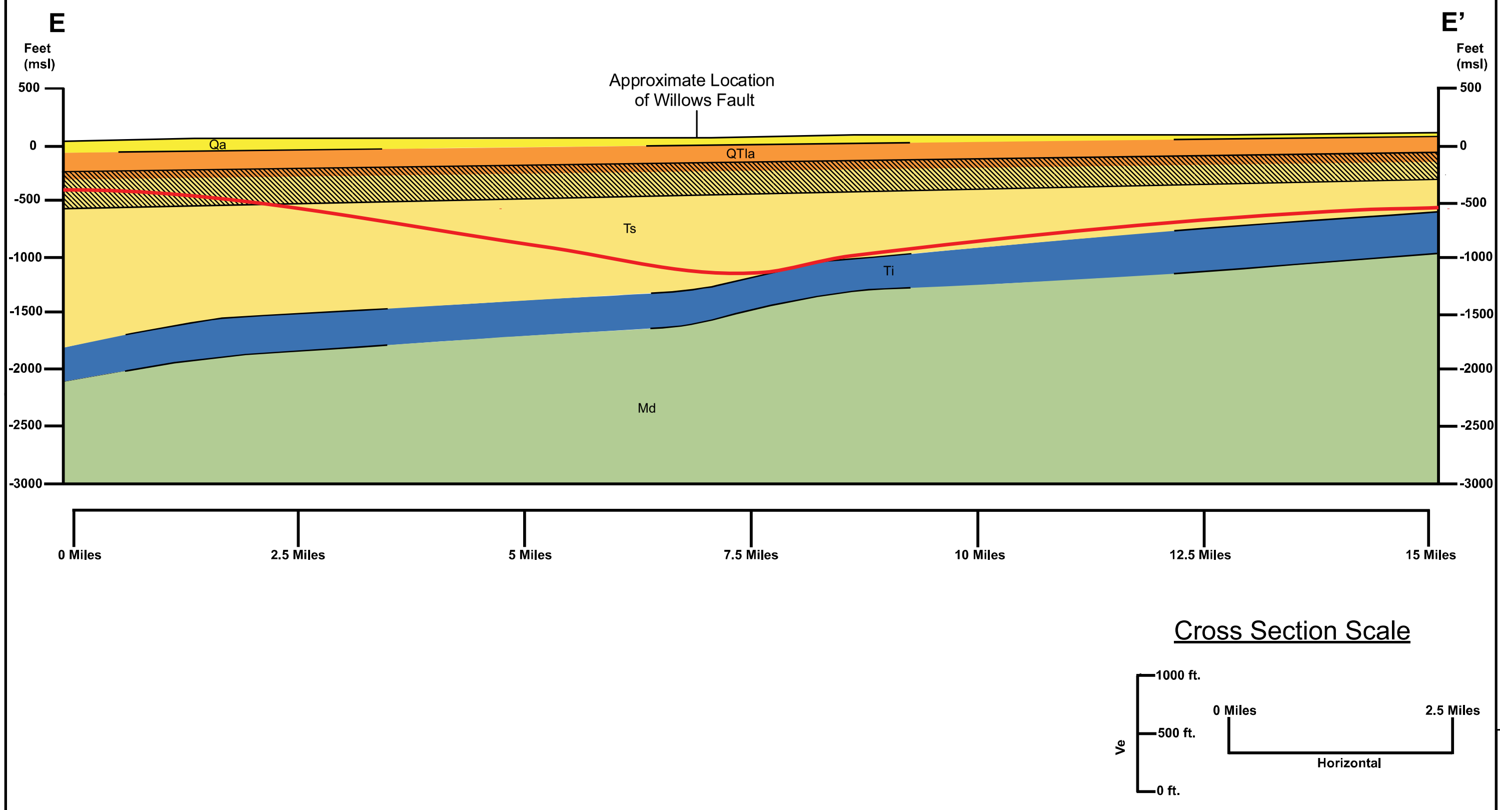

FIGURE 8
SIMPLIFIED CONCEPTUAL GEOLOGIC CROSS SECTION
SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

Explanation

Qa	Alluvial Deposits
QTla	Laguna Formation
▨	Laguna and Sutter Formation Transition (approximate depth)
Ts	Sutter Formation (map unit, Williams and Curtis, 1977; Helley and Harwood, 1985)
Tt	Tuscan Formation (map unit, Helley and Harwood, 1985)
Tm	Mehrten Formation (map unit, Helley and Harwood, 1985)
Ti	Ione Formation (map unit, Helley and Harwood, 1985)
Md	Marine Deposits
—	Inferred Geologic Contact
- - -	Approximate Base of Fresh Water. Line represent depths at which Specific Conductance levels exceed approximately 3,000 umhos/cm

SOURCES: DOGGR; DWR; Springhorn, S. T., Thesis, 2008, Stratigraphic Analysis and Hydrogeologic Characterization of Cenozoic Strata in the Sacramento Valley Near the Sutter Buttes; Berkstresser, C.F. Jr. 1973. Base of Fresh Ground-Water -- Approximately 3,000 micromhos in the Sacramento Valley and Sacramento-San Joaquin Delta, California. U.S. Geological Survey Water-Resource Inv. 40-73; Helley, E. J. and Harwood, D. S., 1985, Geologic Map of Late Cenozoic Deposits of the Sacramento Valley and Northern Sierran Foothills, California.

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J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 8 Geologic Cross Section E-E'.mxd 2/7/2012 12:57:54 PM bdemucha

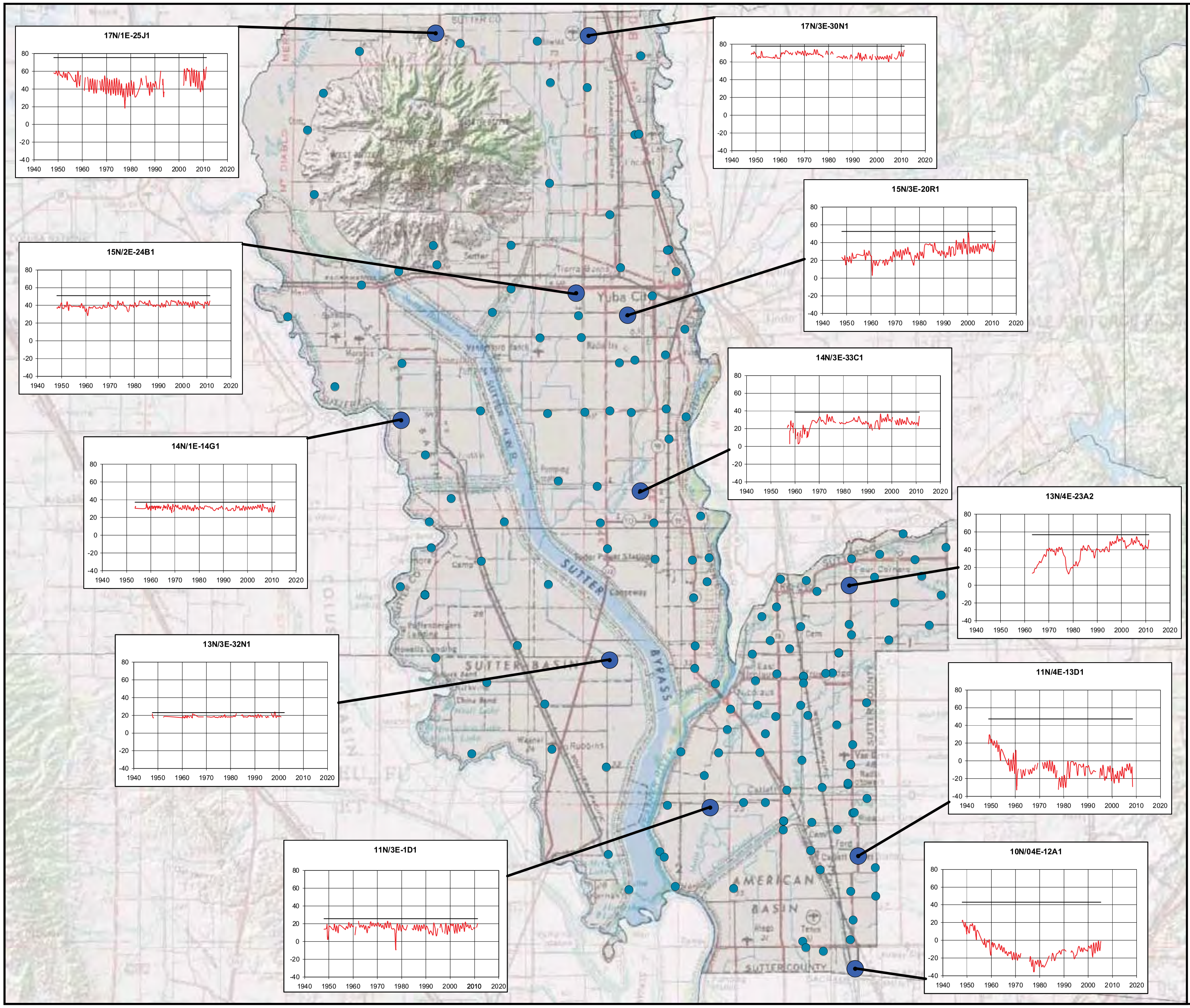
FIGURE 9

HISTORIC GROUNDWATER ELEVATIONS IN SUTTER COUNTY

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 2 4
MILES

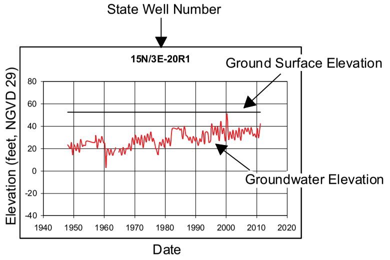


Legend

- ● Well with Hydrograph Shown
- ● Well with Water Level Measurement since 2004

Note: This figure represents wells with historic water level and current measurements either submitted to or obtained by the California Department of Water Resources and may not represent current monitoring activities. Groundwater elevations are in feet above mean sea level.

SOURCE: DWR



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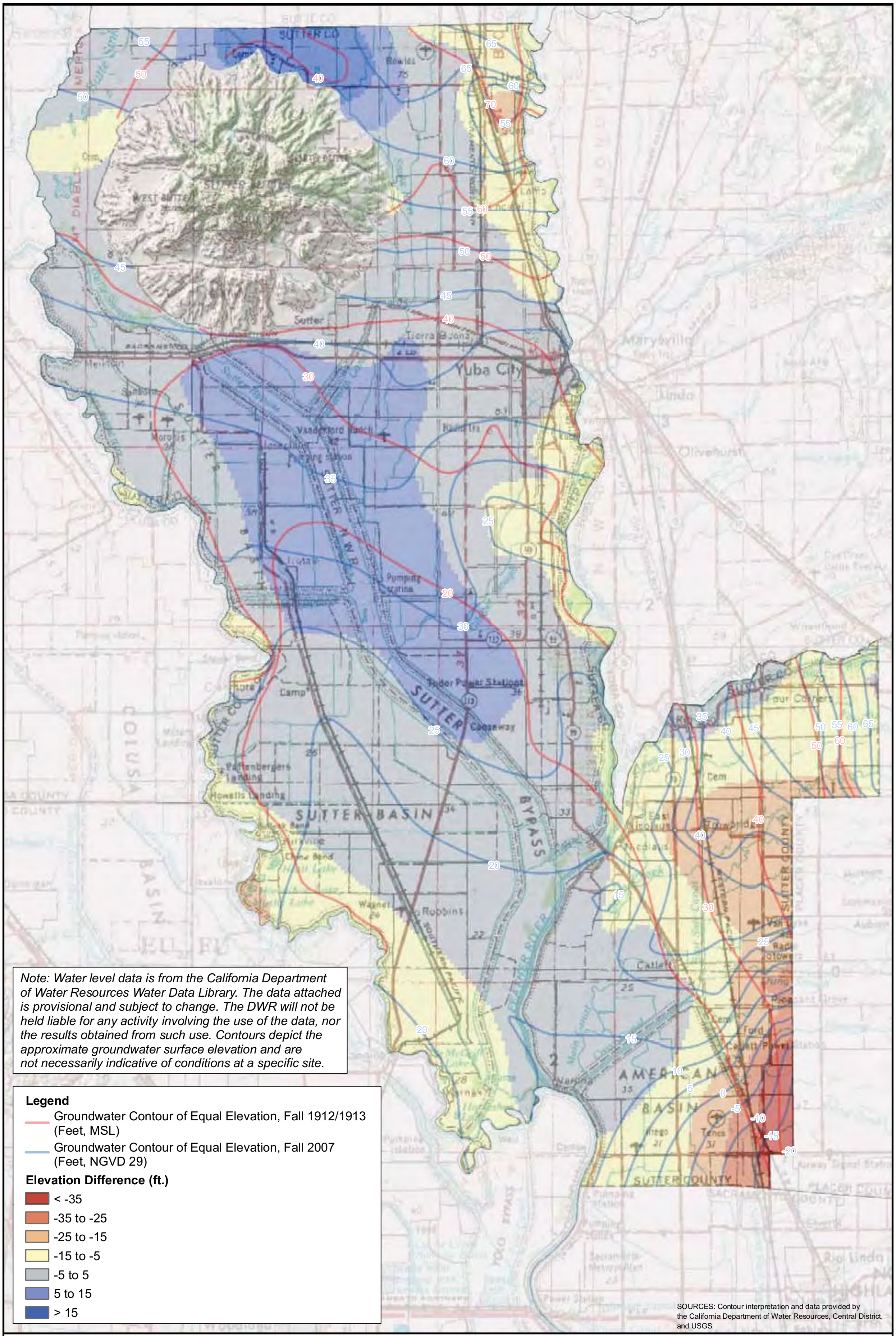
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 9 Historic Groundwater Elevations in Sutter County .mxd 2/7/2012 12:59:56 PM bdemucha



Note: Water level data is from the California Department of Water Resources Water Data Library. The data attached is provisional and subject to change. The DWR will not be held liable for any activity involving the use of the data, nor the results obtained from such use. Contours depict the approximate groundwater surface elevation and are not necessarily indicative of conditions at a specific site.

Legend

Groundwater Contour of Equal Elevation, Fall 1912/1913 (Feet, MSL)

Groundwater Contour of Equal Elevation, Fall 2007 (Feet, NGVD 29)

Elevation Difference (ft.)

- 🟥 < -35
- 🟧 -35 to -25
- 🟧 -25 to -15
- 🟨 -15 to -5
- ⬜ -5 to 5
- 🟦 5 to 15
- 🟦 > 15

SOURCES: Contour interpretation and data provided by the California Department of Water Resources, Central District, and USGS

FIGURE 10

GROUNDWATER LEVEL CHANGE MAP
FALL 2007 AND FALL 1912/1913

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 1.5 3
MILES

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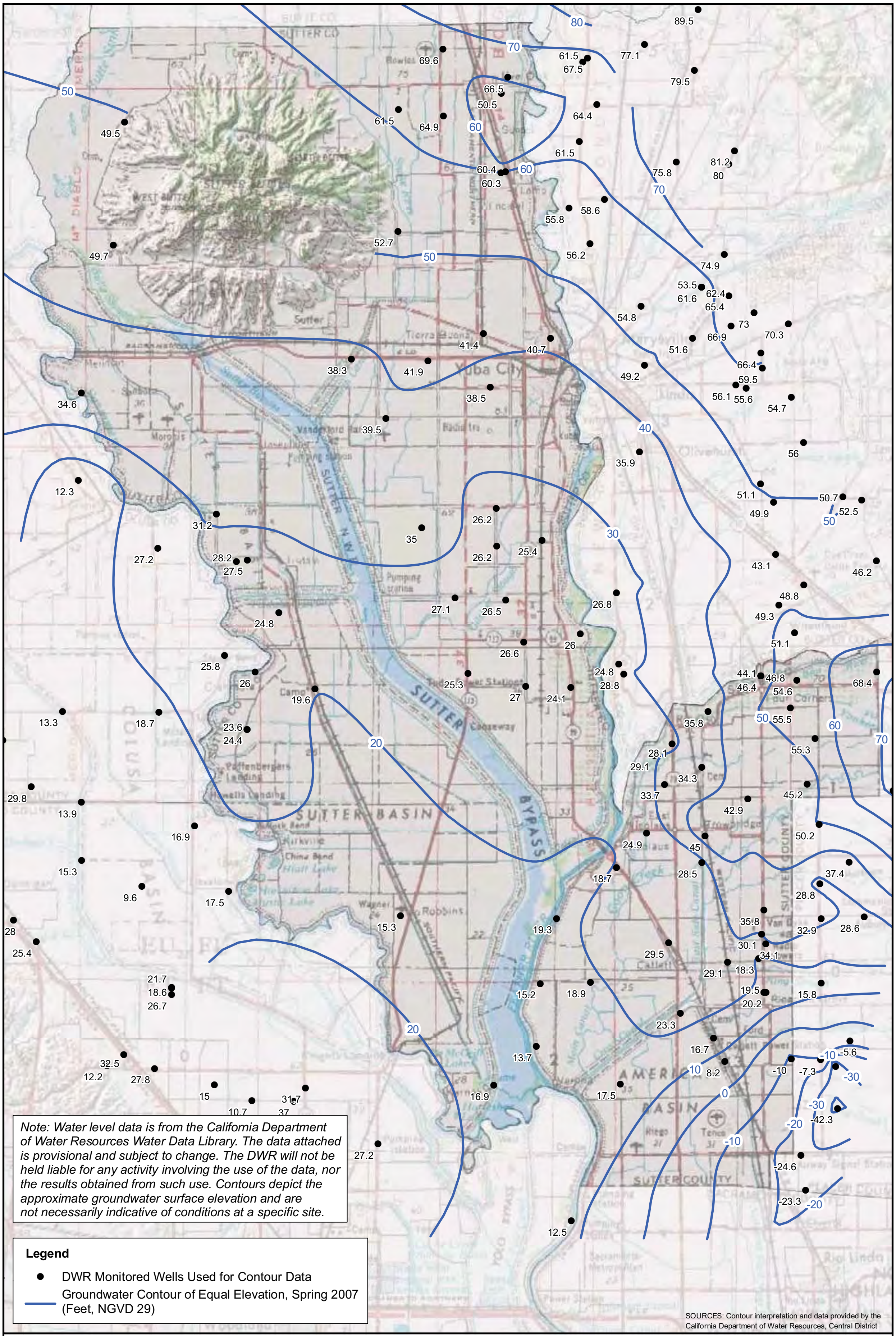

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Legend

- ● DWR Monitored Wells Used for Contour Data
- Groundwater Contour of Equal Elevation, Spring 2007 (Feet, NGVD 29)

SOURCES: Contour interpretation and data provided by the California Department of Water Resources, Central District

FIGURE 11

GROUNDWATER ELEVATION CONTOUR MAP SPRING, 2007

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 1.5 3
MILES

SUTTER COUNTY CALIFORNIA

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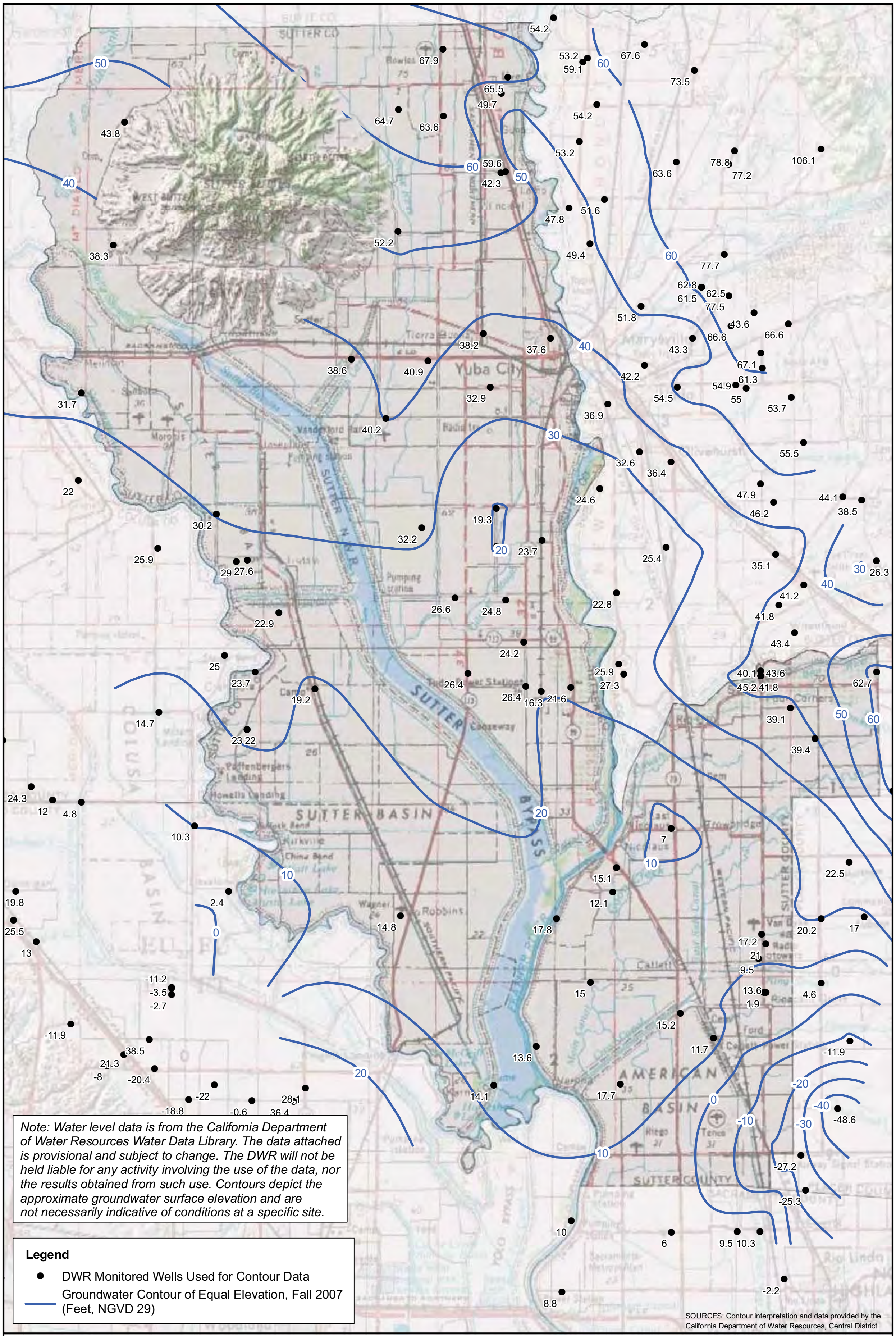

Note: Water level data is from the California Department of Water Resources Water Data Library. The data attached is provisional and subject to change. The DWR will not be held liable for any activity involving the use of the data, nor the results obtained from such use. Contours depict the approximate groundwater surface elevation and are not necessarily indicative of conditions at a specific site.

Legend

● DWR Monitored Wells Used for Contour Data

— Groundwater Contour of Equal Elevation, Fall 2007 (Feet, NGVD 29)

SOURCES: Contour interpretation and data provided by the California Department of Water Resources, Central District

FIGURE 12

GROUNDWATER ELEVATION CONTOUR MAP FALL, 2007

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 1.5 3
Miles

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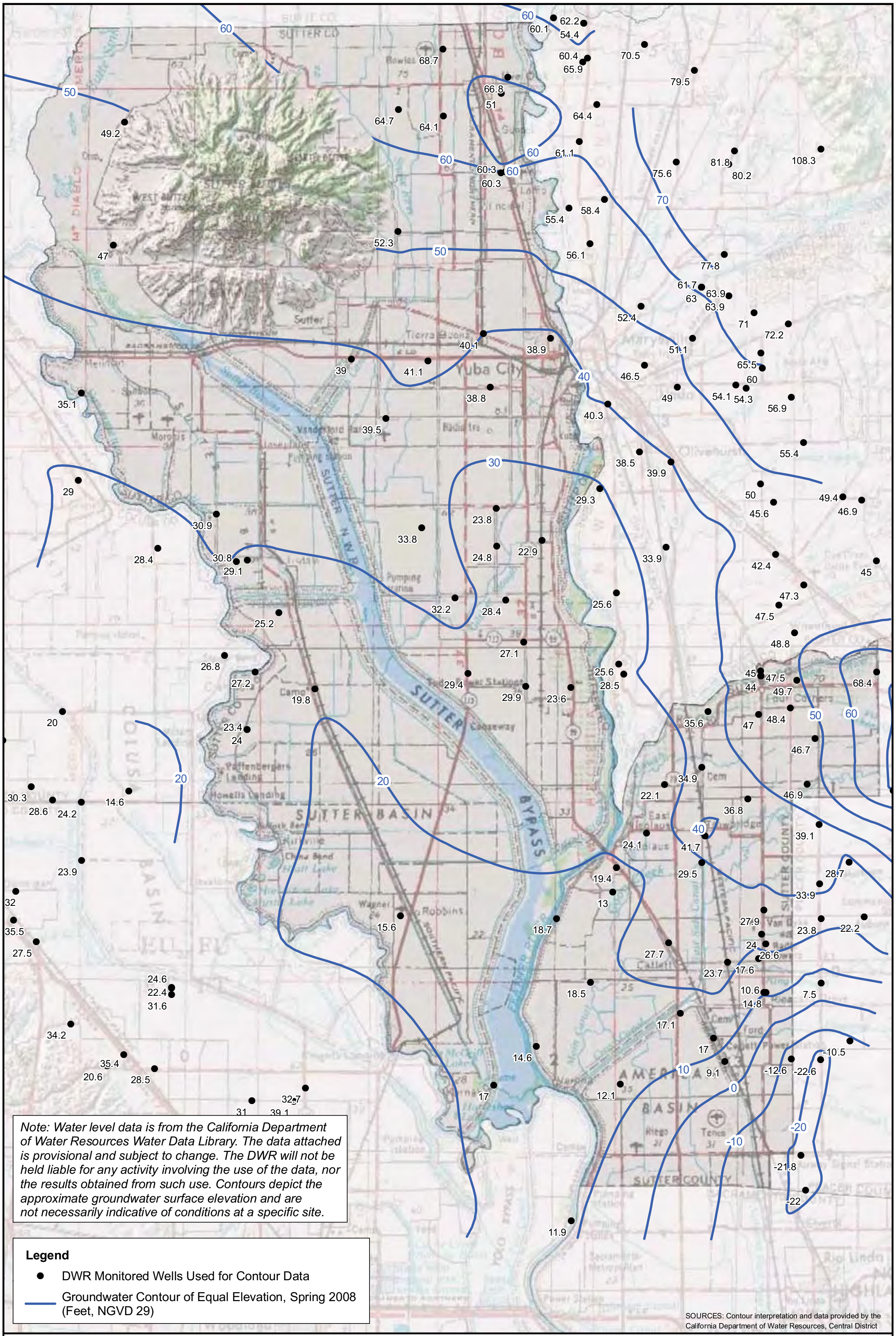
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 12 Groundwater Elevation Contour Map Fall 2007.mxd 2/7/2012 6:07:59 PM bdemucha



Note: Water level data is from the California Department of Water Resources Water Data Library. The data attached is provisional and subject to change. The DWR will not be held liable for any activity involving the use of the data, nor the results obtained from such use. Contours depict the approximate groundwater surface elevation and are not necessarily indicative of conditions at a specific site.

Legend

- ● DWR Monitored Wells Used for Contour Data
- Groundwater Contour of Equal Elevation, Spring 2008 (Feet, NGVD 29)

SOURCES: Contour interpretation and data provided by the California Department of Water Resources, Central District

FIGURE 13

GROUNDWATER ELEVATION CONTOUR MAP SPRING, 2008

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 1.5 3
MILES

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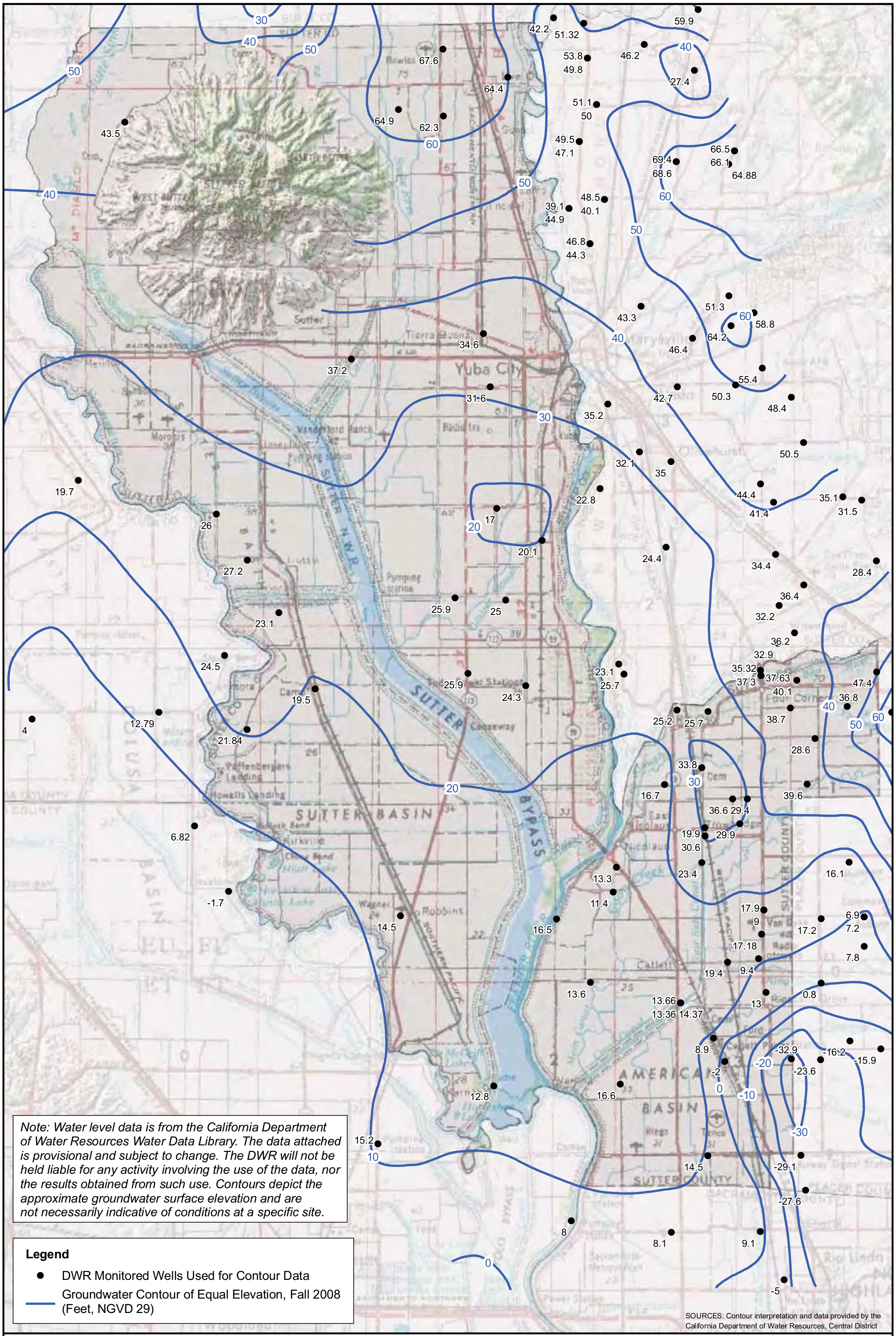
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 13 Groundwater Elevation Contour Map Spring 2008.mxd 2/7/2012 6:20:59 PM bdemucha



Note: Water level data is from the California Department of Water Resources Water Data Library. The data attached is provisional and subject to change. The DWR will not be held liable for any activity involving the use of the data, nor the results obtained from such use. Contours depict the approximate groundwater surface elevation and are not necessarily indicative of conditions at a specific site.

Legend

- ● DWR Monitored Wells Used for Contour Data
- Groundwater Contour of Equal Elevation, Fall 2008 (Feet, NGVD 29)

SOURCES: Contour interpretation and data provided by the California Department of Water Resources, Central District

FIGURE 14

GROUNDWATER ELEVATION CONTOUR MAP FALL, 2008

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 1.5 3
MILES

SUTTER COUNTY CALIFORNIA

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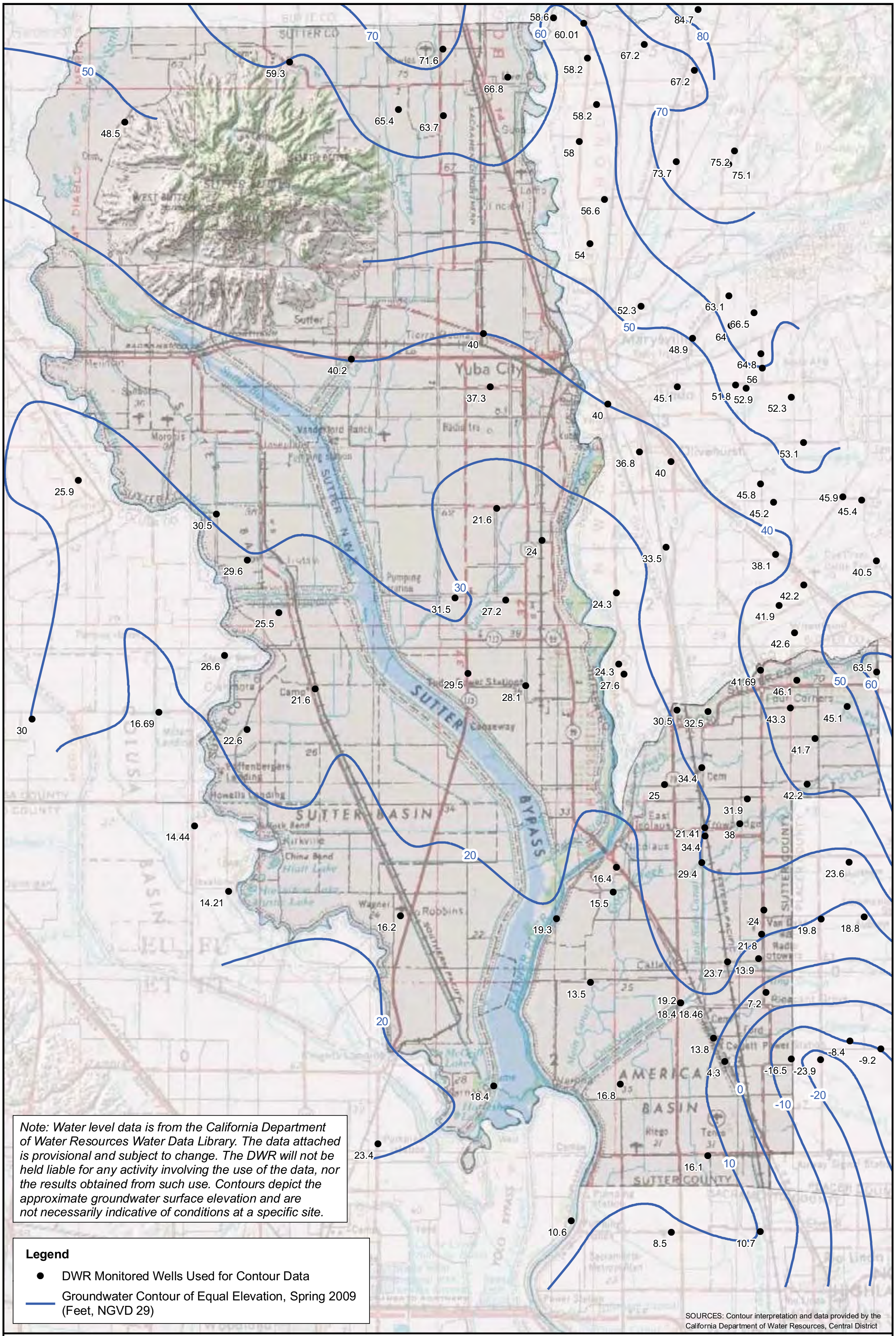
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 14 Groundwater Elevation Contour Map Fall 2008.mxd 2/8/2012 9:20:28 AM bdemucha



Note: Water level data is from the California Department of Water Resources Water Data Library. The data attached is provisional and subject to change. The DWR will not be held liable for any activity involving the use of the data, nor the results obtained from such use. Contours depict the approximate groundwater surface elevation and are not necessarily indicative of conditions at a specific site.

Legend

- ● DWR Monitored Wells Used for Contour Data
- Groundwater Contour of Equal Elevation, Spring 2009 (Feet, NGVD 29)

SOURCES: Contour interpretation and data provided by the California Department of Water Resources, Central District

FIGURE 15

GROUNDWATER ELEVATION CONTOUR MAP SPRING, 2009

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
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NORTH

0 1.5 3
MILES

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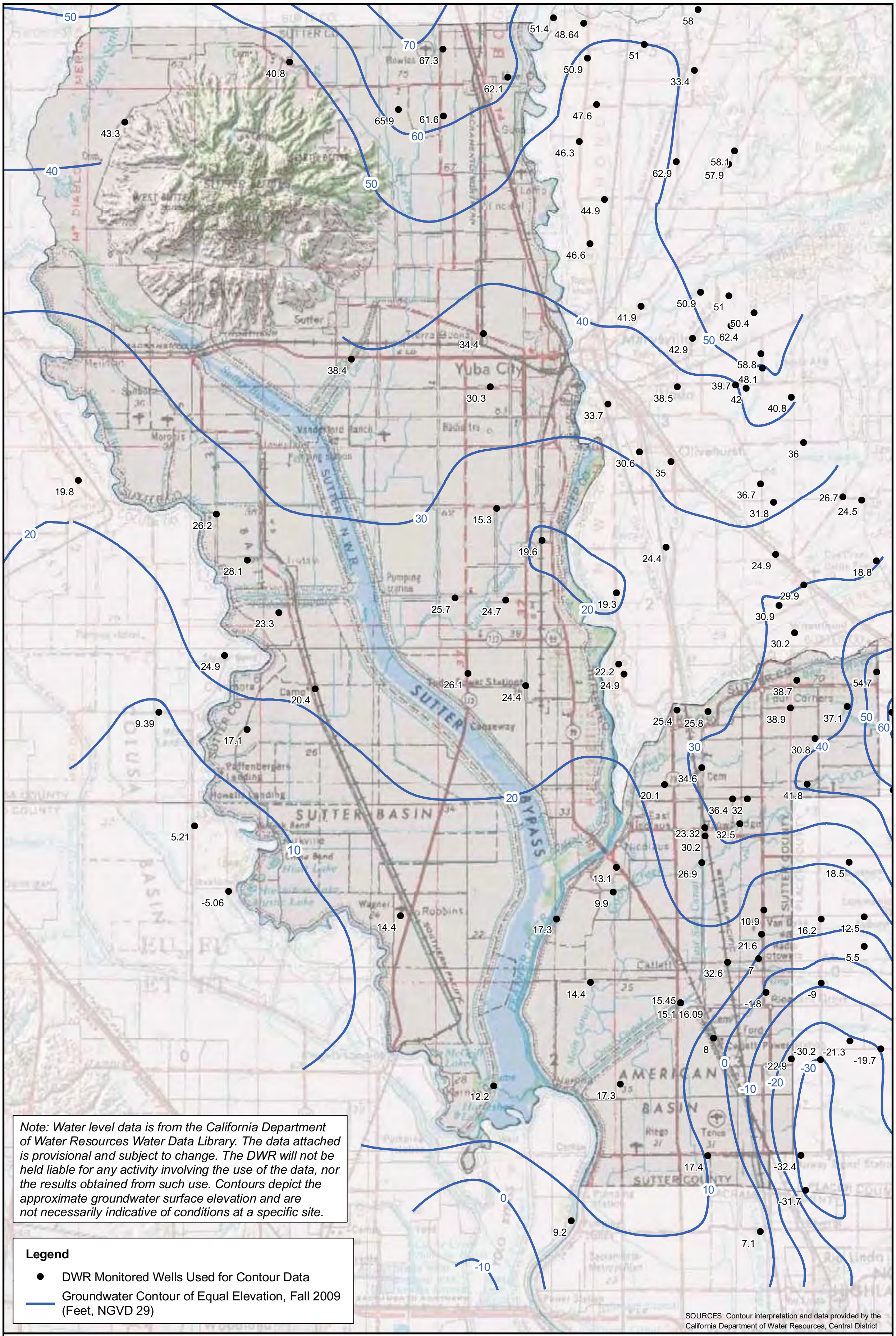
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 15 Groundwater Elevation Contour Map Spring 2009.mxd 2/8/2012 9:33:20 AM bdemucha



Note: Water level data is from the California Department of Water Resources Water Data Library. The data attached is provisional and subject to change. The DWR will not be held liable for any activity involving the use of the data, nor the results obtained from such use. Contours depict the approximate groundwater surface elevation and are not necessarily indicative of conditions at a specific site.

Legend

- ● DWR Monitored Wells Used for Contour Data
- Groundwater Contour of Equal Elevation, Fall 2009 (Feet, NGVD 29)

SOURCES: Contour interpretation and data provided by the California Department of Water Resources, Central District

FIGURE 16
GROUNDWATER ELEVATION CONTOUR MAP
FALL, 2009

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

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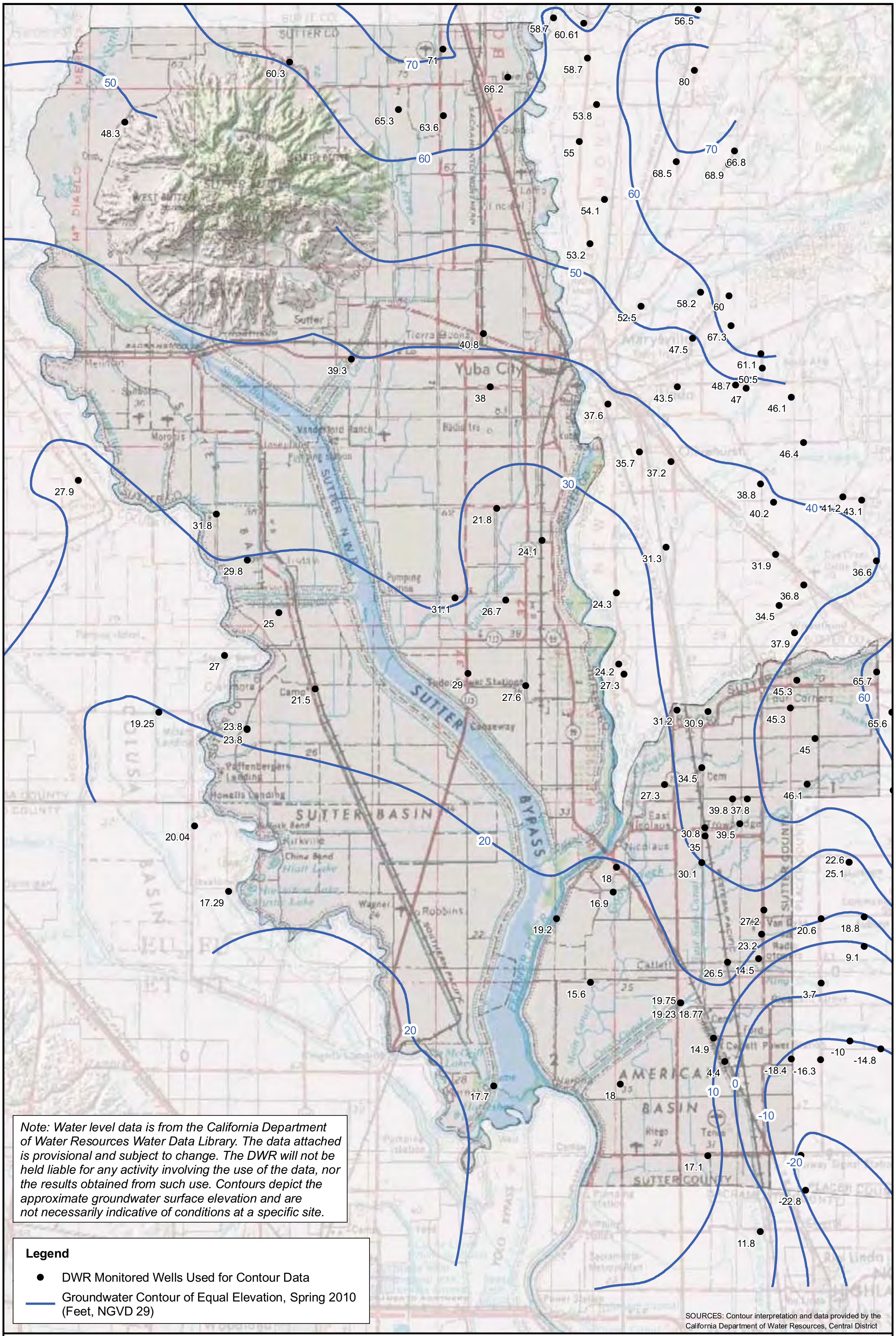

Note: Water level data is from the California Department of Water Resources Water Data Library. The data attached is provisional and subject to change. The DWR will not be held liable for any activity involving the use of the data, nor the results obtained from such use. Contours depict the approximate groundwater surface elevation and are not necessarily indicative of conditions at a specific site.

Legend

● DWR Monitored Wells Used for Contour Data

— Groundwater Contour of Equal Elevation, Spring 2010 (Feet, NGVD 29)

SOURCES: Contour interpretation and data provided by the California Department of Water Resources, Central District

FIGURE 17

GROUNDWATER ELEVATION CONTOUR MAP SPRING, 2010

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 1.5 3
MILES

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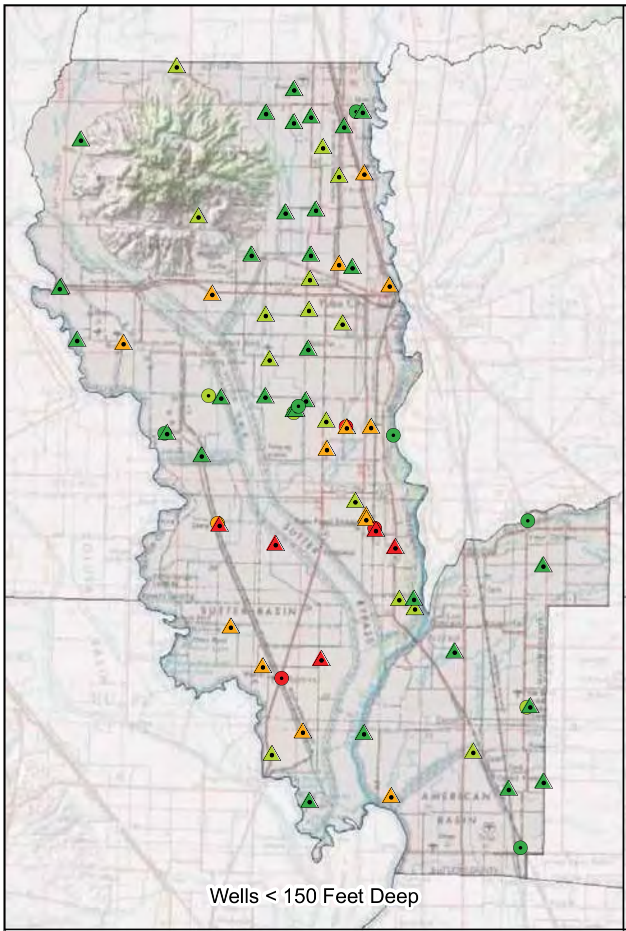
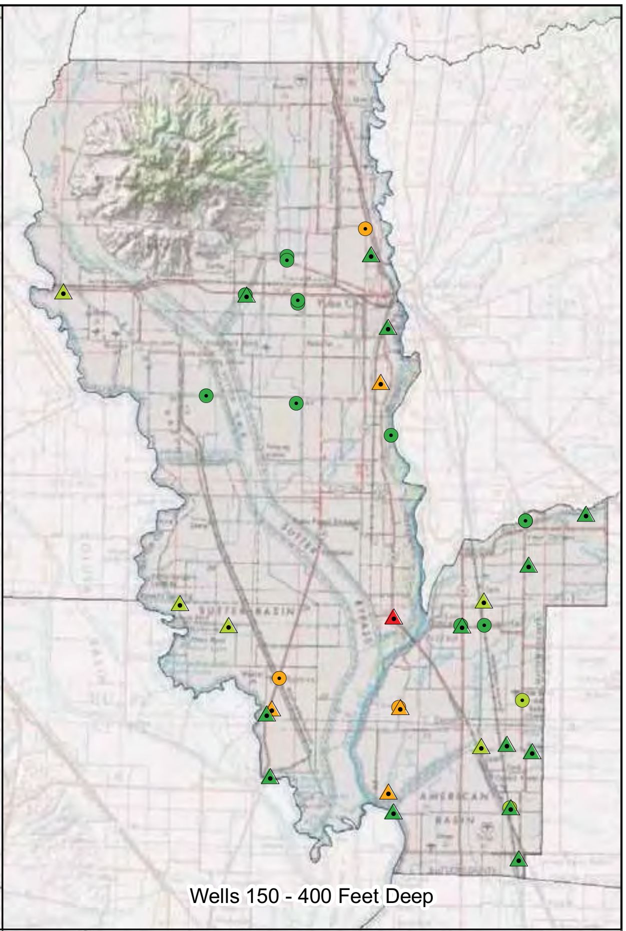

Wells < 150 Feet Deep


Wells 150 - 400 Feet Deep

EC in DWR Wells (µmhos/cm)

- ● < 600
- ● 600 - 900
- ● 900 - 1600
- ● > 1600

EC in USGS Wells (µmhos/cm)

- ▲ < 600
- ▲ 600 - 900
- ▲ 900 - 1600
- ▲ > 1600

Note:
"EC" is an abbreviation for specific conductance, which is related to the salt content of a water sample.

For public drinking water systems, the secondary (aesthetic) maximum contaminant levels for EC are 900 micromhos/centimeter (µmhos/cm) (recommended), 1600 µmhos/cm (upper), and 2200 µmhos/cm (short-term).

For irrigation, crop yields decrease above a threshold EC value, which is crop-dependent. Crop yield potential decreases above these threshold levels:

Almonds - 1000 µmhos/cm
Beans - 700 µmhos/cm
Rice - 2000 µmhos/cm
Squash - 2100-3100 µmhos/cm
Tomatoes - 1700 µmhos/cm
Wheat - 4000 µmhos/cm

SOURCES: USGS, DWR, SEWD, DHS, FAO, EPA

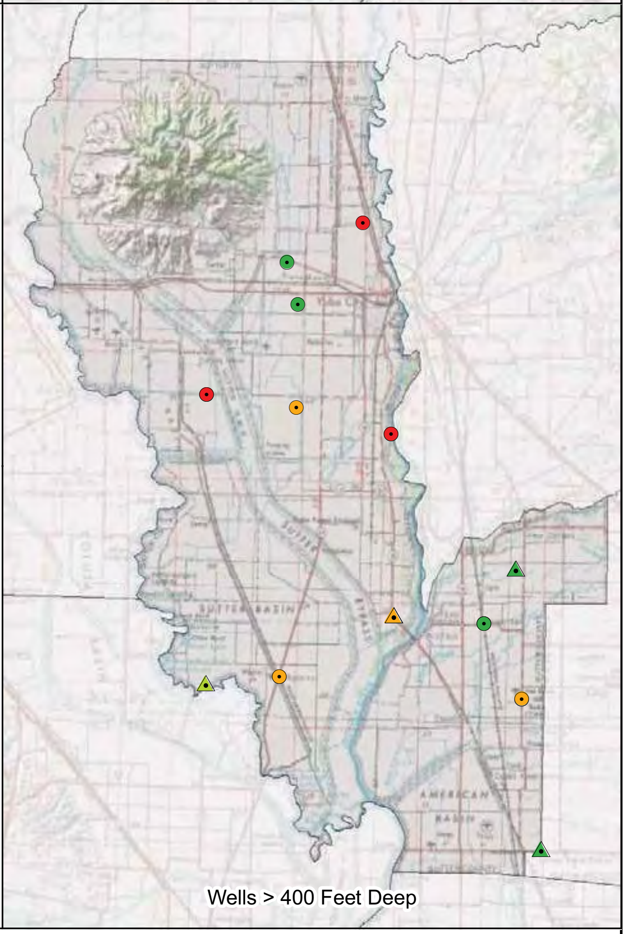

Wells > 400 Feet Deep

FIGURE 18
SPECIFIC CONDUCTANCE BY WELL DEPTH
SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 3 6
MILES

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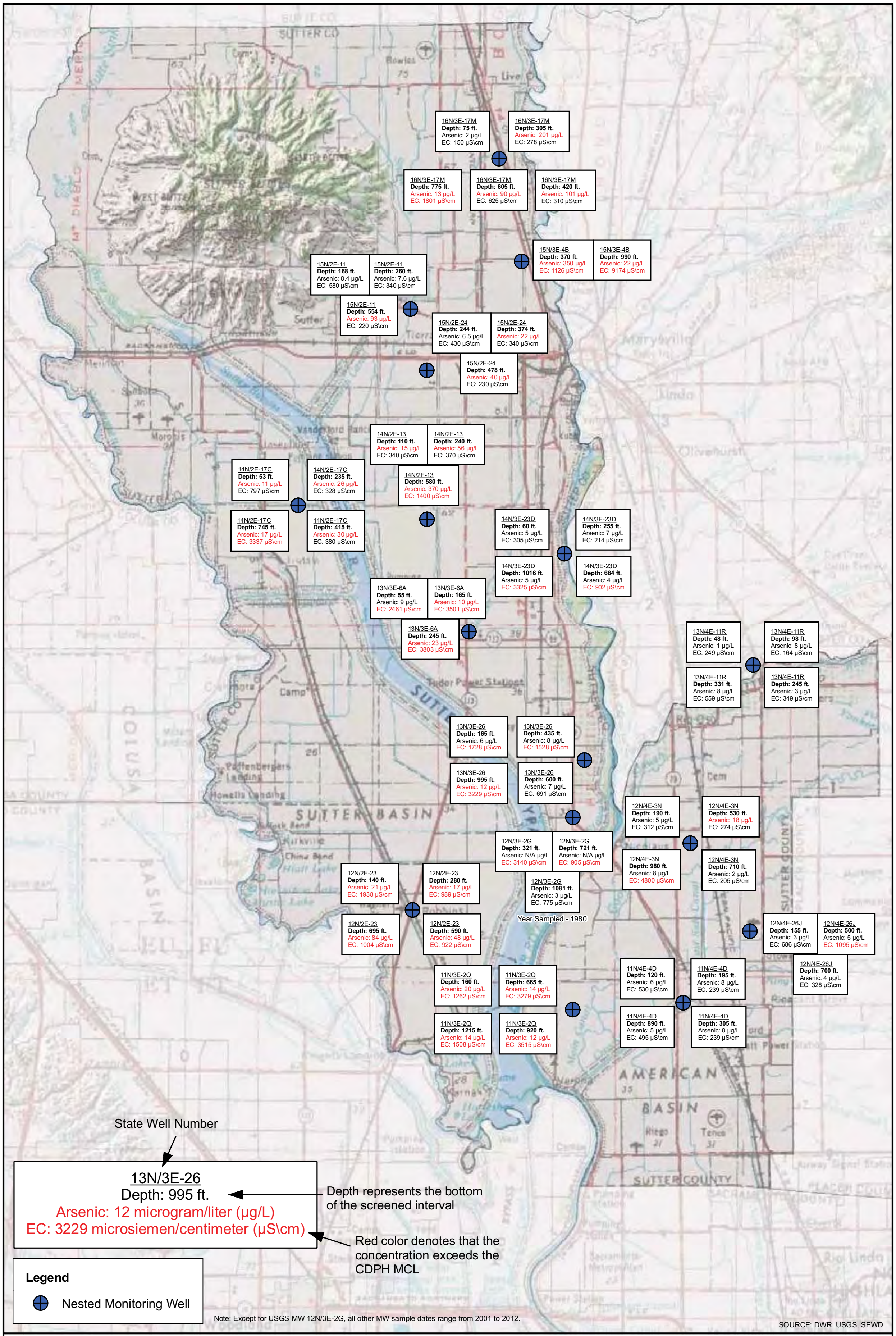
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 18 EC_Well Depth.mxd 2/8/2012 10:00:29 AM bdemucha



Note: Except for USGS MW 12N/3E-2G, all other MW sample dates range from 2001 to 2012.

SOURCE: DWR, USGS, SEWD

FIGURE 19

DEPTH SPECIFIC ARSENIC AND SPECIFIC CONDUCTANCE CONCENTRATIONS

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 1.5 3
MILES

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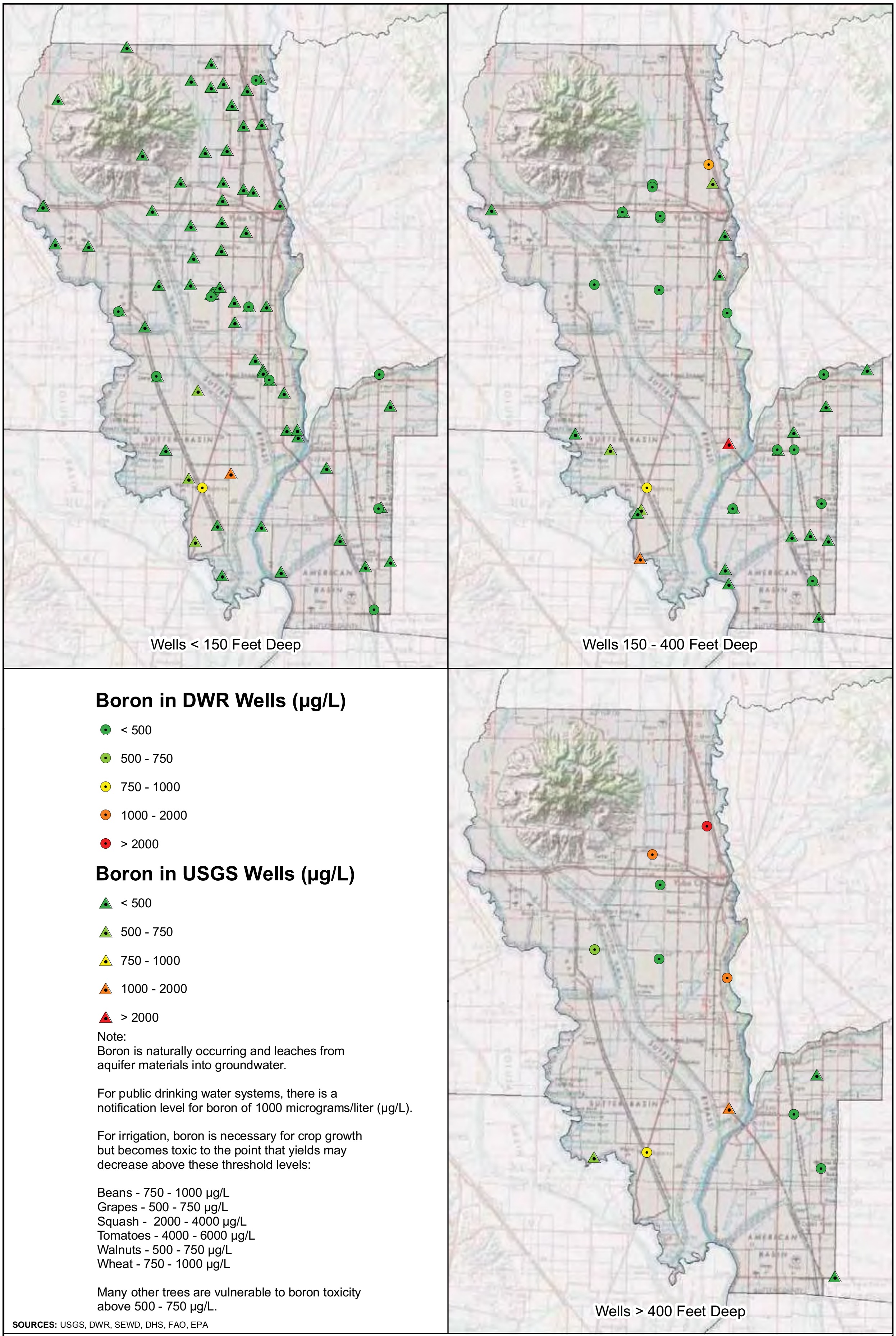
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120201 Final Draft Figure Comments\Figure 19 Depth Specific Arsenic and Specific Conductance.mxd 2/8/2012 11:34:41 AM bdemucha



Note:
Boron is naturally occurring and leaches from aquifer materials into groundwater.

For public drinking water systems, there is a notification level for boron of 1000 micrograms/liter (µg/L).

For irrigation, boron is necessary for crop growth but becomes toxic to the point that yields may decrease above these threshold levels:

Beans - 750 - 1000 µg/L
Grapes - 500 - 750 µg/L
Squash - 2000 - 4000 µg/L
Tomatoes - 4000 - 6000 µg/L
Walnuts - 500 - 750 µg/L
Wheat - 750 - 1000 µg/L

Many other trees are vulnerable to boron toxicity above 500 - 750 µg/L.

SOURCES: USGS, DWR, SEWD, DHS, FAO, EPA

FIGURE 20
BORON BY WELL DEPTHS
SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 3 6
MILES

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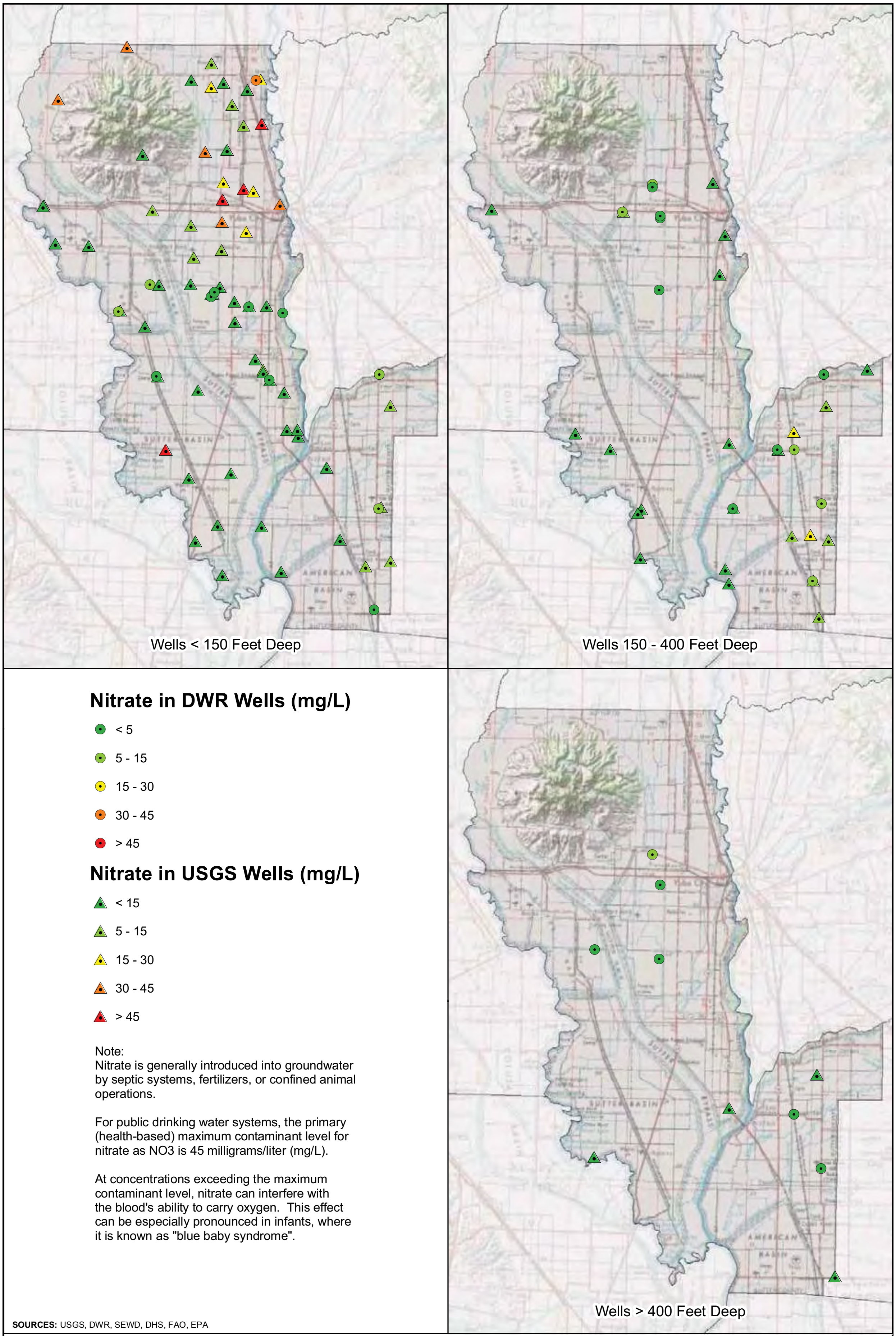
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 20 Boron_Well Depth.mxd 2/8/2012 2:00:06 PM bdemucha



Wells < 150 Feet Deep

Wells 150 - 400 Feet Deep

Wells > 400 Feet Deep

Nitrate in DWR Wells (mg/L)

- ● < 5
- ● 5 - 15
- ● 15 - 30
- ● 30 - 45
- ● > 45

Nitrate in USGS Wells (mg/L)

- ▲ < 15
- ▲ 5 - 15
- ▲ 15 - 30
- ▲ 30 - 45
- ▲ > 45

Note:
Nitrate is generally introduced into groundwater by septic systems, fertilizers, or confined animal operations.

For public drinking water systems, the primary (health-based) maximum contaminant level for nitrate as NO3 is 45 milligrams/liter (mg/L).

At concentrations exceeding the maximum contaminant level, nitrate can interfere with the blood's ability to carry oxygen. This effect can be especially pronounced in infants, where it is known as "blue baby syndrome".

SOURCES: USGS, DWR, SEWD, DHS, FAO, EPA

FIGURE 21
NITRATE BY WELL DEPTH
SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH
0 3 6
MILES

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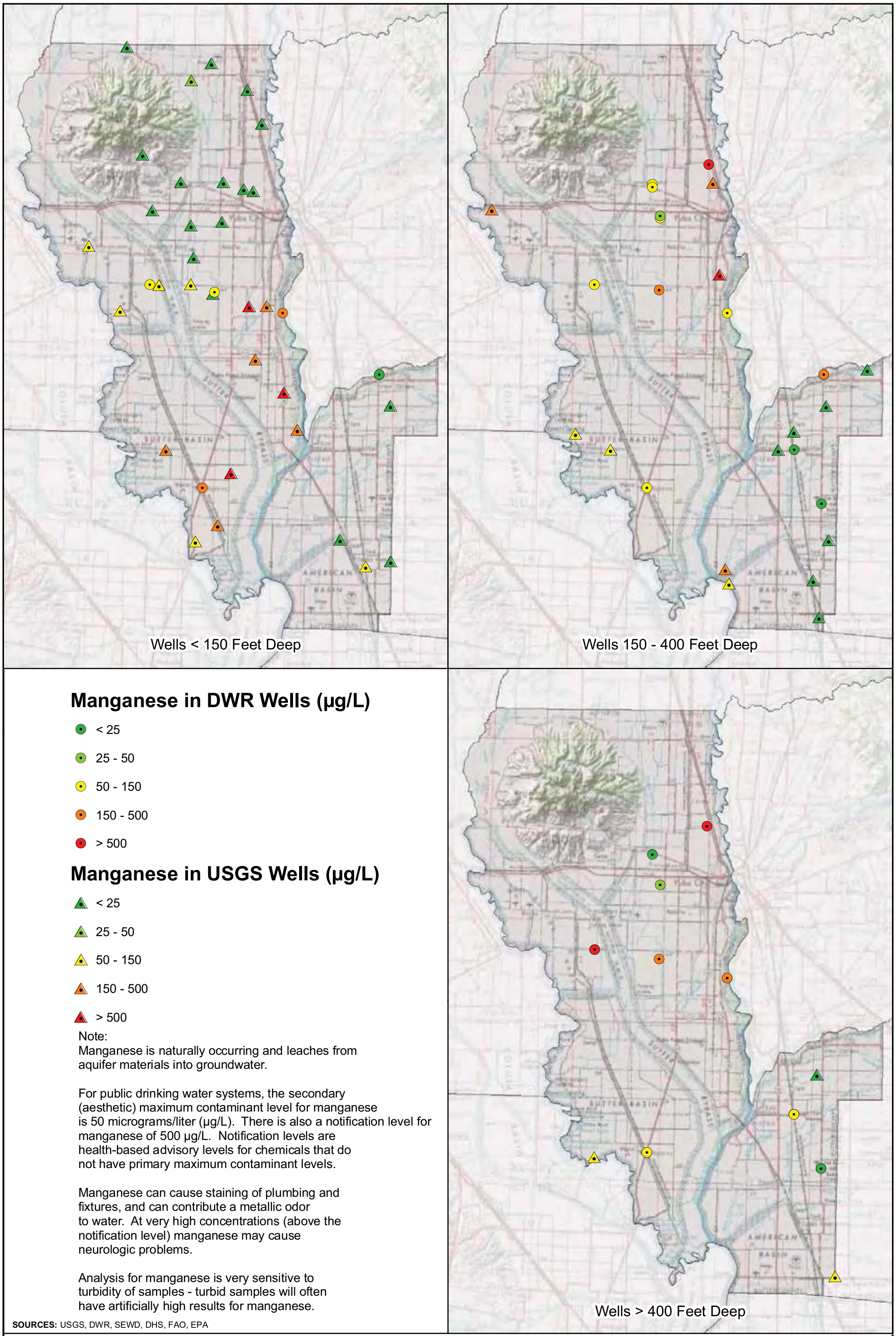

Manganese in DWR Wells (µg/L)

- ● < 25
- ● 25 - 50
- ● 50 - 150
- ● 150 - 500
- ● > 500

Manganese in USGS Wells (µg/L)

- ▲ < 25
- ▲ 25 - 50
- ▲ 50 - 150
- ▲ 150 - 500
- ▲ > 500

Note:
Manganese is naturally occurring and leaches from aquifer materials into groundwater.

For public drinking water systems, the secondary (aesthetic) maximum contaminant level for manganese is 50 micrograms/liter (µg/L). There is also a notification level for manganese of 500 µg/L. Notification levels are health-based advisory levels for chemicals that do not have primary maximum contaminant levels.

Manganese can cause staining of plumbing and fixtures, and can contribute a metallic odor to water. At very high concentrations (above the notification level) manganese may cause neurologic problems.

Analysis for manganese is very sensitive to turbidity of samples - turbid samples will often have artificially high results for manganese.

SOURCES: USGS, DWR, SEWD, DHS, FAO, EPA

FIGURE 22
MANGANESE BY WELL DEPTHS
SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 3 6
MILES

SUTTER COUNTY CALIFORNIA

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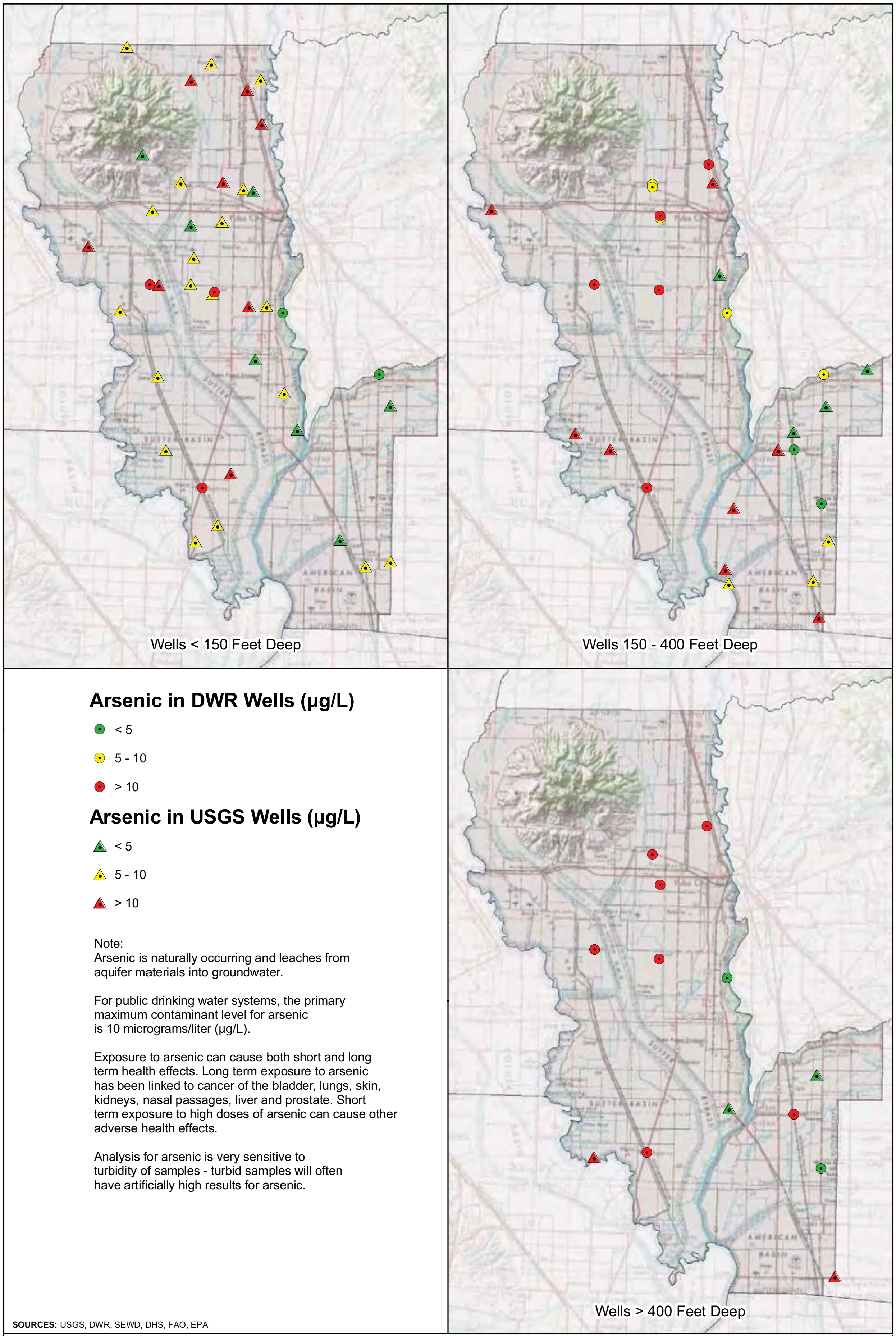
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120201 Final Draft Figure Comments\Figure 22 Manganese_Well Depth.mxd 2/8/2012 3:23:15 PM bdemucha



Arsenic in DWR Wells (µg/L)

- 🟢 < 5
- 🟡 5 - 10
- 🔴 > 10

Arsenic in USGS Wells (µg/L)

- ▲ < 5
- ▲ 5 - 10
- ▲ > 10

Note:
Arsenic is naturally occurring and leaches from aquifer materials into groundwater.

For public drinking water systems, the primary maximum contaminant level for arsenic is 10 micrograms/liter (µg/L).

Exposure to arsenic can cause both short and long term health effects. Long term exposure to arsenic has been linked to cancer of the bladder, lungs, skin, kidneys, nasal passages, liver and prostate. Short term exposure to high doses of arsenic can cause other adverse health effects.

Analysis for arsenic is very sensitive to turbidity of samples - turbid samples will often have artificially high results for arsenic.

SOURCES: USGS, DWR, SEWD, DHS, FAO, EPA

FIGURE 23
ARSENIC BY WELL DEPTHS
SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH
0 3 6
Miles

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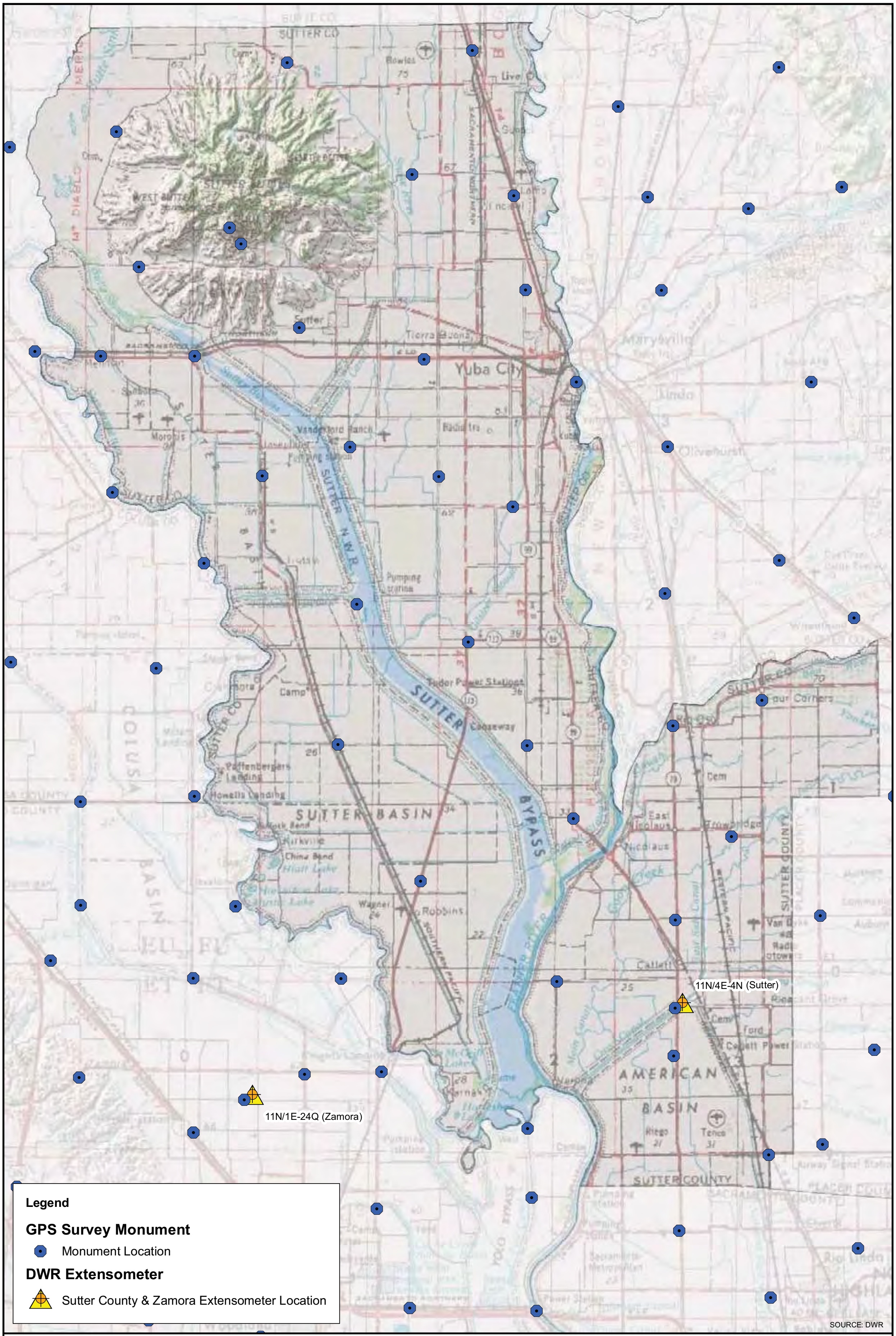

FIGURE 24

LAND SUBSIDENCE NETWORK

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

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J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 24 Land Subsidence Network.mxd 2/8/2012 2:43:42 PM bdemucha

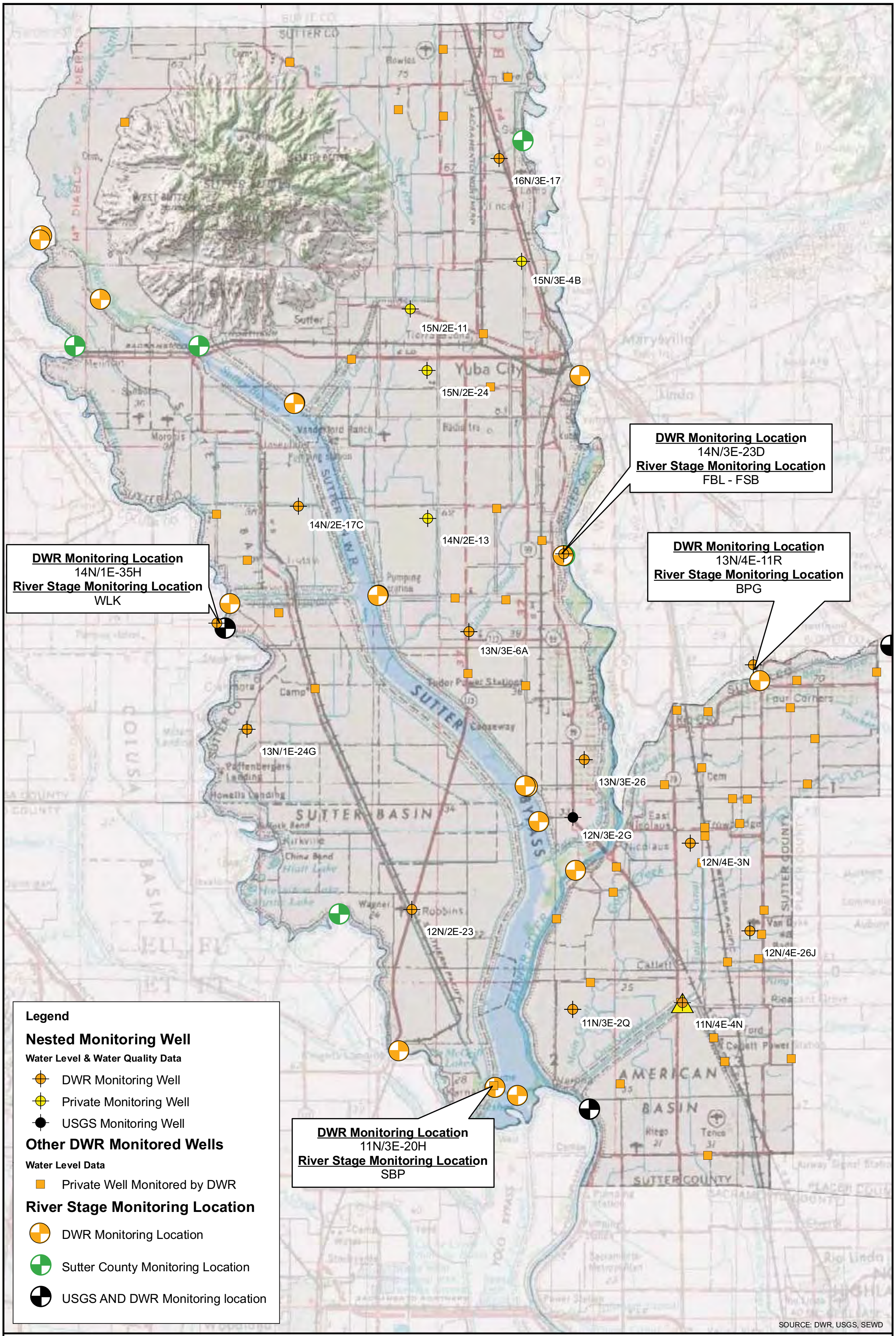

FIGURE 25

GROUNDWATER AND RIVER STAGE MONITORING LOCATIONS

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 1.5 3
MILES

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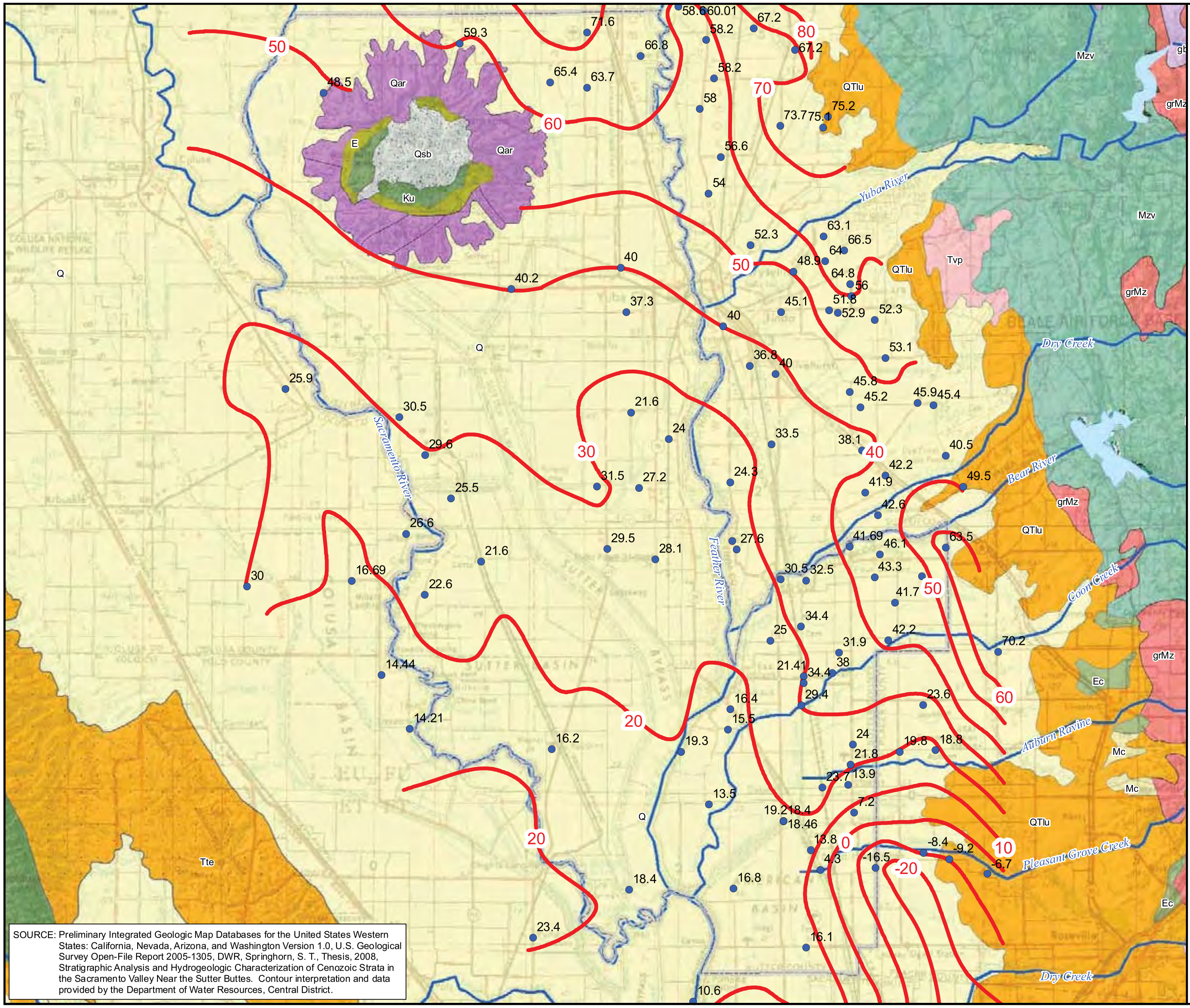
J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 25 Groundwater and River Stage Monitoring Locations.mxd 2/8/2012 2:46:51 PM bdemucha



SOURCE: Preliminary Integrated Geologic Map Databases for the United States Western States: California, Nevada, Arizona, and Washington Version 1.0, U.S. Geological Survey Open-File Report 2005-1305, DWR, Springhorn, S. T., Thesis, 2008, Stratigraphic Analysis and Hydrogeologic Characterization of Cenozoic Strata in the Sacramento Valley Near the Sutter Buttes. Contour interpretation and data provided by the Department of Water Resources, Central District.

FIGURE 26

RECHARGE AND GROUNDWATER ELEVATION CONTOUR MAP SPRING, 2009

SUTTER COUNTY GROUNDWATER MANAGEMENT PLAN
FEBRUARY 2012

NORTH

0 2 4
MILES

- Q - Recent Deposits
  - Qb - Basin Deposits
  - Qm - Modesto Formation
  - Qr - Riverbank Formation
- Qsb - Sutter Buttes Igneous Rocks
- Qar - Sutter Buttes Andesitic Rampart
- QTlu - Laguna Formation
- Tte - Tehama Formation
- Tvp - Andesite, Rhyolite
- Mc - Sandstone, Conglomerate
- Ec - Conglomerate, Sandstone
- E - Mudstone, Sandstone
- Ku - Sandstone, Mudstone
- J - Mudstone, Sandstone, & Slate
- um - Serpentinite
- Mzv - Volcanic, Metavolcanic
- gb - Gabbro, Diorite
- grMz - Granodiorite
- Sutter County
- ● DWR Monitored Wells Used for Contours
- Groundwater Contour of Equal Elevation (Feet, NGVD 29)

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J:\Jobs\8337_SutterCounty\GIS\Tasks\20120116 Final Draft\Figure 26 Recharge and Groundwater Elevation Contour Map Spring, 2009.mxd 2/8/2012 3:11:15 PM bdemucha

Figure 27
Sutter County
Well Construction By Year

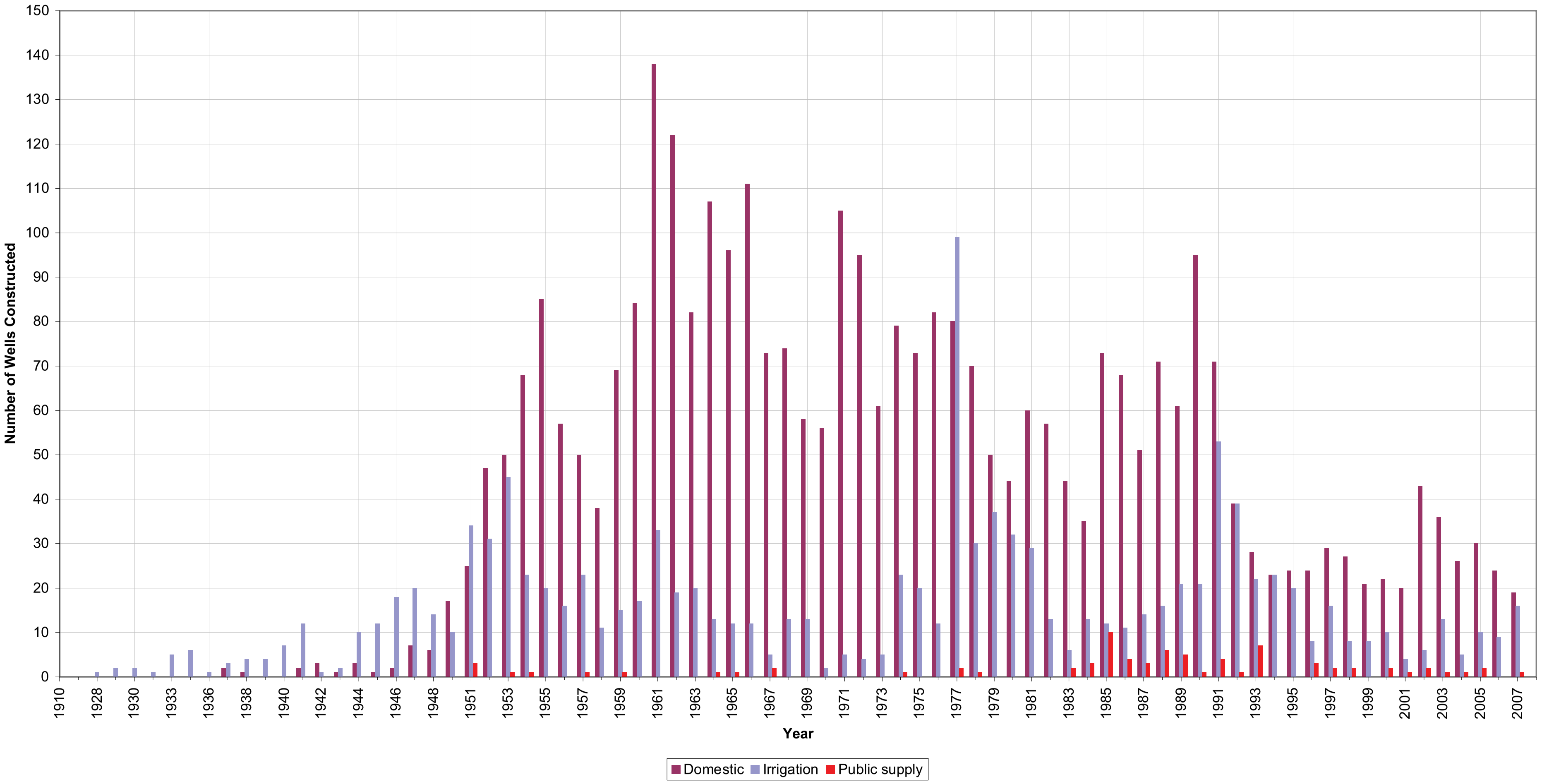
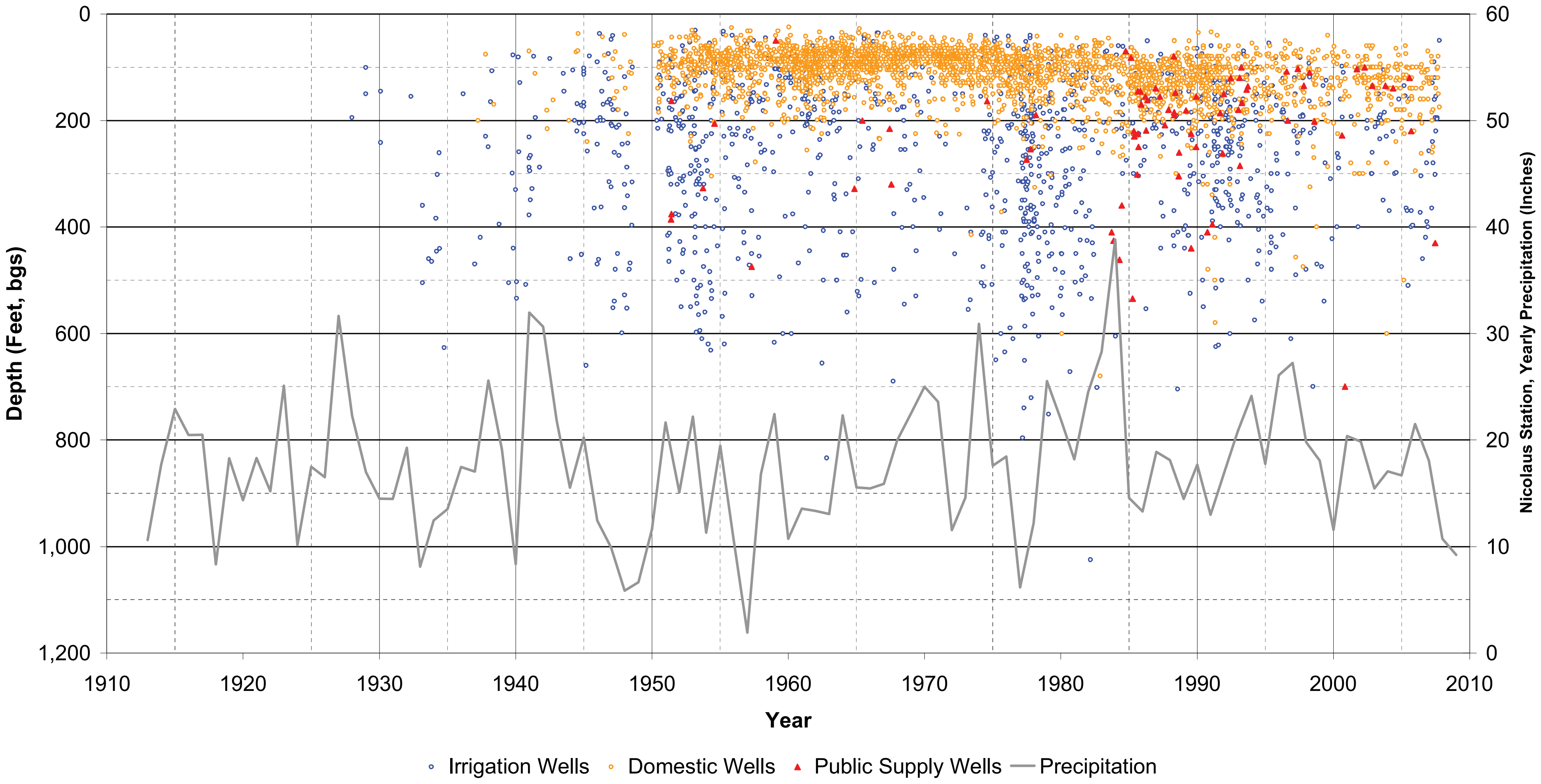
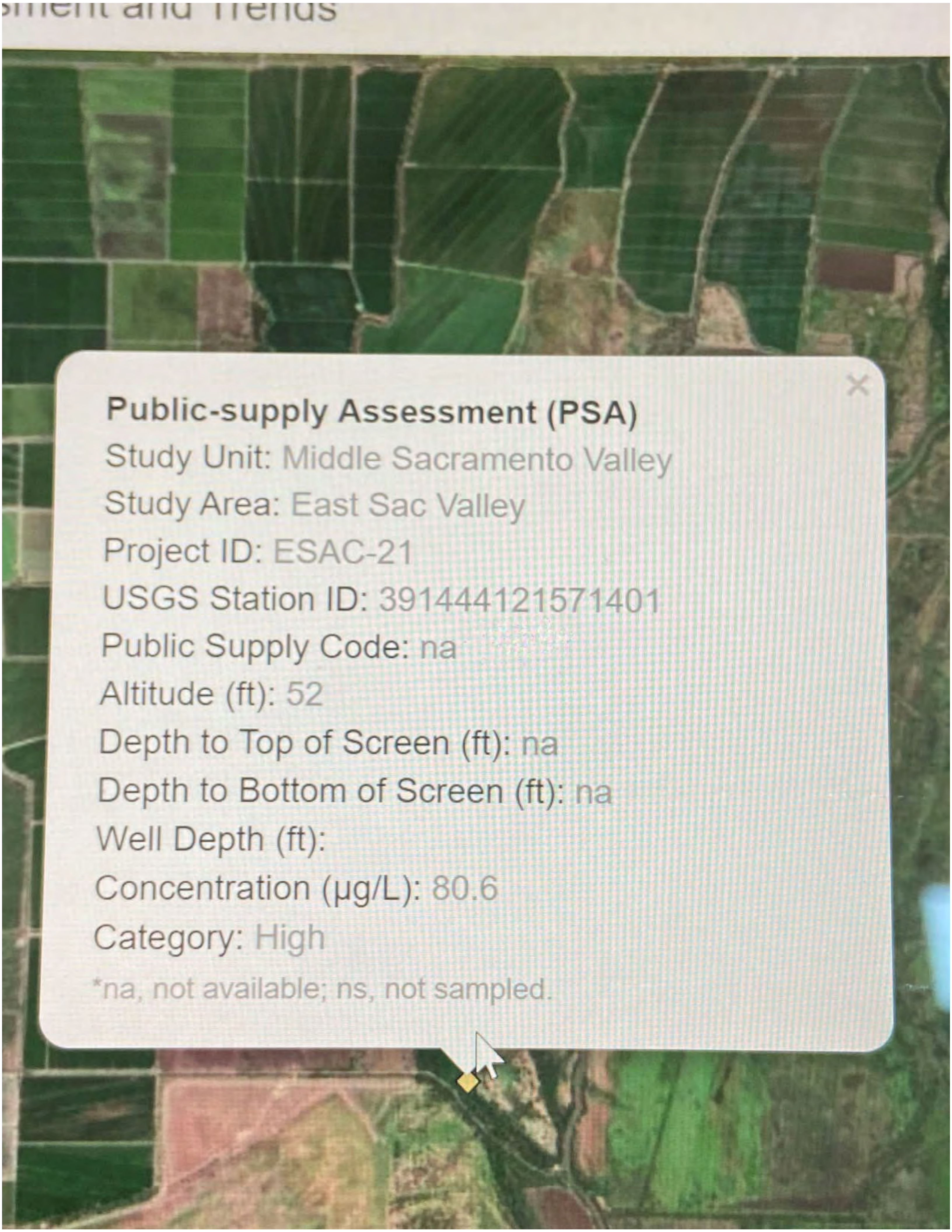


Figure 28
Sutter County
Historic Well Construction by Depth and Annual Precipitation





Public-supply Assessment (PSA)

Study Unit: Middle Sacramento Valley

Study Area: East Sac Valley

Project ID: ESAC-21

USGS Station ID: 391444121571401

Public Supply Code: na

Altitude (ft): 52

Depth to Top of Screen (ft): na

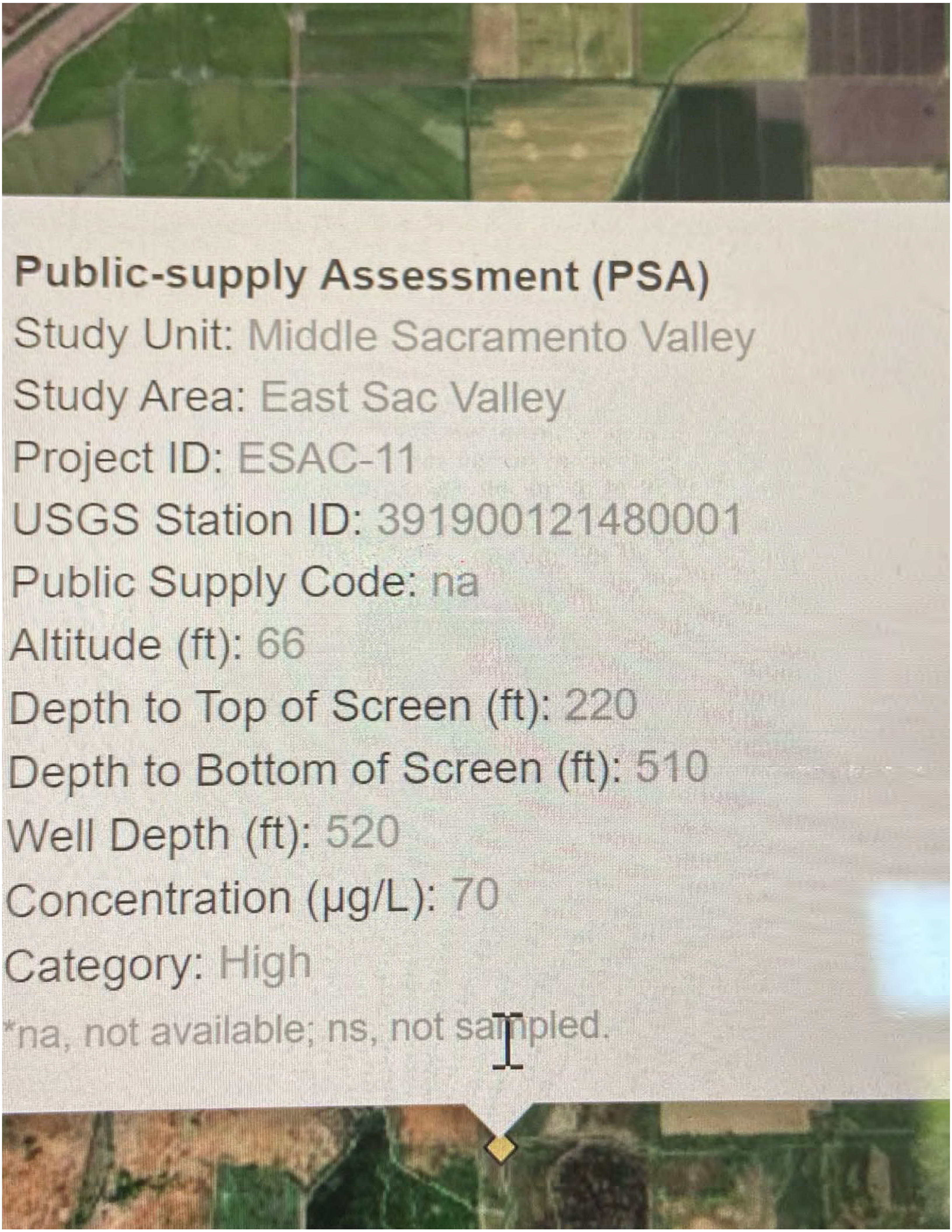
Depth to Bottom of Screen (ft): na

Well Depth (ft):

Concentration (µg/L): 80.6

Category: High

*na, not available; ns, not sampled.



Public-supply Assessment (PSA)
Study Unit: Middle Sacramento Valley
Study Area: East Sac Valley
Project ID: ESAC-11
USGS Station ID: 391900121480001
Public Supply Code: na
Altitude (ft): 66
Depth to Top of Screen (ft): 220
Depth to Bottom of Screen (ft): 510
Well Depth (ft): 520
Concentration (µg/L): 70
Category: High
*na, not available; ns, not sampled.

ARSENIC IN CALIFORNIA DRINKING WATER

Three Years After EPA Notice of Noncompliance to State, Arsenic Levels Still Unsafe in Drinking Water for 55,000 Californians

ENVIRONMENTAL INTEGRITY PROJECT

SEPTEMBER, 2016

ACKNOWLEDGEMENTS

This report was researched and written by Tom Pelton, Courtney Bernhardt, and Eric Schaeffer of the Environmental Integrity Project. The map was created by Kira Burkhart and the graphics by Alana Natke.

THE ENVIRONMENTAL INTEGRITY PROJECT

The Environmental Integrity Project (http://www.environmentalintegrity.org) is a nonpartisan, nonprofit organization established in March of 2002 by former EPA enforcement attorneys to advocate for effective enforcement of environmental laws. EIP has three goals: 1) to provide objective analyses of how the failure to enforce or implement environmental laws increases pollution and affects public health; 2) to hold federal and state agencies, as well as individual corporations, accountable for failing to enforce or comply with environmental laws; and 3) to help local communities obtain the protection of environmental laws.

For questions about this report, please contact EIP Director of Communications
Tom Pelton at (202) 888-2703 or
tpelton@environmentalintegrity.org.

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Arsenic in California Drinking Water

More than three years after the U.S. Environmental Protection Agency found California in noncompliance with the federal Safe Drinking Water Act, 95 community water systems in the state, serving more than 55,000 people, are still providing water with illegal levels of arsenic, according to an examination of state data for the last two years.[1] Arsenic occurs naturally in the soil and groundwater in parts of California and is a known carcinogen that may also damage the developing brains of children and cause other health problems.[2] Many of the people drinking excessive levels of arsenic are poor and/or Latino or African-American, with a cluster in the San Joaquin Valley.[3] Nearly all have been exposed to excessive arsenic levels for at least five years and probably longer.[4]

California requires public water systems to notify their customers when arsenic fails to meet federal health standards. But strangely, the state's language for mailed advisories suggests the water is still safe to drink no matter how high the contimation levels or how long they persist, with the notices telling residents: "You do not need to use an alternative water supply (e.g., bottled water)." [5] That advice conflics with what California tells private well owners (who aren't covered by federal standards) on a state website: "If you suspect that your well may have arsenic, you should not use the water until it is tested, and you take appropriate measures to protect yourself and your family from potential chronic health effects if arsenic is present."[6] Whatever the intention, California's language for people on public water systems is likely to encourage them to drink contaminated water. (For the full text of the California's language, see Appendix A). As the state continues a multi-year effort to solve the contamination problem, it should immediately fix a communications problem so that it clearly warns people not to drink arsenic-tainted tap water.


Arsenic in Tap Water

In 2001
EPA set tighter limits on arsenic in drinking water, limiting the carcinogen to 10 parts per billion (ppb), starting in 2006

California records indicate there were 95 public drinking water systems serving 55,985 people that averaged more than the federal limit of arsenic in 2014 and 2015

There were 70 water systems serving 46,772 people that averaged more than 10 ppb each year over a five year period, from 2011 through 2015

Sources:
National Groundwater Association
United States Environmental Protection Agency
California State Water Resources Control Board

The highest levels of arsenic in drinking water in California from 2011 through 2015 were in a group home for troubled teenage boys, the Valley Teen Ranch in Madera County. About 50 boys assigned by the courts to the facility have been living in a home with water that has arsenic at concentrations averaging more than 12 times the federal limit (10 parts per billion, or ppb) over these five years, according to state records.[7] "Nobody wants to drink the water because it's brown and nasty,"said Connie R. Clendenan, CEO of the nonprofit organization that runs the group home.[8] "It looks bad."

It is bad. Although California has made substantial progress in addressing drinking water problems, the state still has 13 school districts, serving a total of 8,822 students, with arsenic in their drinking water that exceeded the federal limit from 2011 to 2015.[9] Twelve mobile home parks in California, serving 889 people, had arsenic in their tap water that averaged up to five times the legal limit. The average annual concentrations of arsenic in the drinking water of 58 residential communities (other than trailer parks) exceeded the legal limit during this time period, as did a military base, three wineries, two food preparation businesses and two campgrounds.

In many of the schools, the group home and military base, administrators say they verbally warn people not to drink tap water. They also provide bottled water as an alternative. But in the residential neighborhoods and trailer parks, it is not clear what warning – if any -- people are receiving. "There is no warning not to drink it. There is no 'non-drink' order out there," said Robert Johnson, President of the Shaver Lake Point 2 Mutual Water Company, which supplies 210 homes in Fresno County with tap water that has seven times the legal limit of arsenic. When asked if these residents should drink bottled water instead of his arsenic-tainted tap water, Johnson said: "It's one of those things, if you want to do it, that's your deal. It's not being recommended. We're not suggesting it. This is per the state of California. We are following their guidance."

The drinking water crisis in Flint, Michigan, was a reminder of how important it is for state governments to issue clear warnings to people with unhealthy tap water. California's mixed message is nearly identical to the one issued by Texas to homeowners with illegal levels of arsenic in their drinking water. Texas also tells consumers with excessive levels of arsenic: "You do not need an alternative water supply."[10] Many other states, however, are more direct in warning people not to drink water with excessive amounts of arsenic, at least for private well owners. Wisconsin, Michigan, Maine, and Washington, for example, simply tell residents not to consume water with more than 10 ppb arsenic (a health standard set by EPA in 2001). Wisconsin advises private well owners: "If your arsenic level is more than 10 ppb, the Wisconsin Department of Health Services recommends that you stop using your water for drinking or food preparation."[11] Florida advises its consumers to avoid water where arsenic contamination persists.[12] The U.S. Department of Health and Human Services makes similar recommendations.[13] If anything, the most recent science suggests that the current 10 ppb arsenic standard is not protective enough and that the IQ of children may be damaged at much lower exposures.[14]

In the wake of a 2013 EPA notice of noncompliance to California over its failure to invest enough money in its drinking water systems, the state has taken several important steps to fix its problems. Over the last three years, the state has more than doubled the amount of funding to build water treatment plants, pipelines, and new wells. The state and counties have filed compliance orders with local utilities to push them to upgrade their systems and are directing small, underfunded water systems to merge with larger utilities. Because of these measures, EPA announced in May 2016 that California was back in compliance with the federal Safe Drinking Water Act.

But in fact, the work is far from done – as witnessed by the 55,985 people in 95 communities across California who still have illegal levels of the carcinogen in their tap water, according to state records.[15] Why the delays? Local officials say that in some cases, bureaucratic negotiations are holding up projects, which are sometimes stalled because of conflicts between county and state rules. In other cases, local water districts struggle with indecision or a lack of money.

Until these important water system improvements are complete, California and EPA must do a better job of warning consumers to stop drinking water that fails federal health standards. This report recommends:

- California and EPA should revise their regulations and guidance to require that local utilities warn people to stop drinking or cooking with water that fails to meet federal arsenic standards (10 ppb), especially when the contamination persists over several years. The advice should be sensitive to the additional risks posed when children and other sensitive populations drink contaminated water. If there is no reason for consumers to take precautions, there is no reason for Safe Drinking Water Act standards in the first place.

- Public notices mailed to consumers should inform them of options for treating contaminated water at home, e.g., through filtration systems that have proven to be effective. Conversely, the public should be told what doesn't work. For example, boiling water will not reduce arsenic concentrations.

- Federal and state authorities should provide enough money to these 95 California communities to allow them to install water filtration systems or take other steps to eliminate contamination problems. Although the state has already boosted its funding, it still faces a projected $30 billion plus in needed capital improvement projects to help its inadequate systems provide safe drinking water trough 2026.[16]

The big picture is that stepped-up investment in crumbling public infrastructure is sorely needed across the U.S., and it should be regarded as a top priority for both Congress and California lawmakers. But the state also needs to improve its efforts to better inform consumers so people can protect their own health. California does not have to wait for EPA action to strengthen its warnings because the state is already empowered to act independently of EPA.

Public health advisories that are contradictory and confusing – as they are in California -- are as bad as no warnings at all, because they undermine action and weaken public confidence in government.

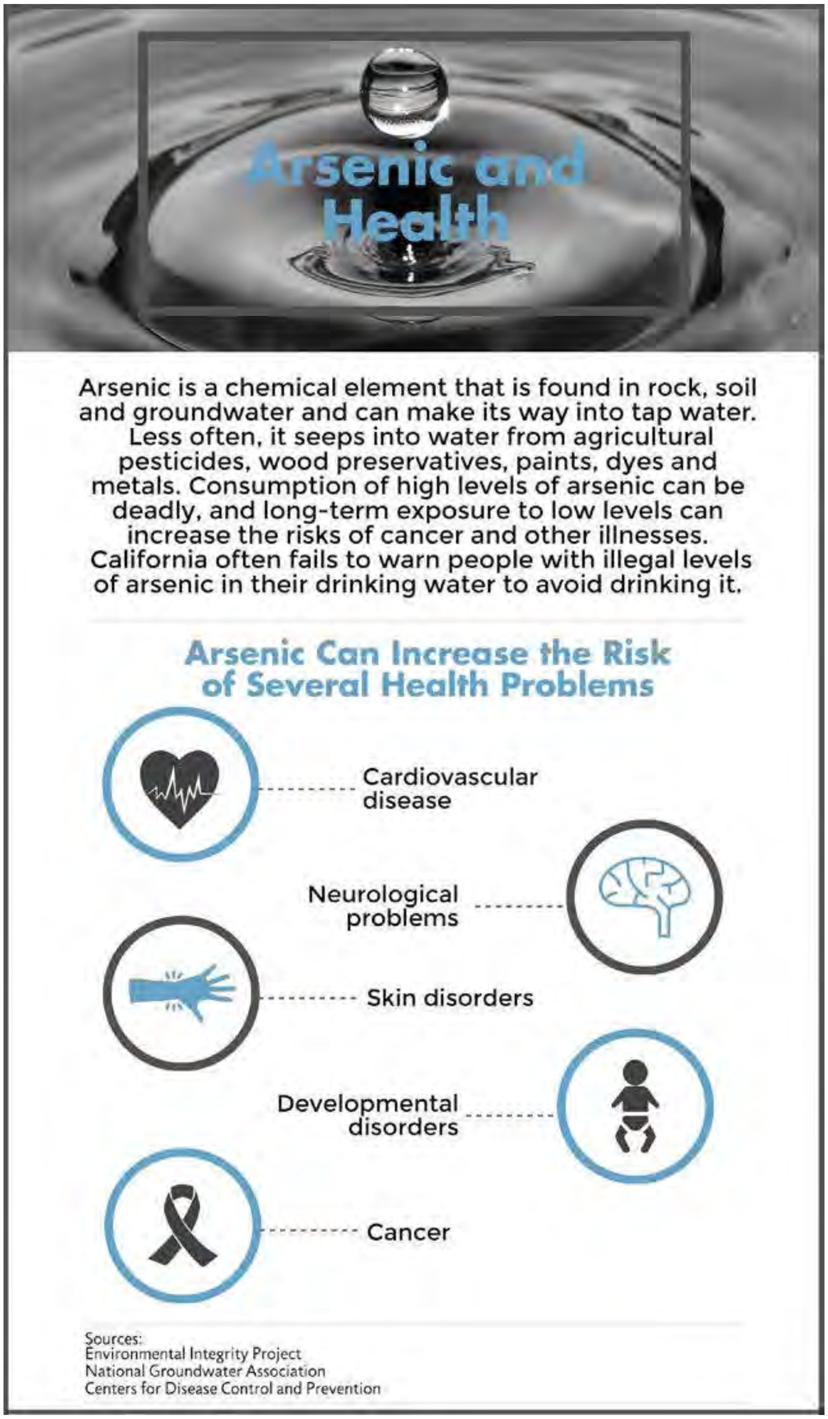
Table 1. Top 20 Arsenic Concentrations in California Public Water Systems

Water System (in Order of Arsenic Levels)	County	Pop. Served	2014-2015 avg (ppb)	2011-2015 avg (ppb)
Lakeview Improvement Association #1	Fresno	160	86.88	86.88*
Fountain Trailer Park Water	Kern	68	85.75	83.90
Hungry Gulch Water System	Kern	33	72.56	70.04
Corral De Tierra Estates WC	Monterey	45	72.50	78.40
Keeler Community Service District	Inyo	50	71.25	75.63
Quail Valley Water District- Eastside System	Kern	60	70.06	69.11
CSA 70 W-4 Pioneertown	San Bernardino	625	64.52	61.55
MD #06 Lake Shore Park	Madera	130	64.25	71.94
Valley Teen Ranch	Madera	50	62.00	120.80
Sierra East Mobile Home Community	Mono	50	54.63	47.03*
Shaver Lake Point #2	Fresno	210	52.31	42.88*
Winterhaven Mobile Estates	Los Angeles	40	52.13	53.35
Olam Spices And Vegetables Inc.	Kings	75	48.38	46.70
The Village Mobile Home Park	Los Angeles	70	45.05	47.04
Callier Water System	San Bernardino	1000	42.13	49.21*
Black Stallion Winery	Napa	25	41.75*	41.75*
Ironwood Camp	San Bernardino	1000	38.38	38.55
Boron CSD	Kern	2500	38.07	37.98
Edgewater Mobile Home Park	Sacramento	40	38.00	37.59
Prunedale MWC	Monterey	252	35.7	32.0

Note: The federal limit for arsenic is 10 ppb. * Average concentrations do not include concentrations from every year. For example, Lakeview Improvement Assn. #1 changed from a non-community water system to a community water system in 2013, and sampling data was only available from 2014 and 2015. Sampling results for Black Stallion Winery were only available for 2015. See Appendix B for annual concentrations in all systems that averaged above 10 ppb.

Health Risks Posed by Arsenic

Arsenic is a chemical element that occurs naturally in geological formations in California and elsewhere, and is also used in a variety of industrial products, including pesticides, paint, and wood preservatives.[17] It is a well-known poison at high doses. At lower doses, researchers have concluded it can cause cancers of the lung, kidney, bladder, skin, and other



Arsenic is a chemical element that is found in rock, soil and groundwater and can make its way into tap water. Less often, it seeps into water from agricultural pesticides, wood preservatives, paints, dyes and metals. Consumption of high levels of arsenic can be deadly, and long-term exposure to low levels can increase the risks of cancer and other illnesses. California often fails to warn people with illegal levels of arsenic in their drinking water to avoid drinking it.

Sources:
Environmental Integrity Project
National Groundwater Association
Centers for Disease Control and Prevention

organs with prolonged exposure. Any level of exposure, however, carries some risk.[18] According to EPA, the risk of developing cancer after drinking water containing 10 ppb arsenic over a lifetime is 1 in 2,000.[19] This level of risk is almost never ‘acceptable’ from a regulatory perspective. The agency usually tries to limit lifetime cancer risk to no more than 1 in 10,000, at most. EPA’s risk estimate assumes that the cancer risk is linear, meaning if water contains 20 ppb arsenic, those who drink it over a long period of time have a 1 in 1,000 chance of developing cancer. People exposed over shorter periods of time have lower risks, but exposure during childhood may have a greater impact than exposure during adulthood.[20]

Morever, these risk calculations reflected the old thinking. New evidence suggests that the actual cancer risk may be much higher. EPA is currently revising its assessment of cancer risks from arsenic to incorporate more recent science. A 2010 draft of the assessment indicated that the risk of getting cancer from drinking water containing 10 ppb of arsenic is closer to 1 in 136, more than 17 times higher than current assumptions.[21] In addition to causing cancer, arsenic is also a neurotoxin that can harm developing brains at levels at or below the allowable limit.[22] One recent study in Maine, for example, found significant reductions in IQ and other problems in children exposed to arsenic concentrations of 5 to 10 ppb.[23] Specifically, children in homes with more than 5 ppb arsenic in the tap water tested roughly 6 points lower on a full-scale IQ test.[24] While EPA’s

Scientific Advisory Board and the most recent studies suggest that the ‘safe’ level of arsenic is likely much lower than 10 ppb, any concentration higher than 10 is clearly unsafe.

Background on California’s Problem

On April 19, 2013, EPA sent a letter to the California Department of Public Health notifying the state that it was out of compliance with the federal Safe Drinking Water Act.[25] The reason was that California’s drinking water system was inadequate – providing contaminated water in many poor, rural communities – and the state was not investing enough money to fix the problem. A state investigation that year revealed that 680 community water systems serving 21 million people relied on groundwater that was compromised by one or more contaminants, with the most common being arsenic.[26]

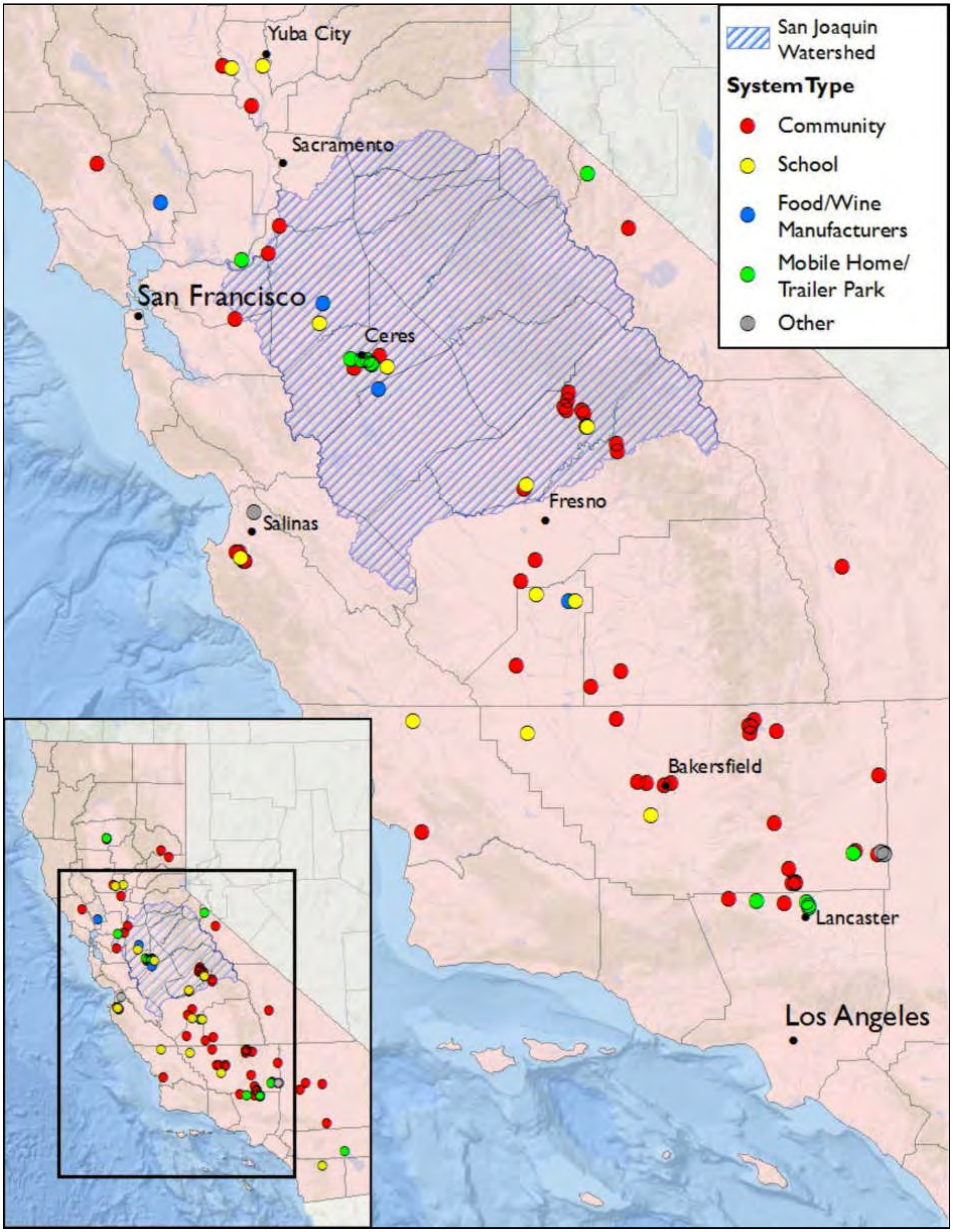
Not all of these 680 water systems provided tap water that had levels of contaminants in excess of federal health standards. In most wealthier and urban communities, the local water utilities treated the groundwater or diluted it with clean water from other wells so that it met the requirements of the federal Safe Drinking Water Act. But in 265 of these communities – often with small populations in rural, isolated areas – the tap water provided to customers had at least one violation of federal standards from 2002 to 2010 for a variety of contaminants, including nitrates from farm fertilizer, according to a 2013 report by the California Department of Health.[27]

In a separate study, researchers at the University of California, Berkeley, examined 464 community water systems serving 1.1 million people in California’s San Joaquin Valley, one of the poorest regions in the state, and found that 15 percent of the systems and 14 percent of the people had tap water with arsenic above the federal limit.[28] Of the people exposed, 61 percent were either Latino or African-American. “Community water systems serving higher percentages of people of color had a 260 percent higher chance of having at least one (arsenic) violation,” researcher Dr. Carolina L. Balazs and colleagues wrote.[29]

In response to the chronic drinking water problem, Congress had approved $1.5 billion to California over a decade to upgrade its water systems through a program called the Safe Drinking Water State Revolving Fund.[30] Yet because of bureaucratic obstacles and inefficiencies, the state by 2013 had not spent $455 million of those funds – the largest unspent balance of any state. According to EPA’s 2013 letter of noncompliance to the California Department of Health, this violated a federal requirement that the state “make *timely* loan or grants using *all available* drinking water funds.”[31]

EPA ordered the state to accelerate its efforts to fix public water systems. California Governor Jerry Brown’s administration took action in several steps. These included switching control of the state’s drinking water program from the Department of Health (where policy focus was dispersed among numerous problems, including drug abuse and AIDS), to the California State Water Resources Control Board (whose only focus is water) under the California Environmental Protection Agency. Since the EPA issued its

Map 1. Public Water Systems with Illegal Levels of Arsenic, 2014-2015



2013 letter of noncompliance, the state has more than doubled the amount of money it is distributing for water system upgrade projects, to an average of $738 million per year, compared to $366 million per year in the period of 2008 to 2012.[32] The unspent balance in the drinking water fund dropped to about $100 million.[33] As a result, EPA in May 2016 decided that California's system was back in compliance.[34]

Recent Analysis of California Records

The problem, however, is still far from fixed. An examination of California's online records by the Environmental Integrity Project (EIP) in May 2016 revealed that there were still 95 community water systems in the state, serving 55,985 people, providing drinking water with levels of arsenic that exceed the federal standard of 10 ppb in 2014 and 2015, according to two-year averages over those years.[35]

Over a longer period of time, 2011 through 2015, state records show 70 systems serving 46,772 residents, that each year have averaged higher than the limit in the Safe Drinking Water Act. These do not include homes on individual private wells, which are not covered by the federal Safe Drinking Water Act.

For a detailed discussion of the methods used to arrive at these numbers, please see Appendix C.

Examples of Drinking Water Contamination

Some of the worst water in community systems in California can be found in the Lakeview Community Association, which serves 160 residents in Shaver Lake (northeast of Fresno, in Fresno County). This community had an average arsenic concentration of nearly nine times the federal limit – 87 ppb – in 2014 and 2015, according to state data.[36]

Four water systems in the unincorporated community of Boron, in San Bernardino County, provided water to about 5,200 residents that had at least three times the safe limit of arsenic in 2014 and 2015.[37] In the city of Keyes in Stanislaus County, 4,891 people have tap water with arsenic concentrations that averaged above the federal limit each year for the last five years. The Pixley Public Utilities District, serving 3,310 residents, had arsenic levels in its drinking water that averaged 50 percent higher than health standards in 2011-2014.

Twelve school districts, serving a combined total of 5,462 students, had arsenic levels that averaged from 30 percent higher to three times the federal limit over the last five years. (See Table 4. Some of these school districts provided explanations, which will be discussed on pages 15 and 16 of this report).

Across California, there were 12 mobile home parks serving 889 people that had average arsenic levels ranging from 20 percent over legal limits to five times the federal standards from 2011 through 2015.[38]

Table 2: Top 10 Mobile Home Parks for Arsenic Contamination

Water System	County	People Served	2014-2015 Avg. (ppb)	2011-2015 Avg. (ppb)
Fountain Trailer Park Water	Kern	68	85.8	83.9
Sierra East Mobile Home Community	Mono	50	54.6	47.0*
Winterhaven Mobile Estates	Los Angeles	40	52.1	53.4
The Village Mobile Home Park	Los Angeles	70	45.1	47.0
Edgewater Mobile Home Park	Sacramento	40	38.0	37.6
Mitchell's Avenue E Mobile Home Park	Los Angeles	26	21.3	21.0
Millstream Mobile Home Park	Tehama	80	20.5	20.0
Country Western Mobile Home Park	Stanislaus	120	20.4	22.2
Saint Anthony Trailer Park	Riverside	300	19.7	21.5
New Orchard Mobile Home Park LLC	Tehama	125	19.6	19.0

Note: federal limit is 10 ppb arsenic. The 2011-2015 average for Sierra East Mobile Home Community reflects fewer than 5 years.

Response from California Officials

The Environmental Integrity Project asked the California State Water Resources Control Board why so many people are still exposed to contaminated drinking water after the state supposedly returned its system to compliance. Officials at the state agency replied in an interview and emails that they had issued orders to nearly all of the local utilities to fix the arsenic problem, but that some local government still need more time to upgrade their systems. In some cases, local utilities are building water filtration systems to remove arsenic, or digging new wells in an effort to extract cleaner water.

"The State Water Board Division of Drinking Water is working with each of these communities to return them to compliance," said Cindy Forbes, Deputy Director of the Division of Drinking Water at the Water Resources Board.[39] "District Office staff are working with these communities to evaluate alternative solutions, including new treatment options, new wells or modification of existing wells, and in some instances consolidation with larger water systems that can provide drinking water that meets all standards. The State Water Board is also helping communities that are struggling financially to reach compliance by offering financial assistance to solutions through low-interest loans and grants."

Public Notification of Drinking Water Violations

As the work continues to upgrade the drinking water systems, however, many citizens of California have not been given warnings to avoid drinking contaminated water.

The background is this: As part of the federal Safe Drinking Water Act, local water utilities are required to periodically test public drinking water systems that serve at least 25 people. When those results show more than 10 ppb arsenic (a standard imposed by EPA in 2001), the utilities must notify residents of the violation in writing by mail "as soon as practical, but within 30 days."[40] In California, however, the warning notices provide a mixed message, stating: "Our water system recently violated a drinking water standard," but also, "you do not need to use an alternative water supply (e.g., bottled water). This is not an emergency…. However, some people who drink water containing arsenic in excess of the (federal limit) over many years may experience skin damage or circulatory system problems, and may have an increased risk to getting cancer."[41] (For the full text of California's notice template for local utilities to use, see Appendix A)

This advisory says two contradictory things: Warning, you have a problem with your water. But don't worry – keep drinking it. If consumers are being told to ignore the federal health standards and keep drinking the contaminated water, there is no reason for the federal Safe Drinking Water standards for arsenic to exist. As stated previously in this report, California is much more clear about warning private well owners to "protect yourself and your family" from arsenic-tainted tap water. And other states – including Wisconsin, Michigan, Maine, and Washington – bluntly advise people not to drink private well water with more than 10 ppb arsenic.

In addition to receiving advisories about violations when they occur, customers also receive annual reports from their local water utilities called "Consumer Confidence Reports." These reports list the levels of more than a dozen different potential contaminants, including bacteria, lead, copper, nitrates and arsenic. When arsenic levels exceed the limit of 10 ppb, these reports provide the numbers and say: "Some people who drink water containing arsenic in excess of the MCL (maximum contaminant level) over many years may experience skin damage or circulatory system problems, and may have an increased risk of getting cancer."[42] But the reports do not tell consumers to stop drinking water with excessive levels of arsenic, and instead hint that it might not be a problem, saying: "Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants."

We asked the California State Water Resources Control Board why the agency doesn't tell people to avoid drinking water with illegal levels of arsenic. In response, Forbes, the deputy director for water, said that the state does provide this kind of blunt and immediate warning for other contaminants that can make consumers sick immediately, such as fecal bacteria. But for arsenic, she said, the threat is more long term. "Arsenic is categorized as a chronic contaminant that poses possible health risks after long-term exposure – 70-plus years of drinking two liters of arsenic-contaminated water a day above the maximum contaminant level," Forbes said. "There are no known acute/immediate health effects that would cause consumers to immediately stop drinking the water."

This answer, however, ignores the fact that many of these California residents have been drinking arsenic-contaminated water for decades. For example, Drs. Carolina Balazs and Isha Ray in 2014 published a study in the American Journal of Public Health in which they interviewed residents with contaminated tap water and found that the current notification requirements are poorly serving people with long-term exposure to pollutants.[43] "A resident from the community of Cutler explained that for years she had received Consumer Confidence Reports indicating that dibromochloropropane levels in the water exceeded the MCL (maximum contaminant level)," Balazs and Ray wrote. "These reports noted that residents should not worry because health impacts were not based on immediate exposure, but rather on lifetime exposure... She had lived in her community for nearly 30 years—so, she asked, should she worry or not? In these situations, water systems simply leave residents to cope with contaminated drinking water as best they can….In these instances, Safe Drinking Water Act regulations ultimately fail the (low-income) household."[44]

California's records identify more than 46,772 people whose tap water has had average levels of arsenic that have exceeded the federal standards for at least five years, from 2011 to 2015. But there is no reason to believe that these people received cleaner water before this. The longer a person drinks water contaminated with excessive levels of arsenic, the higher the increased risk of cancer. In much the same way, smoking a single cigarette is not an immediate health threat, in that it will instantly kill a person. But the longer a person smokes, the worse the health threat. For this reason, California would better protect public health if it told people to stop drinking arsenic-tainted water now, just as health warnings on tobacco required by the U.S. Food and Drug Administration advise, "WARNING: Quitting smoking now greatly reduces serious risks to your health." These advisories do not state, "WARNING: You do not need to change your smoking habits."

Evolution of the Science on Arsenic

One reason for stronger warning language is that scientific research continues to show that arsenic causes health problems – including brain damage in children -- at lower levels than previously thought.

The history of EPA's arsenic rule reflects the continuing evolution of scientific knowledge about the harms that even low levels of the element can cause. Back in 1996, Congress amended the Safe Drinking Water Act and directed EPA to establish new limits for arsenic to replace the old standard of 50 ppb. Based on the best available research, EPA proposed a limit of 5 ppb in 2000. Because arsenic is a carcinogen, some public health experts consider any level above zero to pose some risk. EPA then revised its proposal, based in part on cost considerations, and finalized a new arsenic standard of 10 ppb in 2001.

The EPA Administrator at the time, Christine Todd Whitman, explained that "the 10 ppb protects public health based on the best available science and ensures that the cost of the standard is achievable."[45] The new regulations required that public water systems across the U.S. meet the new standard by January 23, 2006.[46] The law allowed states to grant exemptions until January 23, 2015, for some small community water systems that had trouble complying.[47]

The 2014 Maine study discussed earlier in this report found found significant reductions in IQ in children exposed to arsenic concentrations of 5 to 10 ppb.[48] With this new information, EPA should change its own guidance for notification language so that people – especially parents of young children -- receive a clearer warning not to drink contaminated water. A template for warning language on the federal agency's website for drinking water systems with chemical contaminants such as arsenic advises utilities to tell their customers: "Some people who drink water containing arsenic in excess of the MCL (maxiumum contaminant level) over many years may have an increased risk of getting cancer." But the notices also say: "There is nothing you need to do….If you have specific health concerns, consult your doctor."[49] This is a problem, because many lower-income people do not have doctors with whom they can regularly consult about questions like water quality.

Responses from Local Drinking Water Systems

When asked about their drinking water violations by EIP, some of the utilities in California with illegal levels of arsenic replied that their attempts to fix the problem have been hindered by bureaucratic obstacles at the local level. Others indicated they are taking steps to solve the problem, but simply need more time or money. Not all public systems were contacted by EIP or provided answers.

Table 3. Top 10 Residential Water Systems for Arsenic Contamination (Excluding Mobile Home Parks)

System	County	Population Served	2014-2015 avg (ppb)	2011-2015 avg. (ppb)
Lakeview Improvement Association #1	Fresno	160	86.9	86.9*
Corral De Tierra Estates WC	Monterey	45	72.5	78.4
Keeler Community Service District	Inyo	50	71.3	75.6
Quail Valley Water District-Eastside System	Kern	60	70.1	69.1
MD #06 Lake Shore Park	Madera	130	64.3	71.9
Valley Teen Ranch	Madera	50	62.0	120.8
Shaver Lake Point #2	Fresno	210	52.3	42.9
Boron Community Service District	Kern	2500	38.1	38.0
Monterey Park Tract Comm. Service District	Stanislaus	186	31.9	34.3
North Edwards Water District	Kern	600	31.5	31.6

Note: The federal limit is 10 ppb arsenic. Lakeview had fewer than five years of data available.

At the **Lakeview Improvement Association** in Fresno County, 160 people have been receiving drinking water with more than eight times the legal limit of arsenic on average for at least the last five years, according to state data. State records show that on May 16, 2016, the California Water Resources Control Board issued a citation to the association's water system, imposing a fine of $1,000 for its failure to follow the directives of two earlier compliance orders, in 2014 and 2015. "The water system continues to violate the arsenic maximum contaminant level (MCL) and does not appear to be making progress toward the compliance deadline," says the most recent letter from the state. "Additionally, the water system has failed to routinely conduct the public notification of the arsenic MCL violation, as required."

Philip Dutton, an engineer for surrounding Fresno County, said that the Lakeview Association's plan, as expressed verbally, is to test some in-home water filtration systems and see how well they perform.[50] "They've got a few of these (filtration systems) installed in homes, but they are sampling from different technologies to try and identify what is going to be the best long-term alternative," Dutton said. The California State Water Resources Control Board's website already lists which types of filtration technologies work well to remove arsenic.[51]

In **Kettleman City**, in Kings County, 1,450 residents have had tap water with excessive levels of arsenic for decades. The average from 2011 to 2015 was 20 percent above the legal limit, according to state data. "I have a daughter, a little one, who's still brushing her teeth with contaminated water, taking a bath in contaminated water," said Maricela Mares-Alatorre, a city resident, during a recent public hearing of the state water board.[52] The Kettleman City Community Services District has promised local residents that it will build a $9 million water treatment plant, but the project has been repeatedly delayed – with a target to open in the fall of 2016 recently pushed back to 2018.[53]

At the **Corral De Tierra Estates** subdivision in Monterey County, 45 people have been exposed to drinking water with arsenic levels almost eight times the legal limit from at least 2011 through 2016, state records indicate. This small water system has received 10 violations notices from the state for excessive levels of arsenic over the last decade, with the most recent in the first quarter of 2016, when it had 77 ppb of the contaminant (compared to the 10 ppb limit).

The manager of Monterey County's drinking water program, Cheryl Sandoval, said Corral De Tierra Estates is among at least five privately-owned water systems that have been issued corrective orders by the county because they are in violation of the arsenic standard. Solving the problem is taking longer than expected, Sandoval said, and some of the local water utilities are still debating the best path forward. "Dealing with the problem is very complicated," Sandoval said.[54] "They haven't made a lot of progress toward compliance, but they are going to have to." One challenge is that a water treatment plant for even a small system can cost hundreds of thousands of dollars and cause new waste disposal problems, because the plants produce concentrated arsenic sludge that must be handled carefully as a hazardous material. Corral De Tierra Estates and other subdivisions want to try in-home water treatment systems as a systemic solution, but county rules don't allow that, Sandoval said. However, debate over this in-home option continues, because new state regulations may open the door for in-home filtration as a systemic solution in the future.

Meanwhile, as the bureaucratic discussions continue, residents are receiving confusing advice about whether they should drink the water pouring from their taps with illegal levels of arsenic. One recent report from Corral de Tierra Estates to local water consumers, displayed on the state website and sent to homeowners in July 2014, advised people that arsenic levels were eight times above the legal limit.[55] But that fact was buried in the middle of a dense report with lots of numbers that also gave the impression that the exceedance was not a problem. The report told homeowners: "The presence of contaminants does not necessarily indicate that the water poses a health risk."[56]

At the **Quail Valley Water District-Eastside System** in Kern County, 60 residents have been receiving drinking water with seven times the legal limit of arsenic over the last five years, state records show. In April 2015, the state issued a compliance order to the local utility and mandated that it fix the problem by April 2018.

Randy Hardenbrook, Director of the Quail Valley Water District, said the problem should be solved within the next two years because a $5.8 million grant from the state is allowing the district to build a new pipeline. The pipe will be about 8.5 miles long and will connect a part of the system with arsenic-tainted water to a well that has good water.[57] In the interim, local residents receive quarterly letters with data on the arsenic exceedances but are not being provided with bottled water. More importantly, they are not being told to refrain from consuming the contaminated water. "We're not telling them not to drink it," Hardenbrook said, "but we are telling them there are long-term health effects."[58]

At the **Shaver Lake Point #2** subdivision in Fresno County, 210 people have been receiving tap water with more than four times legal levels of arsenic for at least the last five years, according to state data. In January 2015, the state wrote to the water system's administrators and ordered them to come into compliance with the federal and state arsenic limits by December 31, 2016.

With only four months left until the deadline, the arsenic levels remain illegally high and Robert Johnson, President of the Shaver Lake Point Mutual Water Company, said he is still thinking about what to do about the problem.[59] "Currently, it's being researched. We have engineers involved. We have water experts involved, and we are trying to figure it out," Johnson said. He added that building a water filtration system could cost as much as $250,000, so the subdivision is considering trying to blend water from its arsenic-tainted wells with cleaner water from different wells.

Meanwhile, nobody in the community is being warned to avoid the contaminated water. "There is no warning not to drink it. There is no 'non-drink' order out there," said Johnson.[60] When asked if his customers should drink bottled water as a precaution instead of the arsenic-tainted tap water, Johnson said: "It's one of those things, if you want to do it, that's your deal. It's not being recommended. We're not suggesting it. This is per the state of California."

Group Home for Troubled Children

The **Valley Teen Ranch**, a Christian residential treatment group home for 32 court-referred abused and neglected boys in Madera County, has arsenic in its tap water that averaged more than 12 times the federal limit from 2011 through 2015, according to state records.[61] "We've been out of compliance, but no children have gotten sick, no adults have gotten sick," said Connie R. Clendenan, CEO of the nonprofit organization that runs the group home. "Nobody wants to drink the water here because it's brown and nasty."[62]

About five years ago, the state approved a $5 million grant to help the group home solve the problem by linking its small water system to a larger one run by the county. But the work has not started yet. Because of ongoing negotiations at the county level, the fix could still be three years or more away, Clendanan said. Meanwhile, children are being given bottled water and are verbally warned not to drink tap water, although there are no warning signs posted above sinks.

"I want to get out of the water business. I'm in the kid business," Clendenan said. Of the continuing delays in fixing the problem with contaminated water, she said: "Nobody's mad. But it's government, and it takes a lot of time. It's just the stupid county."

Table 4. Schools with Excessive Arsenic in Drinking Water

System	County	Population Served	2014-2015 avg. (ppb)	2011-2015 avg. (ppb)
Kit Carson Elem. School	Kings	510	34.7	34.7*
Washington School WS	Monterey	250	26.1	27.7
MUSD-Nile Garden School	San Joaquin	804	20.9	22.8
Liberty High School	Madera	1340	17.9	20.5*
Island Union School	Kings	300	11.9	18.8
Winship Elementary School	Sutter	38	16.4	17.3*
Lakeside School	Kern	800	16.3	16.9
Barry Elementary School	Sutter	650	15.2	15.3
Pleasant Valley Elementary	San Luis Obispo	100	13.8	14.1
Gratton School	Stanislaus	110	13.5	13.5
North Fork Union School	Madera	350	12.9	12.4
Warner Unified School District	San Diego	250	10.9	11.4
Central Union Elementary	Kings	320	10.1	13.5

*Note: federal limit is10 ppb arsenic. *Indicates systems with monitoring gaps (less than five years available data)*

Arsenic in School Drinking Water

At the **Washington School in Salinas,** California, the tap water serving about 250 students has had almost three times the federal limit of arsenic for the last five years, 28 ppb on average over this time period, compared to the limit of 10 ppb.[63] School Principal Whitney Meyer said that the local school district has been discussing the problem for several years but does not yet have a solution. Meanwhile, students are given bottled water, she said.

"We remind them over and over that they cannot drink the water," Meyer said.[64] "Many of the students live out in this area and their homes are similarly impacted (with arsenic), so they also hear the message at home. We have drinking stations with clean water in every classroom, teaching space, and hallway. The fountains have all been shut down."

At the **Barry Elementary School in Yuba City**, California, the arsenic levels have averaged 50 percent above the federal limit for arsenic over the last five years. Because of the violations, the state issued a compliance order to the school in May 2015. Tom Butcher, Director of Maintenance and Facilities for the school system, said that the school has not yet solved the problem, but is giving bottled water to students as officials try to figure out a solution.[65] Adminstrators of the water system are discussing a consolidation with a larger neighboring system that has better water. "The (state) Water Board indicates a best case scenario of a consolidation in approximately 1.5 years," Butcher said. "Until the consolidation is completed (the school district) will continue to provide bottled drinking water."

At the **Kit Carson Elementary School**, in Hanford, Ca., arsenic levels in drinking water averaged more than three times the legal limit in 2011 through 2014, according to state records. In January 2015, the school solved the problem by connecting its pipes to the water system of the surrounding city,[66] whose arsenic levels are below the federal limits.

At the **Lakeside School in Bakersfield,** California, the arsenic levels in the drinking water averaged more than 70 percent above the federal limit for arsenic over the last five years, 17 ppb compared to the limit of 10 ppb. Ty Bryson, District Superintendent, said that the school notified all families by sending home notice letters with the students and by posting warnings in the office. "We provide bottled drinking water for students and staff," Bryson said. "We drilled an alternate well, but that also had unacceptable levels of contaminant. We are now pursuing an alternative source of drinking water by connecting to a local municipal water source via pipeline."

At the **Gratton School in Denair,** California, the drinking water system has had arsenic levels that averaged 40 percent above the federal limit for arsenic over the last five years, state records indicate. The school's superintendent, Shannon Sanford, said that students have been provided bottled water for the last two years. "Students were initially warned (not to drink the water) and signs were used until fountains were disabled," Sanford said. More recently, the school drilled a new well that will be used for the 2016-2017 school year that should solve the problem.

At the **Island Union School in Lemoore,** California, arsenic levels in the drinking water were nearly twice the federal limit from 2011 to 2015, averaging 18.8 ppb compared to federal limit of 10 ppb, according to state records. Superintendent Charlotte Hines said the school dug a new well in 2015, and provided students and warnings and bottled water in the interim. "We know that bottled water is only a temporary solution," Hines said. "And in an effort to find a permanent solution, the school requested -- and was awarded -- state funding to drill a new well that would meet all primary drinking water standards."[67]

Military Base with Contaminated Water

At the **U.S. Army Base Fort Irwin** in San Bernardino County, 16,000 soldiers live in facilities that have had arsenic in some tap water at levels 50 percent higher than the federal limit from 2011 through 2015, state records indicate. For the last three years, the Army Corps of Engineers has been building a new $100 million water treatment plant at the base to solve the problem. The plant is now undergoing testing and is scheduled to go online in October 2016, base officials indicate.

"The new plant will treat all Fort Irwin water to comply with Safe Drinking Water act Standards for ALL pollutants of concern including …arsenic," said Muhammad A. Bari, Director Public Works at Fort Irwin.[68]

In the interim, soldiers have been provided with bottled water and warned which faucets to avoid, according to base managers.

Vineyards with High Arsenic Levels

In San Joaquin County, the **Delicato Family Vineyards** had arsenic levels in the tap water that averaged 18 ppb from 2011 through 2014, which was 80 percent higher than the federal limits, state records indicate. Kylie Barnett, a spokeswoman for the company, said that the vineyards worked with county officials in 2014 to build a new drinking water system, including by digging two new wells, which brought the arsenic levels down below the federal standard in 2015 and 2016.[69] "The drinking water is not used in production of our wine," Barnett noted. Before the repair, people working at the vineyards and visiting were provided bottled water, she said.

In Napa County, the **Larkmead Vineyards** had drinking water with six times more arsenic than allowed from 2011 through 2013, according to state records. No results were listed for 2014 or 2015, and it is unclear if the drinking water system, which serves 25 people, is used for workers or guests. (Wine making does not generally use tap water.) Emails sent to managers of the vineyard asking about the water were not returned. The researchers of this report also received no response from the **Black Stallion Winery** in Napa County, whose tap water had four times legal limits of arsenic from 2011 through 2015, according to state records.

Conclusion

California is making progress toward solving its drinking water contamination problem. The state has reorganized its drinking water agency, and increased its financial assistance to local utilities to build water treatment systems, dig new wells, and take other steps to resolve the issue. The work, however, is expected to take many more years. In the meantime, tens of thousands of people continue to be exposed to drinking water with illegal levels of arsenic, a carcinogen that could damage the developing brains of children and cause other health problems. And yet, the warnings that some of these residents receive from the government are contradictory and confusing.

Both California and the federal government need to do more to protect consumers, especially the young. This report recommends:

1) California and EPA should both revise the language for written notifications of violations of arsenic standards, so that people are clearly advised to stop drinking contaminated water. If the violations are in schools or group homes, warning signs should also be posted over all sinks and drinking fountains. The state should help provide bottled water as an interim solution.

2) Consumers should be provided more information through the mail about what works and what does not work to remove arsenic from tap water. Residents need to know, for example, that boiling water will not help, but that certain filtration systems can remove the carcinogen. In some cases, residents may need technical help from the state in understanding how to use filtration systems properly.

3) Both Congress and the state government should increase investments in upgrades to California's drinking water systems. This is not only an environmental justice issue, but also a sensible strategy to boost the local economy through the hiring of engineers, construction workers and others to improve local infrastructure.

Counter arguments made by California officials – that the state is already taking action, and that arsenic is not an immediate threat to public health – do not hold water. Although the state has issued enforcement orders to local utilities, some local officials clearly still need more prodding and money to upgrade their water systems. A growing amount of scientific research suggests that arsenic increases the risk of cancer and other diseases and may do so at a lower level than expressed in current federal regulations. Years more of exposure to arsenic-tainted water will only raise the risk of cancer or neurological damage for California residents.

The state and federal governments should advise people to stop drinking contaminated water immediately, just as public health experts urge smokers to change their habits sooner rather than later because it will increase their odds of survival.

With public health warnings, simple and direct is better than bureaucratic and complex, because safe is better than sorry when people's lives and minds are at risk.

APPENDIX A: California's Language for Public Notices about Arsenic Violations

IMPORTANT INFORMATION ABOUT YOUR DRINKING WATER

Este informe contiene información muy importante sobre su agua potable.
Tradúzcalo o hable con alguien que lo entienda bien.

[System] Has Levels of Arsenic Above the Drinking Water Standard

Our water system recently violated a drinking water standard. Although this is not an emergency, as our customers, you have a right to know what you should do, what happened, and what we are doing to correct this situation.

We routinely monitor for the presence of drinking water contaminants. Water sample results received on [date] showed arsenic levels of [level and units]. This is above the standard, or maximum contaminant level (MCL), of 0.010 milligrams per liter.

What should I do?

- **You do not need to use an alternative water supply (e.g., bottled water).**
- This is not an emergency. If it had been, you would have been notified immediately. However, *some people who drink water containing arsenic in excess of the MCL over many years may experience skin damage or circulatory system problems, and may have an increased risk to getting cancer.*
- If you have other health issues concerning the consumption of this water, you may wish to consult your doctor.

What happened? What is being done?

[Describe corrective action]. We anticipate resolving the problem within [estimated time frame].

For more information, please contact [name of contact] at [phone number] or [mailing address].

Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, *nursing homes, schools, and businesses). You can do this by posting this public notice in a public place or distributing copies by hand or mail.*

Secondary Notification Requirements

Upon receipt of notification from a person operating a public water system, the following notification must be given within 10 days [Health and Safety Code Section 116450(g)]:

- SCHOOLS: Must notify school employees, students, and parents (if the students are minors).
- RESIDENTIAL RENTAL PROPERTY OWNERS OR MANAGERS (including nursing homes and care facilities): Must notify tenants.
- BUSINESS PROPERTY OWNERS, MANAGERS, OR OPERATORS: Must notify employees of businesses located on the property.

This notice is being sent to you by [system].

State Water System ID#: ___________. Date distributed: ___________.

APPENDIX B: Listing of All California Public Drinking Water Systems with Arsenic Levels that Averaged Over the Federal Limit over the Last Five Years

System Name	County	Pop. Served	2014-2015 Avg (ppb)	2011-2015 Avg (ppb)	
Lakeview Improvement Association #1	Fresno	160	86.9	86.9	^
Fountain Trailer Park Water	Kern	68	85.8	83.9	*
Hungry Gulch Water System	Kern	33	72.6	70.0	*
Corral De Tierra Estates WC	Monterey	45	72.5	78.4	*
Keeler Community Service District	Inyo	50	71.3	75.6	*
Quail Valley Water District-Eastside System	Kern	60	70.1	69.1	*
CSA 70 W-4 Pioneertown	San Bernardino	625	64.5	61.6	*
MD #06 Lake Shore Park	Madera	130	64.3	71.9	*
Valley Teen Ranch	Madera	50	62.0	120.8	*
Sierra East Mobile Home Community	Mono	50	54.6	47.0	^
Shaver Lake Point #2	Fresno	210	52.3	42.9	^
Winterhaven Mobile Estates	Los Angeles	40	52.1	53.4	*
Olam Spices And Vegetables Inc.	Kings	75	48.4	46.7	*

System Name	County	Pop. Served	2014-2015 Avg (ppb)	2011-2015 Avg (ppb)	
The Village Mobile Home Park	Los Angeles	70	45.1	47.0	*
Callier Water System	San Bernardino	1000	42.1	49.2	^
Black Stallion Winery	Napa	25	41.8	41.8	^
Ironwood Camp	San Bernardino	1000	38.4	38.6	*
Boron CSD	Kern	2500	38.1	38.0	*
Edgewater Mobile Home Park	Sacramento	40	38.0	37.6	*
Prunedale MWC	Monterey	252	35.7	32.0	
Kit Carson Elem. School	Kings	510	34.7	34.7	^
Darr Water Co.	San Bernardino	1000	34.3	36.0	*
Monterey Park Tract Community Service District	Stanislaus	186	31.9	34.3	*
North Edwards WD	Kern	600	31.5	31.6	*
Desert Lake Community Service District	Kern	700	31.0	32.5	*
Locke Water Works Co [SWS]	Sacramento	80	29.5	29.1	*
Lucky 18 On Rosamond, LLC.	Kern	73	28.0	24.3	*
Washington School WS	Monterey	250	26.1	27.7	*
Rancho Marina	Sacramento	250	24.0	30.1	*
Colusa Co. WWD #1 - Grimes	Colusa	500	23.9	24.7	*
Bridgeport PUD	Mono	850	23.3	24.0	*
Country Hills Estates	San Luis Obispo	60	23.0	26.8	^
Doubletree Ranch Water System	Contra Costa	49	21.6	22.4	*
Mitchell's Avenue E Mobile Home Park	Los Angeles	26	21.3	21.0	*
Vista Del Toro WS	Monterey	87	21.0	20.4	*
MUSD-Nile Garden School	San Joaquin	804	20.9	22.8	*
Country Villa Apts.	Stanislaus	30	20.8	21.1	*
Millstream Mobile Home Park	Tehama	80	20.5	20.0	*
Country Western Mobile Home Park	Stanislaus	120	20.4	22.2	*
Saint Anthony Trailer Park	Riverside	300	19.7	21.5	*
New Orchard Mobile Home Park LLC	Tehama	125	19.6	19.0	*
MD #24 Teaford Meadow Lakes	Madera	150	19.0	12.5	
William Fisher Memorial Water Company	Kern	53	19.0	18.4	*
Ceres West Mobile Home Park	Stanislaus	161	18.9	18.0	*
Boulder Canyon Water Association	Kern	28	18.4	17.9	*
Lakeview Ranchos Mutual Water Company	Kern	120	18.1	22.4	*
Liberty High School	Madera	1340	17.9	20.5	^
Sutter Co. WWD #1 (Robbins)	Sutter	350	17.9	18.1	*
MD #42 Still Meadow	Madera	100	17.7	17.7	^
Maher Mutual Water Company	Kern	150	17.7	20.8	*
Cedar Valley Mutual Water Co.	Madera	137	17.6	18.6	^
First Mutual Water System	Kern	35	17.5	15.1	*
Sierra Co. W.W.D #1 Calpine	Sierra	225	17.0	14.1	*
Bar-Len MWC	San Bernardino	124	16.6	16.2	*

System Name	County	Pop. Served	2014-2015 Avg (ppb)	2011-2015 Avg (ppb)	
Winship Elementary School	Sutter	38	16.4	17.3	^
Lakeside School	Kern	800	16.3	16.9	*
Lanare Community Services Dist	Fresno	660	16.2	17.3	*
Delicato Vineyards	San Joaquin	25	15.6	18.3	^
Fourth Street Water System	Kern	56	15.6	14.0	*
Barry Elementary School	Sutter	650	15.2	15.3	*
Rand Communities Water District	Kern	450	15.1	15.3	*
US Army Fort Irwin	San Bernardino	16000	14.9	15.4	*
Pond Mutual Water Company	Kern	48	14.7	14.4	^
Alpaugh Community Services District	Tulare	1026	14.5	17.8	
Lands Of Promise Mutual Water Associatio	Kern	190	14.4	15.0	*
Pixley Public Util Dist	Tulare	3310	14.4	15.0	*
Caruthers Comm Serv District	Fresno	2497	14.3	15.4	*
Nord Road Water Association	Kern	32	14.2	15.0	*
Lancaster Park Mobile Home Park	Los Angeles	53	14.2	15.0	*
Mesa Del Toro MWC	Monterey	90	14.2	13.1	*
Green Run Mobile Estates	Stanislaus	100	14.0	15.1	*
Pleasant Valley Elementary	San Luis Obispo	100	13.8	14.1	*
Loch Haven Mutual Water Company	Sonoma	50	13.8	13.1	*
Gratton School	Stanislaus	110	13.5	13.5	*
Hillview Water Co-Raymond	Madera	290	13.4	17.8	
Mettler Valley Mutual	Los Angeles	100	13.0	13.1	*
Mobile Plaza Park	Stanislaus	125	13.0	12.7	*
Hilmar Cheese Company	Merced	1000	13.0	13.3	
North Fork Union School	Madera	350	12.9	12.4	*
Yosemite Forks Est Mutual	Madera	110	12.8	11.6	
MD #08 North Fork Water System	Madera	264	12.8	13.9	^
Keyes Community Services Dist.	Stanislaus	4891	12.3	12.8	*
Countryside Mobile Home Park	Stanislaus	60	12.1	12.5	*
Land Project Mutual Water Co.	Los Angeles	1500	12.1	13.5	*
El Adobe POA, Inc.	Kern	200	12.1	12.1	*
Island Union School	Kings	300	11.9	18.8	
Plumas Eureka CSD	Plumas	325	11.6	11.4	*
Kettleman City CSD	Kings	1450	11.4	12.0	*
Laguna Seca WC	Monterey	162	11.1	11.7	*
Los Molinos Comm. Services Dist.	Tehama	1500	11.1	9.0	
R.S. Mutual Water Company	Kern	67	11.0	11.1	*
Oasis Property Owners Association	Kern	100	10.9	10.8	^
Warner Unified School District	San Diego	250	10.9	11.4	^
MD #07 Marina View Heights	Madera	200	10.5	9.3	
Central Union Elementary	Kings	320	10.1	13.5	^

Note: Click on the hyperlink in the name of the system to view the state records for each water system.

** Indicates a system that has had annual concentrations averaging over the federal limit (10 ppb) each year 2011-2015*

^ Indicates that the 2011-2015 average includes years for which data was not available.

APPENDIX C:

Methods

This report is based on public data available from the California Environmental Protection Agency's State Water Resources Control Board (SWRCB) as of May 2016. We downloaded the SWRCB's Water Quality Analyses Database Files for 2011-2016 and identified public water systems that had arsenic concentrations that exceeded the 10 ppb Maximum Contaminant Level, targeting the systems with frequent exceedances between 2011 and 2015. The SWRCB database contained results for each water source used by a drinking water system, such as wells, treated or blended water, and standby wells that are only allowed to be used for a few days during a year. SWRCB warns users of its database that results in the database may not reflect the quality of water that systems actually served their customers.

Calculating average arsenic concentrations

- We calculated the average arsenic concentration from each individual water source at each water system using the sampling results available in SWRCB's database as of May 2016. Some sampling results from the end of 2015 may not have been available in the database at the time we downloaded the data in May.

- We reviewed each water system's source descriptions to determine which sources represented water served to consumers and whether the source should be included in the system-wide average arsenic concentration. For example, if the database showed that a system had two groundwater wells and a 'treated' source, we assumed that consumers would be served the treated source if results for that treated source were available each year. If the database listed a treated source in 2011, for example, but contained no data from that source for the following years, we excluded that source from the average because it was not clear if the system continued treating water for arsenic. If a system listed a source as inactive or as a 'standby' option, we excluded that source from the analysis because we could not determine when or if the water was used. We compared the selected sources with available Consumer Confidence Reports available through California's Drinking Water Watch system and narrative information in public SWRCB enforcement action documents to verify, to the extent possible, that the sources we selected represented water that was provided to consumers. If no information was available for a particular system, we relied on the assumptions described above (i.e. inactive and standby sources were not used, treated sources were used instead of untreated sources when concentrations were available for each year). We did not include purchased water sources.

- After identifying individual sources, we calculated the system's annual average arsenic concentration using the annual average concentrations from each source. The average concentrations during the two-year period between 2014 and 2015 and the five year period between 2011 and 2015 are time-weighted average concentrations (i.e. we averaged the annual average concentrations from each year). This method is similar to how the California EPA's Office of Environmental Health Hazard Assessment calculated average concentrations at drinking water systems for use in it's 2014 CalEnviroScreen 2.0 tool, except we focused on annual average concentrations from 2011-2015, rather than a single average concentration from 2005-2013.

- We excluded entire systems from the analysis if a) they were inactive, b) the available data and source descriptions did not allow us to confidently assume that customers received the sampled water at their taps, and c) the average concentration over the most recent two years (2014-2015) fell below the MCL.

Mapping Public Water Systems

To map water system locations, we found the centroids of public water system boundaries from the California Environmental Health Tracking Program's Water Systems Geographic Reporting Tool, or Water Boundary Tool (WBT). For systems without boundaries in the WBT, we determined coordinates from the addresses in the SWRCB Water Quality Analysis database files and the California Drinking Water Watch system.

Notes

[1] Based on averages for 2014-2015. Numbers in this report from the California State Water Control Resources Board online database, "Drinking Water Watch," https://sdwis.waterboards.ca.gov/PDWW/ Records accessed May, 2016.

[2] U.S. EPA (1998), Integrated Risk Information System, Inorganic Arsenic, available at http://www.epa.gov/iris/subst/0278.htm.

[3] Carolina L. Balazs, Rachel Morello-Frosch, Alan E. Hubbard and Isha Ray, "Environmental justice implications of arsenic contamination in California's San Joaquin Valley: a cross-sectional, cluster-design examining exposure and compliance in community drinking water systems," Environmental Health, 2012. Link: https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-11-84

[4] California State Water Control Resources Board online database, "Drinking Water Watch," https://sdwis.waterboards.ca.gov/PDWW/ Records accessed May. Records show 51,306 residents receiving drinking water from 2011-2015 with annual averages of more than 10 ppb.

[5] California Code of Regulations Title 22, Chapter 15, Section 64463.4(b)] reglations require notifications for arsenic exceedances. The California State Water Resources Board template for the language in notifications to be sent out by local water utilities is available on state agency's website at: http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Notices.shtml.

[6] California State Water Resources Control Board website, link: http://www.waterboards.ca.gov/drinking_water/certlic/device/watertreatmentdevices.shtml
[7] Ibid.
[8] Telephone interview with Connie R. Clendenan, CEO of the Valley Teen Ranch nonprofit organization, on August 1, 2016.
[9] Ibid.
[10] Texas Commission on Environmental Quality Notice of Drinking Water Arsenic Violation. Available at https://www.tceq.texas.gov/assets/public/permitting/watersupply/pdw/notices/chemical/arsenic.pdf
[11] Wisconsin Department of Natural Resources, Arsenic, Available at: http://dnr.wi.gov/topic/groundwater/arsenic/, accessed 3/7/2016.
[12] Florida Department of health, Brueau of Environmental Health, "Chemicals in Private Drinking Water Wells Fact Sheet- Arsenic," Available at: http://www.floridahealth.gov/environmental-health/drinking-water/_documents/arsenic-fs.pdf. Accessed 3/7/2016.
[13] See e.g. U.S. Department of Health and Human Services, (2004), "Health Consultation: Arsenic in Private Drinking Water Wells, Cornville, Yavapai County, Arizona," available at: http://www.atsdr.cdc.gov/HAC/pha/ArsenicInPrivate061504-AZ/ArsenicInPrivateHC061504.pdf, accessed 3/8/2016.
[14] Wasserman et al. (2014), A Cross-Sectional Study of Well Water Arsenic and Child IQ in Maine Schoolchildren, Environ Health 13:23-32.
[15] Based on averages for 2014-2015. Numbers from California State Water Control Resources Board online database, "Drinking Water Watch," https://sdwis.waterboards.ca.gov/PDWW/ Records accessed July 28, 2016.
[16] Letter from Jared Blumenfeld, Director of EPA's Region 9 office, to California Department of Public Health Director Dr. Ron Chapman, April 19, 2013. Link: https://www3.epa.gov/region9/water/grants/pdf/CDPHNoticeofNonCompliance.pdf
[17] U.S. Centers for Disease Control, fact sheet on arsenic. Available at http://www.cdc.gov/biomonitoring/pdf/Arsenic_FactSheet.pdf
[18] U.S. EPA (1998), Integrated Risk Information System, Inorganic Arsenic, available at http://www.epa.gov/iris/subst/0278.htm.

[19] The EPA describes arsenic's cancer-causing potency with a 'slope factor' (because it describes the slope of the dose-response curve). The current EPA slope factor for arsenic is 1.5 per mg/kg-d. This number represents the risk that can be expected from consuming one milligram of arsenic per kilogram of body weight per day. The EPA also translates the slope factor into a 'drinking water unit risk' of 5 x 10^{-5} per μg/L. For carcinogens, the formal MCL Goal is always zero. Zero is an unattainable goal, so in most cases the EPA will reduce exposure to carcinogens to a level of 'acceptable risk,' something between 10^{-6} (1 in 1,000,000) to 10^{-4} (1 in 10,000).[19] One way of looking at this range is to assume that risks less than 1 in 1,000,000 are always 'acceptable,' while risks greater than 1 in 10,000 never are. The risks of drinking arsenic at the MCL of 10 μg /L are much higher than 1 in 10,000.

[20] See, e.g., National Research Council, Critical Aspects of EPA's IRIS Assessment of Inorganic Arsenic – Interim Report, 82 – 83 (2013). For health endpoints like childhood IQ, the critical window of exposure is obviously much less, encompassing in utero development and childhood.

[21] EPA web page, "Drinking Water Arsenic Rule History," available at: https://www.epa.gov/dwreginfo/drinking-water-arsenic-rule-history.
[22] ATSDR (2007), Toxicological Profile for Arsenic; Grandjean and Landrigan (2014), Neurobehavioural Effects of Developmental Toxicity, *Lancet Neurol* 13:330-338.

[23] Wasserman et al. (2014), A Cross-Sectional Study of Well Water Arsenic and Child IQ in Maine Schoolchildren, *Environ Health* 13:23-32.

[24] Ibid.

[25] Ibid.

[26] California Water Resources Board report to the California legislature, "Communities that Rely on a Contaminated Groundwater Source for Drinking Water," January 2013. Link: http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/docs/ab2222.pdf

[27] California Water Resources Board report to the California legislature, "Communities that Rely on a Contaminated Groundwater Source for Drinking Water," January 2013. Link: http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/docs/ab2222.pdf

[28] Carolina L. Balazs and colleagues, "Environmental Justice Implications of Arsenic Contamination In California's San Joaquin Valley: a Cross-Sectional, Cluster-Design Examining Exposure and Compliance in Community Drinking Water Systems," Environmental Health, November 14, 2012. Link: https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-11-84

[29] Ibid.

[30] Letter from Jared Blumenfeld, Director of EPA's Region 9 office, to California Department of Public Health Director Dr. Ron Chapman, April 19, 2013. Link: https://www3.epa.gov/region9/water/grants/pdf/CDPHNoticeofNonCompliance.pdf

[31] Ibid.

[32] California Water Boards press release, "State Water Board, Drinking Water Revolving Fund Return to Safe Drinking Water Act Compliance," May 26, 2016. Link: http://www.waterboards.ca.gov/press_room/press_releases/2016/pr052616_cap_release.pdf

[33] Ibid.

[34] Ibid.

[35] Based on averages for 2014-2015. Numbers from California State Water Control Resources Board online database, "Drinking Water Watch," https://sdwis.waterboards.ca.gov/PDWW/ Records accessed July 28, 2016.

[36] Ibid.

[37] Ibid.

[38] Ibid.

[39] Email from Andrew DiLuccia, Public Information Officer for the California State Water Resources Control Board, containing quote from Cindy Forbes, Deputy Director of the Division of Drinking Water, on August 8, 2016. Telephone interview with Forbes on August 4, 2016.

[40] California State Water Resources Board, template for public notification of Arsenic MCL Exceedance, Link: http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Notices.shtml

[41] Ibid.

[42] Example of Consumer Confidence Report for a California system can be found on the state website: https://sdwis.waterboards.ca.gov/PDWW/JSP/WaterSystemDetail.jsp?tinwsys_is_number=370&tinwsys_st_code=CA&wsnumber=CA1000071#

[43] Carolina L. Balazs and Isha Ray, "The Drinking Water Disparities Framework: On the Origins and Persistence of Inequities in Exposure," American Journal of Public Health, April 2014, Vol 104, No. 4. Link: http://www.ncbi.nlm.nih.gov/pubmed/24524500.

[44] Ibid.

[45] Ibid.

[46] Ibid.

[47] 40 CFR 142.20(a)(2)

[48] Wasserman et al. (2014), A Cross-Sectional Study of Well Water Arsenic and Child IQ in Maine Schoolchildren, Environ Health 13:23-32.

[49] U.S. EPA public notification template on EPA website: https://www.epa.gov/dwreginfo/public-notification-templates-community-and-non-transient-non-community-water-systems

[50] Telephone interview on August 25, 2016 with Philip Dutton, engineer for Fresno County.

[51] California State Water Resources Control Board website, http://www.waterboards.ca.gov/drinking_water/certlic/device/watertreatmentdevices.shtml

[52] KFSN-TV, ABC-30 in Fresno, report "Kettleman City Residents Get Answers to Questions about Construction of Water Treatment Plant," August 31, 2016. Link: http://abc30.com/society/kettleman-city-residents-get-answers-to-questions-about-construction-of-water-treatment-plant/1493726/

[53] Ibid.

[54] Telephone interview on August 26, 2016, with Cheryl Sandoval, Supervising Environmental Health Specialist and Manager of Monterey County's drinking water program.

[55] Corral de Tierra Water Company 2013 Consumer Confidence Report, dated July 11, 2014.

[56] Ibid.

[57] Telephone interview on August 26, 2016, with Randy Hardenbrook, Director of the Quail Valley Water District.

[58] Ibid.

[59] Telephone interview on August 25, 2016, with Robert Johnson, President of the Shaver Lake Point 2 Mutual Water Company.

[60] Ibid.

[61] Numbers from California State Water Control Resources Board online database, "Drinking Water Watch," https://sdwis.waterboards.ca.gov/PDWW/ Records accessed July 28, 2016.

[62] Telephone interview with Connie R. Clendenan, CEO of the Valley Teen Ranch nonprofit organization, on August 1, 2016.

[63] Numbers from California State Water Control Resources Board online database, "Drinking Water Watch," https://sdwis.waterboards.ca.gov/PDWW/ Records accessed July 28, 2016

[64] Email from Whitney Meyer, Principal of the Washington School in Salinas, California, on August 1, 2016.

[65] Email from Robert Shemwell, Assistant Superintendent of Business Services of the Yuba City Unified School District, containing quote from Tom Butcher,Director of Maintenance and Facilities, on August 12, 2016.

[66] Email on August 24, 2016, from Liliana Stransky of the Kings County Department of Public Health.

[67] Email from Superintendent Charlotte Hines of the Island Union School in Lemoore, California, August 4, 2016.

[68] Email from Kenneth Drylie, Public Affairs Specialist at Fort Irwin, containing quotes from Muhammad A. Bari, Director Public Works at the forst, on August 11, 2016.

[69] Email from Kylie Barnett, Director Public Relations at Delicato Family Vineyards, August 10, 2016.

ENVIRONMENTAL INTEGRITY PROJECT

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

May 28, 2004

Mike Paulucci
Treatment Plants Chemist
City of Yuba City
302 Burns Drive
Yuba City, California 95991

Re: 2004 Pretreatment Evaluation

Dear Mr. Paulucci:

Enclosed is the April 30, 2004 report for our pretreatment evaluation of Yuba City. We ask that the City provide short written responses to each of the findings in Sections 2.0 to 8.0 of this inspection report by **July 30, 2003.** We expect to follow this inspection report with an Administrative Order that establishes a 12-month schedule for upgrading the pretreatment program, starting with the budget cycle on July 1.

The new NPDES permit incorporates a number of permit limits for pollutants that were unregulated in the past. There are now many pollutants of concern for which the City must develop and implement a source control program. One noteworthy finding of this inspection is that for most of the new pollutants of concern, the effluent levels for Yuba City exceed those for sewer districts representative of the industrialized Central Valley. Yuba City=s levels are partly explained by the ground water supply (*arsenic, barium*), water delivery system (*copper*), and the fact that the other districts perform advanced treatment, either nutrient removal or tertiary filtration, and thus have higher removal rates (*chromium, manganese, iron, silver*). Nevertheless, for a number of metals, non-domestic contributions appear to be the primary or at least a significant source in the Yuba City effluent (*aluminum, arsenic, copper, iron, manganese, mercury, molybdenum, selenium, and zinc*).

Otherwise, the most significant findings involve the unrepresentative self-monitoring by the industrial users over their reporting periods, the under-developed industrial user inventory, the incorrectly permitted significant industrial users, the lack of an updated sewer use ordinance as approved in 1995, and outdated local limits. Some of these issues were advanced in the EPA inspection reports and follow-up Administrative Orders to three significant industrial users in Yuba City. It is expected that their efforts to meet the requirements of their Administrative Orders will partly address the issues in this report.

Much of the City=s past efforts to regulate non-domestic contributions to the sewers will not have to be reconsidered or redone. In particular, the work done by the City to identify pollutant sources can be built upon, and the annual reports are informative. But the City will have to provide resources to do a number of required functions to address the deficiencies found in this inspection. Local limits will have to be redetermined. The ordinance will have to be updated and adopted. Permits will have to be reissued to most significant industrial users. Self-monitoring requirements will have to be re-evaluated. Fact sheets will have to be prepared. All of these requirements are outlined in the enclosed inspection report.

Thank you for your cooperation during and after this inspection. Please do not hesitate to call (415) 972-3504 or e-mail arthur.greg@epa.gov.

Sincerely,

Original signed by:
Greg V. Arthur

Greg V. Arthur
Clean Water Act Compliance Office

cc: Melissa Hall, RWQCB

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION 9

CLEAN WATER ACT COMPLIANCE OFFICE

PRETREATMENT PERFORMANCE EVALUATION INSPECTION REPORT

NPDES Permittee:	City of Yuba City 302 Burns Drive, Yuba City, California 95991 Wastewater Treatment Plant (NPDES CA0079260) WDRs Orders R5-2003-0085
Dates of Inspection:	August 5, August 20-21, August 27, 2003
Data Review:	Influent and Effluent Conventional: 2003 – 2004 Influent and Effluent Toxics: 2000 – 2004 Sludge toxics: 2000 – 2004

Inspection Participants:

US EPA:	Greg V. Arthur, CWA Compliance Office, (415) 972-3504 Meg Masquelier, CWA Compliance Office, (415) 972-3536
RWQCB:	No Representative
Yuba City:	Mike Paulucci, Chemist, (530) 822-7695 Al Butterfield, Chief Plant Operator
Industrial Users:	Sunsweet Growers, Jerry Ramsey, Engr Mgr, (530) 751-5278 Greenleaf Unit 2, Diane Tullos, Compliance Mgr, (530) 821-2074 Custom Chrome, Gene Hutchinson, Owner, (530) 673-2360

Report Prepared By: Greg V. Arthur, Environmental Engineer
April 30, 2004

Section 1

Introduction and Background

1.0 Scope and Purpose

In April 2004, EPA completed a performance evaluation of the regulatory control of non-domestic wastewaters discharged into the City of Yuba City wastewater treatment plant (“WWTP”). This performance evaluation was one of a series of reviews of small publicly-owned treatment works that accept non-domestic contributions, many of which are not large enough to be mandated to operate EPA-approved pretreatment programs. Yuba City is large enough and has operated an EPA-approved pretreatment program since 1982.

The scope of this performance evaluation comprised:

- Sampling inspection of the Yuba City wastewater treatment plant on August 27, 2003;
- Review of the 2003-2004 Yuba City self-monitoring reports;
- Review of the 2000-2004 influent and effluent sampling records for toxic pollutants;
- Inspections of three significant industrial users including the sampling of two of them;
- Review of the 2000-2003 sampling records for the significant industrial users inspected;
- Interviews with City representatives on August 5, August 20-21, and August 27, 2003;
- Review of the industrial responses to their inspection reports and enforcement actions.

The purpose of this evaluation was to determine if non-domestic discharges into the Yuba City sewer system are properly controlled. The evaluation findings were measured against two fundamental performance objectives. The first is the prevention of sewage treatment works pass-through, interference and sludge contamination as shown by compliance with the Federal sludge limits, the discharge permit limits, and any expected future Clean Water Act requirements. The second is the consistent compliance by the industrial users with their own Clean Water Act requirements, in particular with the Federal best-available-technology standards that apply to certain industrial categories, and any national prohibitions and local limits for pollutants associated with treatment works non-compliance.

This report covers the performance of the pretreatment program as it currently exists in Yuba City. Some pertinent findings from the industrial user inspections are also incorporated. The significant industrial users received individual reports and enforcement actions. Arthur collected samples on August 20, 21, and 27, 2003 for delivery to the EPA Richmond Lab.

1.1 Yuba City Wastewater Treatment Plant

The Yuba City WWTP is a pure-oxygen activated sludge plant that discharges either by diffuser to the Feather River in the winter wet-season or to 120 acres of percolation ponds located alongside the river in the summer dry-season. The wastewater treatment plant provides high-rate treatment of higher-than-typical-strength wastewaters. It has a dry-weather design capacity of 7.0 million gallons per day (“mgd”) and a wet-weather design capacity of 11.0 mgd. The average and calculated peak flows were 6.60 and 8.05 mgd in 2003. See Figure 1.

- Primary and Secondary Treatment - The headworks, which provide grinding and aerated grit removal, is followed by primary sedimentation. Ammonia and phosphates are added, usually in the summer, in order to precondition the high-strength and nutrient-poor contributions from Sunsweet Growers. Primary effluent is then aerobically biodegraded in three treatment trains each with four compressed-gas pure-oxygen aeration cells followed by three secondary clarifiers. Activated sludge returns without re-aeration in order to strip carbon dioxide, and does so at rates to support a mean cell residence time of around 3 days. Real-time metering for dissolved oxygen, solids, and redox potential are used to better ensure the treatment plant can respond to the contributions from Sunsweet.

- Advanced Treatment - There is no capability to provide nitrification or denitrification. There is also no tertiary polishing of secondary effluent and, as a result, no capability to reuse treated wastewater off-site.

- Solids Handling - Waste secondary activated sludge and primary sludge are digested in two anaerobic digestors each with detention times of 25 days and operated in series. Digested sludge dosed with anionic polymer is dewatered through belt pressing, with the cake further dewatered in on-site sludge drying beds for off-site disposal as landfill cover. Grit is hauled off-site to a landfill. The waste activated sludge is first thickened in two polymer-aided dissolved air flotation units. Belt press filtrate returns to the lateral leading into the headworks. Dissolved air flotation subnatant returns to the aeration cells.

- WWTP Sampling - The influent sampling point, located upstream of the headworks is designated as IWD-YC1 for the purposes of this report. All return flows except the belt press filtrate rejoin treatment downstream of influent sampling. The effluent compliance sample point, sited immediately after final dechlorination, is designated as IWD-YC2. The accumulation of filter cake for hauling off-site is designated as the sludge sampling point, IWD-YC3. The receiving water sampling point downstream of the Yuba City outfall is designated in the permit as R-1.

- Water Supply - For most of its sewered users, Yuba City provides surface water drawn from the Feather River and treated through its water treatment plant. Some sewered customers located outside of the city limits receive untreated ground water from the former Hillcrest Water Company system. According to the City’s Urban Water Management Plan, an estimated 1,000 of the 9,020 water users receive the more mineralized ground water. For the purposes of this report, a ratio of 1:9 ground to surface water was used in estimating the flow-weighted average concentrations for the water supply.

- Receiving Water Hardness - The USGS maintains a station on the Feather River at Nicolaus, approximately 13 miles downstream from the Yuba City outfall. This station and six others in Sacramento River basin were extensively sampled under a full range of conditions for conventional, toxic, and pesticide-related pollutants, as part of the 1995-1998 National Water Quality Assessment Program. The calculated 99th% minimum hardness and the minimum sample result for the Feather River station was 22.6 mg/l and 22 mg/l as CaCO3. The lowest minimum sample result recorded for all seven stations both upstream and downstream of the Feather River station was 16 mg/l. For the purposes of this report, a hardness of 22.6 mg/l is used in the calculations of the permit limits for metals to be in effect in 2007. By then, Yuba City will have a better data set of hardness values for the Feather River near the outfall, as required by the NPDES permit.

1.2 Sewer Service Area

The Yuba City sewer service area comprises the incorporated area of the city that receives city supplied surface water as well as the unincorporated county lands southwest of the city limits that receive ground water. The WWTP also serves as a regional disposal point for septage collected from septic tanks in unsewered areas within both the city limits and in the outlying county land. According to the City's Urban Water Management Plant, the service area has a population in 2004 estimated to be 60,000, and 950 commercial and four industrial users, who together contribute 35-40% of the sewered wastewater. The inventory of industrial users includes at least seven considered to be significant industrial users who together discharged an average of 930,000 gallons per day into the sewers in 2003 (14% of total flows).

1.3 Discharge Requirements

Yuba City is authorized by the June 6, 2003 RWQCB Waste Discharge Requirements, Order R5-2003-0085, ("WDRs"), and a concurrent Cease and Desist Order, Order No. R5-2003-0086, ("CDO"), to discharge treated sewage from the Yuba City WWTP either to the Feather River or to percolation ponds sited along the river or from the percolation ponds to the Feather River. The WDRs also function as National Pollutant Discharge Elimination System ("NPDES") permit CA0079260. The WDRs contain narrative prohibitions, effluent limits that implement the California Toxics Rule, receiving water limitations, monitoring requirements, pretreatment provisions, and sludge disposal requirements. In essence, the WDRs and CDO together require Yuba City to comply with effluent limits for conventional pollutants, disinfection, and pH upon issuance of the permit and for pesticides, metals, surfactants, toxic organics, ammonia, and nitrates by November 2007.

The effluent limitations for a discharge to the Feather River are for conventional pollutants, total coliform, ammonia based on temperature and pH, nitrites and nitrates, surfactants, residual chlorine, pH, acute biotoxicity, and various pesticides, metals, and toxic organics. The effluent limits that take effect on November 1, 2007 are for additional metals based on the hardness in the river, and for additional toxic organics. The CDO required the completion of the corrective steps necessary to meet the WDRs for organochlorine pesticides, thiobencarb, aluminum, ammonia, arsenic, chloroform, diazinon, cis-1,2-dichloroethene, ethion, iron, manganese, MTBE, surfactants, molybdenum, and nitrates also by November 1, 2007.

The limitations for a discharge to percolation ponds are limited to narrative prohibitions against public contact, objectionable odors, anoxic conditions, the proliferation of mosquitoes, inadequate freeboard, degraded ground waters, and exceeding numerical limitations for pH. The receiving water limitations include narrative provisions against causing a visible film, discoloration, objectionable growths, nuisance conditions, the bioaccumulation of toxics, bad tasting fish, increased temperatures over 5°F, increased turbidity, increased specific conductivity, high or low pH's, and any adverse effect on the beneficial uses of the receiving waters.

1.4 Legal Authorities

Yuba City obtained approval of its pretreatment program in 1982. Yuba City operates under the authority of Public Works Title 6, Wastewater Collection and Treatment Chapter 5 of its municipal code as adopted in 1976. Yuba City began the process of revising its ordinance to be in accord-ance with the requirements of 40 CFR 403 in the late 1980's and submitted a draft ordinance for review in 1990. EPA and the RWQCB provided numerous and extensive reviews of the ordinance culminating in an approval letter from the RWQCB issued on November 29, 1995. Yuba City has not readopted the revised ordinance. As a result, the local limits and the regulatory provisions in effect are those in the 1976 ordinance. The WDRs since 1990 have imposed pretreatment provisions that require implementation of the regulatory controls necessary to enact all of 40 CFR 403. The current WDRs issued in June 2003, require Yuba City to resubmit pretreatment program for approval. Requirements to obtain and implement an approved pretreatment program would include the following:

- The implementation of the general and specific national prohibitions in 40 CFR 403.5 for industrial users against the introduction of incompatible wastewaters;
- The requirement in 40 CFR 403.5 to develop locally-determined limits necessary to protect the treatment works from potential adverse impacts, such as operational interference, worker health and safety risks, the pass-through of pollutants to the receiving waters, and sludge contamination;
- The performance of the program functions set forth in 40 CFR 403.8, such as identifying industrial users, issuing permits, inspecting and sampling industrial users, providing adequate funding, and enforcing against violators;
- The implementation of an industrial users self-monitoring program under 40 CFR 403.12;
- The implementation of Federal categorical standards under 40 CFR 403.6; and
- The enacting of the local legal authorities necessary to operate an approved pretreatment program under 40 CFR 403.8.

Section 1 – Introduction and Background

This evaluation did not involve a review of the 1976 ordinance because the proposed 1990 revised ordinance has not been adopted. As a result, the administrative record since the late 1980’s stands as the determination that Yuba City does not have the legal authority to implement all aspects of an approved pretreatment program.

Section 2

Wastewater Treatment Plant Performance

The Yuba City WWTP must meet permit effluent limits for conventional pollutants, nutrients, pesticides, metals, toxic organics, pH, surfactants, and biotoxicity. 40 CFR 403.5(a,b,c) and 403.6.

Non-domestic wastewaters may not result in unpermitted releases, hazardous or explosive conditions with the sewers, or operational interferences in the collection system. 40 CFR 403.5(b).

2.0 Summary

The WWTP has the capacity and capability to handle the domestic wastewaters in the Yuba City service area as well as the high-strength wastes generated by Sunsweet. However, without a change in the influent loadings, removal rates, or disinfection methods, the WWTP is expected to experience the pass-through of a number of metals, chlorination byproducts, toxic organics, and pesticides once their NPDES permit limits take full effect in 2007. Moreover, without nitrification and denitrification, the WWTP is also expected to experience the pass-through of ammonia and the toxicity associated with ammonia. Finally, the nutrient-poor nature of Sunsweet's contributions caused operational interferences related to WWTP responses, however, better metering has lessened those risks.

<u>See</u> Tables 1 - 3 for wastewater and sludge summaries, Table 4 for statistical probabilities of violation, Table 5 for a comparison of Yuba City with representative Central Valley sewer districts, Table 6 for the EPA sampling results, and Table 8 for the definitions of 'pass-through' and 'interference'.

Requirements

- The domestic, non-domestic, and water supply sources of aluminum, arsenic, copper, iron, manganese, molybdenum, and zinc must be identified and quantified.

Recommendations

- The wastewater treatment plant influent should be monitored for aluminum, arsenic, copper, iron, manganese, mercury, molybdenum, selenium, and zinc.
- The receiving waters should be monitored for hardness, pH, and temperature.
- The cause of the instances of low pH in the influent should be determined.

Recommendations – continued

- Corrosion controls of the water delivery system should be implemented in order to reduce the leaching of copper, thereby reducing the copper discharged from the treatment plant.

- Sunsweet and septage deliveries should be monitored for the farm-related contaminants such as arsenic and selenium.

- Sunsweet and the power plants should be monitored for the corrosion-related contaminants associated with circulating water systems such as iron, molybdenum, and zinc.

- A specific prohibition against abrupt changes in organic loads, such as a restriction in the percentage change in mass loads per day, should be considered for Sunsweet.

- The water service newsletter should be supplemented to also inform rate payers of the wastewater compliance status and the on-going need to fund the capital improvements, pretreatment, and operations to protect and maintain the public wastewater investment.

2.1 Conventional Pollutants

The WWTP produces high-quality secondary-treated wastewaters. As a result, it consistently complies with its permit limits for conventional pollutants. The average and calculated 99th% peaks are less than 11 and 22 mg/l BOD and 9 and 16 mg/l TSS even through Sunsweet's contributions elevate the average influent BOD to 339 mg/l. The WWTP discharged to the percolation basins May 1 through October 31, and to the river otherwise.

There were four instances of the effluent pH below the lower 6.5 limit and one above the upper 8.5 limit. There were also two unrelated instances of low influent pH, (2.62 on 11/14/03 and 4.99 on 11/22/03). The national prohibitions not only prohibit discharges that cause structural damage to the sewerage works but also specifically prohibit discharges below 5.0 s.u. because pHs below that level are known to cause concrete degradation.

2.2 Ammonia Toxicity

The permit sets sliding-scale effluent limits for ammonia which are most stringent when pH and temperature are high. During the winter wet-season when the WWTP discharges to the Feather River, the monthly-average and sample-maximum ammonia limits bottom out at 3.56 and 19.7 mg/l based on and assumed maximums for pH and temperature of 7.2 s.u and 70ºF. Sampling required by the permit would result in actual values for maximum pH and temperature in the Feather River and better establish the ammonia limits. Against these preliminary sliding-scale ammonia limits, the WWTP inconsistently complies when it discharges to the river, with the average and calculated 99th% peak ammonia concentrations of 12.9 and 36.9 mg/l. As a result, there is a >20% chance of violating the lowest expected maximum limit and 99%+ chance of violating the lowest expected monthly-average limit.

2.3 Nitrates Plus Nitrites

The WWTP complies with the permit limits for nitrite plus nitrate of 10 mg/l primarily because it does not nitrify by design. The WWTP would be expected to comply with the permit limits upon the 2007 compliance deadline only upon completion of upgrades for both full nitrification and denitrification.

2.4 Salts

The permit does not limit salts but requires monitoring for total dissolved solids, hardness, and electrical conductivity. The monitoring results for salts are all well below what could adversely impact reuse, or in the case of sulfate, impart an acute toxicity.

2.5 Toxic Metals

Without decreased loadings, corrosion controls, or increased removals, the WWTP would be expected to exceed the permit limits for aluminum, arsenic, copper, iron, lead, manganese, molybdenum, and zinc. See Table 2 for a summary of toxics in the influent, effluent, and water supply, Table 4 for statistical probabilities of exceeding limits, and Table 5 for comparisons with representative of Central Valley sewer districts with industrial contributions. (The sewer districts selected for comparison were Deer Creek, El Dorado Hills, Grass Valley, Nevada City, Placer County No.1, Red Bluff, and Stockton.)

For most metals, the effluent concentration averages for Yuba City exceed the averages for sewer districts representative of the industrialized Central Valley. Elevated levels for Yuba City are partly explained by the water supply (*arsenic, barium*), water delivery (*copper*), and the fact that the other districts perform advanced treatment of some sort, either nutrient removal or tertiary filtration, and thus have higher removal rates (*chromium, manganese, iron, silver*). Nevertheless, for a number of metals, unidentified non-domestic contributions appear to be the primary or at least a significant cause of the elevated levels in the Yuba City effluent *(aluminum, iron, manganese, mercury, molybdenum, selenium, zinc*).

Aluminum - Influent concentrations are significantly higher than can be explained by the water supply or known non-domestic sources. In fact, the influent levels are so high, up to 6,225 µg/l, that the sources are likely limited to utilities' use of alum for water, wastewater, or sludge conditioning or water conditioning at industries that discharge the generated sludges or backwashes. A sample of 3,600 µg/l from Greenleaf Unit 2 partly bears this out. Since the 85%+ removal rate is typical for secondary wastewater treatment, not only the influent but also effluent concentrations far exceed the averages for representative Central

Valley sewer districts. The effluent average and calculated 99th% peaks are 256 and 571 µg/l resulting in a >80% chance of a sample violating the 120 µg/l maximum limit.

Arsenic - Influent concentrations are higher than can be explained by known sources. The ground water used in part of the city accounts for nearly half of the elevated influent levels. However, for the remainder, arsenic in fruit pesticides makes it possible that fruit washing at Sunsweet and farm-related run-off or septage are likely sources that account for the increases from 2.5 µg/l in the water supply to 6.1 µg/l in the influent. Both the average influent and effluent concentrations are >400% higher for Yuba City than for representative Central Valley sewer districts. The effluent average and calculated 99% peaks are 7.8 and 33.5 µg/l which result in a >40% chance of samples violating the 10 µg/l monthly limit.

Barium - The permit does not set effluent limits for barium. Average effluent concentrations are >400% higher than representative Central Valley sewer districts, and ground water may account for nearly half of the elevated levels. Potential non-domestic sources might include the removal of barium sulfate deposits from circulating cooling water circuits.

Cadmium - The industrial discharge from Custom Chrome is the likely source of the small concentrations of cadmium found in the influent and effluent. No cadmium was detected in the water supply and the WWTP levels are consistent with those for representative Central Valley sewer districts. The effluent average and calculated 99% peaks are 0.17 and 0.31 µg/l which result in far less than a 1% chance of a sample exceeding the calculated 0.85 µg/l maximum limit.

Chromium - The industrial discharge from Custom Chrome is the likely source of the small concentrations of chromium found in the influent and effluent. No chromium was detected in the water supply and the WWTP levels are consistent with those for representative Central Valley sewer districts. The effluent average and calculated 99% peaks are 0.94 and 1.14 µg/l which result in far less than a 1% chance of a sample exceeding the calculated 106 µg/l maximum limit.

Copper – Corrosion of household plumbing appears to be the principal source. Surveys conducted by Yuba City found 10% of the households with copper concentrations at their taps over 199 µg/l if served by surface water and 459 µg/l if served by ground water. These concentrations are high enough to account for the significant increases from 1.3 µg/l in the surface water supply to 50.1 µg/l in the WWTP influent. The removal rate of 80%+ is in the typical range for secondary wastewater treatment. As a result, the effluent average and calculated 99th% peaks are 8.5 and 18.7 µg/l which result in a >90% chance of a sample violating the 2.65 µg/l maximum limit. This means Yuba City is likely to nearly always exceed permit limits without preconditioning the water supply to inhibit corrosion.

The principal corrosion control methods in use by other water suppliers include the following:

- carbonate passivation of copper pipes through the increase of both pH and alkalinity,
- silicate passivation of copper pipes through the application of sodium silicates and sodium carbonate, and
- precipitation of scale within the pipes through the supersaturation of calcium.

(EPA publication EPA-811-B-92-002, September 1992, "Lead and Copper Rule Guidance Manual, Vol. II: Corrosion Control Treatment).

Iron - Lone samples of 15,000 and 9,800 µg/l from Sunsweet and Greenleaf Unit 2, respectively, could easily account for the significant increase between the flow-weighted average of 25.3 µg/l for the water supply and the average WWTP influent of 960 µg/l. The removal rate of 80%+ is typical for secondary wastewater treatment. The effluent concentrations exceed the averages for repre-sentative Central Valley sewer districts. The effluent average and calculated 99th% peaks are 164 and 309 µg/l which result in a slight >1% chance of a sample violating the 300 µg/l maximum limit.

Lead - There is not enough data to make conclusions regarding future compliance with the 0.83 µg/l maximum or 0.38 µg/l monthly-average limits. All water supply samples were below detection, but the 1 µg/l detection limit is over the limits.

Manganese - Effluent concentrations are far higher than typical for representative Central Valley sewer districts because treatment plant removals are essentially 0% in Yuba City but between 60% and 97% at the representative Central Valley sewer districts. The effluent average and calculated 99th% peaks are 53 and 156 µg/l which result in a >50% chance of a sample violating the 50 µg/l maximum limit. Influent concentrations are typical for representative sewer districts, although there are no sources identified at this time that could account for the increase between the flow-weighted average for the water supply of 11.5 µg/l and the WWTP influent of 49.8 µg/l.

Mercury – There is a negligible chance of even a single sample violating the 0.05 µg/l monthly-average limit, even though both influent and effluent concentrations exceed the averages for representative Central Valley sewer districts. The removal rate of 95%+ is typical for secondary wastewater treatment. Effluent average and calculated 99th% peaks are 0.017 and 0.048 µg/l.

Molybdenum - Molybdate is a corrosion inhibitor in widespread use in circulating cooling water circuits, which account for a significant fraction of the non-domestic contributions into the Yuba City sewers. As a result, circulated cooling at Sunsweet and the power plants are likely sources of the significant increase in the average concentration from less than 1.0 µg/l in the water supply to 10.3 µg/l in the influent. Both influent and effluent concentrations exceed the averages for the representative Central Valley sewer district with molybdenum samples. The effluent average and calculated 99th% peaks for Yuba City are 11.0 and 31.6 µg/l which result in a >50% chance of a sample violating the 10 µg/l maximum limit.

Nickel - The industrial discharge from Custom Chrome is the likely source of the small concentrations of nickel found in the influent and effluent. No nickel was detected in the water supply and the WWTP levels are consistent with representative Central Valley sewer districts. The effluent average and calculated 99th% peak concentrations are 1.78 and 3.96 µg/l, which result in less than a 1% chance of a sample violating the 23.6 µg/l maximum limits.

Selenium - The permit does not set effluent limits. Selenium has farm-related uses in veterinary medicine, fungicides, and insecticides. As a result, fruit washing at Sunsweet and farm related run-off or septage are likely sources of the increase in the average concentration from less than 1.0 µg/l in the water supply to 7.1 µg/l in the influent. Both influent and effluent concentrations far exceed the averages for the representative Central Valley sewer district. The effluent average and calculated 99th% peaks for Yuba City are 7.1 and 44.7 µg/l.

Silver - There is not enough data to make conclusions regarding future compliance with the 0.31 µg/l maximum limits, even though the single effluent sample exceeded the limit. All water supply samples were below detection, but the 1 µg/l detection limit is over the limit.

Zinc - Zinc phosphates are corrosion inhibitors in widespread use in circulating cooling water circuits, which account for a significant fraction of the non-domestic contributions into the Yuba City sewers. As a result, the circulated cooling at Sunsweet and the power plants are likely sources of the huge increase in the average concentration from less than 1.0 µg/l in the water supply to 157 µg/l in the influent. The influent and effluent concentrations are within the ranges at the representative Central Valley sewer districts. The effluent average and calculated 99th% peaks for Yuba City are 51.8 and 86.7 µg/l which result in a >80% chance of a sample violating the 34.0 µg/l maximum limit.

2.6 Toxic Organics and Pesticides

A number of other toxic pollutants were detected but most of them did not or will not exceed the permit limits. Those detected but not exceeding permit limits include MTBE (*methyl-tert-butyl ether*). The principle exceptions were the permit limits for two chlorination byproducts (*dichloro-bromomethane, dibromochromomethane*), a pesticide (*diazinon*), and two chlorinated solvents (*chloroform, tetrachloroethylene*). However, no definitive conclusions regarding any of these pollutants can be made at this time because there are only three samples for each and the permit limits are not much higher than the detection limits.

2.7 Federal Sludge Limits

The WWTP sludges consistently comply with the Federal sludge limits for disposal as landfill cover. The WWTP sludges also would likely consistently comply with the Federal clean sludge limits suitable for any reuse in Table 3 of 40 CFR 503.13 although the more stringent limits do not apply as long as the Yuba City disposes of sludge as landfill cover.

2.8 WWTP Interference

Sunsweet poses two operational risks to the Yuba City treatment works. First, sharp drops in loadings have in the past resulted in operational interferences at the WWTP related to the treatability of the nutrient-deficient discharges from Sunsweet and the responsive dosing of nutrients by Yuba City. Second, the high-strength organic discharges could cause sulfide degradation of concrete sewers if they become anoxic.

Yuba City has instituted permit requirements to Sunsweet to keep the pH above 8.5 and to provide 48-hour prior notification for impending shutdowns of more than 24 hours. Yuba City also has real-time probes with automatic alarms for dissolved oxygen, solids, and redox potential at various locations in the WWTP. Nevertheless, within the permit requirements, the variabilities in the organics, suspended solids, and hydraulic loadings from Sunsweet still have the potential to be large enough to adversely effect the operation of the WWTP because the mitigating actions rely solely on operators and procedures. It would be better for the City if Sunsweet installed some form of built-in load equalization that does not rely on operating procedures. See the February 20, 2004 EPA report of the inspection of Sunsweet and Sunsweet’s May 26, 2004 response for a larger discussion.

Section 3

Local Limits

Pretreatment programs are required to develop local limits to prevent pass-through, interference, sludge contamination or other adverse effects upon the treatment works. 40 CFR 403.5(c).

3.0 Summary

Yuba City has an ordinance to prohibit discharges that exceed local limits or could harm the treatment works. However, the technical basis of the local limits is questionable since they are not based on the current conditions or permit. Furthermore, Yuba City did not adopt an updated sewer ordinance reviewed by EPA and approved by the RWQCB to reflect changes in the Federal pretreatment rule promulgated after 1982. Sampling has indicated that without a change in the influent loadings, or removal rates, the WWTP would be expected to experience the pass-through of a number of metals, toxic organics, and pesticides once the permit limits take full effect in 2007. See Table 7 for a definition of 'local limits'. Also see Item 1.4 of this report for more detail regarding Yuba City's legal authority.

Requirements

- Yuba City must determine the maximum allowable headworks loadings for aluminum, arsenic, copper, iron, manganese, molybdenum, and zinc, and enact new local limits, prohibitions or control strategies.

- The sewer use ordinance must be updated to reflect the changes in the Federal rules.

Recommendations

- The WWTP influent and effluent should be sampled to determine whether diazinon, chloroform, tetrachloroethylene are pollutants of concern present at levels above their detection limits.

3.1 Sewer Use Ordinance

This pretreatment program evaluation did not include a new review of the sewer use ordinance. However, the ordinance has not be updated to reflect the changes in the Federal pretreatment rules in the ways outlined in the reviews by EPA of the ordinance and culminating in the approval letter issued by the RWQCB on November 29, 1985.

3.2 National Prohibitions

The national prohibitions apply to every non-domestic discharge into the sewers nationwide to prevent harm to the treatment works. They consist of the general prohibitions in 40 CFR 403.5(a) against harm and the specific prohibitions in 40 CFR 403.5(b). In practice, local limits, covering a range of pollutants, and developed in accordance with 40 CFR 403.5(c), replace most of the effective span of the national prohibitions.

3.3 Pollutants of Concern

The pollutants of concern are those related to non-domestic sources with a statistical chance of over 1% to cause a violation of the WDRs or the Federal sludge limits. The pollutants with a statistical chance over 1% are aluminum, ammonia, arsenic, chloroform, copper, diazinon, dibromochloro-methane, dichlorobromomethane, iron, lead, manganese, molybdenum, tetrachloroethylene, and zinc. Of these, dibromochloromethane and dichromobromomethane would not be pollutants of concern because they are chlorination by-product unrelated to influent quality. Ammonia and nitrates also would not be pollutants of concern because their effluent concentrations are a function of the treatment plant operations. It cannot be determined without further monitoring of both the influent and effluent whether diazinon, chloroform, and tetrachloroethylene are pollutants of concern.

A number of other pollutants with a statistical chance below 1% to cause a violation, nevertheless, should be pollutants of concern because of discernible sources. Cadmium, chromium, and nickel are entrained in solution and rinse tanks at metal finishers (*Custom Chrome*). Selenium is associated with farm-related uses (*Sunsweet, septage*). Lead and barium are scoured from boilers (*Sunsweet, power plant*). Mercury has non-domestic commercial sources (*dentists*). MTBE at aquifer clean-up sites are pollutants of site-specific concern. And oil & grease is a concern in every sewer district.

3.4 Maximum Allowable Headworks Loadings

Every sewer district must determine the maximum loading of pollutants it can accept and still comply with the permit requirements and Federal sludge limits. The maximum allowable headworks loadings (“MAHLs”) form the technical basis for determining local limits. All this requires influent, effluent, and sludge monitoring under the range of conditions expected during the year, in order to determine the WWTP removal efficiencies. EPA has a free spread sheet program called Prelim to assist in the calculations. WEF also has a fate and transport model available for purchase on its web-site.

3.5 Allocation Method

The MAHLs for each of the pollutants of concern must be allocated between uncontrollable and controllable sources. The uncontrollable sources comprise domestic sewage, and infiltration and inflow. The controllable sources are those that could be regulated under permits or best-management practices. This will require background monitoring of domestic sewage, and infiltration and inflow, in order to determine the pollutant loadings that cannot be allocated to the controllable sources. The remaining loadings can then be allocated in any fashion to the individual industrial and commercial sources. For example, Yuba City could set different local limits by individual industrial discharge, or by flow-weighted average, or uniformily across the entire service area for some pollutants but differentially set for others. The allocation method does not matter as long as the total allocation out to the domestic and non-domestic users does not exceed the calculated MAHLs.

It is possible that the main sources of certain pollutants are domestic in nature and largely uncontrollable by ordinance through permitting or best-management practices. For example, significant loadings of copper likely come from the delivery pipes and pesticides may come primarily from infiltration and inflow off of nearby fields, or household use. In these cases, Yuba City would have to redetermine the MAHLs after the sources are mitigated through some other means.

3.6 Industrial User Compliance with Local Limits

The Federal regulations do not define how to determine regulatory success. Moreover, any conclusion regarding industrial user compliance with the local limits would be premature since they are not technically-based to protect the Yuba City treatment works from adverse impacts, and the sources of the pollutants of concern are not yet identified. Once the local limits are sound and implemented through industrial user permits, however, the following performance measures determine regulatory success in achieving industrial user compliance.

- <u>Treatment Plant Performance</u> - EPA Region 9 bases its primary determinations on the purpose of local limits and the national prohibitions to prevent pass-through, interference, sludge con-tamination, or potential worker safety risks. As a result, the best measure of a program's effectiveness is consistent compliance with the NPDES permit and sludge limits. By this measure, Yuba City would not be successful if the pass-through of aluminum, arsenic, chloro-form, copper, diazinon, iron, lead, manganese, molybdenum, tetrechloroethylene, and zinc continues to persist.

- <u>Cost Effective On-Site Treatment</u> - Conventional pollutants can be treated at the sources and the sewage treatment plant. In general, primary treatment for solids and organics, pH adjustment, and gravity oil-water separation, are cost effective at the sources, while secondary treatment for dissolved organics, nitrification and denitrification are much more cost effective at the sewage treatment plant. On the other hand, toxics must be entirely controlled by the sources since sewage treatment plants are not designed to for toxics. By this measure, Yuba City would not be successful in ensuring all non-domestic dischargers of acidic and alkaline wastewaters provide final pH adjustment.

- Significant Non-Compliance - Significant non-compliance will be based on industrial user compliance rates once the local limits are re-developed and implemented into the permits.

Section 4

Industrial User Compliance with Federal Standards

Pretreatment programs are required to be administered to ensure industrial user compliance with Federal categorical pretreatment standards. 40 CFR 403.8(b).

4.0 Summary

Best-available-technology ("BAT") treatment or its equivalent was not applied and in place at the identified Federally-regulated industrial process within the Yuba City service area.

Requirements

- Compliance sampling points, monitoring requirements, and on-demand rinsing practices must be established and implemented in order to determine whether treatment is necessary at Custom Chrome.

Recommendations

- The operational and disposal procedures to ensure compliance with Federal categorical pretreatment standards through the achievement of zero-discharge should be determined.

4.1 Treatment In-Place

EPA Region 9 uses two performance measures that together reflect the purpose of the various Federal categorical pretreatment standards to bring about the nationwide use of model BAT treat-ment. The first measure is BAT treatment across the industrial inventory. The Federal standards for each Federally-regulated industrial category were based on the statistical performance of model BAT treatment as it is separately defined for each category. For job-shop electroplating, BAT treatment is metals precipitation, settling and solids removal, and if necessary, cyanide destruction and chromium reduction.

The lone industrial user identified during this evaluation by EPA as a Federally-regulated user, was not found to comply with its Federal standards either through BAT treatment or through facility configurations and practices to keep from discharging to the sewers.

> <u>Custom Chrome</u> - This metal finishing job-shop is required to comply with either the expanded list of pollutants in the Federal job-shop electroplating for dischargers over 10,000 gpd, or the abbreviated list of standards for dischargers under 10,000 gpd. Compliance cannot be determined at this time with either set of standards because the rinses discharge continuously irrespective metal finishing work and the spent solutions

are not specifically monitored. This constitutes "dilution as a substitute for treatment" since the Federally-regulated wastewaters discharge without treatment for metals or cyanide. None of the previous samples are usable for the determination of compliance.

- Power Plants - No Federal categorical standards apply (*Calpine Greenleaf Unit 2, Calpine Feather River Energy Center, Calpine Yuba City Energy Center, and Yuba City Cogeneration*).

4.2 Comparison with Model IU Performance

The second measure, derived from statistical comparisons with the performance of model categorical industrial users, only applies to larger industrial user inventories.

Section 5

Industrial User Inventory

Pretreatment programs are required to develop a complete inventory of industrial users, as part of ensuring industrial user compliance. 40 CFR 403.8(b,f1iii,f2i).

5.0 Summary

Yuba City has identified for regulation its significant industrial users ("SIUs"). However it has misclassified the SIUs qualifying as either categorical industrial users. Yuba City does not have a current inventory of non-significant industrial users nor of any zero-discharge categorical industrial users who would be subject to Federal standards if they discharged. Yuba City does have an unverified business list. See Table 7 for a list of identified SIUs and Table 8 for a definition of SIU.

Requirements

- Yuba City must field verify its industrial user inventory and institute formal documented procedures to continually identify additions, deletions and changes.
- Yuba City must re-identify the SIUs in its inventory as categorical, non-categorical, and zero-discharging categorical.

Recommendations

- Yuba City should maintain its industrial user inventory by non-domestic wastewater discharge point, with each discharge point characterized by Federal point source category, annual average flow rate, type of wastewater, and owner or operator.

5.1 Inventory Completeness

Yuba City has identified SIUs but has not identified, visited, or permitted all of its commercial and industrial users in its sewer service area. As a result, EPA could not produce a completed inventory during this performance evaluation and cannot verify that all SIUs are identified. The following four characteristics would be considered by EPA as good indications of a complete inventory. First, the inventory should include commercial sources, such as dentist, supermarkets, restaurants, and automobile repair shops, none of which would be expected to pose a significant risk to the treatment works. Second, the inventory should include commercial and industrial dischargers of less than 25,000 gpd designated by SIC code. Third, the inventory should include "zero-dischargers" that would be categorical if they discharged. Fourth, the industrial users with multiple non-domestic discharges to the sewers should be identified and permitted by separate discharge points. All of these modifications to the basic definition in 40 CFR 403.3(t) of an SIU are good indications of the successful identification of the potential threats to its treatment works. EPA found none of these modifications to the basic definitions in effect in Yuba City, however, the inventory would include two non-categorical power plants with discharges averaging less than 25,000 gpd once they are reclassified.

5.2 Inventory Classifications

The Yuba City must re-determine which industries qualify as SIUs and re-classify the five of SIUs identified by Yuba City that were found to be misclassified.

- Custom Chrome - Job-shop electroplaters subject to the Federal standards in 40 CFR 413 qualify for regulation under either a full set of regulated pollutants or an abbreviated set depending on the discharge flow rate. If every day of discharge to the sewers is under 10,000 gpd, then the abbreviated set of standards apply for cadmium, lead, cyanide, and toxic organics. If any one day exceeds 10,000 gpd, then the full set of standards apply for cadmium, lead, cyanide, and toxic organics, as well as chromium copper, nickel, silver, and zinc. Yuba City classified Custom Chrome as a job-shop electroplater discharging more than 10,000 gpd. Custom Chrome has show that its average discharges are less than 10,000 gpd. It is not clear that there is not any one day exceeding 10,000 gpd. EPA expects Custom Chrome to qualify as a job-shop electroplater that always discharges less than 10,000 gpd once it documents its daily discharges and reduces flow by instituting on-demand rinsing in response to an EPA Order.

- Calpine Greenleaf Unit 2 - This industry qualifies as an SIU because the highly mineralized nature of its wastewater discharges poses the risks of sewer line disintegration and the pass-through of toxics. Furthermore, its discharges average more than 25,000 gpd. It was misclassified as a steam electric power generating station subject to the Federal standards in 40 CFR 423. It does not qualify because it does not generate any power through steam-driven turbines. The steam electric rule would cover combined-cycle cogeneration plants that use steam-driven turbines to generate power from exhaust heat.

- Calpine Feather River Energy Center - This industry qualifies as an SIU and was misclassified as a steam electric power generating station for the same reasons stated above for Calpine Greenleaf Unit 2.

- Calpine Yuba City Energy Center - This industry qualifies as an SIU and was misclassified as a steam electric power generating station for the same reasons stated above for Calpine Greenleaf Unit 2, except its discharges do not average more than 25,000 gpd.

- Yuba City Cogeneration - This industry qualifies as an SIU and was misclassified as a steam electric power generating station for the same reasons stated above for Calpine Greenleaf Unit 2, except its discharges do not average more than 25,000 gpd.

- Sunsweet and Franklin Circle K - These are properly classified as non-categorical SIUs.

- Metal-Bearing Discharges - These might include glass polishers, metal finishers, metals formers, radiator shops, water purification facilities, and agricultural-chemical sources. See the discussion in item 2.5 of this report for sources of aluminum, arsenic, copper, iron, manganese, molybdenum, and zinc. Possibles: Chipco Mfg., Transitional Systems Mfg., Cal Classic Custom Trim.

- Other Possibles - These would include any other large dischargers, categoricals, or toxic loaders. Possibles: Paperboard Packaging Corp.

5.3 Zero-Discharging Categorical Industrial Users

Yuba City should institute the good practice of identifying and permitting industrial users that would qualify as categoricals if they discharged their Federally-regulated process-related wastewaters to the sewers. In essence these are the industrial users that comply with their Federal standards by maintaining the steps necessary to prevent the discharge of process-related wastewaters to the sewers. Including zero-discharging CIUs in the inventory ensures the local regulatory control over industrial users who would violate their Clean Water Act requirements and could endanger the operations of the treatment works if they discharged to the sewers.

Section 6

Industrial User Permits

Pretreatment programs are required to issue permits with standards and limits, sampling locations, self-monitoring requirements, and a 5-year or less expiration, as part of ensuring industrial user compliance. 40 CFR 403.8(b,f1iii,f2i).

6.0 Summary

Yuba City has a good permit program and has successfully issued valid permits to all of its identified SIUs. The permits all have standards and limits, self-monitoring requirements, and a 2-year expira-tion, but they do not specify sampling locations nor define what constitutes representative sampling. Permits will have to be re-issued once the local limits are re-determined, the SIU inventory is re-determined, and the Federal standards are re-applied. See item 7.0 for this report for a discussion on representative sampling.

Requirements

- Each permit issued to an SIU must explicitly state all applicable Federal standards, national prohibitions, and local limits, as well as the self-monitoring and reporting requirements, and sampling locations.

Recommendations

- Permits should be issued with the applicable Federal standards and national prohibitions, and then reissued to include the local limits once they are re-determined.

- Each permit issued to an SIU should list all standards, limits, self-monitoring and analytical requirements on one page, and the sampling location(s) on a site map.

- The information in the permit applications as well as any other information gathered to issue the permits, such as statistical analyses of sample representativeness, should be field verified and documented in fact sheets prepared for each SIU.

6.1 Permit Accuracy and Fact Sheets

Yuba City will have to reissue permits with the applicable Federal standards and national prohibit-tions to all of its SIUs, and then reissue them again with local limits once they are re-determined. Fact sheets should be prepared to document the information and decisions behind the permit provisions, such as Federal category, sample point, pollutants of concern, representative sampling, and self-certifications in lieu of self-monitoring.

- Sunsweet - A permit must be reissued to apply the national prohibitions and the local limits, once they are re-determined. The permit should require self-monitoring for all of the local limits as well as any other toxics that identified by Sunsweet under the EPA Order, with a provision to re-open the self-monitoring requirements depending on the results. The national prohibitions should be restated to explicitly prohibit the identified discharges and conditions from Sunsweet that have or could have adversely effected the sewers or the WWTP. See items 2.0 and 2.8 of this report. Sampling protocols set in the permit should reflect the variabilities from plant operations and treatment associated with the defined sample point not only over the sampling day but also over the reporting period.

- Power Plants - The permits for the power plants must be reissued to apply the national prohibitions, to remove the Federal standards for steam electric power stations, and add the local limits, once they are re-determined. The permits should require self-monitoring for all of the local limits, with a provision to re-open the self-monitoring requirements depending on the results. The national prohibitions should be restated to explicitly prohibit the discharges and conditions that could adversely affect the sewers or the WWTP. Sampling protocols set in the permit should reflect the variabilities from plant operations and treatment associated with the defined sample points not only over the sampling day but also over the reporting period. In particular, the permit should address the entire schedule of batch, slug, blowdown, or continuous discharges through the sample point.

- Zero-Discharging CIUs - Zero-discharge permits should be issued to any industries found to comply with Federal categorical pretreatment standards by not discharging Federally-regulated process-related wastewaters. A zero-discharge permit should explicitly prohibit the discharge of the Federally-regulated wastewaters and require the industry to certify every six months to not discharging in lieu of self-monitoring. A zero-discharge permit would strengthen enforcement efforts against the illegal dumping to the sewer because the establishment of violation depends only on whether a discharge occurred and not on surveillance sampling and the difficult arguments surround the representativeness of sampling.

6.2 Permit Clarity

All of the permits issued to the SIUs should clearly communicate the applicable Federal standards, national prohibitions, local limits, sample type, sampling frequency, self-certifications in lieu of self-monitoring, analytical test methods and the associated detection limits, and, if necessary, the flow and production rates behind the Federal standards. All of this information can be presented in table form on a single page of the permit with one line per pollutant. The compliance sampling locations also could be clearly delineated on a site map annotated with a description of the location. Each permit should clearly state the effective duration and the procedures for re-applying.

Section 7

Monitoring, Self-Monitoring and Inspections

Pretreatment programs, as part of ensuring industrial user compliance [40 CFR 403.8(b)], are required to:

- Cause industrial users to self-monitoring at least twice per year unless the program samples for them [40 CFR 403.8(f1iii), 403.12(e1,g10)];
- Inspect industrial users at least once per year;
- Sample industrial users at least once per year if they self-monitor or twice per year if they are not required to self-monitor [40 CFR 403.8(f2v), 403.12(i2,e1,g10)];
- Ensure that all sampling and self-monitoring is representative of the reporting period [40 CFR 403.12(g3)].

7.0 Summary

For the most part, Yuba City successfully obtains self-monitoring as well as performs the inspections and city sampling necessary to determine compliance independent of the information submitted by the SIUs. However, the self-monitoring is not representative over the reporting periods and the sample records do not cover all of the pollutants of concern.

Requirements

- The self-monitoring records for each SIU must be complete in the number and type of

- Yuba City must sample each SIU, including Franklin Circle K, at least once per year.

Recommendations

- Inspection reports should include an analysis that the sampling is representative of both the sampling day and reporting period.

- Inspection reports should document the findings that establish the sewer discharge permit conditions and prompt any necessary revisions or enforcement actions.

- All self-certifications in lieu of self-monitoring should be explicitly stated in the permit.

Section 7 – Monitoring, Self-Monitoring and Inspections

7.1 City Inspections and Sampling

Yuba City performs routine inspections of each SIU once per year and samples them at least once per year since its permits require self-monitoring. Sunsweet is sampled each weekday and the power plants are sampled once per week. The one exception is the contaminated groundwater clean-up site, Franklin Circle K, which is not sampled by the City.

7.2 Self-Monitoring

Frequency and Coverage - The permits require daily self-monitoring for Sunsweet and quarterly self-monitoring for the others. However, the self-monitoring and city monitoring do not cover all of the pollutants of concern (aluminum, arsenic, chloroform, copper, diazinon, iron, lead, manganese, molybdenum, tetrachloroethylene, and zinc), nor the potential pollutants of concern (barium, cadmium, chromium, mercury, nickel, oil & grease, selenium, and MTBE).

Sampling Representativeness - Representative sampling points have been established and known even though they are not specified in the permits. However, the self-monitoring frequencies do not ensure representative sampling over the reporting period because the significant slug, batch and variable discharges, such as spent solutions, blowdowns and regenerants, are not specifically required by the permits to be self-monitored. Both of these findings regarding the representative-ness of sampling were illustrated at each of the SIUs inspected during this inspection.

7.3 Self-Certifications

Self-certifications in lieu of any required self-monitoring for Federal standards or local limits should be explicitly stated in the permits. In particular, the Custom Chrome permit should explicitly state which toxic organic pollutants do not have to be self-monitored if Custom Chrome self-certifies to following a previously submitted and approved toxic organics management plan, as allowed under the Federal job-shop electroplating standards in 40 CFR 413.

Section 8

Enforcement and Compliance Assistance

Pretreatment programs, as part of ensuring industrial user compliance are required to enforce their permits following an enforcement response plan, and to publish annual significant non-compliance lists [40 CFR 403.8(b,f1ii,f2vii,f5)].

8.0 Summary

The Federal regulations do not define how to determine a program's success in enforcing permit limits. However, an evaluation of enforcement and the City's enforcement response plan is premature since the SIU permits need to be revised to include updated local limits, result in representative sampling records, and apply the proper Federal standards.

Requirements

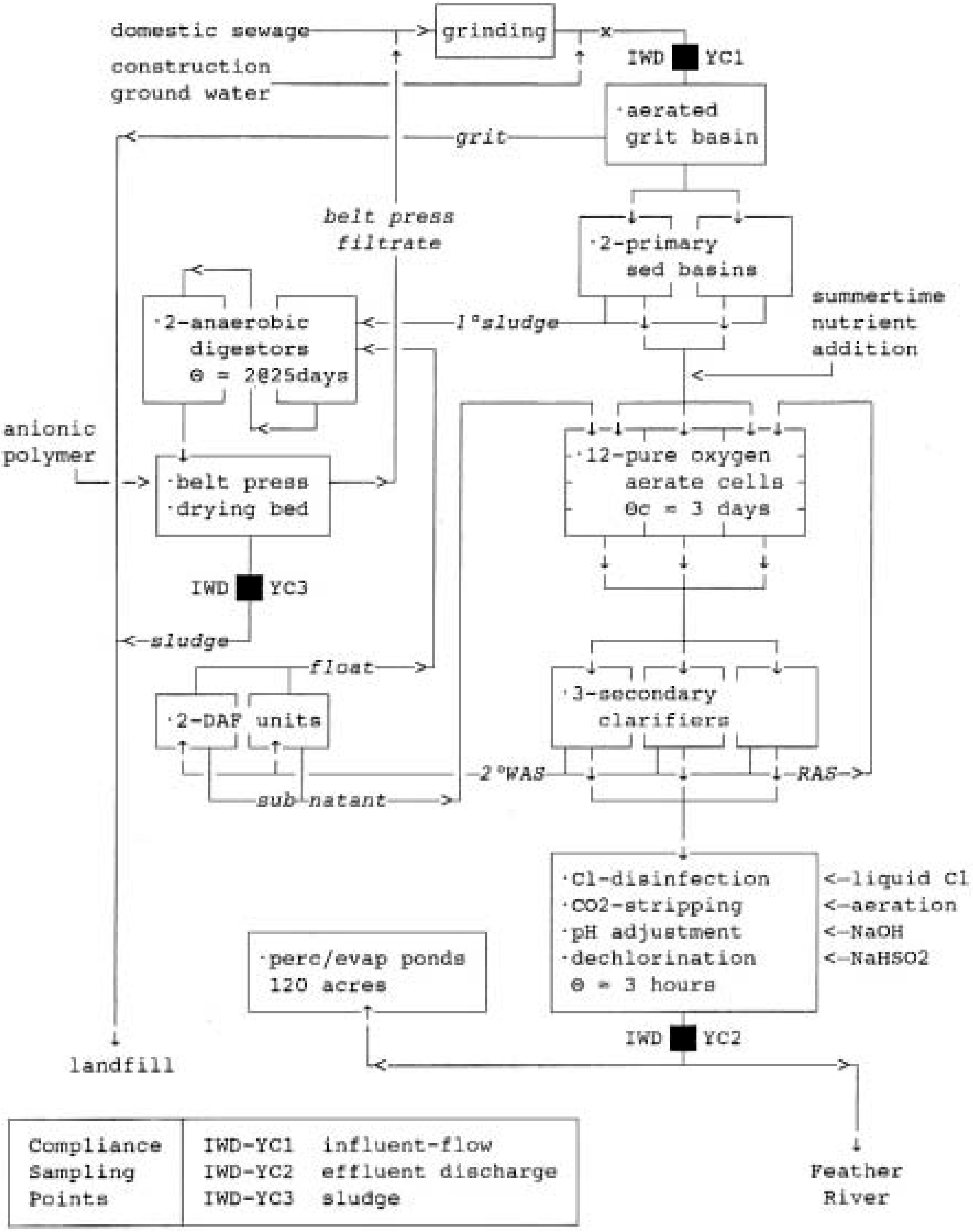
- Approved pretreatment programs are required to develop and follow an enforcement response plan that specifies the actions, and their time frames, that the City will take in response to each type of industrial user permit.

Recommendations

- None.

Figure 1

Yuba City Water Pollution Control Facility
Schematic of the Wastewater Treatment



Compliance Sampling Points		
	IWD-YC1	influent-flow
	IWD-YC2	effluent discharge
	IWD-YC3	sludge

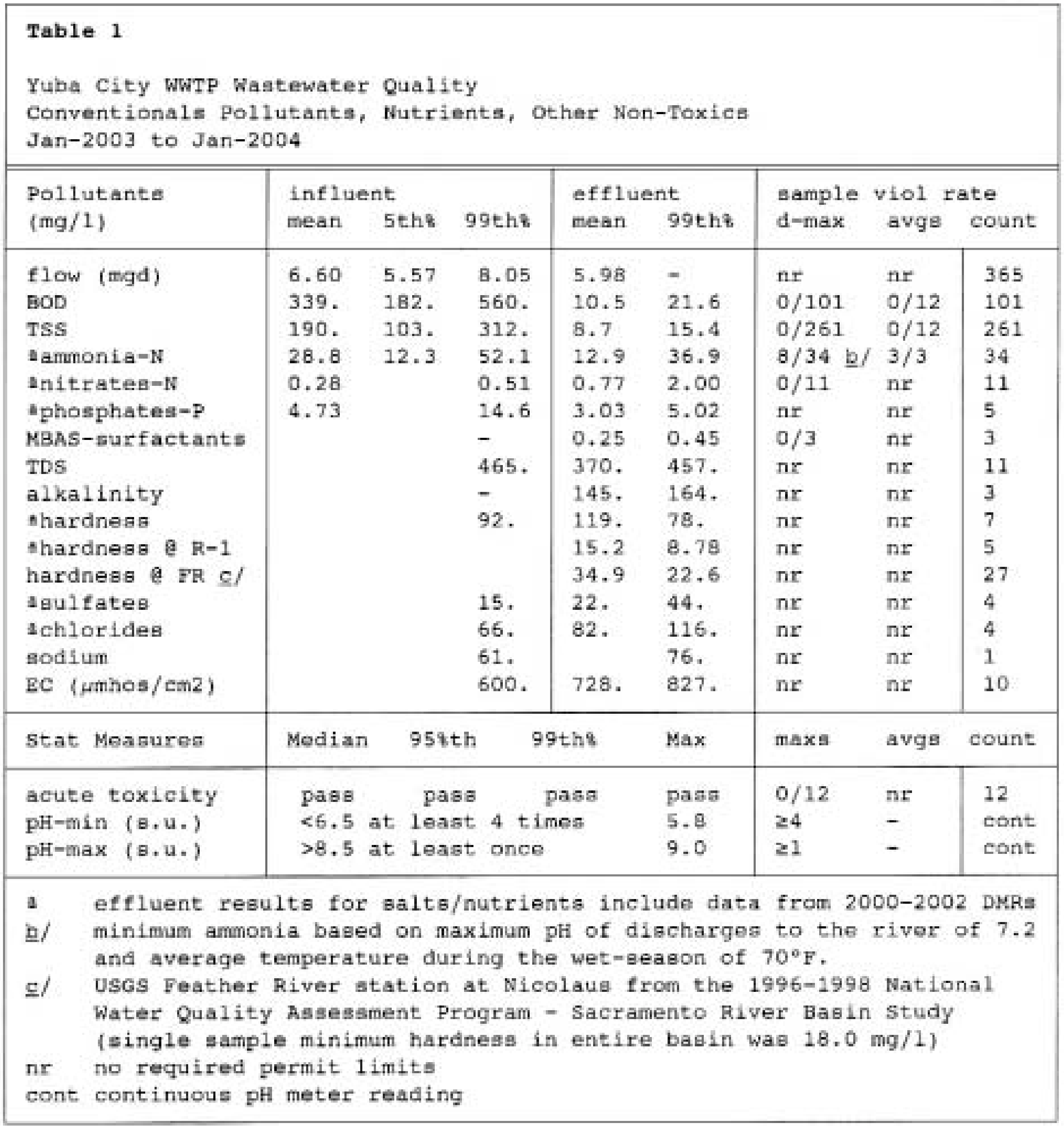


Table 1

Yuba City WWTP Wastewater Quality
Conventionals Pollutants, Nutrients, Other Non-Toxics
Jan-2003 to Jan-2004

Pollutants (mg/l)	influent mean	5th%	99th%	effluent mean	99th%	sample viol rate d-max	avgs	count
flow (mgd)	6.60	5.57	8.05	5.98	-	nr	nr	365
BOD	339.	182.	560.	10.5	21.6	0/101	0/12	101
TSS	190.	103.	312.	8.7	15.4	0/261	0/12	261
[a]ammonia-N	28.8	12.3	52.1	12.9	36.9	8/34 b/	3/3	34
[a]nitrates-N	0.28		0.51	0.77	2.00	0/11	nr	11
[a]phosphates-P	4.73		14.6	3.03	5.02	nr	nr	5
MBAS-surfactants			-	0.25	0.45	0/3	nr	3
TDS			465.	370.	457.	nr	nr	11
alkalinity			-	145.	164.	nr	nr	3
[a]hardness			92.	119.	78.	nr	nr	7
[a]hardness @ R-1				15.2	8.78	nr	nr	5
hardness @ FR c/				34.9	22.6	nr	nr	27
[a]sulfates			15.	22.	44.	nr	nr	4
[a]chlorides			66.	82.	116.	nr	nr	4
sodium			61.		76.	nr	nr	1
EC (µmhos/cm2)			600.	728.	827.	nr	nr	10

Stat Measures	Median	95%th	99th%	Max	maxs	avgs	count
acute toxicity	pass	pass	pass	pass	0/12	nr	12
pH-min (s.u.)	<6.5 at least 4 times			5.8	≥4	-	cont
pH-max (s.u.)	>8.5 at least once			9.0	≥1	-	cont

[a] effluent results for salts/nutrients include data from 2000-2002 DMRs
b/ minimum ammonia based on maximum pH of discharges to the river of 7.2 and average temperature during the wet-season of 70°F.
c/ USGS Feather River station at Nicolaus from the 1996-1998 National Water Quality Assessment Program - Sacramento River Basin Study (single sample minimum hardness in entire basin was 18.0 mg/l)
nr no required permit limits
cont continuous pH meter reading

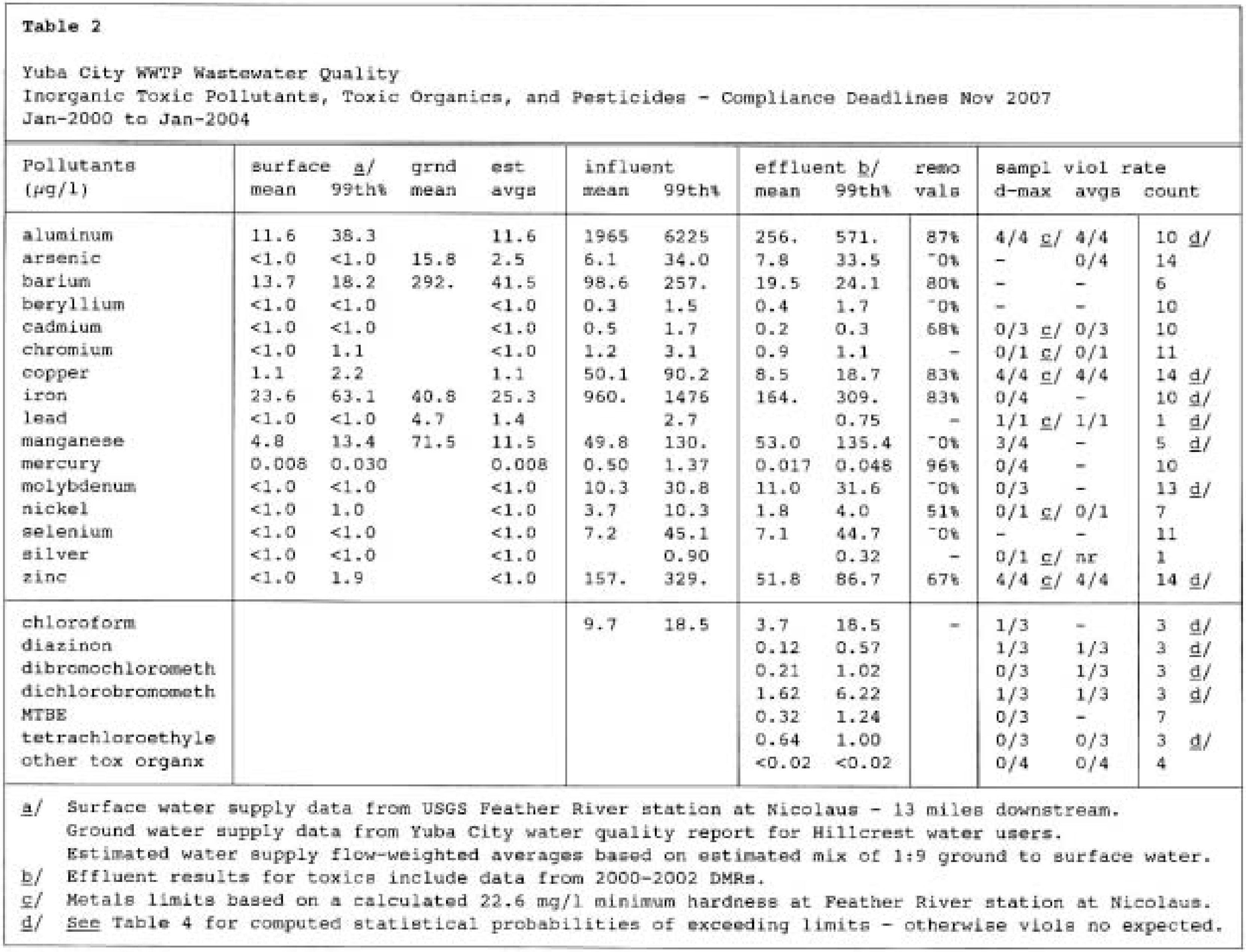


Table 2

Yuba City WWTP Wastewater Quality
Inorganic Toxic Pollutants, Toxic Organics, and Pesticides - Compliance Deadlines Nov 2007
Jan-2000 to Jan-2004

Pollutants	surface a/		grnd	est	influent		effluent b/		remo	sampl	viol	rate
(µg/l)	mean	99th%	mean	avgs	mean	99th%	mean	99th%	vals	d-max	avgs	count
aluminum	11.6	38.3		11.6	1965	6225	256.	571.	87%	4/4 c/	4/4	10 d/
arsenic	<1.0	<1.0	15.8	2.5	6.1	34.0	7.8	33.5	~0%	-	0/4	14
barium	13.7	18.2	292.	41.5	98.6	257.	19.5	24.1	80%	-	-	6
beryllium	<1.0	<1.0		<1.0	0.3	1.5	0.4	1.7	~0%	-	-	10
cadmium	<1.0	<1.0		<1.0	0.5	1.7	0.2	0.3	68%	0/3 c/	0/3	10
chromium	<1.0	1.1		<1.0	1.2	3.1	0.9	1.1	-	0/1 c/	0/1	11
copper	1.1	2.2		1.1	50.1	90.2	8.5	18.7	83%	4/4 c/	4/4	14 d/
iron	23.6	63.1	40.8	25.3	960.	1476	164.	309.	83%	0/4	-	10 d/
lead	<1.0	<1.0	4.7	1.4		2.7		0.75	-	1/1 c/	1/1	1 d/
manganese	4.8	13.4	71.5	11.5	49.8	130.	53.0	135.4	~0%	3/4	-	5 d/
mercury	0.008	0.030		0.008	0.50	1.37	0.017	0.048	96%	0/4	-	10
molybdenum	<1.0	<1.0		<1.0	10.3	30.8	11.0	31.6	~0%	0/3	-	13 d/
nickel	<1.0	1.0		<1.0	3.7	10.3	1.8	4.0	51%	0/1 c/	0/1	7
selenium	<1.0	<1.0		<1.0	7.2	45.1	7.1	44.7	~0%	-	-	11
silver	<1.0	<1.0		<1.0		0.90		0.32	-	0/1 c/	nr	1
zinc	<1.0	1.9		<1.0	157.	329.	51.8	86.7	67%	4/4 c/	4/4	14 d/
chloroform					9.7	18.5	3.7	18.5	-	1/3	-	3 d/
diazinon							0.12	0.57		1/3	1/3	3 d/
dibromochlorometh							0.21	1.02		0/3	1/3	3 d/
dichlorobromometh							1.62	6.22		1/3	1/3	3 d/
MTBE							0.32	1.24		0/3	-	7
tetrachloroethyle							0.64	1.00		0/3	0/3	3 d/
other tox organx							<0.02	<0.02		0/4	0/4	4

a/ Surface water supply data from USGS Feather River station at Nicolaus - 13 miles downstream.
Ground water supply data from Yuba City water quality report for Hillcrest water users.
Estimated water supply flow-weighted averages based on estimated mix of 1:9 ground to surface water.
b/ Effluent results for toxics include data from 2000-2002 DMRs.
c/ Metals limits based on a calculated 22.6 mg/l minimum hardness at Feather River station at Nicolaus.
d/ See Table 4 for computed statistical probabilities of exceeding limits - otherwise viols no expected.

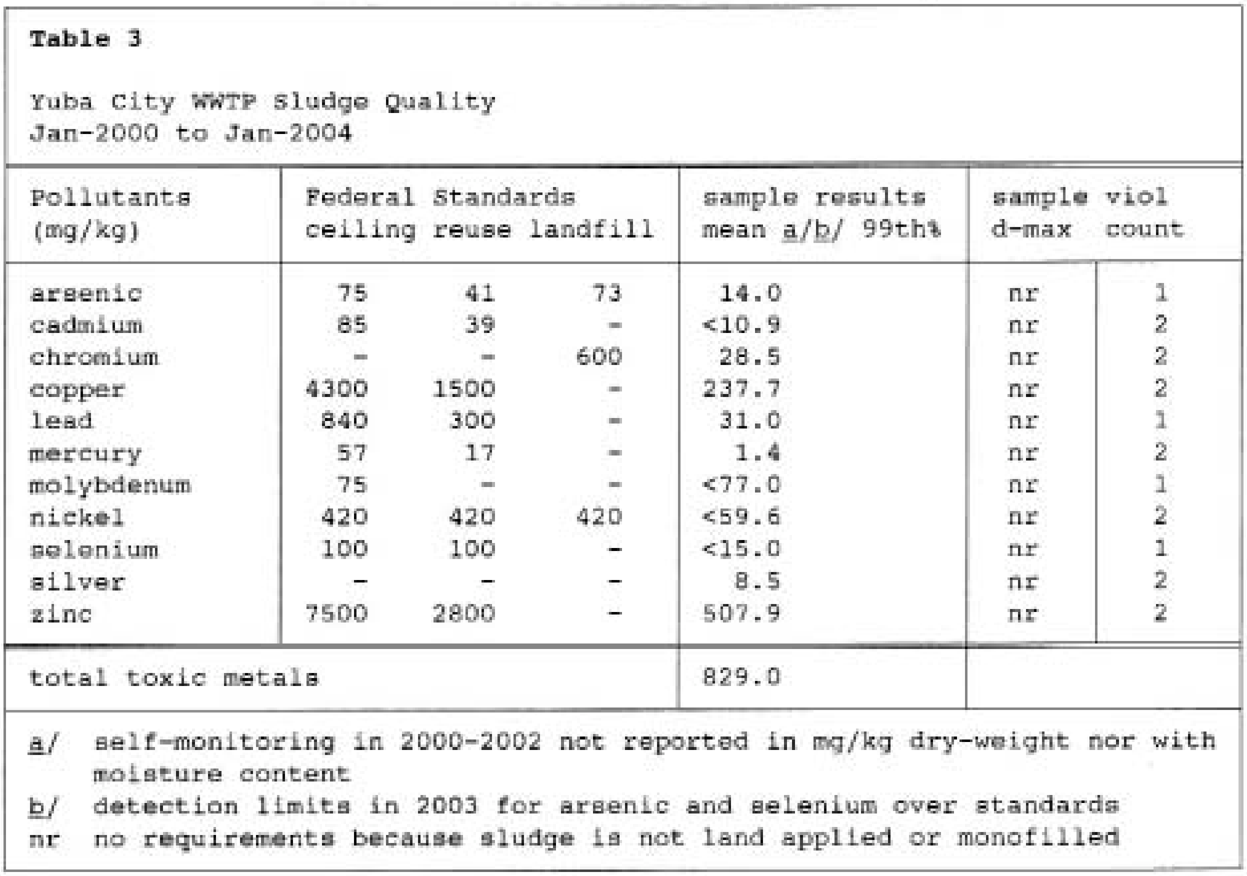


Table 3

Yuba City WWTP Sludge Quality
Jan-2000 to Jan-2004

Pollutants (mg/kg)	Federal Standards ceiling	reuse	landfill	sample results mean a/b/	99th%	sample viol d-max	count
arsenic	75	41	73	14.0		nr	1
cadmium	85	39	-	<10.9		nr	2
chromium	-	-	600	28.5		nr	2
copper	4300	1500	-	237.7		nr	2
lead	840	300	-	31.0		nr	1
mercury	57	17	-	1.4		nr	2
molybdenum	75	-	-	<77.0		nr	1
nickel	420	420	420	<59.6		nr	2
selenium	100	100	-	<15.0		nr	1
silver	-	-	-	8.5		nr	2
zinc	7500	2800	-	507.9		nr	2
total toxic metals				829.0			

a/ self-monitoring in 2000-2002 not reported in mg/kg dry-weight nor with moisture content
b/ detection limits in 2003 for arsenic and selenium over standards
nr no requirements because sludge is not land applied or monofilled

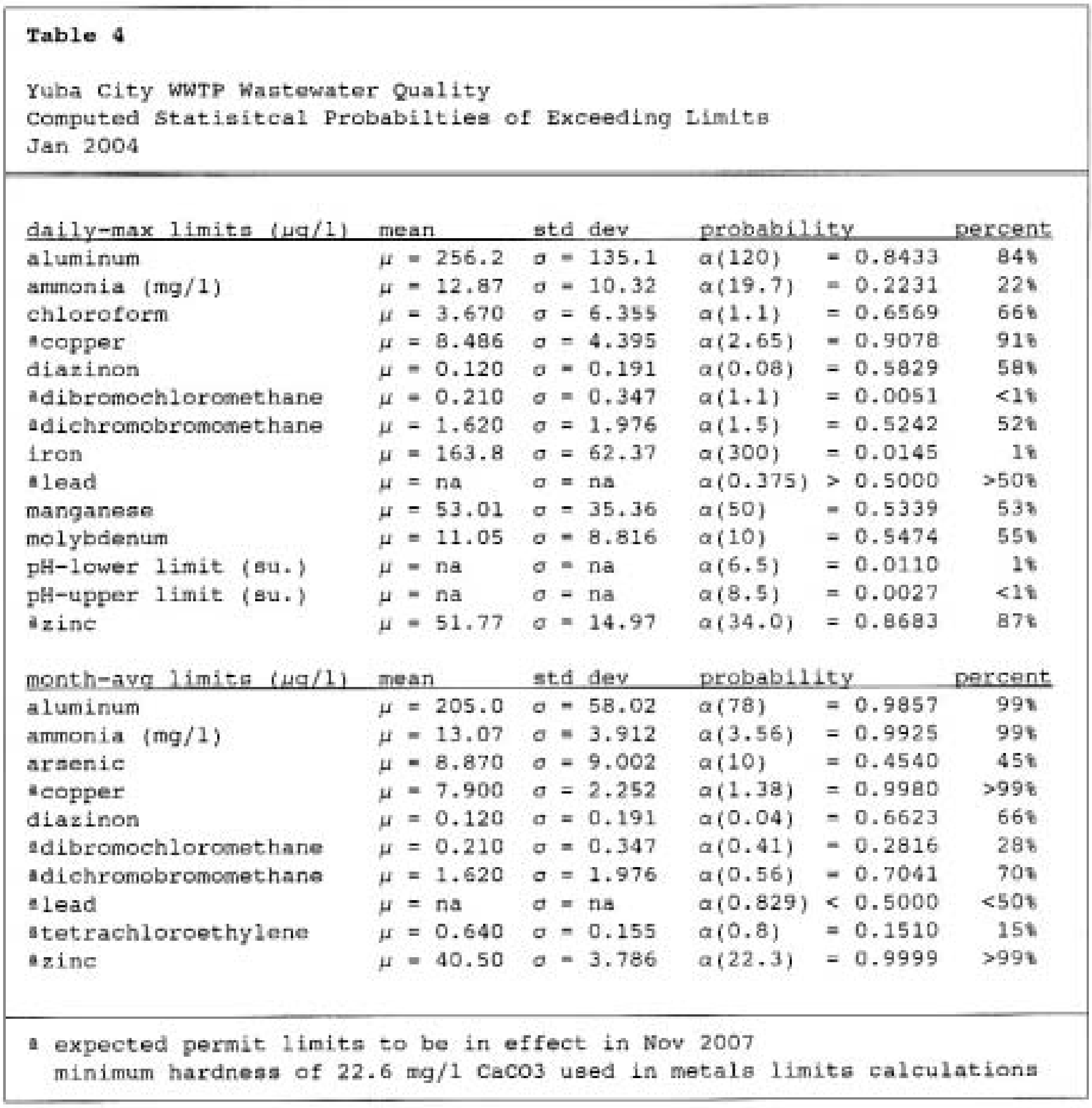


Table 4

Yuba City WWTP Wastewater Quality
Computed Statisitcal Probabilties of Exceeding Limits
Jan 2004

daily-max limits (μg/l)	mean	std dev	probability	percent
aluminum	$\mu = 256.2$	$\sigma = 135.1$	$\alpha(120) = 0.8433$	84%
ammonia (mg/l)	$\mu = 12.87$	$\sigma = 10.32$	$\alpha(19.7) = 0.2231$	22%
chloroform	$\mu = 3.670$	$\sigma = 6.355$	$\alpha(1.1) = 0.6569$	66%
[a]copper	$\mu = 8.486$	$\sigma = 4.395$	$\alpha(2.65) = 0.9078$	91%
diazinon	$\mu = 0.120$	$\sigma = 0.191$	$\alpha(0.08) = 0.5829$	58%
[a]dibromochloromethane	$\mu = 0.210$	$\sigma = 0.347$	$\alpha(1.1) = 0.0051$	<1%
[a]dichromobromomethane	$\mu = 1.620$	$\sigma = 1.976$	$\alpha(1.5) = 0.5242$	52%
iron	$\mu = 163.8$	$\sigma = 62.37$	$\alpha(300) = 0.0145$	1%
[a]lead	$\mu =$ na	$\sigma =$ na	$\alpha(0.375) > 0.5000$	>50%
manganese	$\mu = 53.01$	$\sigma = 35.36$	$\alpha(50) = 0.5339$	53%
molybdenum	$\mu = 11.05$	$\sigma = 8.816$	$\alpha(10) = 0.5474$	55%
pH-lower limit (su.)	$\mu =$ na	$\sigma =$ na	$\alpha(6.5) = 0.0110$	1%
pH-upper limit (su.)	$\mu =$ na	$\sigma =$ na	$\alpha(8.5) = 0.0027$	<1%
[a]zinc	$\mu = 51.77$	$\sigma = 14.97$	$\alpha(34.0) = 0.8683$	87%

month-avg limits (μg/l)	mean	std dev	probability	percent
aluminum	$\mu = 205.0$	$\sigma = 58.02$	$\alpha(78) = 0.9857$	99%
ammonia (mg/l)	$\mu = 13.07$	$\sigma = 3.912$	$\alpha(3.56) = 0.9925$	99%
arsenic	$\mu = 8.870$	$\sigma = 9.002$	$\alpha(10) = 0.4540$	45%
[a]copper	$\mu = 7.900$	$\sigma = 2.252$	$\alpha(1.38) = 0.9980$	>99%
diazinon	$\mu = 0.120$	$\sigma = 0.191$	$\alpha(0.04) = 0.6623$	66%
[a]dibromochloromethane	$\mu = 0.210$	$\sigma = 0.347$	$\alpha(0.41) = 0.2816$	28%
[a]dichromobromomethane	$\mu = 1.620$	$\sigma = 1.976$	$\alpha(0.56) = 0.7041$	70%
[a]lead	$\mu =$ na	$\sigma =$ na	$\alpha(0.829) < 0.5000$	<50%
[a]tetrachloroethylene	$\mu = 0.640$	$\sigma = 0.155$	$\alpha(0.8) = 0.1510$	15%
[a]zinc	$\mu = 40.50$	$\sigma = 3.786$	$\alpha(22.3) = 0.9999$	>99%

[a] expected permit limits to be in effect in Nov 2007
minimum hardness of 22.6 mg/l CaCO3 used in metals limits calculations

Table 5

Comparison of Wastewater Quality
Average Concentrations of Toxics Jan-00 to Jan-2004

Influent (µg/l)	Yuba City	Deer Creek	ElDor Hills	Grass Vally	Nevad City	Placr Co#1	Red Bluff	Stock -ton	norm a/
aluminum	**1965**					820.			+0.7
arsenic	**6.1**	<1.0	1.4	<1.0	1.1	<1.0	1.33	4.4	+2.0
barium	98.6								
beryllium	0.3							<0.5	
cadmium	**0.5**	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.4	
chromium	1.2	<5.0	5.5	<1.0	<5.0	<5.0	7.6	**8.0**	-1.4
copper	50.1	83.0	**110.**	45.5	20.0	22.5	26.0	39.0	+0.0
iron	960.	430.	**1600**	510.	1500	1425			-0.2
lead	2.7	<5.0	<5.0	<5.0	5.8	10.4	<5.0	**10.9**	-0.6
manganese	49.8	24.0	**200.**	98.0	46.0	87.0			-0.5
mercury	**0.50**	0.26	0.43	0.26	0.21	<0.2	<0.2	0.30	+1.7
molybdenum	**10.3**							4.6	+0.7
nickel	3.7	3.3	5.5	4.6	3.1	5.1	5.0	**9.1**	-0.6
selenium	**7.2**	1.1	1.4	<1.0	<1.0	<1.0	<1.0	<0.5	+2.4
silver	0.90	1.1	2.5	**3.7**	1.0	1.3	2.86	1.8	-1.0
zinc	157.	120.	160.	**225.**	91.0	110.	77.5	138.	+0.5

Effluent (µg/l)	Yuba City	Deer Creek	ElDora Hills	Grass Valley	Nevada City	Placer Co#1	Red Bluff	Stock -ton	norm a/
aluminum	**256.**	39.0	36.4	26.8	47.1	101.			+2.0
arsenic	**7.75**	0.4	0.50	1.29	1.5	0.43	1.44	3.6	+2.3
barium	**19.5**	4.05	2.02	4.04	9.2	4.82			+1.9
beryllium	**0.44**	0.022	<0.003	<0.1	<0.1	<0.02	<1.0	<0.5	+2.1
cadmium	0.17	<1.0	0.071	0.05	<1.0	0.05	**0.39**	<0.1	+0.2
chromium	0.94	0.34	0.48	0.30	0.30	0.25	1.13	**1.6**	+0.6
copper	8.49	**20.4**	13.7	4.03	2.4	2.00	7.62	5.6	+0.1
iron	**164.**	31.4	8.40	87.1	44.0	79.2			+1.7
lead	**0.75**	0.50	0.061	0.41	0.33	0.73	0.45	<1.0	+0.9
manganese	**53.0**	1.58	2.57	35.9	10.8	34.7			+1.4
mercury	**0.017**	<2.0	0.002	0.005	0.013	0.004	<0.2	<0.2	+1.4
molybdenum	**10.5**							5.1	+0.7
nickel	1.78	**24.0**	3.28	4.15	1.8	2.62	1.55	7.1	-0.5
selenium	**7.10**	<1.0	0.28	0.45	0.3	0.15	0.57	<0.5	+2.5
silver	**0.76**	<1.0	0.006	<0.08	<1.0	0.07	0.34	<0.4	+1.7
zinc	51.8	36.5	22.9	**60.7**	34.5	27.3	53.0	14.8	+0.9
Flow (mgd)	6.60	2.94	1.94	1.75	0.42	1.95	1.35	32.4	

bold highest sampling averages highlighted in bold

a/ calculated norm for Yuba City versus 8-city averages

$$\text{norm} = \frac{(x - \mu)}{\sigma}$$

x - Yuba City average
μ - 8-city averages
σ - 8-city std deviation

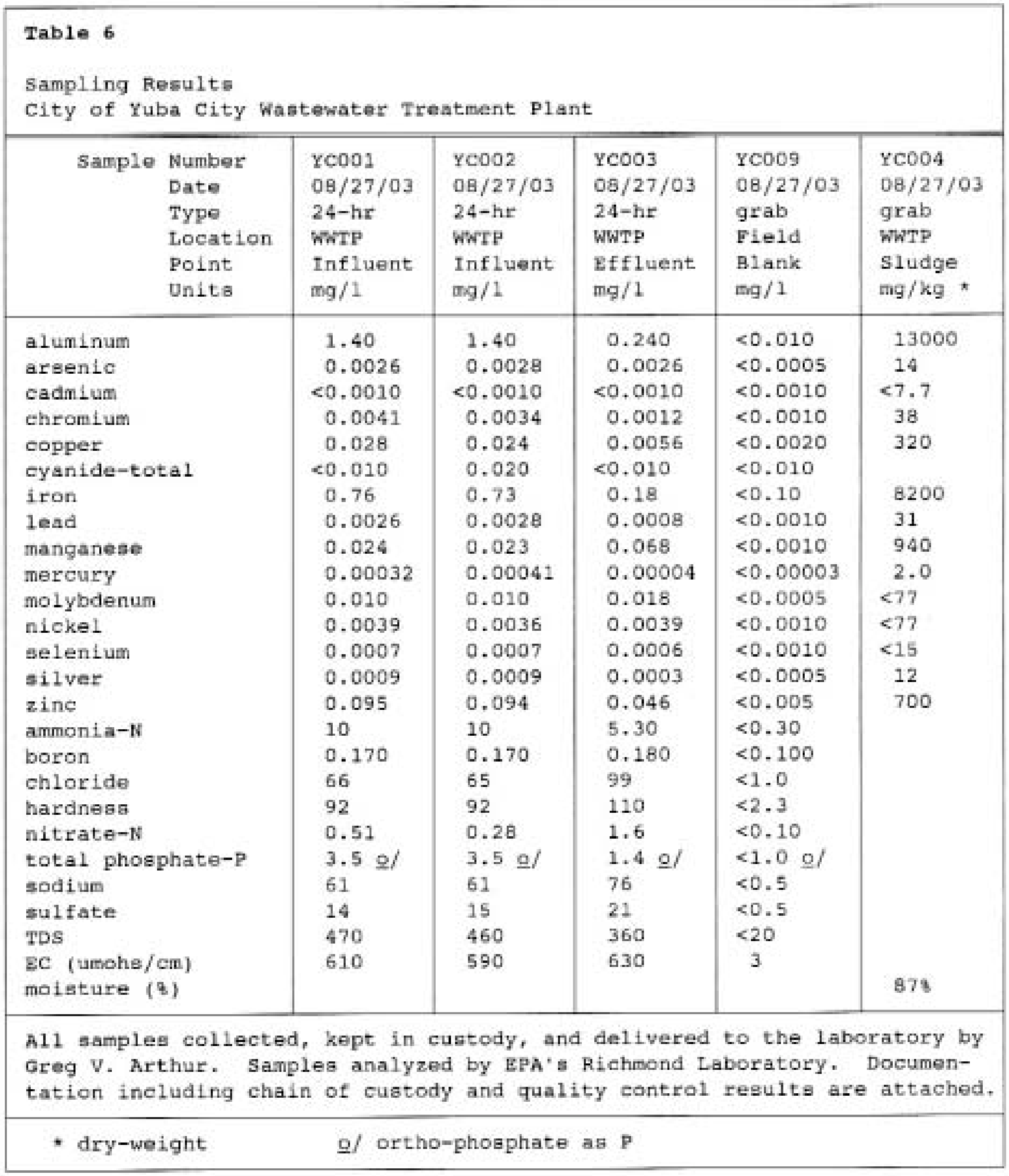


Table 6

Sampling Results
City of Yuba City Wastewater Treatment Plant

Sample Number	YC001	YC002	YC003	YC009	YC004
Date	08/27/03	08/27/03	08/27/03	08/27/03	08/27/03
Type	24-hr	24-hr	24-hr	grab	grab
Location	WWTP	WWTP	WWTP	Field	WWTP
Point	Influent	Influent	Effluent	Blank	Sludge
Units	mg/l	mg/l	mg/l	mg/l	mg/kg *
aluminum	1.40	1.40	0.240	<0.010	13000
arsenic	0.0026	0.0028	0.0026	<0.0005	14
cadmium	<0.0010	<0.0010	<0.0010	<0.0010	<7.7
chromium	0.0041	0.0034	0.0012	<0.0010	38
copper	0.028	0.024	0.0056	<0.0020	320
cyanide-total	<0.010	0.020	<0.010	<0.010	
iron	0.76	0.73	0.18	<0.10	8200
lead	0.0026	0.0028	0.0008	<0.0010	31
manganese	0.024	0.023	0.068	<0.0010	940
mercury	0.00032	0.00041	0.00004	<0.00003	2.0
molybdenum	0.010	0.010	0.018	<0.0005	<77
nickel	0.0039	0.0036	0.0039	<0.0010	<77
selenium	0.0007	0.0007	0.0006	<0.0010	<15
silver	0.0009	0.0009	0.0003	<0.0005	12
zinc	0.095	0.094	0.046	<0.005	700
ammonia-N	10	10	5.30	<0.30	
boron	0.170	0.170	0.180	<0.100	
chloride	66	65	99	<1.0	
hardness	92	92	110	<2.3	
nitrate-N	0.51	0.28	1.6	<0.10	
total phosphate-P	3.5 o/	3.5 o/	1.4 o/	<1.0 o/	
sodium	61	61	76	<0.5	
sulfate	14	15	21	<0.5	
TDS	470	460	360	<20	
EC (umohs/cm)	610	590	630	3	
moisture (%)					87%

All samples collected, kept in custody, and delivered to the laboratory by Greg V. Arthur. Samples analyzed by EPA's Richmond Laboratory. Documentation including chain of custody and quality control results are attached.

* dry-weight o/ ortho-phosphate as P

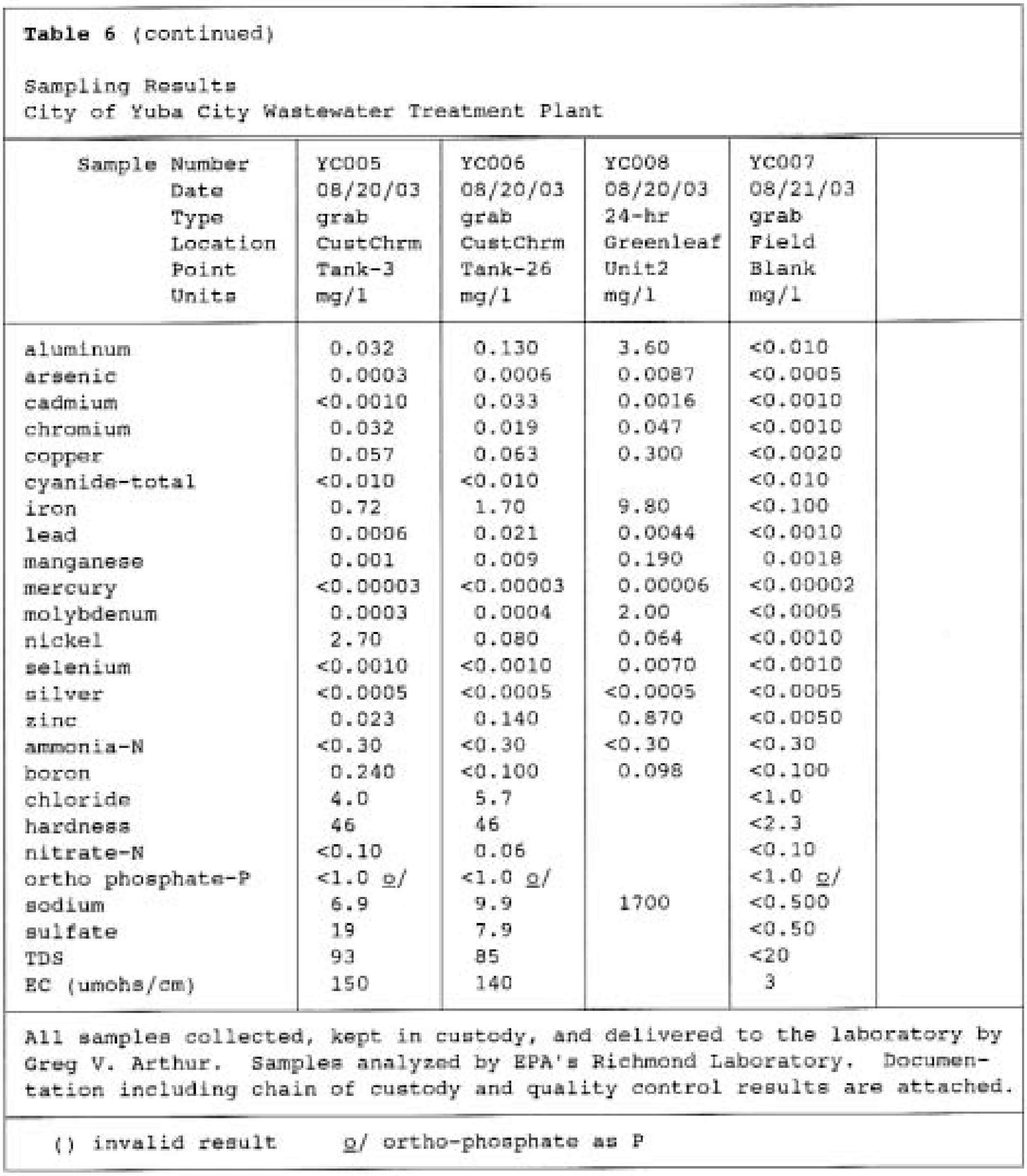


Table 6 (continued)

Sampling Results
City of Yuba City Wastewater Treatment Plant

Sample Number	YC005	YC006	YC008	YC007
Date	08/20/03	08/20/03	08/20/03	08/21/03
Type	grab	grab	24-hr	grab
Location	CustChrm	CustChrm	Greenleaf	Field
Point	Tank-3	Tank-26	Unit2	Blank
Units	mg/l	mg/l	mg/l	mg/l
aluminum	0.032	0.130	3.60	<0.010
arsenic	0.0003	0.0006	0.0087	<0.0005
cadmium	<0.0010	0.033	0.0016	<0.0010
chromium	0.032	0.019	0.047	<0.0010
copper	0.057	0.063	0.300	<0.0020
cyanide-total	<0.010	<0.010		<0.010
iron	0.72	1.70	9.80	<0.100
lead	0.0006	0.021	0.0044	<0.0010
manganese	0.001	0.009	0.190	0.0018
mercury	<0.00003	<0.00003	0.00006	<0.00002
molybdenum	0.0003	0.0004	2.00	<0.0005
nickel	2.70	0.080	0.064	<0.0010
selenium	<0.0010	<0.0010	0.0070	<0.0010
silver	<0.0005	<0.0005	<0.0005	<0.0005
zinc	0.023	0.140	0.870	<0.0050
ammonia-N	<0.30	<0.30	<0.30	<0.30
boron	0.240	<0.100	0.098	<0.100
chloride	4.0	5.7		<1.0
hardness	46	46		<2.3
nitrate-N	<0.10	0.06		<0.10
ortho phosphate-P	<1.0 o/	<1.0 o/		<1.0 o/
sodium	6.9	9.9	1700	<0.500
sulfate	19	7.9		<0.50
TDS	93	85		<20
EC (umohs/cm)	150	140		3

All samples collected, kept in custody, and delivered to the laboratory by Greg V. Arthur. Samples analyzed by EPA's Richmond Laboratory. Documentation including chain of custody and quality control results are attached.

( ) invalid result o/ ortho-phosphate as P

Table 7

City of Yuba City Service Area 2004 Inventory
(based solely on EPA observations)

SIGNIFICANT INDUSTRIAL USERS ("SIUs")	FLOW in gpd	PRETREATMENT-IN-PLACE	FEDERAL CATEGORY	BAT
Sunsweet Growers	764485	SCRN PH	non-cat	n/a
Custom Chrome & Bumper	15000	-	413	BAT-
Calpine-Greenleaf #2	47600	PH	non-cat	n/a
Calpine-Feather River EC	50000	PH	non-cat	n/a
Calpine-Yuba City EC	20000	PH	non-cat	n/a
Calpine-Yuba City Cogen	5000	PH	non-cat	n/a
Franklin Circle K	25000	CARBON	non-cat	n/a

<u>Federal Category and Best Available Technology</u>

413	Job-shop Electroplating >10,000 gpd
non-cat	Non-Categorical SIU
BAT	Best-Available-Technology treatment (equivalent to the model treatment used in setting the Federal standards)
BAT+	Exceeds BAT treatment
BAT-	Falls short of BAT treatment
n/a	No applicable Fed standards that are that are based on model treatment

<u>Treatment-In-Place</u>

CARBON	Activated Carbon
PH	pH Adjustment
SCRN	Screening

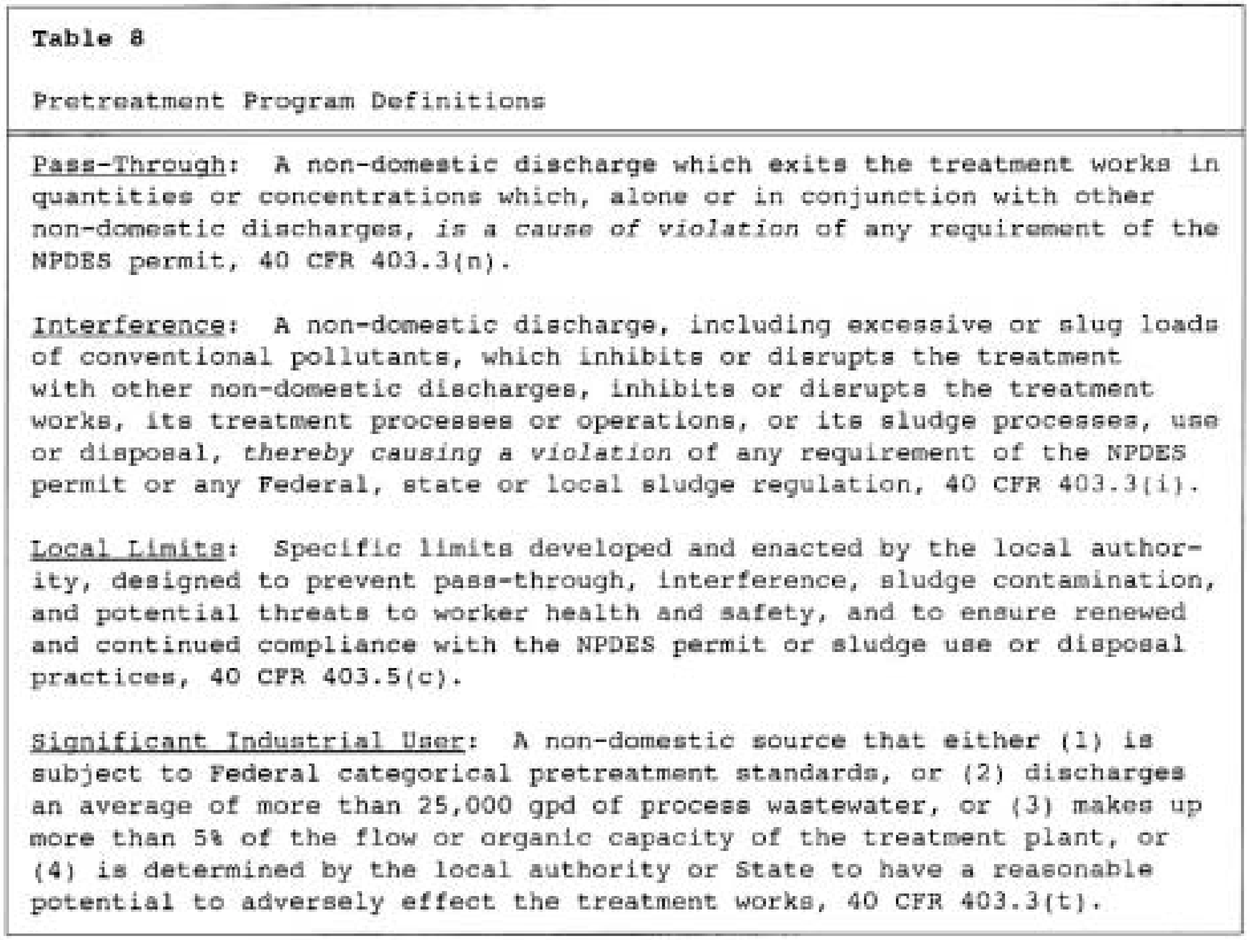


Table 8

Pretreatment Program Definitions

<u>Pass-Through</u>: A non-domestic discharge which exits the treatment works in quantities or concentrations which, alone or in conjunction with other non-domestic discharges, *is a cause of violation* of any requirement of the NPDES permit, 40 CFR 403.3(n).

<u>Interference</u>: A non-domestic discharge, including excessive or slug loads of conventional pollutants, which inhibits or disrupts the treatment with other non-domestic discharges, inhibits or disrupts the treatment works, its treatment processes or operations, or its sludge processes, use or disposal, *thereby causing a violation* of any requirement of the NPDES permit or any Federal, state or local sludge regulation, 40 CFR 403.3(i).

<u>Local Limits</u>: Specific limits developed and enacted by the local authority, designed to prevent pass-through, interference, sludge contamination, and potential threats to worker health and safety, and to ensure renewed and continued compliance with the NPDES permit or sludge use or disposal practices, 40 CFR 403.5(c).

<u>Significant Industrial User</u>: A non-domestic source that either (1) is subject to Federal categorical pretreatment standards, or (2) discharges an average of more than 25,000 gpd of process wastewater, or (3) makes up more than 5% of the flow or organic capacity of the treatment plant, or (4) is determined by the local authority or State to have a reasonable potential to adversely effect the treatment works, 40 CFR 403.3(t).

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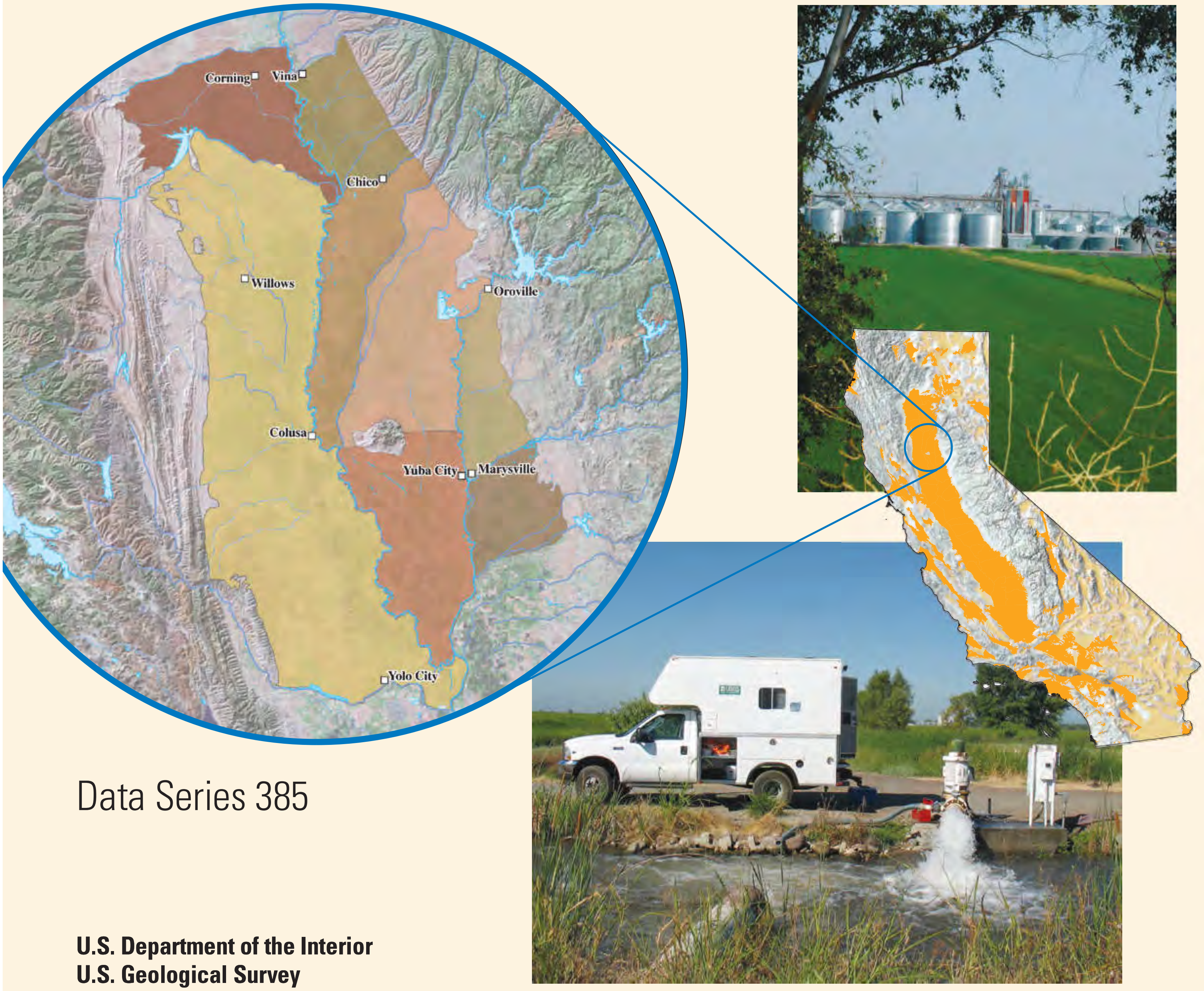
Ground-Water Quality Data in the Middle Sacramento Valley Study Unit, 2006—Results from the California GAMA Program



Data Series 385

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

Cover Photographs:
Top: Rice field and grain silos in Colusa County, California, July 2008. (Photograph taken by Cathy Munday, U.S. Geological Survey.)
Bottom: Irrigation well in Butte County, California, July 2008. (Photograph taken by Michael Judd, U.S. Geological Survey.)

Ground-Water Quality Data in the Middle Sacramento Valley Study Unit, 2006—Results from the California GAMA Program

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Appendix Tables

Abbreviations and Acronyms

(Additional information or clarification given in parentheses)

AB	Assembly Bill (through the California State Assembly)
AL	action level
AL-US	action level (USEPA)
CAS	Chemical Abstracts Service (American Chemical Society)
CSU	combined standard uncertainty
D	detected
DLR	detection level for the purpose of reporting (CDPH)
E	estimated or having a higher degree of uncertainty
ESAC	East study area of the Middle Sacramento Valley study unit
FP	flow path
GAMA	Groundwater Ambient Monitoring and Assessment (program)
GPS	global positioning system
HAL-US	Lifetime Health Advisory Level (USEPA)
HPLC	high-performance liquid chromatography
IBW	inorganic blank water
LRL	laboratory reporting level
LSD	land-surface datum
LT-MDL	long-term method detection level
MCL	maximum contaminant level
MCL-CA	maximum contaminant level (CDPH)
MCL-US	maximum contaminant level (USEPA)
MDL	method detection limit
MRL	minimum reporting level
MSACV	Middle Sacramento Valley study unit
MU	method uncertainty
N	normal (1-gram-equivalent per liter of solution)
na	not available
NAWQA	National Water Quality Assessment (USGS)
nc	sample not collected
NL	notification level
NL-CA	California notification level (CDPH)
NRP	National Research Program (USGS)
NWIS	National Water Information System (USGS)
P	probability
PCFF-GAMA	Personal Computer Field Forms program designed for GAMA sampling
pK	logarithm of the reciprocal of the equilibrium constant for a specified reaction under specific conditions
QC	quality control
RICE	rice agriculture
RPD	relative percent difference
RSD	relative standard deviation
RSD5	risk-specific dose at 10^{-5}

Abbreviations and Acronyms—Continued

RSD5-US	risk-specific dose at 10^{-5} (USEPA)
SMCL	secondary maximum contaminant level
SMCL-CA	secondary maximum contaminant level (CDPH)
SMCL-US	secondary maximum contaminant level (USEPA)
SSMDC	sample-specific minimum detectable concentration
TT	treatment technique
TT-US	treatment technique (USEPA)
U.S.	United States
V	analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results
VBW	VOC-free (nitrogen-purged) blank water
VPDB	Vienna Peedee Belemnite (the international reference standard for carbon isotopes)
VSMOW	Vienna Standard Mean Ocean Water (an isotopic water standard defined in 1968 by the International Atomic Energy Agency)
WSAC	West study area of the Middle Sacramento Valley study unit

Organizations

CDPH	California Department of Public Health (formerly the California Department of Health Services until July 1, 2007)
LLNL	Lawrence Livermore National Laboratory
MWH	Montgomery Watson Harza (laboratory)
NELAP	National Environmental Laboratory Accreditation Program
NWQL	National Water Quality Laboratory (USGS)
SWRCB	State Water Resources Control Board (California)
TML	Trace Metal Laboratory (USGS)
USEPA	U.S. Environmental Protection Agency
USGS	U. S. Geological Survey

Selected Chemical Names

$CaCO_3$	calcium carbonate
CO_3^{-2}	carbonate
DOC	dissolved organic carbon
HCl	hydrochloric acid
HCO_3^-	bicarbonate
MTBE	methyl *tert*-butyl ether
NDMA	*N*-Nitrosodimethylamine
1,2,3-TCP	1,2,3-trichloropropane
TDS	total dissolved solids
THM	trihalomethane
VOC	volatile organic compound

Abbreviations and Acronyms—Continued

Units of Measurement

ft	foot (feet)
in.	inch
L	liter
mg	milligram
mg/L	milligrams per liter (parts per million)
mi	mile
mL	milliliter
mm of Hg	millimeters of mercury
µg/L	micrograms per liter (parts per billion)
µL	microliter
µm	micrometer
NTU	nephelometric turbidity units
pCi/L	picocuries per liter
per mil	parts per thousand
$\delta^{i}E$	standard 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 in per mil

Notes

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).

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).

Ground-Water Quality Data in the Middle Sacramento Valley Study Unit, 2006—Results from the California GAMA Program

By Stephen J. Schmitt, Miranda S. Fram, Barbara J. Milby Dawson, and Kenneth Belitz

Abstract

Ground-water quality in the approximately 3,340 mi^2 Middle Sacramento Valley study unit (MSACV) was investigated from June through September, 2006, as part of the California Groundwater Ambient Monitoring and Assessment (GAMA) program. The GAMA Priority Basin Assessment 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 Middle Sacramento Valley study was designed to provide a spatially unbiased assessment of raw ground-water quality within MSACV, as well as a statistically consistent basis for comparing water quality throughout California. Samples were collected from 108 wells in Butte, Colusa, Glenn, Sutter, Tehama, Yolo, and Yuba Counties. Seventy-one wells were selected using a randomized grid-based method to provide statistical representation of the study unit (grid wells), 15 wells were selected to evaluate changes in water chemistry along ground-water flow paths (flow-path wells), and 22 were shallow monitoring wells selected to assess the effects of rice agriculture, a major land use in the study unit, on ground-water chemistry (RICE wells).

The ground-water samples were analyzed for a large number of synthetic organic constituents (volatile organic compounds [VOCs], gasoline oxygenates and degradates, pesticides and pesticide degradates, and pharmaceutical compounds), constituents of special interest (perchlorate, *N*-nitrosodimethylamine [NDMA], and 1,2,3-trichloropropane [1,2,3-TCP]), inorganic constituents (nutrients, major and minor ions, and trace elements), radioactive constituents, and microbial indicators. Naturally occurring isotopes (tritium, and carbon-14, and stable isotopes of hydrogen, oxygen, nitrogen, and carbon), and dissolved noble gases also were measured to help identify the sources and ages of the sampled ground water.

Quality-control samples (blanks, replicates, laboratory matrix spikes) were collected at approximately 10 percent of the wells, and the results for these samples were used to evaluate the quality of the data for the ground-water samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that contamination was not a noticeable source of bias in the data for the ground-water samples. Differences between replicate samples were within acceptable ranges, indicating acceptably low variability. Matrix spike recoveries were within acceptable ranges for most constituents.

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

Most constituents that were detected in ground-water samples were found at concentrations below drinking-water thresholds. VOCs were detected in less than one-third and pesticides and pesticide degradates in just over one-half of the grid wells, and all detections of these constituents in samples from all wells of the MSACV study unit were below health-based thresholds. All detections of trace elements in samples from MSACV grid wells were below health-based thresholds, with the exceptions of arsenic and boron.

Arsenic concentrations were above the USEPA maximum contaminant level (MCL-US) threshold in eight grid wells, and boron concentrations were above the CDPH notification level (NL-CA) in two grid wells. Arsenic was detected above the MCL-US in two flow-path wells. Arsenic, barium, boron, molybdenum, strontium, and vanadium were detected above health-based thresholds in a few of the RICE wells; these wells are not used to supply drinking water. All detections of radioactive constituents were below health-based thresholds, although six samples had activities of radon-222 above the lower proposed MCL-US threshold. Most of the samples from the MSACV wells had concentrations of major elements, total dissolved solids, and trace elements below the non-enforceable thresholds set for aesthetic concerns. Chloride and sulfate concentrations exceeded SMCL-CA thresholds in two and one grid well, respectively. Iron, manganese, and total dissolved solids concentrations were above the SMCL-CA thresholds in 1, 12, and 6 grid wells, respectively. Nitrate (nitrite plus nitrate, as dissolved nitrogen) concentrations from two grid wells were above the MCL-US threshold. There were no detections of microbial indicators in MSACV.

Introduction

Ground water comprises nearly half of the public water supply used in California (Hutson and others, 2004). To assess the quality of ground water from public-supply wells and establish a program for monitoring trends in ground-water quality, the California State Water Resource Control Board (SWRCB), in collaboration with the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL), implemented a statewide Groundwater Ambient and Monitoring and Assessment (GAMA) program (http://www.waterboards.ca.gov/gama). The GAMA program consists of three projects: Priority Basin Assessment, conducted by the USGS (http://ca.water.usgs.gov/gama/); Voluntary Domestic Well Assessment, conducted by the SWRCB; and Special Studies, conducted by LLNL.

The SWRCB initiated the GAMA Priority Basin Assessment project in response to the Ground-Water Quality Monitoring Act of 2001 (Sections 10780–10782.3 of the California Water Code, Assembly Bill 599). AB 599 is a public mandate to assess and monitor the quality of ground water used as public supply for municipalities in California. The project is a comprehensive assessment of statewide ground-water quality designed to help better understand and identify risks to ground-water resources and to increase the availability of information about ground-water quality to the public. As part of the AB 599 process, the USGS, in collaboration with the SWRCB, developed the monitoring plan for the project (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 Assessment project is unique in California because the data collected during the study include analyses for an extensive number of chemical constituents at very low concentrations—analyses that are not normally available. A broader understanding of ground-water composition will be especially useful for providing an early indication of changes in water quality and for identifying the natural and human factors affecting water quality. Additionally, the GAMA Priority Basin Assessment project will analyze a broader suite of constituents than required by the California Department of Public Health (CDPH, formerly the California Department of Health Services). An understanding of the occurrence and distribution of these constituents is important for the long-term management and protection of ground-water resources.

The range of hydrologic, geologic, and climatic conditions that exist in California must be considered in an assessment of ground-water quality. Belitz, and others (2003) partitioned the state into 10 hydrogeologic provinces, each with distinctive hydrologic, geologic, and climatic characteristics (fig. 1), and representative regions in all 10 provinces were included in the project design. Eighty percent of California's approximately 16,000 public-supply wells are located in ground-water basins within these hydrologic provinces. These ground-water basins, defined by the California Department of Water Resources, generally consist of relatively permeable, unconsolidated deposits of alluvial or volcanic origin (California Department of Water Resources, 2003). Ground-water basins were prioritized for sampling on the basis of the number of public-supply wells in the basin, with secondary consideration given to municipal ground-water use, agricultural pumping, the number of leaking underground fuel tanks, and pesticide applications within the basins (Belitz, and others, 2003). In addition, some ground-water basins or groups of adjacent similar basins with relatively few public-supply wells were assigned high priority so that all hydrogeologic provinces would be represented in the subset of basins sampled. The 116 priority basins were grouped into 35 study units. Some areas not in the defined ground-water basins were included in several of the study units to achieve representation of the 20 percent of public-supply wells not located in the ground-water basins.

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

Provinces from Belitz and others, 2003

Figure 1. The hydrogeologic provinces of California and the location of the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study unit (black area).

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

The Middle Sacramento Valley GAMA study unit, hereinafter referred to as "MSACV," lies in the Central Valley hydrogeologic province (Belitz and others, 2003). MSACV contains eight subbasins of the Sacramento Valley ground-water basin (California Department of Water Resources, 2003) (fig. 2). MSACV was considered high priority for sampling because of the number of public-supply wells, basin area, number of sections with pesticide applications, and the amount of agricultural pumping (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 sampling, analytical, and quality assurance methods used during the study; (3) to present the results of quality-control (QC) tests; and (4) to present the analytical results for ground-water samples collected in MSACV.

Ground-water samples were analyzed for organic, inorganic, and microbial constituents, field parameters, and chemical tracers. The chemical and microbial data presented in this report were evaluated by comparison with state and federal drinking-water regulatory thresholds and other health-based standards that are applied to treated drinking water. Regulatory thresholds considered for this report are those established by the U.S. Environmental Protection Agency (USEPA) and the California Department of Public Health (CDPH) (U.S. Environmental Protection Agency, 2008a, 2008b, 2008c; California Department of Public Health, 2008a, 2008b).

The data presented in this report are intended to characterize the quality of untreated ground-water resources within the study unit, not the treated drinking water delivered to consumers by water purveyors. Discussions of the factors that influence the distribution and occurrence of the constituents detected in ground-water samples will be the subject of subsequent publications.

Acknowledgments

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Hydrogeologic Setting

Knowledge of the hydrogeologic setting is important in the design of a ground-water-quality investigation. MSACV lies within the Central Valley hydrogeologic province of California and covers approximately 3,340 mi^2 in Butte, Colusa, Glenn, Sutter, Tehama, Yolo, and Yuba Counties (fig. 2). The long axis of the study unit trends north-south for a distance of approximately 90 mi along the Sacramento River, and the short axis is approximately 40 mi long and corresponds to the width of the Central Valley between the Coast Ranges to the west and the Sierra Nevada to the east (fig. 2). MSACV contains eight subbasins of the Sacramento Valley ground-water basin (California Department of Water Resources, 2003) (fig. 2). For the purposes of this study, these eight subbasins were grouped into the East and West study areas, separated by the Sacramento River (fig. 3). The East study area includes the subbasins of Vina, West Butte, East Butte, North Yuba, South Yuba, and Sutter, whereas the West study area includes the Colusa and Corning subbasins.

The main water-bearing deposits of MSACV are primarily composed of continental and marine sediments overlying the consolidated Sierra Nevada block (California Department of Water Resources, 2003). These recent Quaternary (Holocene) to Late Tertiary (Miocene) deposits have a cumulative thickness of several hundred feet near the foothills of the Coast Ranges and Sierra Nevada and deepen to approximately 2,000 ft near the valley center. Sources of ground-water recharge include deep infiltration of precipitation, river and stream flow, and agricultural irrigation return flow.

The primary surface-water features of MSACV include the Sacramento River and smaller rivers and their principal tributaries. The rivers and tributaries include Stony Creek and Cache Creek in the West study area, and Butte Creek, the Feather, Yuba, and Bear Rivers in the East study area (fig. 2).

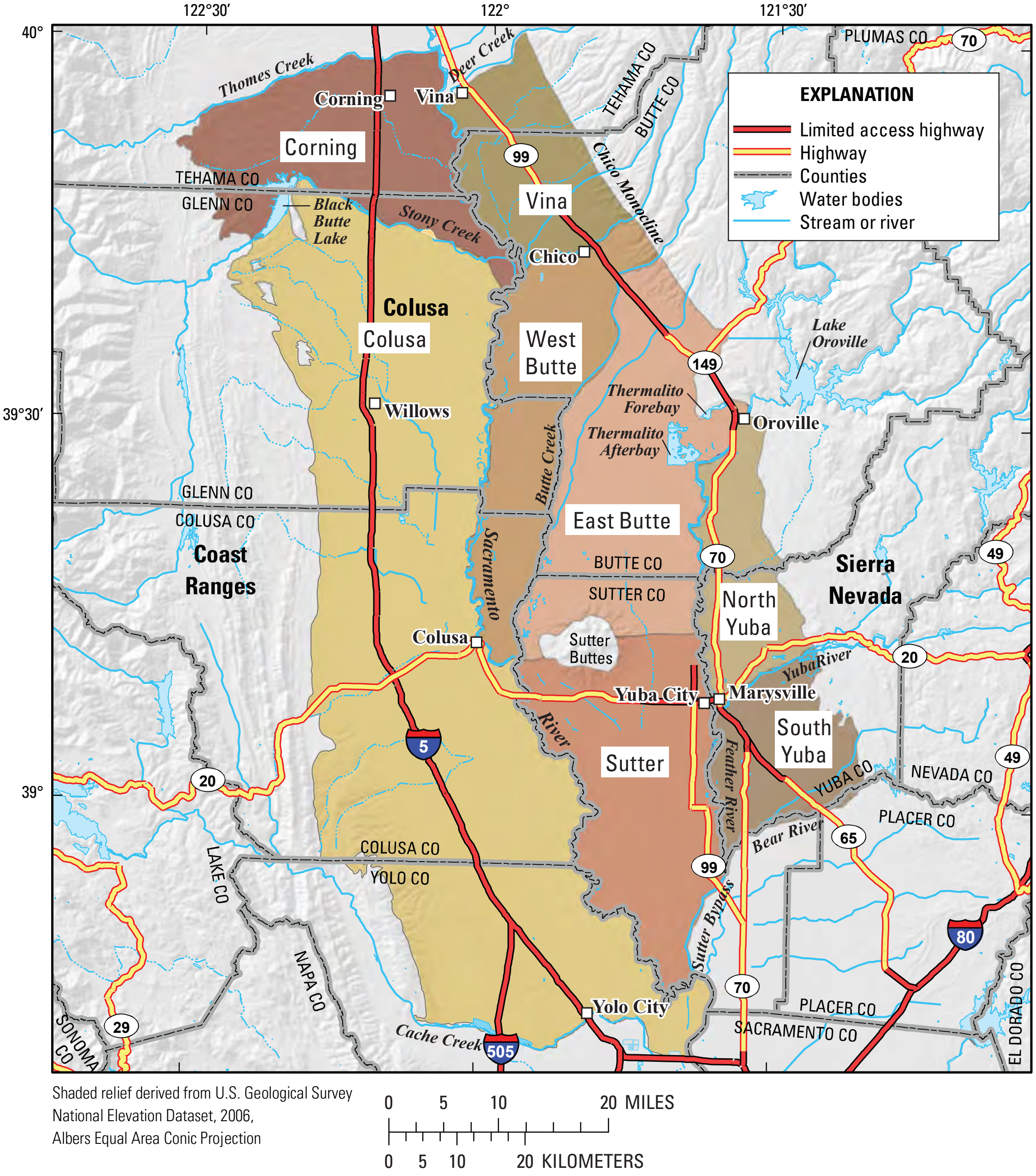


Figure 2. The Middle Sacramento Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the California Department of Water Resources defined ground-water basins and major hydrologic features within the study unit.

West Study Area—Corning and Colusa Subbasins

The West study area is bounded to the north by Thomes Creek, to the south by Cache Creek, to the west by the Coastal Ranges, and to the east by the Sacramento River (fig. 3). It covers an area of approximately 1,756 mi^2 and includes parts of Colusa, Glenn, Tehama, and Yolo Counties (California Department of Water Resources, 2003). The average annual precipitation ranges from 17 to 27 in., increasing to the north and west. The main water-bearing aquifer within this study area is the Tehama formation (Pliocene). The formation consists of unconsolidated to moderately consolidated coarse- and fine-grained sediments, indicative of floodplain deposits. The Tehama formation is up to 2,000 ft thick and varies in depth from a few feet to several hundred feet below the land surface with depth generally increasing to the east. The Tehama formation is confined by the Tertiary-age Tuscan formation, which contains low permeability lahar layers (California Department of Water Resources, 2003).

East Study Area—Vina, W. Butte, E. Butte, N. Yuba, S. Yuba, and Sutter Subbasins

The East study area is bounded to the north by Deer Creek, to the south by Sutter Bypass and Bear River, to the west by the Sacramento River, and to the east by the Chico Monocline and the Sierra Nevada (fig. 3). It covers an area of approximately 1,584 mi^2 and includes parts of Butte, Colusa, Glenn, Sutter, Tehama and Yuba Counties (California Department of Water Resources, 2003). The average annual precipitation is 17 to 32 in., with increasing rainfall to the north and east. Aquifers within this study area are composed of Tertiary to late Quaternary age deposits, with the younger Quaternary deposits typically representing the unconfined portion of the aquifer system. The Quaternary portion of the aquifer system is largely composed of unconsolidated gravel, sand, silt, and clay stream channel and alluvial fan deposits. South and east of the Sutter Buttes, the deposits contain Pleistocene alluvium, which is composed of loosely compacted silts, sands, and gravels that are moderately permeable; however, nearly impermeable hardpans and claypans do exist in this deposit, which restrict the vertical movement of ground water. The confined portion of the aquifer system includes the Tertiary-age Tuscan and Laguna formations. The Tuscan formation consists of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash deposits up to 1,250 ft thick. The Laguna formation consists of moderately consolidated and poorly to well cemented interbedded alluvial sand, gravel, and silt with a low permeability, overall (California Department of Water Resources, 2003).

Methods

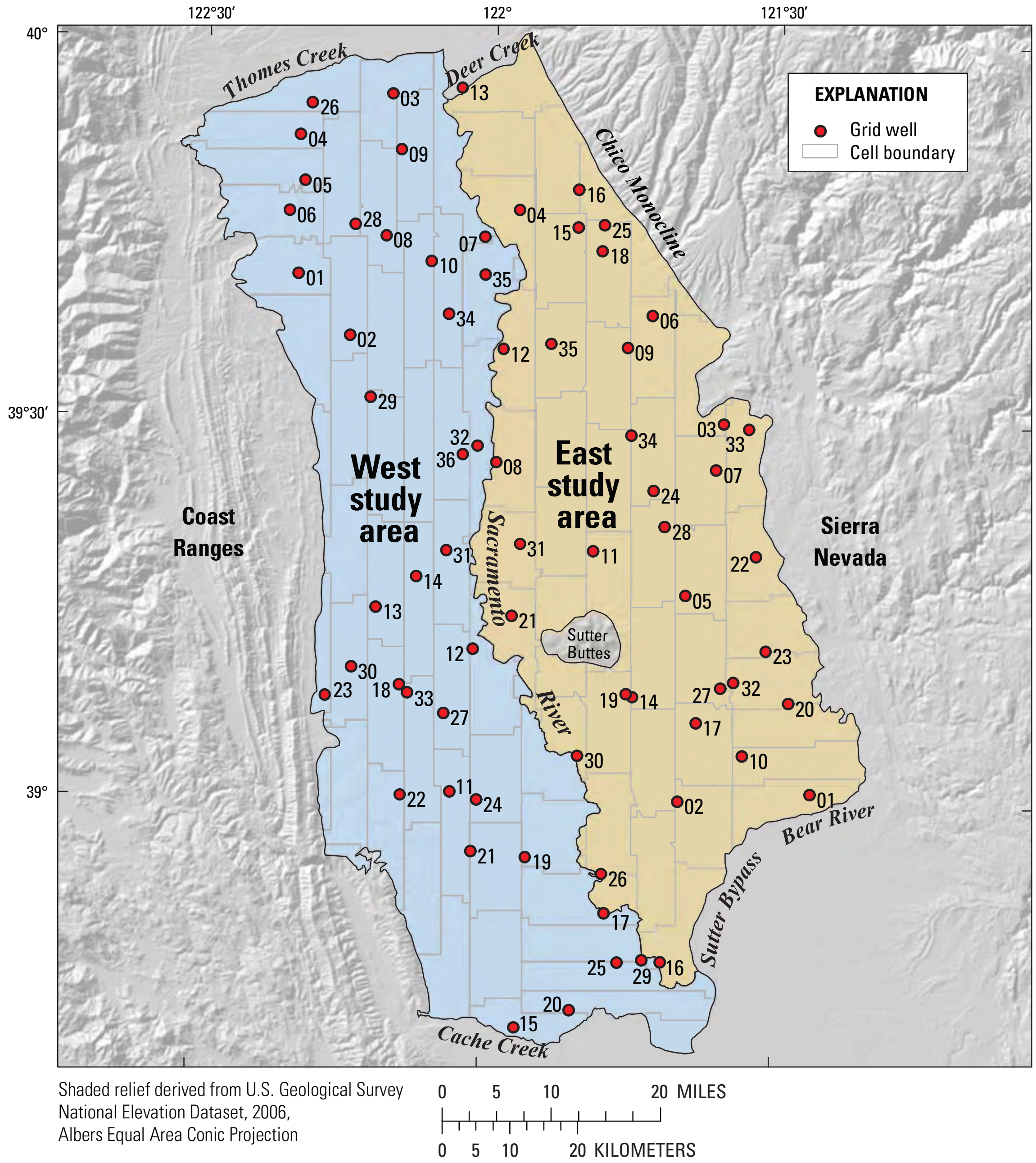
The methods used for the GAMA program were selected to achieve the following objectives: (1) design a sampling plan suitable for statistical analysis, (2) collect samples in a consistent manner, (3) analyze samples using proven and reliable laboratory methods, (4) assure the quality of the ground-water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

Study Design

The wells selected for sampling in this study reflect the combination of two well selection strategies. Seventy-one wells were selected to provide a statistically unbiased, spatially distributed assessment of the quality of ground-water resources used for public drinking-water supply (fig. 3), and 37 additional wells were selected to provide greater sampling density in several areas to address specific ground-water quality issues in the study unit (fig. 4).

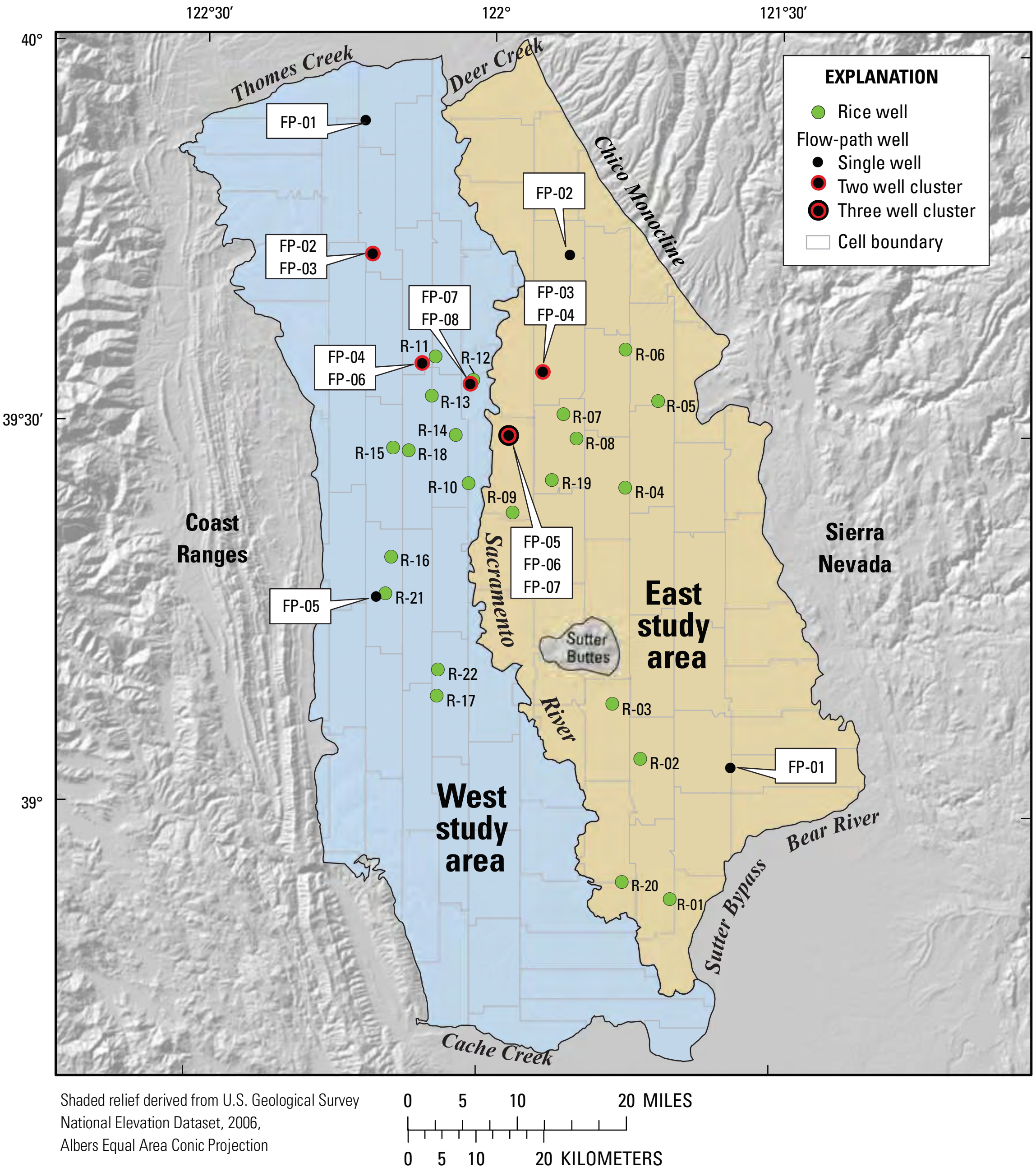
The spatially distributed wells were selected using a randomized grid-based method (Scott, 1990). Each of the study areas was subdivided into grid cells that were 38.6 mi^2 (100 km^2) in area. This grid-cell size met GAMA objectives for the Central Valley hydrogeologic province of a sampling density of at least one well per 38.6 mi^2 and having at least 10 grid cells per study area. For this assessment, the East study area was divided into 41 grid cells and the West study area into 46 grid cells.

Seventy-one of the 87 grid cells in MSACV contained wells that could be sampled; the other 16 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 prior to 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, 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 randomized grid-cell network are hereinafter referred to as “grid wells.” Grid wells sampled in MSACV were numbered in the order of sample collection, with the following prefixes that are based on study area: “ESAC” for the East study area of the Middle Sacramento Valley study unit, and “WSAC” for the West study area of the Middle Sacramento Valley study unit.



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

Figure 3. The East and West study areas of the Middle Sacramento Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the distribution of study area grids cells, the locations of sampled grid cell wells, and the study area boundaries.



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

Figure 4. The East and West study areas of the Middle Sacramento Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the distribution of study area grid cells, the locations of sampled flow-path (FP) and RICE (R) wells (RICE wells are part of a well network monitoring the shallow ground-water quality associated with rice agriculture), and the study area boundaries.

In addition to the 71 grid wells, two types of nonrandomized wells were sampled in the East and West study areas. The first type of nonrandomized wells included 15 wells to evaluate changes in water chemistry along ground-water flow paths; these wells are referred to as “flow-path wells.” Flow-path wells were numbered in the order of sample collection, with the prefixes ESAC-FP for wells in the East Sacramento Valley study area and WSAC-FP for wells in the West Sacramento Valley study area. The second type of nonrandomized wells consisted of 22 shallow monitoring wells selected to assess the effects of rice agriculture, a major land-use in the study unit, on shallow ground-water chemistry. In 1997, the USGS installed and sampled a set of monitoring wells in rice-growing areas of the Sacramento Valley as part of the National Water-Quality Assessment Program (Milby Dawson, 2001). Many of those monitoring wells are in the MSACV area and were resampled as part of this study. The monitoring wells are numbered in the order of sample collection with the prefix “RICE.” Flow-path wells and RICE wells sampled as part of this study for better understanding were not included in the statistical characterization of water quality in MSACV, as the inclusion of these wells would have caused overrepresentation of certain grid wells and of shallow ground water.

Table 1 provides the GAMA alphanumeric identification number for each well, along with the date sampled, sampling schedule, well elevation, and well-construction information.

Well locations and identifications were verified using a global positioning system (GPS) receiver, 1:24,000 scale USGS topographic maps, comparison with existing well information in USGS and CDPH databases, and information provided by well owners. Drillers’ logs 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’s 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 MSACV were sampled using a tiered analytical approach. All wells were sampled for a standard set of constituents, including field water-quality indicators, volatile organic compounds (VOCs), pesticides and pesticide degradates, perchlorate, stable isotopes of water, and dissolved noble gases and tritium and helium age dates. The standard set of constituents was termed the fast schedule (table 2). Wells on the intermediate schedule were sampled for all the constituents on the fast schedule, plus pharmaceuticals, *N*-nitrosodimethylamine (NDMA), 1,2,3-trichloropropane (1,2,3-TCP), nutrients, stable isotopes of oxygen and nitrogen in nitrate, major and minor ions, trace elements, species of arsenic, iron, and chromium, and carbon isotopes. Wells on the slow schedule were sampled for all the constituents on the intermediate schedule, plus dissolved organic carbon, radium 226/228, radon-222, gross alpha and beta radiation, coliform, coliphage, alkalinity, and turbidity (table 2). Fast, intermediate, and slow refer to the time required to sample the well for all the analytes on the schedule. Generally, one slow, two intermediate, or three fast wells could be sampled in one day. RICE wells were sampled on a modified intermediate schedule. In MSACV, 26 wells were sampled on the fast schedule, 52 were sampled on the intermediate schedule, 8 on the slow schedule, and 22 on the RICE monitoring-well schedule (table 2).

Sample Collection and Analysis

Samples were collected in accordance with the protocols established by the USGS’s National Water Quality Assessment (NAWQA) program (Koterba and others, 1995) and the National Field Manual (U.S. Geological Survey, variously dated). These sampling protocols ensure that a representative sample of ground water is collected at each site, and that the samples are collected and handled in a way that minimizes the potential for contamination. The methods used for sample collection are described in the Appendix section “Sample Collection and Analysis.”

Tables 3A–L list the compounds analyzed in each constituent class. Raw (untreated) ground-water samples were analyzed for 85 VOCs (table 3A) and 8 gasoline additives (table 3B), 135 pesticide and pesticide degradates (tables 3C, 3D), 14 pharmaceutical compounds (table 3E), 3 constituents of special interest (table 3F), 5 nutrients and dissolved organic carbon (table 3G), 10 major and minor ions and total dissolved solids (table 3H), 25 trace elements (table 3H), 6 species of arsenic, iron, and chromium (table 3I), 5 stable isotope ratios and 7 radioactive constituents, tritium, and carbon-14 (table 3J), 5 dissolved noble gases, helium stable isotope ratios, and tritium (table 3K), and 4 microbial constituents (table 3L). 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. Thirteen constituents analyzed in this study were measured by more than one method at the USGS’s National Water Quality Laboratory (NWQL), but only the results from the preferred method for each of the constituents are reported. Arsenic, iron, and chromium concentrations, and tritium activities were analyzed by more than one laboratory, and both sets of results are reported.

Quality Assurance

The protocols used for this study are those used by the NAWQA program (U.S. Geological Survey, variously dated; Koterba and others, 1995), and the quality assurance protocols are described in the NWQL quality assurance plan (Maloney, 2005; Pirkey and Glodt, 1998). QC samples collected in the MSACV study include source-solution blanks, field blanks, replicates, and matrix and surrogate spikes. QC samples were collected to evaluate contamination, bias, and variability of the water-quality data that may have resulted from sample collection, processing, storage, transportation, and laboratory analysis. Quality-assurance methods and results are described in the Appendix section “Quality Assurance.”

Water-Quality Results

Quality-Control Sample Results

Results of QC analyses (blanks, replicates, matrix spikes, and surrogates) were used to evaluate the quality of the data for the ground-water samples (see Appendix). Assessment of the QC data from blanks resulted in some ground-water samples being censored, as indicated with “V” codes in tables 5–14. Of the 300 constituents analyzed, 35 were detected in at least one field blank. For 15 of these constituents, concentrations detected in the field blanks were below the lowest concentration detected in ground-water samples, or the constituent was not detected in ground-water samples; thus, no data were affected. Some reported detections for five organic constituents in ground-water samples were flagged as potentially contaminated, and, therefore, were not considered as detections for ground-water quality assessment. Some low concentration detections of 12 inorganic constituents were flagged because contamination may have raised the concentrations sufficiently to have changed a nondetection into a low-level detection relative to the stated reporting limit.

Data from replicates indicate that variability between measurements generally was low, with relative standard deviations (RSD) below 5 percent for most replicate pairs for most constituents. Of the 30 pairs with RSDs above the acceptable limit of 20 percent, 29 had data that were estimated concentrations at or below the laboratory reporting level (LRL) for the constituent analyzed. At these low concentrations, small differences in the measured values in the replicate pairs account for the large RSDs. These results from the replicates confirm that the procedures used to collect and analyze the samples were consistent.

Median matrix-spike recoveries for 35 of the 232 constituents analyzed were lower than the acceptable limits, which may indicate that these constituents might not have been detected in some samples if they were present at very low concentrations.

More than 90 percent of the samples analyzed with surrogates had surrogate recoveries within acceptable limits. The QC results are described in the Appendix section “Quality-Control Sample Results.”

Comparison Thresholds

Concentrations in ground-water samples were compared with CDPH and USEPA drinking-water health-based thresholds. Concentrations were also compared with thresholds established for aesthetics—secondary maximum contaminant levels (SMCLs) (California Department of Health Services, 2007a; California Department of Public Health, 2008a, 2008b; U.S. Environmental Protection Agency, 2006, 2008a, 2008b, 2008c). CDPH became the California Department of Health Services (CDHS) on July 1, 2007. The chemical and microbial data presented in this report are meant to characterize the quality of the untreated ground-water resources within MSACV, 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 untreated ground water because treated drinking water may be subjected to disinfection, filtration, mixing with other waters, and exposure to the atmosphere prior to its delivery to consumers.

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. National MCLs established by the USEPA are the minimum standards with which states are required to comply, and individual states may choose to set more stringent standards. CDPH has established MCLs for additional constituents not regulated by the USEPA, as well as lowered the threshold concentration for a number of constituents with MCLs established by the USEPA. In this report, a threshold set by the USEPA is labeled “MCL-US,” and one set by CDPH that is different from the MCL-US is labeled “MCL-CA.” CDPH is notified when constituents are detected at concentrations exceeding MCL-US or MCL-CA thresholds in samples collected for the GAMA Priority Basin Assessment, but these detections do not constitute violations of CDPH regulations

AL—Action Level. Legally enforceable standards that apply to public-water systems and are designed to protect public health by limiting the levels of copper and lead in drinking water. Detections of copper or lead above the action-level thresholds trigger requirements for mandatory water treatment to reduce the corrosiveness of water to water pipes. The action levels established by the USEPA and CDPH are the same, thus these 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 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 these thresholds are labeled "TT-US" in this report.

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

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

HAL—Lifetime Health Advisory Level. The maximum concentration of a constituent at which its presence in drinking water is not expected to cause any adverse carcinogenic effects for a lifetime of exposure. HALs are established by the USEPA (HAL-US) and are calculated assuming consumption of two liters of water per day over a 70-year lifetime by a 70-kilogram 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 concentrations established by the USEPA by ten (RSD5-US).

For constituents with MCLs, detections in ground-water samples were compared with the MCL-US or MCL-CA. Constituents with SMCLs were compared with the SMCL-CA. For chloride, sulfate, specific conductance, and total dissolved solids, CDPH defines a "recommended" and an "upper" SMCL-CA; detections of these constituents in ground-water samples were compared with both levels. The SMCL-US for these constituents corresponds to the recommended SMCL-CA. Detected concentrations of constituents that lack MCLs and SMCLs were compared with NL-CAs. 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-CA, detected concentrations were compared with the RSD5-US. Note this hierarchy of selection of comparison thresholds means that for constituents with multiple types of established thresholds, the threshold used for comparison purposes may not be the one with the lowest concentration. The comparison thresholds used in this report are listed in tables 3A–L for all constituents and in tables 4–14 for constituents detected in ground-water samples from the MSACV. Not all constituents analyzed for this study have established thresholds. Concentrations greater than the selected comparison threshold are marked with asterisks in tables 4–14.

Ground-Water-Quality Data

Results from analyses of raw (untreated) ground-water samples from MSACV are presented in tables 4–14. Ground-water samples collected in MSACV were analyzed for up to 280 constituents, and 195 of those constituents were not detected in any of the samples (tables 3A–L). The results tables present only the constituents that were detected and list only samples that had at least one constituent detected. For constituent classes that were analyzed at all of the grid wells, the tables include the number of wells at which each analyte was detected, the frequency at which it was detected (in relation to the number of grid wells), and the total number of constituents detected at each well. Results from the flow-path and RICE wells are presented in the tables, but these results were excluded from the detection frequency calculations to avoid statistically over-representing the areas in the vicinity of these wells.

Table 4 includes water-quality indicators measured in the field and at NWQL. Tables 5–14 present the results of ground-water laboratory analyses organized by compound classes:

- Organic constituents
  - VOCs and gasoline oxygenates and degradates (table 5)
  - Pesticides and pesticide degradates (table 6)
- Constituents of special interest (table 7)
- Inorganic constituents
  - Nutrients and dissolved organic carbon (table 8)
  - Major and minor ions (table 9)
  - Trace elements (table 10)
  - Species of inorganic arsenic, iron, and chromium (table 11)
- Inorganic tracer constituents
  - Hydrogen and oxygen isotopes and tritium (table 12)
  - Stable isotopes of nitrogen and carbon and carbon-14 (table 13)
- Radioactive constituents (table 14)

Results for pharmaceutical compounds, dissolved noble gases, and tritium/helium age dates are not presented in this report; they will be included in subsequent GAMA publications. No summary table is presented for microbial constituents because none were detected in any of the samples analyzed.

Water-Quality Indicators

Field and laboratory measurements of water-quality indicators, including dissolved oxygen, pH, specific conductance, alkalinity, and associated parameters (turbidity and water temperature) are presented in table 4. Dissolved oxygen and alkalinity are used as indicators of natural processes that control water chemistry. Specific conductance is the unit electrical conductivity of the water and is proportional to the amount of total dissolved solids (TDS) in the water. The pH value indicates the acidity or basicity of the water. Six wells (3 grid wells, 2 flow-path wells, and 1 RICE well) had pH values outside of the SMCL-CA range for pH. Laboratory pH values may be higher than field pH values because the pH of ground water often increases upon exposure to the atmosphere (see Appendix). Twenty-two wells (11 grid, 1 flow-path well, and 10 RICE wells) had specific conductance values above the recommended SMCL-CA, with 9 of those wells (4 grid wells and 5 RICE wells) above the upper threshold.

Organic Constituents

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

Of the 85 VOCs analyzed, 24 were detected in ground-water samples; all detections were below health-based thresholds and most were less than one-hundredth of the threshold values (table 5). The only VOC detected in more than 10 percent of the grid wells was chloroform, a byproduct of drinking-water disinfection. Chloroform was the most frequently detected VOC in ground water nationally (Zogorski and others, 2006).

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 135 pesticides and pesticide degradates analyzed, 30 were detected in ground-water samples; all detections were below health-based thresholds and all were less than one-hundredth of the threshold values (table 6). The only pesticides detected in more than 10 percent of the grid wells were the herbicides bentazon, simazine, atrazine, and deethylatrazine, a degradate of atrazine. Simazine, atrazine, and deethlyatrazine are among the most commonly detected pesticide compounds in ground water nationally (Gilliom and others, 2006). Bentazon is primarily used in rice agriculture.

Constituents of Special Interest

Perchlorate, 1,2,3-TCP, and NDMA are constituents of special interest in California because they may adversely affect water quality and recently have been found in water supplies (California Department of Health Services, 2007b). Perchlorate is used as an oxidizer in rocket fuel and explosives, 1,2,3-TCP is used as a chemical synthesis product, and NDMA is an industrial by-product. Perchlorate was detected in approximately 6 percent of the grid wells, and all concentrations measured in the MSACV wells were less than one-third of the NL-CA (table 7). 1,2,3-TCP and NDMA were not detected in any samples.

Inorganic Constituents

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

The nutrients, nitrogen and phosphorus, and dissolved organic carbon present in ground water can affect biological activity in aquifers and in surface water bodies that receive ground-water discharge. Nitrogen may be present in the form of ammonia, nitrite, or nitrate depending on the oxidation–reduction state of the ground water. High concentrations of nitrate can adversely affect human health, particularly the health of infants. Ground-water samples from two grid wells in MSACV had concentrations of nitrate (nitrite plus nitrate, dissolved as nitrogen) above the health-based threshold (table 8). All concentrations of nitrite and ammonia measured in ground-water samples were below health-based thresholds. Concentrations of orthophosphate (as phosphorus) and dissolved organic carbon were also low.

The major-ion composition, total dissolved solids (TDS) content, and levels of certain trace elements in ground water may produce undesirable effects on the aesthetic and technical properties of the water. Undesirable aesthetic properties include poor taste, color, or odor, and staining. Undesirable technical properties include scaling, and reduced effectiveness of treatment for other contaminants. CDPH has established non-enforceable thresholds (SMCL-CAs) that are based on aesthetic or technical properties rather than on health-based concerns for the major ions chloride and sulfate, TDS, and several trace elements. Chloride was detected in two grid wells above the recommended SMCL-CA, with one of those detections above the upper SMCL-CA. Sulfate was detected in one grid well above the lower SMCL-CA. Samples from six grid wells contained TDS above the recommended SMCL-CA, although only two of these samples were also above the upper SMCL-CA for TDS (table 9).

Iron and manganese are trace elements whose concentrations are affected by the oxidation–reduction state of the ground water. Precipitation of minerals containing iron or manganese may cause orange or black staining of surfaces. Samples from 12 grid wells had manganese concentrations above the SMCL-CA, and one of these samples also had an iron concentration above the MCL-CA (table 10).

Eighteen of the 25 trace elements analyzed in this study have health-based thresholds. Of the 18 trace elements with health-based thresholds, 2 were not detected in any samples, and all detections of 16 trace elements were below health-based thresholds (table 10). Samples from eight grid wells had arsenic concentrations above the MCL-US and samples from two grid wells had concentrations of boron above the NL-CA.

Arsenic, iron, and chromium occur in different species depending on the oxidation–reduction state of the ground water. The oxidized and reduced species have different solubilities in ground water and may have different effects on human health. The relative proportions of the oxidized and reduced species of each element can be used to aid in interpretation of the oxidation–reduction state of the aquifer. Table 11 reports measured concentrations of total arsenic, iron, and chromium, and the concentrations of the oxidized or the reduced species of each element. The concentration of the other species can be calculated by difference. For example, chromium(III) is equal to chromium(total) minus chromium(VI). The concentrations of arsenic, iron, and chromium reported in table 11 may be different than those reported in table 10 because different analytical methods were used (see Appendix). The concentrations reported in table 10 are considered more accurate.

Inorganic Tracer Constituents

Stable isotope ratios, tritium and carbon-14 activities, and noble gas concentrations are used as tracers of natural processes affecting ground-water composition. The stable isotope ratios of oxygen and hydrogen in water (table 12) may aid in interpretation of ground-water recharge sources. These stable isotope ratios reflect the altitude, latitude, and temperature of precipitation and the extent of evaporation of surface water or soil water. The nitrogen and oxygen stable isotope ratios in nitrate (table 13) may aid in interpretation of sources and processes affecting nitrate concentrations in ground water. Concentrations of dissolved noble gases are used to estimate the conditions of ground-water recharge, particularly the temperature of the recharge water. Noble gases from air dissolve in water that is in contact with the atmosphere, and the solubilities of the different noble gases vary with temperature. Results of noble gas analyses were not available in time for inclusion in this report; they will be presented in a subsequent GAMA report.

Tritium activities (table 12), carbon-14 activities (table 13), and helium isotope ratios provide information about the age of the ground water. 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 by atmospheric testing of nuclear weapons between 1952 and 1963. Thus, concentrations of tritium above background levels generally indicate the presence of water recharged since the early 1950s (Thatcher and others, 1977). Helium isotope ratios are used in conjunction with tritium concentrations to estimate ages for young ground water. Helium isotope analyses were not completed in time for inclusion in this report; they will be presented in a subsequent GAMA report.

Carbon-14 (table 13) 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 and water that is in contact with the atmosphere. Because carbon-14 decays with a half-life of approximately 5,700 years, low activities of carbon-14 relative to modern values generally indicate presence of ground water that is several thousand years old.

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

Radioactive Constituents

Radioactivity is the release of energy or energetic particles during changes in the structure of the nucleus of an atom. Most of the radioactivity in ground water comes from decay of naturally occurring isotopes of uranium and thorium that are present in minerals in the sediments or fractured rocks of an aquifer. Both uranium and thorium decay in a series of steps, eventually forming stable isotopes of lead. Radium-226, radium-228, and radon-222 are radioactive isotopes formed during the uranium and thorium decay series. In each step of 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 cancer risk in humans.

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

The eight MSACV samples analyzed for radioactive constituents had activities of radium and of gross alpha and beta emitters less than established health-based thresholds (table 14). Activities of radon-222 in samples from six grid wells were above the proposed MCL-US of 300 pCi/L, but all were below the proposed alternative MCL-US of 4,000 pCi/L. The 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).

Microbial Indicators

Water is disinfected during drinking-water treatment to prevent diseases that may be spread by water-borne microbial constituents derived from human or animal wastes. The specific viruses and bacteria responsible for diseases generally are not measured because routine analytical methods are not available. Measurements are made of more easily analyzed microbial constituents that serve as indicators of the presence of human or animal waste in water. Drinking-water purveyors respond to detections of microbial indicators by applying additional disinfection techniques to the water.

Samples from eight MSACV wells were analyzed for microbial indicators. None of the samples contained viral indicators F-specific and somatic coliphage, and none contained the bacterial indicator *Escherichia* coliform (*E. coli*) or total coliforms.

Future Work

Subsequent reports will focus on assessment of the data presented in this report using a variety of statistical, qualitative, and quantitative approaches to evaluate the natural and human factors affecting ground-water quality. Water-quality data contained in the CDPH and 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 presented in this report.

Summary

Ground-water quality in the approximately 3,340 mi^2 Middle Sacramento Valley study unit (MSACV) was investigated from June to September, 2006, as part of the Priority Basin Assessment project of Ground-Water Ambient Monitoring and Assessment (GAMA) program. The California State Water Resources Control Board (SWRCB), in collaboration with the U.S. Geological Survey and the Lawrence Livermore National Laboratory, is implementing the GAMA program (http://www.waterboards.ca.gov/gama/). The Priority Basin Assessment project was designed by the SWRCB and the USGS in response to the Ground-Water Quality Monitoring Act of 2001 (Belitz and others, 2003; State Water Resources Control Board, 2003). The project is a comprehensive assessment of statewide ground-water quality designed to identify and characterize risks to ground-water resources and to increase the availability of information about ground-water quality to the public. MSACV was the twelfth study unit sampled as part of the project.

MSACV is in the Central Valley hydrogeologic province, and includes within it eight ground-water basins, as defined by the California Department of Water Resources (California Department of Water Resources, 2003). The MSACV study included assessment of ground-water quality from 108 wells in Butte, Colusa, Glenn, Sutter, Tehama, Yolo, and Yuba Counties. Seventy-one of the wells (grid wells) were selected using a spatially distributed, randomized grid-based method to achieve statistically unbiased representation of the portion of the ground-water resource used for public drinking-water supplies. Fifteen of the wells (flow-path wells) were selected to provide additional sampling density to aid in understanding processes affecting ground-water quality. Twenty-two of the wells (RICE wells) were sampled for better understanding of the contribution of rice agriculture land use to ground-water conditions.

Ground-water samples were analyzed for volatile organic compounds (VOCs), pesticides and pesticide degradates, constituents of special interest, pharmaceutical compounds, nutrients, major and minor ions, trace elements, radioactivity, and microbial indicators. Naturally occurring isotopes (stable isotopes of hydrogen, oxygen, nitrogen, and carbon, and activities of tritium and carbon-14) and dissolved noble gases also were measured to provide a dataset that will be used to help interpret the source and age of the sampled ground water. This report describes the hydrogeologic setting of the MSACV region, details the sampling, analytical, and quality-assurance methods used in the study, and presents the results of the chemical and microbial analyses made of the ground-water samples collected during June to September, 2006.

QC samples (blanks, replicates, samples for matrix spikes) were collected at approximately 10 percent of the wells, and the results for these samples were used to evaluate the quality of the data for the ground-water samples. Field blanks rarely contained detectable concentrations of any constituent, suggesting that contamination was not a noticeable source of bias in the data for the ground-water samples. Most of the differences between replicate samples were within acceptable ranges, indicating acceptably low variability. Matrix spike recoveries were within acceptable ranges for most compounds.

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

All detections of VOCs, pesticides, and pesticide degradates were below health-based thresholds, and most were less than one-hundredth of the threshold values. All detections of perchlorate, and radioactive constituents were below established thresholds. Arsenic, nitrate, and boron were the only constituents detected at concentrations above health-based thresholds in samples from the grid wells. Total dissolved solids, specific conductance, pH, iron, chloride, sulfate, and manganese were detected at concentrations above the SMCL-CA, a non-enforceable threshold set for aesthetic concerns, in samples from several of the grid wells.

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Table 1. Identification, sampling, and construction information for wells sampled for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; ft, foot (feet); LSD, land surface datum; mm/dd/yy, month/day/year; na, not available; no., number; RICE, rice agriculture; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path]

GAMA identification no.	Sampling information		Well type	Construction information			
	Date (mm/dd/yy)	Sampling schedule[1]		Elevation of LSD (ft above NAVD88)[2]	Well depth (ft below LSD)	Top perforation (ft below LSD)	Bottom perforation (ft below LSD)
Grid wells							
ESAC-01	6/29/06	Fast	Production	76	278	150	252
ESAC-02	6/29/06	Fast	Production	38	160	140	160
ESAC-03	7/10/06	Intermediate	Production	176	272	110	150
ESAC-04	7/10/06	Fast	Production	154	200	140	200
ESAC-05	7/10/06	Intermediate	Production	77	410	207	395
ESAC-06	7/12/06	Intermediate	Production	182	260	148	260
ESAC-07	7/12/06	Fast	Production	153	220	80	220
ESAC-08	7/12/06	Fast	Production	89	108	68	108
ESAC-09	7/13/06	Fast	Production	129	554	140	554
ESAC-10	7/13/06	Intermediate	Production	60	316	96	303
ESAC-11	7/13/06	Intermediate	Production	68	520	220	510
ESAC-12	7/17/06	Intermediate	Production	107	375	0	370
ESAC-13	7/17/06	Fast	Production	207	355	na	na
ESAC-14	7/17/06	Fast	Production	47	280	140	280
ESAC-15	7/20/06	Intermediate	Production	197	500	200	480
ESAC-16	7/20/06	Intermediate	Production	297	560	240	540
ESAC-17	7/20/06	Intermediate	Production	52	200	150	na
ESAC-18	7/20/06	Intermediate	Production	220	560	240	540
ESAC-19	7/20/06	Intermediate	Production	48	265	185	265
ESAC-20	7/25/06	Fast	Production	84	354	212	354
ESAC-21	7/25/06	Intermediate	Production	53	na	na	na
ESAC-22	7/26/06	Intermediate	Production	105	90	na	na
ESAC-23	7/26/06	Fast	Production	93	72	na	na
ESAC-24	7/26/06	Fast	Production	94	327	84	318
ESAC-25	7/27/06	Slow	Production	264	570	290	550
ESAC-26	7/31/06	Slow	Production	37	200	160	200
ESAC-27	8/2/06	Slow	Production	54	135	65	125
ESAC-28	8/3/06	Slow	Production	92	360	102	360
ESAC-29	8/3/06	Intermediate	Production	31	223	199	215
ESAC-30	8/7/06	Intermediate	Production	43	na	na	na
ESAC-31	8/7/06	Intermediate	Production	62	235	48	235
ESAC-32	8/17/06	Intermediate	Production	66	140	64	124
ESAC-33	8/17/06	Fast	Production	212	335	na	na
ESAC-34	8/17/06	Intermediate	Production	102	60	na	na
ESAC-35	8/24/06	Intermediate	Production	114	558	74	558
WSAC-01	7/10/06	Fast	Production	446	na	na	na
WSAC-02	7/11/06	Fast	Production	179	na	na	na
WSAC-03	7/11/06	Slow	Production	274	na	115.5	253
WSAC-04	7/11/06	Intermediate	Production	452	880	320	880
WSAC-05	7/12/06	Fast	Production	367	236	136	236
WSAC-06	7/12/06	Intermediate	Production	485	na	na	na
WSAC-07[3]	7/18/06, 8/10/06	Fast	Production	152	220	71	200
WSAC-08	7/18/06	Slow	Production	248	180	56	170
WSAC-09[3]	7/18/06, 8/10/06	Fast	Production	222	na	na	na
WSAC-10[3]	7/18/06, 8/10/06	Intermediate	Production	187	225	145	225
WSAC-11[3]	7/19/06, 8/9/06	Intermediate	Production	142	570	240	561
WSAC-12	7/19/06	Slow	Production	52	490	na	na
WSAC-13	7/24/06	Fast	Production	87	na	na	na

Table 1. Identification, sampling, and construction information for wells sampled for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; ft, foot (feet); LSD, land surface datum; mm/dd/yy, month/day/year; na, not available; no., number; RICE, rice agriculture; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path]

GAMA identification no.	Sampling information		Well type	Construction information			
	Date (mm/dd/yy)	Sampling schedule[1]		Elevation of LSD (ft above NAVD88)[2]	Well depth (ft below LSD)	Top perforation (ft below LSD)	Bottom perforation (ft below LSD)
WSAC-14	7/24/06	Intermediate	Production	62	159	157	159
WSAC-15	7/31/06	Intermediate	Production	147	610	280	610
WSAC-16	7/31/06	Fast	Production	30	332	313	na
WSAC-17	8/1/06	Intermediate	Production	32	260	230	260
WSAC-18	8/1/06	Slow	Production	85	402	160	380
WSAC-19	8/1/06	Fast	Production	37	364	348	356
WSAC-20	8/2/06	Fast	Production	81	340	253	340
WSAC-21	8/2/06	Intermediate	Production	168	369	237	256
WSAC-22	8/8/06	Intermediate	Production	358	870	408	870
WSAC-23	8/8/06	Fast	Production	43	56	31	56
WSAC-24	8/9/06	Fast	Production	75	185	165	185
WSAC-25	8/9/06	Intermediate	Production	45	na	na	na
WSAC-26	8/14/06	Intermediate	Production	413	330	110	330
WSAC-27	8/15/06	Fast	Production	65	300	140	300
WSAC-28	8/15/06	Intermediate	Production	292	165	145	165
WSAC-29	8/16/06	Intermediate	Production	142	759	173	651
WSAC-30	8/16/06	Intermediate	Production	121	na	na	na
WSAC-31	8/21/06	Intermediate	Production	60	260	145	245
WSAC-32	8/21/06	Fast	Production	93	180	110	180
WSAC-33	8/22/06	Fast	Production	88	205	na	na
WSAC-34	8/22/06	Intermediate	Production	144	197	60	180
WSAC-35	8/23/06	Intermediate	Production	143	410	100	410
WSAC-36	8/23/06	Intermediate	Production	82	260	160	260
Flow-path wells							
ESAC-FP-01	7/13/06	Intermediate	Production	51	750	580	720
ESAC-FP-02	8/21/06	Intermediate	Monitoring	181	na	na	na
ESAC-FP-03	8/23/06	Intermediate	Monitoring	105	130	98.8	109
ESAC-FP-04	8/23/06	Intermediate	Monitoring	107	583	509	562
ESAC-FP-05	8/24/06	Intermediate	Monitoring	105	100	80	90
ESAC-FP-06	8/24/06	Intermediate	Monitoring	105	380	340	350
ESAC-FP-07	8/25/06	Intermediate	Monitoring	105	555	520	530
WSAC-FP-01	8/14/06	Intermediate	Monitoring	312	na	na	na
WSAC-FP-02	8/15/06	Intermediate	Monitoring	257	421	390	400
WSAC-FP-03	8/15/06	Intermediate	Monitoring	257	310	270	290
WSAC-FP-04	8/16/06	Intermediate	Monitoring	131	200	138	180
WSAC-FP-05	8/16/06	Intermediate	Production	94	625	540	625
WSAC-FP-06	8/16/06	Intermediate	Monitoring	131	540	445	525
WSAC-FP-07	8/17/06	Intermediate	Monitoring	99	490	415	470
WSAC-FP-08	8/17/06	Intermediate	Monitoring	99	280	190	260
RICE wells							
RICE-01	7/17/06	RICE	Monitoring	24	50	40	45
RICE-02	7/18/06	RICE	Monitoring	38	44	34	39
RICE-03	7/18/06	RICE	Monitoring	43	35	25	30
RICE-04	7/18/06	RICE	Monitoring	88	35	25	30
RICE-05	7/19/06	RICE	Monitoring	126	35	25	30
RICE-06	7/19/06	RICE	Monitoring	138	35	25	30
RICE-07	7/20/06	RICE	Monitoring	91	45	35	40
RICE-08	7/20/06	RICE	Monitoring	88	35	25	30
RICE-09	7/24/06	RICE	Monitoring	70	34	24	28

Table 1. Identification, sampling, and construction information for wells sampled for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; ft, foot (feet); LSD, land surface datum; mm/dd/yy, month/day/year; na, not available; no., number; RICE, rice agriculture; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path]

GAMA identification no.	Sampling information		Well type	Construction information			
	Date (mm/dd/yy)	Sampling schedule[1]		Elevation of LSD (ft above NAVD88)[2]	Well depth (ft below LSD)	Top perforation (ft below LSD)	Bottom perforation (ft below LSD)
RICE-10	7/24/06	RICE	Monitoring	80	35	25	30
RICE-11	7/25/06	RICE	Monitoring	127	35	25	30
RICE-12	7/25/06	RICE	Monitoring	98	35	25	30
RICE-13	7/26/06	RICE	Monitoring	110	35	25	30
RICE-14	7/26/06	RICE	Monitoring	82	36	26	30
RICE-15	7/27/06	RICE	Monitoring	100	35	25	30
RICE-16	7/27/06	RICE	Monitoring	82	35	25	30
RICE-17	8/15/06	RICE	Monitoring	57	35	25	30
RICE-18	8/16/06	RICE	Monitoring	99	38	28	34
RICE-19	8/16/06	RICE	Monitoring	74	38	28	34
RICE-20	8/17/06	RICE	Monitoring	24	29	19	24
RICE-21	9/12/06	RICE	Monitoring	76	35	25	30
RICE-22	9/13/06	RICE	Monitoring	51	35	25	30

[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 sampled twice (well was partially resampled to replace some sample containers lost in shipping prior to analysis).

Table 2. Classes of water-quality indicators, chemical constituents, and microbial constituents collected for the slow, intermediate, fast, and RICE well sampling schedules in the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[DO, dissolved oxygen; NDMA, *N*-nitrosodimethylamine; SC, specific conductance]

Analyte classes	Analyte list table	Slow schedule	Intermediate schedule	Fast schedule	RICE schedule
Water-quality indicators					
DO, SC, pH, temperature		X	X	X	X
Alkalinity, turbidity		X			X
Organic constituents					
Volatile organic compounds	3A	X	X	X	X
Gasoline additives and oxygenates	3B	X			
Pesticides and pesticide degradates	3C, 3D	X	X	X	X
Pharmaceutical compounds	3E	X	X		X
Constituents of special interest					
Perchlorate	3F	X	X	X	X
N-Nitrosodimethylamine (NDMA)	3F	X	X		
1,2,3-Trichloropropane (1,2,3-TCP)	3F	X	X		
Inorganic constituents					
Nutrients	3G	X	X		X
Dissolved organic carbon (DOC)	3G	X			X
Major and minor ions and trace elements	3H	X	X		X
Arsenic, iron, and chromium speciation	3I	X	X		X
Stable isotopes					
Stable isotopes of hydrogen and oxygen in water	3J	X	X	X	X
Stable isotopes of nitrogen and oxygen in nitrate	3J	X	X		
Stable isotopes of carbon and carbon-14 abundance	3J	X	X		
Radioactivity and gases					
Tritium	3J	X	X	X	
Tritium and noble gases	3K	X	X	X	X
Radium isotopes	3J	X			
Radon-222	3J	X			
Gross alpha and beta radiation	3J	X			
Microbial constituents					
Escherichia coliform and total coliform	3L	X			
F-specific and somatic coliphage	3L	X			

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; NL-CA, notification level (CDPH); RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); THM, trihalomethane; USEPA, U.S. Environmental Protection Agency; µg/L, micrograms per liter; —, analyzed but not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type	Threshold value (µg/L)	Detection
Acetone	Solvent	81552	67-64-1	6	na	na	D
Acrylonitrile	Organic synthesis	34215	107-13-1	0.8	RSD5-US	0.6	—
Benzene	Gasoline hydrocarbon	34030	71-43-2	0.021	MCL-CA	1	D
Bromobenzene	Solvent	81555	108-86-1	0.028	na	na	—
Bromochloromethane	Fire retardant	77297	74-97-5	0.12	HAL-US	90	—
Bromodichloromethane	Disinfection by-product (THM)	32101	75-27-4	0.028	MCL-US[1]	80	D
Bromoform (Tribromomethane)	Disinfection by-product (THM)	32104	75-25-2	0.10	MCL-US[1]	80	D
2-Butanone (MEK, Methyl ethyl ketone)	Solvent	81595	78-93-3	2	HAL-US	4,000	D
n-Butylbenzene	Gasoline hydrocarbon	77342	104-51-8	0.12	NL-CA	260	—
sec-Butylbenzene	Gasoline hydrocarbon	77350	135-98-8	0.06	NL-CA	260	—
tert-Butylbenzene	Gasoline hydrocarbon	77353	98-06-6	0.06	NL-CA	260	—
Carbon disulfide	Organic synthesis	77041	75-15-0	0.038	NL-CA	160	D
Carbon tetrachloride (Tetrachloromethane)	Solvent	32102	56-23-5	0.06	MCL-CA	0.5	D
Chlorobenzene	Solvent	34301	108-90-7	0.028	MCL-CA	70	—
Chloroethane	Solvent	34311	75-00-3	0.12	na	na	—
Chloroform (Trichloromethane)	Disinfection by-product (THM)	32106	67-66-3	0.024	MCL-US[1]	80	D
Chloromethane	Refrigerant/organic synthesis	34418	74-87-3	0.17	HAL-US	30	D
3-Chloro-1-propene	Organic synthesis	78109	107-05-1	0.5	na	na	—
2-Chlorotoluene	Solvent	77275	95-49-8	0.04	NL-CA	140	—
4-Chlorotoluene	Solvent	77277	106-43-4	0.05	NL-CA	140	—
Dibromochloromethane	Disinfection by-product (THM)	32105	124-48-1	0.10	MCL-US[1]	80	D
1,2-Dibromo-3-chloropropane (DBCP)	Fumigant	82625	96-12-8	0.51	MCL-US	0.2	—
1,2-Dibromoethane (EDB)	Fumigant	77651	106-93-4	0.036	MCL-US	0.05	—
Dibromomethane	Solvent	30217	74-95-3	0.050	na	na	—
1,2-Dichlorobenzene	Solvent	34536	95-50-1	0.048	MCL-CA	600	—
1,3-Dichlorobenzene	Solvent	34566	541-73-1	0.03	HAL-US	600	—
1,4-Dichlorobenzene	Fumigant	34571	106-46-7	0.034	MCL-CA	5	—
trans-1,4-Dichloro-2-butene	Organic synthesis	73547	110-57-6	0.70	na	na	—
Dichlorodifluoromethane (CFC-12)	Refrigerant	34668	75-71-8	0.18	NL-CA	1,000	—
1,1-Dichloroethane	Solvent	34496	75-34-3	0.035	MCL-CA	5	D
1,2-Dichloroethane	Solvent	32103	107-06-2	0.13	MCL-CA	0.5	—
1,1-Dichloroethene (DCE)	Organic synthesis	34501	75-35-4	0.024	MCL-CA	6	—
cis-1,2-Dichloroethene	Solvent	77093	156-59-2	0.024	MCL-CA	6	D
trans-1,2-Dichloroethene	Solvent	34546	156-60-5	0.032	MCL-CA	10	D
Dichloromethane (Methylene chloride)	Solvent	34423	75-09-2	0.06	MCL-US	5	—
1,2-Dichloropropane	Fumigant	34541	78-87-5	0.029	MCL-US	5	—
1,3-Dichloropropane	Fumigant	77173	142-28-9	0.06	na	na	—
2,2-Dichloropropane	Fumigant	77170	594-20-7	0.05	na	na	—
1,1-Dichloropropene	Organic synthesis	77168	563-58-6	0.026	na	na	—
cis-1,3-Dichloropropene	Fumigant	34704	10061-01-5	0.05	RSD5-US[2]	4	—
trans-1,3-Dichloropropene	Fumigant	34699	10061-02-6	0.09	RSD5-US[2]	4	—
Diethyl ether	Solvent	81576	60-29-7	0.08	na	na	—
Diisopropyl ether (DIPE)	Gasoline oxygenate	81577	108-20-3	0.10	na	na	—
Ethylbenzene	Gasoline hydrocarbon	34371	100-41-4	0.030	MCL-CA	300	—
Ethyl *tert*-butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.030	na	na	—

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; NL-CA, notification level (CDPH); RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); THM, trihalomethane; USEPA, U.S. Environmental Protection Agency; µg/L, micrograms per liter; —, analyzed but not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type	Threshold value (µg/L)	Detection
Ethyl methacrylate	Organic synthesis	73570	97-63-2	0.18	na	na	—
1-Ethyl-2-methylbenzene (*o*-Ethyl toluene)	Gasoline hydrocarbon	77220	611-14-3	0.06	na	na	D
Hexachlorobutadiene	Organic synthesis	39702	87-68-3	0.14	RSD5-US	90	—
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	—
Isopropylbenzene (Cumene)	Gasoline hydrocarbon	77223	98-82-8	0.038	NL-CA	770	—
4-Isopropyl-1-methylbenzene	Gasoline hydrocarbon	77356	99-87-6	0.08	na	na	D
Methyl acrylate	Organic synthesis	49991	96-33-3	1.0	na	na	—
Methyl acrylonitrile	Organic synthesis	81593	126-98-7	0.40	na	na	—
Methyl bromide (Bromomethane)	Fumigant	34413	74-83-9	0.33	HAL-US	10	—
Methyl *tert*-butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.10	MCL-CA	13	D
Methyl iodide (Iodomethane)	Organic synthesis	77424	74-88-4	0.50	na	na	—
Methyl isobutyl ketone (MIBK)	Solvent	78133	108-10-1	0.37	NL-CA	120	—
Methyl methacrylate	Organic synthesis	81597	80-62-6	0.20	na	na	—
Methyl *tert*-pentyl ether (*tert*-Amyl methyl ether, TAME)	Gasoline oxygenate	50005	994-05-8	0.04	na	na	—
Naphthalene	Gasoline hydrocarbon	34696	91-20-3	0.52	NL-CA	17	—
n-Propylbenzene	Solvent	77224	103-65-1	0.042	NL-CA	260	—
Styrene	Gasoline hydrocarbon	77128	100-42-5	0.042	MCL-US	100	—
1,1,1,2-Tetrachloroethane	Solvent	77562	630-20-6	0.03	HAL-US	70	—
1,1,2,2-Tetrachloroethane	Solvent	34516	79-34-5	0.08	MCL-CA	1	—
Tetrachloroethene (PCE)	Solvent	34475	127-18-4	0.030	MCL-US	5	D
Tetrahydrofuran	Solvent	81607	109-99-9	1.2	na	na	—
1,2,3,4-Tetramethylbenzene	Gasoline hydrocarbon	49999	488-23-3	0.14	na	na	D
1,2,3,5-Tetramethylbenzene	Gasoline hydrocarbon	50000	527-53-7	0.18	na	na	D
Toluene	Gasoline hydrocarbon	34010	108-88-3	0.02	MCL-CA	150	D
1,2,3-Trichlorobenzene	Organic synthesis	77613	87-61-6	0.18	na	na	—
1,2,4-Trichlorobenzene	Solvent	34551	120-82-1	0.12	MCL-CA	5	—
1,1,1-Trichloroethane (TCA)	Solvent	34506	71-55-6	0.032	MCL-US	200	—
1,1,2-Trichloroethane	Solvent	34511	79-00-5	0.04	MCL-US	5	—
Trichloroethene (TCE)	Solvent	39180	79-01-6	0.038	MCL-US	5	D
Trichlorofluoromethane (CFC-11)	Refrigerant	34488	75-69-4	0.08	MCL-CA	150	D
1,2,3-Trichloropropane (1,2,3-TCP)	Solvent/organic synthesis	77443	96-18-4	0.18	NL-CA	0.005	—
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)	Refrigerant	77652	76-13-1	0.038	MCL-CA	1,200	—
1,2,3-Trimethylbenzene	Gasoline hydrocarbon	77221	526-73-8	0.09	na	na	—
1,2,4-Trimethylbenzene	Gasoline hydrocarbon	77222	95-63-6	0.056	NL-CA	330	D
1,3,5-Trimethylbenzene	Organic synthesis	77226	108-67-8	0.044	NL-CA	330	D
Vinyl bromide (Bromoethene)	Fire retardant	50002	593-60-2	0.10	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	0.06	MCL-CA	1,750	D
o-Xylene	Gasoline hydrocarbon	77135	95-47-6	0.038	MCL-CA	1,750	—

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[1] The MCL-US and MCL-CA thresholds for trihalomethanes are the sum of chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; DLR-CA, detection level for the purpose of reporting (CDPH); LRL, laboratory reporting level; MCL-US, maximum contaminant level (USEPA); na, not available; NL-CA, notification level (CDPH); USEPA, U.S. Environmental Protection Agency; µg/L, micrograms per liter; —, analyzed but not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Threshold type	Threshold value (µg/L)	Detection
Acetone	Degradate	81552	67-64-1	1.8	na	na	D
tert-Amyl alcohol	Gasoline oxygenate	77073	75-85-4	1	na	na	—
tert-Butyl alcohol (TBA)	Oxygenate/degradate	77035	75-65-0	1	NL-CA	12	—
Diisopropyl ether	Gasoline oxygenate	81577	108-20-3	0.04	na	na	—
Ethyl *tert*-butyl ether (ETBE)	Gasoline oxygenate	50004	637-92-3	0.06	DLR-CA	3	—
Methyl acetate	Degradate	77032	79-20-9	0.43	na	na	—
Methyl *tert*-butyl ether (MTBE)	Gasoline oxygenate	78032	1634-04-4	0.05	MCL-US	13	D
Methyl *tert*-pentyl ether	Gasoline oxygenate	50005	994-05-8	0.05	DLR-CA	3	—

Table 3C. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032 and 2033.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Rice wells were sampled for Schedule 2033, whereas all other wells were sampled for Schedule 2032. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; µg/L, micrograms per liter; —, analyzed but not detected]

Constituent[1]	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Type of comparison threshold	Threshold (µg/L)	Detection
Acetochlor	Herbicide	49260	34256-82-1	0.006	na	na	D
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	0.05	na	na	—
Azinphos-methyl-oxon	Degradate	61635	961-22-8	0.042	na	na	—
Benfluralin	Herbicide	82673	1861-40-1	0.01	na	na	—
Carbaryl	Insecticide	82680	63-25-2	0.041	RSD5	400	D
Carbofuran	Herbicide	82674	1563-66-2	0.02	MCL-CA	18	—
2-Chloro-2,6-diethylacetanilide	Degradate	61618	6967-29-9	0.0065	na	na	—
2-Chloro-4-isopropylamino-6-amino-s-triazine (deethylatrazine)	Degradate	04040	6190-65-4	0.014	na	na	D
4-Chloro-2-methylphenol	Degradate	61633	1570-64-5	0.005	na	na	—
Chlorpyrifos	Insecticide	38933	2921-88-2	0.005	HAL-US	2	D
Chlorpyrofos, oxygen analog	Degradate	61636	5598-15-2	0.0562	na	na	—
Cyanazine[2]	Herbicide	04041	21725-46-2	0.018	HAL-US	1	—
Cyfluthrin	Insecticide	61585	68359-37-5	0.053	na	na	—
λ-Cyhalothrin	Insecticide	61595	91465-08-6	0.014	na	na	—
Cypermethrin	Insecticide	61586	52315-07-8	0.046	na	na	—
DCPA (Dacthal) monoacid	Herbicide	82682	1861-32-1	0.003	HAL-US	70	—
Desulfinylfipronil	Degradate	62170	na	0.012	na	na	D
Desulfinylfipronil amide	Degradate	62169	na	0.029	na	na	—
Diazinon	Insecticide	39572	333-41-5	0.005	HAL-US	1	—
3,4-Dichloroaniline	Degradate	61625	95-76-1	0.0045	na	na	D
3,5-Dichloroaniline[2]	Degradate	61627	626-43-7	0.012	na	na	—
Dichlorvos	Fumigant	38775	62-73-7	0.013	na	na	—
Dicrotophos	Insecticide	38454	141-66-2	0.0843	na	na	—
Dieldrin	Insecticide	39381	60-57-1	0.009	RSD5	0.2	—
2,6-Diethylaniline	Degradate	82660	579-66-8	0.006	na	na	—
Dimethoate	Insecticide	82662	60-51-5	0.0061	na	na	—
Disulfoton[2]	Insecticide	82677	298-04-4	0.021	HAL-US	0.7	—
Disulfoton sulfone[2]	Degradate	61640	218208	0.014	na	na	—
α-Endosulfan[2]	Insecticide	34362	959-98-8	0.011	na	na	—
Endosulfan sulfate[2]	Degradate	61590	1031-07-8	0.022	na	na	—
EPTC[2]	Herbicide	82668	759-94-4	0.004	na	na	—
Ethion	Insecticide	82346	563-12-2	0.016	na	na	—
Ethion monoxon	Degradate	61644	17356-42-2	0.021	na	na	—
Ethoprophos[2]	Insecticide	82672	13194-48-4	0.012	na	na	—
2-Ethyl-6-methylaniline	Degradate	61620	24549-06-2	0.01	na	na	—
Fenamiphos	Insecticide	61591	22224-92-6	0.029	HAL-US	0.7	—
Fenamiphos sulfone	Degradate	61645	31972-44-8	0.053	na	na	—
Fenamiphos sulfoxide	Degradate	61646	31972-43-7	0.04	na	na	—
Fipronil	Insecticide	62166	120068-37-3	0.016	na	na	D
Fipronil sulfide	Degradate	62167	120067-83-6	0.013	na	na	D
Fipronil sulfone	Degradate	62168	120068-36-2	0.024	na	na	D
Fonofos	Insecticide	04095	944-22-9	0.0053	HAL-US	10	—
Hexazinone	Herbicide	04025	51235-04-2	0.026	HAL-US	400	D
Isofenphos	Insecticide	61594	25311-71-1	0.011	na	na	—
Malaoxon	Degradate	61652	1634-78-2	0.039	na	na	—

Table 3C. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032 and 2033.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. Rice wells were sampled for Schedule 2033, whereas all other wells were sampled for Schedule 2032. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; µg/L, micrograms per liter; —, analyzed but not detected]

Constituent[1]	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Type of comparison threshold	Threshold (µg/L)	Detection
Malathion	Insecticide	39532	121-75-5	0.027	HAL-US	100	—
Metalaxyl	Fungicide	61596	57837-19-1	0.0069	na	na	—
Methidathion	Insecticide	61598	950-37-8	0.0087	na	na	—
Methyl paraoxon[2]	Degradate	61664	950-35-6	0.019	na	na	—
Methyl parathion	Insecticide	82667	298-00-0	0.015	HAL-US	1	—
Metolachlor	Herbicide	39415	51218-45-2	0.006	HAL-US	700	D
Metribuzin	Herbicide	82630	21087-64-9	0.028	HAL-US	70	—
Molinate	Herbicide	82671	2212-67-1	0.003	MCL-CA	20	D
Myclobutanil	Fungicide	61599	88671-89-0	0.033	na	na	—
1-Naphthol	Degradate	49295	90-15-3	0.0882	na	na	—
Oxyfluorfen[2]	Herbicide	61600	42874-03-3	0.017	na	na	—
Pendimethalin	Herbicide	82683	40487-42-1	0.022	na	na	—
cis-Permethrin	Insecticide	82687	54774-45-7	0.006	na	na	—
Phorate	Insecticide	82664	298-02-2	0.055	na	na	—
Phorate oxygen analog	Degradate	61666	2600-69-3	0.027	na	na	—
Phosmet	Insecticide	61601	732-11-6	0.0079	na	na	D
Phosmet oxon	Degradate	61668	3735-33-9	0.0511	na	na	D
Prometon	Herbicide	04037	1610-18-0	0.01	HAL-US	100	—
Prometryn	Herbicide	04036	7287-19-6	0.0059	na	na	—
Pronamide	Herbicide	82676	23950-58-5	0.004	RSD5	200	—
Propargite[2]	Insecticide	82685	2312-35-8	0.023	na	na	—
Propanil	Herbicide	82679	709-98-8	0.011	na	na	D
cis-Propiconazole	Fungicide	79846	60207-90-1	0.013	na	na	D
trans-Propiconazole	Fungicide	79847	60207-90-1	0.034	na	na	D
Simazine	Herbicide	04035	122-34-9	0.005	MCL-US	4	D
Tebuconazole[2]	Fungicide	62852	107534-96-3	0.0136	na	na	—
Tebuthiuron	Herbicide	82670	34014-18-1	0.016	HAL-US	500	D
Tefluthrin[2]	Insecticide	61606	79538-32-2	0.0033	na	na	—
Terbufos	Insecticide	82675	13071-79-9	0.017	HAL-US	0.4	—
Terbufos oxygen analog sulfone	Degradate	61674	56070-15-6	0.045	na	na	—
Terbuthylazine	Herbicide	04022	5915-41-3	0.0083	na	na	—
Thiobencarb	Herbicide	82681	28249-77-6	0.01	MCL-CA	70	—
Tribufos	Herbicide	61610	78-48-8	0.035	na	na	—
Trifluralin	Herbicide	82661	1582-09-8	0.009	HAL-US	10	—

[1] Constituents on both Schedules 2032 and 2033 unless noted otherwise.

[2] Constituent on Schedule 2033 only.

Table 3D. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedule 2060.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; µg/L, micrograms per liter; —, analyzed but not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Type of comparison threshold	Threshold (µg/L)	Detection
Acifluorfen	Herbicide	49315	50594-66-6	0.028	na	na	—
Aldicarb	Insecticide	49312	116-06-3	0.15	MCL-US	3	—
Aldicarb sulfone	Insecticide/degradate	49313	1646-88-4	0.018	MCL-US	2	—
Aldicarb sulfoxide	Degradate	49314	1646-87-3	0.1	MCL-US	4	—
Atrazine	Herbicide	39632	1912-24-9	0.008	MCL-CA	1	D
Bendiocarb	Insecticide	50299	22781-23-3	0.08	na	na	—
Benomyl	Fungicide	50300	17804-35-2	0.022	na	na	—
Bensulfuron-methyl	Herbicide	61693	83055-99-6	0.018	na	na	D
Bentazon	Herbicide	38711	25057-89-0	0.024	MCL-CA	18	D
Bromacil	Herbicide	04029	314-40-9	0.018	HAL-US	70	—
Bromoxynil	Herbicide	49311	1689-84-5	0.044	na	na	—
Caffeine	Beverages	50305	58-08-2	0.018	na	na	—
Carbaryl	Insecticide	49310	63-25-2	0.018	RSD5	400	D
Carbofuran	Herbicide	49309	1563-66-2	0.016	MCL-CA	18	—
Chloramben, methyl ester	Herbicide	61188	7286-84-2	0.024	na	na	—
Chlorimuron-ethyl	Herbicide	50306	90982-32-4	0.032	na	na	D
2-Chloro-6-ethylamino-4-amino-*s*-triazine (deisopropylatrazine)	Degradate	04038	1007-28-9	0.08	na	na	D
2-Chloro-4-isopropylamino-6-amino-*s*-triazine (deethylatrazine)	Degradate	04040	6190-65-4	0.028	na	na	D
3-(4-Chlorophenyl)-1-methyl urea	Degradate	61692	5352-88-5	0.036	na	na	—
Clopyralid	Herbicide	49305	1702-17-6	0.067	na	na	—
Cycloate	Herbicide	04031	1134-23-2	0.014	na	na	—
DCPA (Dactal) monoacid	Degradate	49304	887-54-7	0.028	na	na	—
Dicamba	Herbicide	38442	1918-00-9	0.036	HAL-US	400	—
2,4-D and 2,4-D methyl ester, summed on molar basis, reported as 2,4-D	Herbicide	66496	94-75-7	0.009	MCL-US	70	D
4-(2,4-Dichlorophenoxy)butyric acid (2,4-DB)	Herbicide	38746	94-82-6	0.020	na	na	—
Dichlorprop	Herbicide	49302	120-36-5	0.028	na	na	—
Dinoseb	Herbicide	49301	88-85-7	0.038	MCL-US	7	D
Diphenamid	Herbicide	04033	957-51-7	0.010	HAL-US	200	—
Diuron	Herbicide	49300	330-54-1	0.016	RSD5	200	D
Fenuron	Herbicide	49297	101-42-8	0.01	na	na	—
Flumetsulam	Herbicide	61694	98967-40-9	0.04	na	na	—
Fluometuron	Herbicide	38811	2164-17-2	0.016	HAL-US	90	—
3-Hydroxycarbofuran	Degradate	49308	16655-82-6	0.008	na	na	—
2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine (hydroxyatrazine)	Degradate	50355	2163-68-0	0.032	na	na	D
Imazaquin	Herbicide	50356	81335-37-7	0.036	na	na	—
Imazethapyr	Herbicide	50407	81335-77-5	0.038	na	na	—
Imidacloprid	Insecticide	61695	138261-41-3	0.02	na	na	—
Linuron	Herbicide	38478	330-55-2	0.014	na	na	—
Metalaxyl	Fungicide	50359	57837-19-1	0.03	na	na	—
Methiocarb	Insecticide	38501	2032-65-7	0.034	na	na	—
Methomyl	Insecticide	49296	16752-77-5	0.07	HAL-US	200	—
2-Methyl-4-chlorophenoxyacetic acid (MCPA)	Herbicide	38482	94-74-6	0.07	HAL-US	4	D

Table 3D. Pesticides and pesticide degradates, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedule 2060.—Continued

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; µg/L, micrograms per liter; —, analyzed but not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	LRL (µg/L)	Type of comparison threshold	Threshold (µg/L)	Detection
4-(2-Methyl-4-chlorophenoxy) butyric acid (MCPB)	Herbicide	38487	94-81-5	0.1	na	na	—
Metsulfuron methyl[1]	Herbicide	61697	74223-64-6	0.067	na	na	—
Neburon	Herbicide	49294	555-37-3	0.012	na	na	—
Nicosulfuron	Herbicide	50364	111991-09-4	0.04	na	na	—
Norflurazon	Herbicide	49293	27314-13-2	0.02	na	na	—
Oryzalin	Herbicide	49292	19044-88-3	0.023	na	na	—
Oxamyl	Insecticide	38866	23135-22-0	0.05	MCL-CA	50	—
Picloram	Herbicide	49291	1918-02-01	0.032	MCL-US	500	—
Propham	Herbicide	49236	122-42-9	0.03	HAL-US	100	—
Propiconazole	Fungicide	50471	60207-90-1	0.01	na	na	D
Propoxur	Insecticide	38538	114-26-1	0.008	na	na	—
Siduron	Herbicide	38548	1982-49-6	0.02	na	na	—
Sulfometuron-methyl	Herbicide	50337	74222-97-2	0.09	na	na	—
Tebuthiuron	Herbicide	82670	34014-18-1	0.026	HAL-US	500	D
Terbacil	Herbicide	04032	5902-51-2	0.026	HAL-US	90	—
Triclopyr	Herbicide	49235	55335-06-3	0.026	na	na	D

[1] These constituents were reported using method reporting levels (MRLs) during the period of this study.

Table 3E. Pharmaceutical compounds, primary uses or sources, comparative thresholds, and reporting information for the U.S. Geological Survey's (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 February 10, 2007. CAS, Chemical Abstracts Service; MDL, method detection limit; na, not available; µg/L, micrograms per liter]

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

[1] The California Groundwater Ambient Monitoring and Assessment (GAMA) program uses more conservative reporting limits for the pharmaceutical compounds than recommended by the USGS's National Water Quality Laboratory. For albuterol, carbamazepine, codeine, dehydronifedipine, diltiazem, sulfamethoxazole, thiabendazole, trimethoprim, and warfarin, the MDL corresponds to the long-term method detection limit determined by the USGS's Branch of Quality Systems in October 2007 (BQS LT-MDL). For acetaminophen, caffeine, cotinine, diphenhydramine, and paraxanthine, the MDL corresponds to the effective method detection limit determined from assessment of quality-control data associated with GAMA samples collected from May 2004 to September 2007 (GAMA E-MDL). The GAMA E-MDL is higher than the BQS LT-MDL for those compounds. Detections reported by the USGS's National Water Quality Laboratory with concentrations lower than the BQS LT-MDL or GAMA E-MDL are reported as nondetections by the GAMA program.

Table 3F. Constituents of special interest, primary uses or sources, comparative thresholds, and reporting information for the Montgomery Watson Harza 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 October 18, 2007. The laboratory entity code for the Montgomery Watson Harza laboratory in the USGS's National Water Information System (NWIS) is CA-MWHL. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; HAL-CA, Lifetime Health Advisory Level (CDPH); MCL-CA, maximum contaminant level (CDPH); MRL, minimum reporting level; NL-CA, notification level (CDPH); µg/L, micrograms per liter; —, not detected]

Constituent	Primary use or source	USGS parameter code	CAS number	MRL (µg/L)	Threshold type	Threshold value (µg/L)	Detection
Perchlorate	Rocket fuel, fireworks, flares	61209	14797-73-0	0.5	MCL-CA	6	D
1,2,3-Trichloropropane (1,2,3-TCP)	Fumigant, solvent	77443	96-18-4	0.005	HAL-CA	40	—
N-Nitrosodimethylamine (NDMA)	Rocket fuel, plasticizer	64176	62-75-9	0.002	NL-CA	10	—

Table 3G. Nutrients and dissolved organic carbon, comparative thresholds, and reporting information for the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedule 2755 and parameter code 2613.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. CAS, Chemical Abstracts Service; D, detected; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-US, maximum contaminant level (USEPA); mg/L, milligrams per liter; na, not available; USEPA, U.S. Environmental Protection Agency]

Constituent	USGS parameter code	CAS number	LRL (mg/L)	Threshold type	Threshold value (mg/L)	Detection
Ammonia (as nitrogen)	00608	7664-41-7	0.01	HAL-US	30	D
Nitrate plus nitrite (as nitrogen)	00631	na	0.06	MCL-US	10	D
Nitrite (as nitrogen)	00613	14797-65-0	0.002	MCL-US	1	D
Total nitrogen (ammonia + nitrate + nitrite + organic nitrogen as nitrogen)	62854	17778-88-0	0.06	na	na	D
Orthophosphate (as phosphorus)	00671	14265-44-2	0.006	na	na	D
Dissolved organic carbon (DOC)	00681	na	0.33	na	na	D

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. AL-US, action level (USEPA); CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); mg/L, milligrams per liter; na, not available; NL-CA, notification level (CDPH); SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; µg/L, micrograms per liter; —, not detected]

Constituent	USGS parameter code	CAS number	LRL	Threshold type	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	0.2	SMCL-CA	250 (500)[1]	D
Fluoride	00950	16984-48-8	0.1	MCL-CA	2	D
Iodide	78165	7553-56-2	0.002	na	na	D
Magnesium	00925	7439-95-4	0.008	na	na	D
Potassium	00935	7440-09-7	0.16	na	na	D
Silica	00955	7631-86-9	0.04	na	na	D
Sodium	00930	7440-23-5	0.2	na	na	D
Sulfate	00945	14808-79-8	0.18	SMCL-CA	250 (500)[1]	D
Total dissolved solids (TDS)	70300	na	10	SMCL-US	500 (1,000)[1]	D
Trace elements (µg/L)						
Aluminum	01106	7429-90-5	1.6	MCL-CA	1,000	D
Antimony	01095	7440-36-0	0.2	MCL-US	6	D
Arsenic	01000	7440-38-2	0.12	MCL-US	10	D
Barium	01005	7440-39-3	0.2	MCL-CA	1,000	D
Beryllium	01010	7440-41-7	0.06	MCL-US	4	—
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	0.4	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	0.08	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
Mercury	71890	7439-97-6	0.01	MCL-US	2	—
Molybdenum	01060	7439-98-7	0.4	HAL-US	40	D
Nickel	01065	7440-02-0	0.06	MCL-CA	100	D
Selenium	01145	7782-49-2	0.8	MCL-US	50	D
Silver	01075	7440-22-4	0.2	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	0.1	NL-CA	50	D
Zinc	01090	7440-66-6	0.6	SMCL-US	5,000	D

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

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

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. The laboratory entity code for the USGS Trace Metal Laboratory in the USGS's National Water Information System (NWIS) is USGSTMCO. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); MDL, method detection limit; na, not available; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; µg/L, micrograms per liter]

Constituent (valence state)	USGS parameter code	CAS number	MDL (µg/L)	Threshold type	Threshold level (µg/L)	Detection
Inorganic Arsenic(III)	99034	22569-72-8	1	na	na	D
Inorganic 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

Table 3J. 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. The laboratory entity codes for the laboratories in the USGS's National Water Information System (NWIS) listed in the footnotes are shown in parentheses following the laboratory name. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; D, detected; hr, hour; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); MRL, minimum reporting level; MU, method uncertainty; na, not available; pCi/L, picocuries per liter; SSMDC, sample-specific minimum detectable concentration; USEPA, U.S. Environmental Protection Agency; —, not detected]

Constituent	USGS parameter code	CAS number	Reporting level type	Reporting level or uncertainty	Threshold type[1]	Threshold value	Detection
Stable isotope ratios (per mil)							
δ^{2}H of water[2]	82082	na	MU	2	na	na	D
δ^{18}O of water[2]	82085	na	MU	0.20	na	na	D
δ^{15}N of nitrate[2]	82690	na	MU	0.50	na	na	D
δ^{18}O of nitrate[2]	63041	na	MU	1.00	na	na	D
δ^{13}O of dissolved carbonates[3]	82081	na	1 sigma	0.05	na	na	D
Radioactive constituents (percent modern)							
Carbon-14[4]	49933	14762-75-5	1 sigma	0.0015	na	na	D
Radioactive constituents (pCi/L)							
Radon-222[5]	82303	14859-67-7	SSMDC	see table 14	Proposed MCL-US[2]	[6]300 (4,000)	D
Tritium[7]	07000	10028-17-8	MRL	1	MCL-CA	20,000	D
Gross-alpha radioactivity, 72-hr count and 30-day counts[8]	62636, 62639	12587-46-1	SSMDC	see table 14	MCL-US	15	D
Gross-beta radioactivity, 72-hr count and 30-day counts[8]	62642, 62645	12587-47-2	SSMDC	see table 14	MCL-CA	50	D
Radium-226[8]	09511	13982-63-3	SSMDC	see table 14	MCL-US[9]	5	D
Radium-228[8]	81366	15262-20-1	SSMDC	see table 14	MCL-US[9]	5	D

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[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 (USGSSIVA).

[3] University of Waterloo (contract laboratory) (CAN-UWIL).

[4] University of Arizona, Accelerator Mass Spectrometry Laboratory (contract laboratory) (AZ-UAMSL).

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

[6] Two MCLs have been proposed for radon-222. The proposed alternaltive MCL is given in parentheses.

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

[8] Eberline Analytical Services (contract laboratory) (CA-EBERL).

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

Table 3K. 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. The laboratory entity code for the Lawrence Livermore National Laboratory in the USGS's National Water Information System (NWIS) is CA-LLNL. CAS, Chemical Abstracts Service; CDPH, California Department of Public Health; cm^3 STP/g H_2O, cubic centimeters of gas at standard temperature and pressure per gram of water; MCL-CA, maximum contaminant level (CDPH); na, not available; pCi/L, picocuries per liter]

Constituent	USGS parameter code	CAS number	MU (percent)	Reporting units	Threshold type	Threshold value (pCi/L)	Detection
Helium-3/Helium-4	61040	na/7440-59-7	0.75	atom ratio	na	na	na
Argon	85563	7440-37-1	2	cm^3STP/g H_2O	na	na	na
Helium-4	85561	7440-59-7	2	cm^3STP/g H_2O	na	na	na
Krypton	85565	7439-90-9	2	cm^3STP/g H_2O	na	na	na
Neon	61046	7440-01-09	2	cm^3STP/g H_2O	na	na	na
Xenon	85567	7440-63-3	2	cm^3STP/g H_2O	na	na	na
Tritium	07000	10028-17-8	1	pCi/L	MCL-CA	20,000	na

Table 3L. Microbial constituents, comparison thresholds, and reporting information for the U.S. Geological Survey's (USGS) Ohio Microbiology Laboratory parameter codes 90901, 90900, 99335, and 99332.

[The five-digit USGS parameter code is used to uniquely identify a specific constituent or property. The laboratory entity code for the USGS's Ohio Microbiology Laboratory in the USGS's National Water Information System (NWIS) is given in footnote 3. MCL-US, maximum contaminant level (USEPA); MDL, method detection limit; mL, milliliters; na, not available; TT-US, U.S. Environmental Protection Agency treatment technique—a required process intended to reduce the level of contamination in drinking water; USEPA, U.S. Environmental Protection Agency; —, analyzed but not detected]

Constituent	USGS parameter code	Primary source	MDL	Threshold type[1]	Threshold value	Detection
Escherichia coliform[2]	90901	Sewage and animal waste indicator/intestinal tracts of humans and animals	1 colony/100 mL	TT-US	No fecal coliforms are allowed.	—
Total coliform (including fecal coliform and *E. coli*)[2]	90900	Water-quality indicator/soil, water and intestinal tracts of animals	1 colony/100 mL	MCL-US	No more then 5 percent samples total coliform-positives in a month. Every sample that has total coloforms must be analyzed for fecal coliforms; no fecal coliforms are allowed.	—
F-specific coliphage[3]	99335	Viral indicator/intestinal tracts of warm-blooded animals	na	TT-US	99.99 percent killed/inactivated	—
Somatic coliphage[3]	99332	Viral indicator/fecal contaminated waters	na	TT-US	99.99 percent killed/inactivated	—

[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] Analyzed in the field.

[3] Analyzed by the USGS's Ohio Microbiology Laboratory (laboratory entity code USGSOHML).

Table 4. Water-quality indicators in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[The five-digit number below the constituent name in the headings is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. °C, degrees Celsius; CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; mg/L, milligrams per liter; mm, millimeter; na, not available; nc, sample not collected; no., number; NTU, nephelometric turbidity unit; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); SMCL-U.S., secondary maximum contaminant level (USEPA); WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µS/cm, microsiemens per centimeter; *, value above recommended threshold level; **, value above upper threshold level; <, less than]

GAMA identification no.	Turbidity (NTU) (63676)	Dissolved oxygen (mg/L) (00300)	Water temperature (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25°C) (90095)	Specific conductance, field (µS/cm at 25°C) (00095)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)
Reporting limit or range	**0.1**	**0.2**	**0.0-38.5**	**0-14**	**0-14**	**5**	**5**	**1**	**1**
Threshold type	**na[1]**	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA[2]**	**SMCL-CA[2]**	**na**	**na**
Threshold level	**na[1]**	**na**	**na**	**6.5–8.5**	**6.5–8.5**	**900 (1,600)**	**900 (1,600)**	**na**	**na**
				Grid wells					
ESAC-01	nc	2.4	19.0	nc	nc	nc	372	nc	nc
ESAC-02	nc	<0.2	19.0	nc	nc	nc	** 2,040	nc	nc
ESAC-03	nc	3.2	23.0	7.8	7.8	432	417	146	nc
ESAC-04	nc	6.8	19.5	nc	7.5	nc	422	nc	nc
ESAC-05	nc	1.6	19.0	7.7	7.1	511	507	195	nc
ESAC-06	nc	6.9	21.0	7.5	7.1	209	208	106	nc
ESAC-07	nc	4.7	21.5	nc	7.7	nc	255	nc	nc
ESAC-08	nc	1.9	16.5	nc	7.7	nc	459	nc	nc
ESAC-09	nc	2.6	19.0	nc	* 6.3	nc	418	nc	nc
ESAC-10	nc	0.4	19.5	7.6	7.3	511	513	210	nc
ESAC-11	nc	0.4	21.0	7.7	7.4	212	220	111	nc
ESAC-12	nc	nc	18.5	7.9	nc	338	341	179	nc
ESAC-13	nc	3.9	16.5	nc	nc	nc	322	nc	nc
ESAC-14	nc	2.5	19.5	nc	7.0	nc	373	nc	nc
ESAC-15	nc	10.1	18.0	7.8	7.6	281	280	118	nc
ESAC-16	nc	9.9	20.0	7.7	7.5	385	380	134	nc
ESAC-17	nc	<0.2	19.0	7.7	7.3	* 959	898	304	nc
ESAC-18	nc	8.7	19.0	7.9	7.7	227	227	111	nc
ESAC-19	nc	2.3	21.0	7.6	7.0	429	421	191	nc
ESAC-20	nc	<0.2	20.6	nc	7.5	nc	321	nc	nc
ESAC-21	nc	<0.2	17.5	7.9	7.6	** 2,380	** 2,370	218	nc
ESAC-22	nc	8.9	18.5	7.0	* 6.5	312	314	81	nc
ESAC-23	nc	3.4	17.0	nc	* 6.3	nc	254	nc	nc
ESAC-24	nc	nc	19.5	nc	7.5	nc	281	nc	nc
ESAC-25	0.2	6.9	21.5	7.8	7.2	205	207	106	98
ESAC-26	0.1	<0.2	16.0	7.9	7.9	306	292	162	148
ESAC-27	0.1	0.8	19.0	7.3	7.1	497	486	221	212

Table 4. Water-quality indicators in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[The five-digit number below the constituent name in the headings is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. °C, degrees Celsius; CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; mg/L, milligrams per liter; mm, millimeter; na, not available; nc, sample not collected; no., number; NTU, nephelometric turbidity unit; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); SMCL-U.S., secondary maximum contaminant level (USEPA); WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µS/cm, microsiemens per centimeter; *, value above recommended threshold level; **, value above upper threshold level; <, less than]

GAMA identification no.	Turbidity (NTU) (63676)	Dissolved oxygen (mg/L) (00300)	Water temperature (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25°C) (90095)	Specific conductance, field (µS/cm at 25°C) (00095)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)
Reporting limit or range	**0.1**	**0.2**	**0.0-38.5**	**0-14**	**0-14**	**5**	**5**	**1**	**1**
Threshold type	**na**[1]	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**[2]	**SMCL-CA**[2]	**na**	**na**
Threshold level	**na**[1]	**na**	**na**	**6.5–8.5**	**6.5–8.5**	**900 (1,600)**	**900 (1,600)**	**na**	**na**
ESAC-28	0.1	2.1	20.0	7.4	7.4	371	368	186	180
ESAC-29	nc	<0.2	17.0	8.0	nc	473	465	225	nc
ESAC-30	nc	0.2	15.5	7.9	7.8	432	408	121	nc
ESAC-31	nc	<0.2	18.5	7.8	7.6	642	613	297	nc
ESAC-32	nc	1.0	18.0	7.4	7.2	356	362	174	nc
ESAC-33	nc	4.1	20.0	nc	7.0	nc	367	nc	nc
ESAC-34	nc	2.5	17.5	7.6	7.2	593	591	273	nc
ESAC-35	nc	nc	17.5	7.7	7.4	331	324	168	nc
WSAC-01	nc	2.0	22.5	nc	8.1	nc	367	nc	nc
WSAC-02	nc	6.3	19.0	nc	7.3	nc	476	nc	nc
WSAC-03	0.1	7.7	20.0	7.5	7.3	338	337	133	122
WSAC-04	nc	<0.2	24.5	8.2	7.9	318	321	173	nc
WSAC-05	nc	<0.2	19.0	nc	7.9	nc	354	nc	nc
WSAC-06	nc	2.7	19.5	7.3	7.0	572	574	275	nc
WSAC-07	nc	7.0	18.0	nc	nc	nc	500	nc	nc
WSAC-07	nc	5.4	18.0	nc	7.1	nc	481	nc	nc
WSAC-08	0.2	4.1	20.5	7.4	7.0	535	536	221	202
WSAC-09	nc	6.3	19.0	nc	nc	nc	392	nc	nc
WSAC-09	nc	5.9	18.5	nc	6.9	nc	387	nc	nc
WSAC-10	nc	6.9	19.5	7.5	7.4	597	602	231	nc
WSAC-10	nc	6.2	19.5	nc	7.2	nc	562	nc	nc
WSAC-11	nc	7.1	23.5	7.8	7.8	652	649	189	nc
WSAC-11	nc	5.6	20.5	nc	7.7	nc	625	nc	nc
WSAC-12	0.3	<0.2	20.5	8.1	7.6	719	729	213	nc
WSAC-13	nc	2.1	20.0	nc	7.1	nc	782	nc	nc
WSAC-14	nc	<0.2	17.5	7.8	7.2	** 2,040	** 2,100	324	nc
WSAC-15	nc	6.9	18.0	7.6	7.1	* 938	* 931	388	nc

Table 4. Water-quality indicators in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[The five-digit number below the constituent name in the headings is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. °C, degrees Celsius; CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; mg/L, milligrams per liter; mm, millimeter; na, not available; nc, sample not collected; no., number; NTU, nephelometric turbidity unit; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); SMCL-U.S., secondary maximum contaminant level (USEPA); WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µS/cm, microsiemens per centimeter; *, value above recommended threshold level; **, value above upper threshold level; <, less than]

GAMA identification no.	Turbidity (NTU) (63676)	Dissolved oxygen (mg/L) (00300)	Water temperature (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25°C) (90095)	Specific conductance, field (µS/cm at 25°C) (00095)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)
Reporting limit or range	**0.1**	**0.2**	**0.0-38.5**	**0-14**	**0-14**	**5**	**5**	**1**	**1**
Threshold type	**na**[1]	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**[2]	**SMCL-CA**[2]	**na**	**na**
Threshold level	**na**[1]	**na**	**na**	**6.5–8.5**	**6.5–8.5**	**900 (1,600)**	**900 (1,600)**	**na**	**na**
WSAC-16	nc	<0.2	19.0	nc	7.5	nc	* 1,240	nc	nc
WSAC-17	nc	1.3	18.0	7.5	7.2	428	429	204	nc
WSAC-18	0.1	<0.2	20.5	7.8	7.8	* 1,080	* 1,050	320	295
WSAC-19	nc	0.7	20.5	nc	7.6	nc	567	nc	nc
WSAC-20	nc	5.9	17.0	nc	7.0	nc	* 958	nc	nc
WSAC-21	nc	7.8	20.0	7.6	7.0	416	415	172	nc
WSAC-22	nc	5.1	21.0	7.8	7.7	516	523	211	nc
WSAC-23	nc	5.4	19.0	nc	7.2	nc	* 1,210	nc	nc
WSAC-24	nc	6.8	20.0	nc	7.2	nc	* 1,470	nc	nc
WSAC-25	nc	<0.2	19.5	8.0	7.8	465	449	222	nc
WSAC-26	nc	10.8	20.0	7.7	7.6	325	325	158	nc
WSAC-27	nc	0.5	18.5	nc	7.8	nc	* 914	nc	nc
WSAC-28	nc	4.8	19.5	7.4	7.2	433	425	168	nc
WSAC-29	nc	3.2	20.0	8.1	8.0	423	422	201	nc
WSAC-30	nc	2.2	19.0	7.7	7.4	** 1680	** 1,670	204	nc
WSAC-31	nc	1.8	19.0	8.2	8.0	279	280	129	nc
WSAC-32	nc	1.8	18.0	nc	7.8	nc	409	nc	nc
WSAC-33	nc	5.4	19.5	nc	7.6	nc	733	nc	nc
WSAC-34	nc	20.4	18.5	7.4	7.1	835	816	259	nc
WSAC-35	nc	13.3	18.5	7.6	7.3	475	478	206	nc
WSAC-36	nc	nc	18.5	7.9	7.6	424	461	216	nc
Flow-path wells									
ESAC-FP-01	nc	<0.2	23.5	7.7	7.6	547	553	75	nc
ESAC-FP-02	6.6	4.0	23.5	7.5	7.2	441	449	202	nc
ESAC-FP-03	0.3	0.3	20.5	7.5	7.5	379	379	197	nc
ESAC-FP-04	1.0	0.5	20.5	8.2	8.3	206	206	108	nc
ESAC-FP-05	0.2	1.5	22.0	7.7	7.5	742	742	355	nc
ESAC-FP-06	3.1	0.2	22.0	* 8.9	* 8.8	315	316	134	nc

Table 4. Water-quality indicators in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[The five-digit number below the constituent name in the headings is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. °C, degrees Celsius; CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; mg/L, milligrams per liter; mm, millimeter; na, not available; nc, sample not collected; no., number; NTU, nephelometric turbidity unit; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); SMCL-U.S., secondary maximum contaminant level (USEPA); WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µS/cm, microsiemens per centimeter; *, value above recommended threshold level; **, value above upper threshold level; <, less than]

GAMA identification no.	Turbidity (NTU) (63676)	Dissolved oxygen (mg/L) (00300)	Water temperature (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25°C) (90095)	Specific conductance, field (µS/cm at 25°C) (00095)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)
Reporting limit or range	**0.1**	**0.2**	**0.0-38.5**	**0-14**	**0-14**	**5**	**5**	**1**	**1**
Threshold type	**na**[1]	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**[2]	**SMCL-CA**[2]	**na**	**na**
Threshold level	**na**[1]	**na**	**na**	**6.5–8.5**	**6.5–8.5**	**900 (1,600)**	**900 (1,600)**	**na**	**na**
ESAC-FP-07	2.9	0.2	21.5	8.5	8.3	405	407	158	nc
WSAC-FP-01	0.7	5.7	24.0	7.9	7.6	342	338	182	nc
WSAC-FP-02	2.6	2.7	22.5	8.2	8.2	315	323	143	nc
WSAC-FP-03	3.6	5.8	23.0	8.0	7.8	416	421	176	nc
WSAC-FP-04	1.1	<0.2	20.0	* 8.6	* 8.6	315	312	148	nc
WSAC-FP-05	nc	0.2	21.5	8.0	8.0	* 928	* 934	250	nc
WSAC-FP-06	2.1	<0.2	21.0	8.5	8.4	349	344	142	nc
WSAC-FP-07	0.6	0.2	20.5	8.4	8.2	326	330	145	nc
WSAC-FP-08	1.4	1.4	20.5	7.9	7.6	403	409	185	nc
				RICE wells					
RICE-01	4.0	<0.2	19.0	7.0	6.8	** 13,600	** 13,800	nc	nc
RICE-02	0.3	<0.2	18.5	7.8	7.3	591	593	nc	335
RICE-03	0.2	<0.2	19.5	7.5	7.0	853	875	nc	432
RICE-04	0.7	0.4	17.5	7.4	6.8	630	644	nc	328
RICE-05	0.3	0.2	18.0	7.0	* 6.4	890	* 930	nc	426
RICE-06	0.2	<0.2	18.0	7.1	6.6	720	756	nc	384
RICE-07	1.1	0.2	20.0	7.8	7.3	784	803	nc	421
RICE-08	0.1	0.4	18.0	7.7	7.3	780	796	nc	378
RICE-09	1.8	<0.2	19.5	7.9	7.2	239	267	nc	128
RICE-10	0.4	<0.2	21.0	8.0	7.4	330	363	nc	169
RICE-11	0.9	0.2	20.0	7.3	7.0	*937	* 968	nc	414
RICE-12	0.9	<0.2	21.5	7.7	7.3	798	818	nc	397
RICE-13	1.0	<0.2	19.0	7.5	7.1	*915	* 944	nc	416
RICE-14	0.5	<0.2	18.5	7.3	7.0	823	844	nc	401
RICE-15	0.5	<0.2	17.0	7.8	7.3	* 947	* 944	nc	436
RICE-16	0.6	1.5	20.0	7.8	7.3	** 1,870	** 1840	nc	596

Table 4. Water-quality indicators in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[The five-digit number below the constituent name in the headings is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. °C, degrees Celsius; CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; mg/L, milligrams per liter; mm, millimeter; na, not available; nc, sample not collected; no., number; NTU, nephelometric turbidity unit; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); SMCL-U.S., secondary maximum contaminant level (USEPA); WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µS/cm, microsiemens per centimeter; *, value above recommended threshold level; **, value above upper threshold level; <, less than]

GAMA identification no.	Turbidity (NTU) (63676)	Dissolved oxygen (mg/L) (00300)	Water temperature (°C) (00010)	pH, lab (standard units) (00403)	pH, field (standard units) (00400)	Specific conductance, lab (µS/cm at 25°C) (90095)	Specific conductance, field (µS/cm at 25°C) (00095)	Alkalinity, lab (mg/L as $CaCO_3$) (29801)	Alkalinity, field (mg/L as $CaCO_3$) (29802)
Reporting limit or range	**0.1**	**0.2**	**0.0-38.5**	**0-14**	**0-14**	**5**	**5**	**1**	**1**
Threshold type	**na**[1]	**na**	**na**	**SMCL-US**	**SMCL-US**	**SMCL-CA**[2]	**SMCL-CA**[2]	**na**	**na**
Threshold level	**na**[1]	**na**	**na**	**6.5–8.5**	**6.5–8.5**	**900 (1,600)**	**900 (1,600)**	**na**	**na**
RICE-17	0.5	<0.2	18.5	7.7	7.4	** 4,770	** 4750	nc	350
RICE-18	0.4	<0.2	19.0	7.7	7.3	855	863	nc	343
RICE-19	0.2	<0.2	18.5	7.8	7.4	481	489	nc	245
RICE-20	0.2	<0.2	18.0	7.7	7.3	* 1,000	* 1,010	nc	407
RICE-21	0.1	0.2	18.5	7.6	7.3	** 1,650	** 1,680	nc	347
RICE-22	0.6	0.2	18.0	7.5	7.3	** 3,290	** 3,310	nc	415

[1] A TT-US threshold of 5 NTU does exist, but it applies to surface water and, therefore, is not included with this table.

[2] Specific conductance has a recommended and an upper threshold value. The upper value is shown in parentheses.

Table 5. Volatile organic compounds (VOCs), and gasoline oxygenates and degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use or source, and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; NL-CA, notification level (CDPH); no., number; RICE, RICE well; USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Trihalomethanes			**Gasoline Hydrocarbons and Oxygenates**										
GAMA identification no.	**Chloroform (Trichloromethane) (µg/L) (32106)**	**Bromodichloromethane (µg/L) (32101)**	**Bromoform (µg/L) (32104)**	**Methyl *tert*-butyl ether (MTBE) (µg/L) (78032)**	**1,2,4-Trimethylbenzene (µg/L) (77222)**	**1,3,5-Trimethylbenzene (µg/L) (77226)**	**1,2,3-Trimethylbenzene (µg/L) (77221)**	**1,2,3,4-Tetramethylbenzene (µg/L) (49999)**	**1,2,3,5-Tetramethylbenzene (µg/L) (50000)**	**2-Ethyltoluene (µg/L) (77220)**	**4-Isopropyltoluene (µg/L) (77356)**	**Benzene (µg/L) (34030)**	***m*- and *p*-Xylene (µg/L) (85795)**	**Toluene (µg/L) (34010)**
[LRL]	**[0.024]**	**[0.028]**	**[0.1]**	**[0.1]**	**[0.056]**	**[0.044]**	**[0.09]**	**[0.14]**	**[0.18]**	**[0.06]**	**[0.08]**	**[0.021]**	**[0.06]**	**[0.02]**
Threshold type[1]	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-CA**	**NL-CA**	**NL-CA**	**na**	**na**	**na**	**na**	**na**	**MCL-CA**	**MCL-CA**	**MCL-CA**
Threshold (µg/L)	**[2]80**	**[2]80**	**[2]80**	**13**	**330**	**330**	**na**	**na**	**na**	**na**	**na**	**1**	**1750**	**150**
Grid wells														
ESAC-01	V0.01	—	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-02	V0.01	—	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-03	0.14	—	—	E0.1	—	—	—	—	—	—	—	—	—	—
ESAC-07	E0.06	—	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-15	E0.06	—	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-17	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-21	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-22	—	—	—	—	E0.07	E0.02	—	—	—	—	—	—	—	—
ESAC-25	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—
ESAC-27	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—
ESAC-28	E0.09	—	—	—	V0.05	—	—	—	—	—	—	—	—	—
ESAC-32	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-33	0.86	E0.04	—	0.1	—	—	—	—	—	—	—	—	—	—
WSAC-03	0.2	E0.03	0.11	—	—	—	—	—	—	—	—	—	—	—
WSAC-05	—	—	—	E0.1	—	—	—	—	—	—	—	—	—	—
WSAC-11	E0.08	—	—	—	—	—	—	—	—	—	—	—	—	—
WSAC-12	—	—	—	—	V0.02	—	—	—	—	—	—	—	—	—
WSAC-16	0.16	E0.02	—	—	—	—	—	—	—	—	—	—	—	—
WSAC-17	E0.05	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 5. Volatile organic compounds (VOCs), and gasoline oxygenates and degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use or source, and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; NL-CA, notification level (CDPH); no., number; RICE, RICE well; USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Trihalomethanes			**Gasoline Hydrocarbons and Oxygenates**										
GAMA identification no.	**Chloroform (Trichloromethane) (µg/L) (32106)**	**Bromodichloromethane (µg/L) (32101)**	**Bromoform (µg/L) (32104)**	**Methyl *tert*-butyl ether (MTBE) (µg/L) (78032)**	**1,2,4-Trimethylbenzene (µg/L) (77222)**	**1,3,5-Trimethylbenzene (µg/L) (77226)**	**1,2,3-Trimethylbenzene (µg/L) (77221)**	**1,2,3,4-Tetramethylbenzene (µg/L) (49999)**	**1,2,3,5-Tetramethylbenzene (µg/L) (50000)**	**2-Ethyltoluene (µg/L) (77220)**	**4-Isopropyltoluene (µg/L) (77356)**	**Benzene (µg/L) (34030)**	***m*- and *p*-Xylene (µg/L) (85795)**	**Toluene (µg/L) (34010)**
[LRL]	**[0.024]**	**[0.028]**	**[0.1]**	**[0.1]**	**[0.056]**	**[0.044]**	**[0.09]**	**[0.14]**	**[0.18]**	**[0.06]**	**[0.08]**	**[0.021]**	**[0.06]**	**[0.02]**
Threshold type[1]	**MCL-US**	**MCL-US**	**MCL-US**	**MCL-CA**	**NL-CA**	**NL-CA**	**na**	**na**	**na**	**na**	**na**	**MCL-CA**	**MCL-CA**	**MCL-CA**
Threshold (µg/L)	**[2]80**	**[2]80**	**[2]80**	**13**	**330**	**330**	**na**	**na**	**na**	**na**	**na**	**1**	**1750**	**150**
WSAC-18	—	—	—	—	0.15	—	—	—	—	—	—	—	—	—
WSAC-24	V0.02	—	—	—	—	—	—	—	—	—	—	—	—	—
WSAC-27	—	—	—	—	V0.06	E0.04	E0.1	E0.1	E0.1	E0.02	E0.01	—	—	—
WSAC-28	—	—	—	—	V0.04	—	—	—	—	—	—	—	—	—
WSAC-33	E0.08	—	—	—	—	—	—	—	—	—	—	—	—	—
Number of wells with detections	10	3	1	4	3	2	1	1	1	1	1	0	0	0
Detection frequency (percent)	14	4	1	6	4	3	1	1	1	1	1			
Flow-path wells														
ESAC-FP-02	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-FP-03	—	—	—	—	—	—	—	—	—	—	—	—	—	V0.02
ESAC-FP-06	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-FP-07	—	—	—	—	V0.02	—	—	—	—	—	—	—	—	—
WSAC-FP-04	—	—	—	—	—	—	—	—	E0.1	—	—	—	—	—
WSAC-FP-05	—	—	—	—	V0.03	—	—	—	—	—	—	—	—	—
WSAC-FP-06	—	—	—	—	—	—	—	—	E0.2	—	—	—	—	—
RICE wells														
RICE-01	—	—	—	—	—	—	—	—	—	—	—	E0.02	—	—
RICE-05	—	—	—	—	—	—	—	—	—	—	—	—	V0.01	—

Table 5. Volatile organic compounds (VOCs), and gasoline oxygenates and degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Contined

[Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use or source, and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; NL-CA, notification level (CDPH); no., number; RICE, RICE well; USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Solvents								Organic synthesis	Refrigerant	
GAMA identification no.	Perchloro ethene (PCE) (µg/L) (34475)	1,1-Dichloro-ethane (µg/L) (34496)	*cis*-1,2-Dichloro-ethene (µg/L) (77093)	Carbon tetra-chloride (µg/L) (32102)	*trans*-1,2-Dichloro-ethene (µg/L) (34546)	Trichloro-ethene (TCE) (µg/L) (39180)	Acetone (µg/L) (81552)	2-Butanone (MEK, Methyl ethyl ketone) (µg/L) (81595)	Carbon disulfide (µg/L) (77041)	Trichloro-fluoro-methane (CFC-11) (µg/L) (34488)	VOC detections per well
[LRL]	**[0.03]**	**[0.035]**	**[0.024]**	**[0.06]**	**[0.032]**	**[0.038]**	**[6]**	**[2]**	**[0.038]**	**[0.08]**	
Threshold type[1]	**MCL-US**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**MCL-US**	**na**	**HAL-US**	**NL-CA**	**MCL-CA**	
Threshold (µg/L)	**5**	**5**	**6**	**0.5**	**10**	**5**	**na**	**4000**	**160**	**150**	
Grid wells											
ESAC-01	—	—	—	—	—	—	—	—	—	—	0
ESAC-02	—	—	—	—	—	—	—	—	—	—	0
ESAC-03	E0.02	E0.03	—	—	—	—	—	—	—	—	4
ESAC-07	—	—	—	—	—	—	—	—	—	—	1
ESAC-15	0.51	0.11	2.06	—	E0.01	0.11	—	—	—	—	6
ESAC-17	—	—	—	—	—	—	—	—	0.15	—	1
ESAC-21	—	—	—	—	—	—	—	—	E0.05	—	1
ESAC-22	—	—	—	—	—	—	—	—	—	—	2
ESAC-25	—	—	—	—	—	—	—	—	—	—	1
ESAC-27	—	—	—	—	—	—	—	—	—	—	1
ESAC-28	—	—	—	—	—	—	—	—	—	—	1
ESAC-32	E0.05	—	—	—	—	—	—	—	—	—	1
ESAC-33	0.96	—	—	—	—	—	—	—	—	0.11	5
WSAC-03	—	—	—	—	—	—	—	—	—	—	3
WSAC-05	—	—	—	—	—	—	—	—	—	—	1
WSAC-11	—	—	—	—	—	—	—	—	—	—	1
WSAC-12	—	—	—	—	—	—	—	—	—	—	0
WSAC-16	—	—	—	—	—	—	—	—	—	—	2
WSAC-17	—	—	—	—	—	—	—	—	—	—	1

Table 5. Volatile organic compounds (VOCs), and gasoline oxygenates and degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —Contined

[Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use or source, and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; NL-CA, notification level (CDPH); no., number; RICE, RICE well; USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

GAMA identification no.	Solvents								Organic synthesis	Refrigerant	VOC detections per well
	Perchloro ethene (PCE) (µg/L) (34475)	1,1-Dichloro-ethane (µg/L) (34496)	*cis*-1,2-Dichloro-ethene (µg/L) (77093)	Carbon tetra-chloride (µg/L) (32102)	*trans*-1,2-Dichloro-ethene (µg/L) (34546)	Trichloro-ethene (TCE) (µg/L) (39180)	Acetone (µg/L) (81552)	2-Butanone (MEK, Methyl ethyl ketone)	Carbon disulfide (µg/L) (77041)	Trichloro-fluoro-methane (CFC-11) (µg/L) (34488)	
[LRL]	**[0.03]**	**[0.035]**	**[0.024]**	**[0.06]**	**[0.032]**	**[0.038]**	**[6]**	**[2]**	**[0.038]**	**[0.08]**	
Threshold type[1]	**MCL-US**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**MCL-CA**	**MCL-US**	**na**	**HAL-US**	**NL-CA**	**MCL-CA**	
Threshold (µg/L)	**5**	**5**	**6**	**0.5**	**10**	**5**	**na**	**4000**	**160**	**150**	
WSAC-18	—	—	—	—	—	—	—	—	—	—	1
WSAC-24	—	—	—	E0.04	—	—	—	—	—	—	1
WSAC-27	—	—	—	—	—	—	—	—	—	—	6
WSAC-28	—	—	—	—	—	—	—	—	—	—	0
WSAC-33	—	—	—	—	—	—	—	—	—	—	1
Number of wells with detections	4	2	1	1	1	1	0	0	2	1	
Detection frequency (percent)	6	3	1	1	1	1			3	1	[3]28
Flow-path wells											
ESAC-FP-02	E0.03	—	—	0.18	—	—	—	—	—	—	2
ESAC-FP-03	—	—	—	—	—	—	—	—	—	—	0
ESAC-FP-06	—	—	—	—	—	—	—	—	E0.03	—	1
ESAC-FP-07	—	—	—	—	—	—	E2	6.4	E0.03	—	3
WSAC-FP-04	—	—	—	—	—	—	—	—	—	—	1
WSAC-FP-05	—	—	—	—	—	—	—	—	—	—	0
WSAC-FP-06	—	—	—	—	—	—	—	—	—	—	1
RICE wells											
RICE-01	—	—	—	—	—	—	—	—	—	—	1
RICE-05	—	—	—	—	—	—	—	—	—	—	0

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[1] Maximum contaminant level thresholds are listed as MCL-US when 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 trihalomethanes is the sum of chloroform, bromodichloromethane, dibromochloromethane, and bromoform.

[3] Frequency of detection of at least one VOC in the grid wells. Detections with V remark codes are not included.

Table 6. Pesticides and pesticide degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Results are from the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032, 2033, and 2060. Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use of source and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name is used by the USGS to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; no., number; RICE, RICE well; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Herbicides											
GAMA identification no.	**Bentazon (µg/L) (38711)**	**Atrazine (µg/L) (39632)**	**Simazine (µg/L) (04035)**	**Metolachlor (µg/L) (39415)**	**Hexazinone (µg/L) (04025)**	**Dinoseb (µg/L) (49301)**	**Molinate (µg/L) (82671)**	**Prometon (µg/L) (04037)**	**Acetochlor (µg/L) (49260)**	**Metribuzin (µg/L) (82630)**	**Tebuthiuron (µg/L) (82670)**	**Propanil (µg/L) (82679)**
[LRL]	**[0.024]**	**[0.008]**	**[0.005]**	**[0.006]**	**[0.026]**	**[0.038]**	**[0.003]**	**[0.01]**	**[0.006]**	**[0.028]**	**[0.026]**	**[0.011]**
Threshold type[1]	**MCL-CA**	**MCL-CA**	**MCL-US**	**HAL-US**	**HAL-US**	**MCL-US**	**MCL-CA**	**HAL-US**	**na**	**HAL-US**	**HAL-US**	**na**
Threshold value	**18**	**1**	**4**	**700**	**400**	**7**	**20**	**100**	**na**	**70**	**500**	**na**
Grid wells												
ESAC-01	—	E0.004	E0.003	—	—	—	—	—	—	—	—	—
ESAC-05	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-09	0.09	—	E0.004	—	—	—	E0.02	—	—	—	—	0.097
ESAC-10	0.47	0.008	—	—	—	—	—	—	—	—	—	—
ESAC-20	0.02	—	—	—	—	—	0.013	—	—	—	—	—
ESAC-22	—	E0.004	E0.004	—	—	—	—	—	—	—	—	—
ESAC-23	—	0.077	—	0.028	—	—	—	0.02	0.059	—	—	—
ESAC-24	—	E0.007	E0.005	—	—	—	—	—	—	—	—	—
ESAC-26	—	—	0.011	—	—	—	—	—	—	—	—	—
ESAC-27	0.03	0.011	0.024	—	—	—	—	—	—	—	—	—
ESAC-28	0.05	E0.005	—	—	—	—	—	—	—	—	—	—
ESAC-31	0.43	—	—	—	—	—	—	—	—	—	—	—
ESAC-32	0.04	—	—	—	—	—	—	—	—	—	—	—
ESAC-33	0.04	E0.004	—	—	—	E0.004	—	—	—	—	—	—
ESAC-34	0.1	—	—	—	—	E0.01	—	—	—	—	—	—
ESAC-35	0.08	—	—	—	—	—	—	—	—	—	—	—
WSAC-02	—	0.04	E0.005	—	—	—	—	—	—	—	—	—
WSAC-06	—	E0.004	E0.004	—	—	—	—	—	—	—	—	—
WSAC-07	—	E0.005	E0.005	—	—	—	—	—	—	—	—	—
WSAC-08	—	—	—	—	—	—	—	—	—	—	—	—
WSAC-09	—	E0.007	E0.004	—	—	—	—	—	—	—	—	—
WSAC-11	—	—	E0.005	—	—	—	—	—	—	—	—	—
WSAC-12	0.09	—	—	—	—	—	—	—	—	—	—	—
WSAC-13	0.08	—	—	—	—	—	—	—	—	—	—	—
WSAC-14	E0.01	—	—	—	—	—	—	—	—	—	—	—
WSAC-15	—	—	0.009	E0.005	E0.009	—	—	—	—	—	0.03	—
WSAC-16	E0.005	—	—	—	—	—	—	—	—	—	—	—

Table 6. Pesticides and pesticide degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —Continued

[Results are from the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032, 2033, and 2060. Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use of source and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name is used by the USGS to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; no., number; RICE, RICE well; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Herbicides											
GAMA identification no.	**Bentazon (µg/L) (38711)**	**Atrazine (µg/L) (39632)**	**Simazine (µg/L) (04035)**	**Metolachlor (µg/L) (39415)**	**Hexazinone (µg/L) (04025)**	**Dinoseb (µg/L) (49301)**	**Molinate (µg/L) (82671)**	**Prometon (µg/L) (04037)**	**Acetochlor (µg/L) (49260)**	**Metribuzin (µg/L) (82630)**	**Tebuthiuron (µg/L) (82670)**	**Propanil (µg/L) (82679)**
[LRL]	**[0.024]**	**[0.008]**	**[0.005]**	**[0.006]**	**[0.026]**	**[0.038]**	**[0.003]**	**[0.01]**	**[0.006]**	**[0.028]**	**[0.026]**	**[0.011]**
Threshold type[1]	**MCL-CA**	**MCL-CA**	**MCL-US**	**HAL-US**	**HAL-US**	**MCL-US**	**MCL-CA**	**HAL-US**	**na**	**HAL-US**	**HAL-US**	**na**
Threshold value	**18**	**1**	**4**	**700**	**400**	**7**	**20**	**100**	**na**	**70**	**500**	**na**
WSAC-17	—	—	E0.006	—	E0.008	—	—	—	—	—	—	—
WSAC-18	E0.02	—	—	—	—	—	—	—	—	—	—	—
WSAC-20	—	E0.004	0.01	E0.005	—	—	—	—	—	0.113	—	—
WSAC-23	—	—	0.008	—	—	—	—	—	—	—	—	—
WSAC-27	0.29	—	—	—	—	—	—	—	—	—	—	—
WSAC-28	—	—	—	—	—	—	—	—	—	—	—	—
WSAC-29	E0.004	E0.006	—	—	—	—	—	—	—	—	—	—
WSAC-31	0.09	—	—	—	—	—	—	—	—	—	—	—
WSAC-32	E0.01	E0.005	E0.004	—	—	—	—	—	—	—	—	—
WSAC-34	—	E0.008	—	—	—	—	—	—	—	—	—	—
WSAC-35	E0.005	E0.005	E0.004	—	E0.016	—	—	—	—	—	—	—
WSAC-36	0.11	—	—	—	—	—	—	—	—	—	—	—
Number of wells with detections	21	17	17	3	3	2	2	1	1	1	1	1
Detection frequency (percent)	30	24	24	4	4	3	3	1	1	1	1	1
	Flow-path wells											
ESAC-FP-03	0.15	—	—	—	—	—	—	—	—	—	—	—
ESAC-FP-05	E0.01	—	—	—	—	—	—	—	—	—	—	—
ESAC-FP-06	—	—	—	—	—	—	—	—	—	—	—	—
ESAC-FP-07	—	—	—	—	—	—	—	—	—	—	—	—
WSAC-FP-06	—	—	—	—	—	—	—	—	—	—	—	—
WSAC-FP-08	0.13	—	—	—	—	—	—	—	—	—	—	—

Table 6. Pesticides and pesticide degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —Continued

[Results are from the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032, 2033, and 2060. Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use of source and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name is used by the USGS to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; no., number; RICE, RICE well; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Herbicides											
GAMA identification no.	**Bentazon (µg/L) (38711)**	**Atrazine (µg/L) (39632)**	**Simazine (µg/L) (04035)**	**Metolachlor (µg/L) (39415)**	**Hexazinone (µg/L) (04025)**	**Dinoseb (µg/L) (49301)**	**Molinate (µg/L) (82671)**	**Prometon (µg/L) (04037)**	**Acetochlor (µg/L) (49260)**	**Metribuzin (µg/L) (82630)**	**Tebuthiuron (µg/L) (82670)**	**Propanil (µg/L) (82679)**
[LRL]	**[0.024]**	**[0.008]**	**[0.005]**	**[0.006]**	**[0.026]**	**[0.038]**	**[0.003]**	**[0.01]**	**[0.006]**	**[0.028]**	**[0.026]**	**[0.011]**
Threshold type[1]	**MCL-CA**	**MCL-CA**	**MCL-US**	**HAL-US**	**HAL-US**	**MCL-US**	**MCL-CA**	**HAL-US**	**na**	**HAL-US**	**HAL-US**	**na**
Threshold value	**18**	**1**	**4**	**700**	**400**	**7**	**20**	**100**	**na**	**70**	**500**	**na**
RICE wells												
RICE-01	—	—	—	—	—	—	0.008	—	—	—	—	—
RICE-03	—	E0.007	E0.005	—	—	—	—	—	—	—	—	E0.006
RICE-04	0.11	—	—	—	—	—	—	—	—	—	—	—
RICE-06	0.04	—	E0.003	—	—	—	—	—	—	—	—	—
RICE-07	1.46	—	—	—	—	—	—	—	—	—	—	—
RICE-08	E0.02	—	—	—	—	—	—	—	—	—	—	—
RICE-09	—	—	E0.004	—	E0.013	—	—	—	—	—	—	—
RICE-10	—	—	0.082	—	—	—	—	—	—	—	—	—
RICE-11	0.03	E0.007	E0.005	—	—	—	—	—	—	—	—	—
RICE-12	0.42	E0.005	E0.008	—	—	—	—	—	—	—	—	—
RICE-13	0.32	—	—	—	—	—	—	—	—	—	—	—
RICE-14	0.14	—	—	—	—	—	—	—	—	—	0.02	—
RICE-15	0.32	E0.007	—	—	—	—	—	—	—	—	—	—
RICE-16	0.29	—	—	—	—	—	—	—	—	—	—	—
RICE-17	1.7	—	—	—	—	—	—	—	—	—	—	—
RICE-18	1.82	—	—	—	—	—	—	—	—	—	—	—
RICE-19	0.08	0.008	—	—	—	—	—	—	—	—	—	—
RICE-20	0.21	—	E0.004	—	—	—	—	—	—	—	—	—
RICE-21	0.45	—	—	—	—	—	—	—	—	—	—	—
RICE-22	0.23	—	—	—	E0.014	—	—	—	—	—	—	—

Table 6. Pesticides and pesticide degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —Continued

[Results are from the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032, 2033, and 2060. Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use of source and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name is used by the USGS to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; no., number; RICE, RICE well; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Herbicides—continued						**Insecticides**		
GAMA identification no.	**Bensulfuron-methyl (µg/L) (61693)**	**MCPA (µg/L) (38482)**	**Triclopyr (µg/L) (49235)**	**2,4-D, (µg/L) (39732)**	**Chlorimuron (µg/L) (50306)**	**Bromacil (µg/L) (04029)**	**Chlorpyrifos (µg/L) (38933)**	**Carbaryl (µg/L) (82680)**	**Fipronil (µg/L) (62166)**
[LRL]	**[0.018]**	**[0.07]**	**[0.026]**	**[0.038]**	**[0.032]**	**0.018**	**[0.005]**	**[0.041]**	**[0.016]**
Threshold type[1]	**na**	**HAL-US**	**na**	**MCL-US**	**na**	**HAL-US**	**HAL-US**	**RSD5-US**	**na**
Threshold value	**na**	**30**	**na**	**70**	**na**	**70**	**2**	**400**	**na**
Grid wells									
ESAC-01	—	—	—	—	—		—	—	—
ESAC-05	—	—	—	—	—	V0.01	—	—	—
ESAC-09	E0.01	E0.02	0.12	—	—	—	—	E0.007	—
ESAC-10	—	—	na	—	—	—	—	—	—
ESAC-20	—	—	na	—	—	—	—	—	—
ESAC-22	—	—	—	—	—	V0.03	—	—	—
ESAC-23	—	—	na	—	—	—	0.008	—	E0.017
ESAC-24	—	—	na	—	—	—	—	—	—
ESAC-26	—	—	na	—	—	—	—	—	—
ESAC-27	—	—	na	—	—	—	—	—	—
ESAC-28	—	—	—	—	—	—	—	—	—
ESAC-31	—	—	—	—	—	—	—	—	—
ESAC-32	—	—	—	—	—	—	—	—	—
ESAC-33	—	—	—	—	—	—	—	—	—
ESAC-34	—	—	—	—	—	—	—	—	—
ESAC-35	—	—	—	—	—	—	—	—	—
WSAC-02	—	—	—	—	—	—	—	—	—
WSAC-06	—	—	—	—	—	—	—	—	—
WSAC-07	—	—	—	—	—	V0.004	—	—	—
WSAC-08	—	—	na	—	—	—	—	—	—
WSAC-09	—	—	—	—	—	—	—	—	—
WSAC-11	—	—	—	—	—	—	—	—	—
WSAC-12	—	—	—	—	—	—	—	—	—
WSAC-13	—	—	na	—	—	—	—	—	—
WSAC-14	—	—	na	—	—	—	—	—	—
WSAC-15	—	—	—	—	—	—	—	—	—
WSAC-16	—	—	na	—	—	—	—	—	—
WSAC-17	—	—	na	—	—	—	—	—	—

Table 6. Pesticides and pesticide degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —Continued

[Results are from the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032, 2033, and 2060. Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use of source and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name is used by the USGS to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; no., number; RICE, RICE well; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

GAMA identification no.	Herbicides—continued						Insecticides		
	Bensulfuron-methyl (µg/L) (61693)	**MCPA (µg/L) (38482)**	**Triclopyr (µg/L) (49235)**	**2,4-D, (µg/L) (39732)**	**Chlorimuron (µg/L) (50306)**	**Bromacil (µg/L) (04029)**	**Chlorpyrifos (µg/L) (38933)**	**Carbaryl (µg/L) (82680)**	**Fipronil (µg/L) (62166)**
[LRL]	**[0.018]**	**[0.07]**	**[0.026]**	**[0.038]**	**[0.032]**	**0.018**	**[0.005]**	**[0.041]**	**[0.016]**
Threshold type[1]	**na**	**HAL-US**	**na**	**MCL-US**	**na**	**HAL-US**	**HAL-US**	**RSD5-US**	**na**
Threshold value	**na**	**30**	**na**	**70**	**na**	**70**	**2**	**400**	**na**
WSAC-18	—	—	—	—	—	—	—	—	—
WSAC-20	—	—	—	—	—	—	—	—	—
WSAC-23	—	—	—	—	—	—	—	—	—
WSAC-27	—	—	—	—	—	—	—	—	—
WSAC-28	—	—	—	—	—	—	—	—	—
WSAC-29	—	—	—	—	—	—	—	—	—
WSAC-31	—	—	—	—	—	—	—	—	—
WSAC-32	—	—	—	—	—	—	—	—	—
WSAC-34	—	—	—	—	—	—	—	—	—
WSAC-35	—	—	—	—	—	—	—	—	—
WSAC-36	—	—	—	—	—	—	—	—	—
Number of wells with detections	1	1	1	0	0	0	1	1	1
Detection frequency (percent)	1	1	1				1	1	1
Flow-path wells									
ESAC-FP-03	—	—	—	—	—	—	—	—	—
ESAC-FP-05	—	—	—	E0.004	—	—	—	—	—
ESAC-FP-06	—	—	E0.02	—	—	—	—	—	—
ESAC-FP-07	—	—	E0.01	—	—	—	—	—	—
WSAC-FP-06	—	—	—	—	—	—	—	—	—
WSAC-FP-08	—	—	—	—	—	—	—	—	—

Table 6. Pesticides and pesticide degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —Continued

[Results are from the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032, 2033, and 2060. Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use of source and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name is used by the USGS to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; no., number; RICE, RICE well; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Herbicides—continued						**Insecticides**		
GAMA identification no.	**Bensulfuron-methyl (µg/L) (61693)**	**MCPA (µg/L) (38482)**	**Triclopyr (µg/L) (49235)**	**2,4-D, (µg/L) (39732)**	**Chlorimuron (µg/L) (50306)**	**Bromacil (µg/L) (04029)**	**Chlorpyrifos (µg/L) (38933)**	**Carbaryl (µg/L) (82680)**	**Fipronil (µg/L) (62166)**
[LRL]	**[0.018]**	**[0.07]**	**[0.026]**	**[0.038]**	**[0.032]**	**0.018**	**[0.005]**	**[0.041]**	**[0.016]**
Threshold type[1]	**na**	**HAL-US**	**na**	**MCL-US**	**na**	**HAL-US**	**HAL-US**	**RSD5-US**	**na**
Threshold value	**na**	**30**	**na**	**70**	**na**	**70**	**2**	**400**	**na**
RICE wells									
RICE-01	—	—	—	—	—	—	—	—	—
RICE-03	—	—	—	—	—	—	—	—	—
RICE-04	—	—	—	—	—	—	—	—	—
RICE-06	—	—	—	—	—	—	—	—	—
RICE-07	—	—	—	—	—	—	—	—	—
RICE-08	—	—	—	—	—	—	—	—	—
RICE-09	—	—	—	—	—	—	—	—	—
RICE-10	—	—	—	—	1.57	—	—	—	—
RICE-11	—	—	—	—	—	—	—	—	—
RICE-12	—	—	—	—	—	—	—	—	—
RICE-13	—	—	—	—	—	—	—	—	—
RICE-14	—	—	—	—	—	—	—	—	—
RICE-15	—	—	—	—	—	—	—	—	—
RICE-16	—	—	—	—	—	—	—	—	—
RICE-17	—	—	—	—	—	—	—	—	—
RICE-18	—	—	—	—	—	—	—	—	—
RICE-19	—	—	—	—	—	—	—	—	—
RICE-20	—	—	—	—	—	—	—	—	—
RICE-21	—	—	—	—	—	—	—	—	—
RICE-22	—	—	—	—	—	—	—	—	—

Table 6. Pesticides and pesticide degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —Continued

[Results are from the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032, 2033, and 2060. Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use of source and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name is used by the USGS to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; no., number; RICE, RICE well; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Fungicides		**Degradates**							
GAMA identification no.	***cis*-Propiconazole (µg/L) (79846)**	***trans*-Propiconazole (µg/L) (79847)**	**Deethylatrazine (µg/L) (04040)**	**3,4-Dichloroaniline (µg/L) (61625)**	**Hydroxyatrazine (µg/L) (50355)**	**Desulfinylfipronil (µg/L) (62170)**	**Fipronil sulfide (µg/L) (62167)**	**Fipronil sulfone (µg/L) (62168)**	**Deisopropylatrazine (µg/L) (04038)**	**Pesticide detections per well**
[LRL]	**[0.013]**	**[0.034]**	**[0.028]**	**[0.0045]**	**[0.032]**	**[0.012]**	**[0.013]**	**[0.024]**	**[0.08]**	
Threshold type[1]	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	
Threshold value	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	
Grid wells										
ESAC-01	—	—	E0.006	—	—	—	—	—	—	3
ESAC-05	—	—	—	—	—	—	—	—	—	0
ESAC-09	—	—	—	E0.541	—	—	—	—	—	9
ESAC-10	—	—	E0.008	—	—	—	—	—	—	3
ESAC-20	—	—	—	—	—	—	—	—	—	2
ESAC-22	—	—	—	—	—	—	—	—	—	2
ESAC-23	—	—	E0.022	—	—	E0.008	E0.006	E0.008	—	10
ESAC-24	—	—	E0.007	—	—	—	—	—	—	3
ESAC-26	—	—	—	—	—	—	—	—	—	1
ESAC-27	—	—	E0.011	—	—	—	—	—	—	4
ESAC-28	—	—	E0.009	—	—	—	—	—	—	3
ESAC-31	—	—	—	—	—	—	—	—	—	1
ESAC-32	—	—	—	—	—	—	—	—	—	1
ESAC-33	—	—	E0.01	—	—	—	—	—	—	4
ESAC-34	—	—	—	—	—	—	—	—	—	2
ESAC-35	—	—	—	—	—	—	—	—	—	1
WSAC-02	—	—	E0.057	E0.006	E0.003	—	—	—	—	5
WSAC-06	—	—	E0.007	—	na	—	—	—	—	3
WSAC-07	—	—	E0.006	—	—	—	—	—	—	3
WSAC-08	—	—	E0.007	—	—	—	—	—	—	1
WSAC-09	—	—	E0.009	—	—	—	—	—	—	3
WSAC-11	—	—	—	—	—	—	—	—	—	1
WSAC-12	—	—	—	—	—	—	—	—	—	1
WSAC-13	—	—	—	—	—	—	—	—	—	1
WSAC-14	—	—	—	—	—	—	—	—	—	1
WSAC-15	—	—	E0.005	—	—	—	—	—	—	5
WSAC-16	—	—	—	—	—	—	—	—	—	1

Table 6. Pesticides and pesticide degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —Continued

[Results are from the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032, 2033, and 2060. Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use of source and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name is used by the USGS to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; no., number; RICE, RICE well; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Fungicides		**Degradates**							
GAMA identification no.	***cis*-Propiconazole (µg/L) (79846)**	***trans*-Propiconazole (µg/L) (79847)**	**Deethylatrazine (µg/L) (04040)**	**3,4-Dichloroaniline (µg/L) (61625)**	**Hydroxyatrazine (µg/L) (50355)**	**Desulfinylfipronil (µg/L) (62170)**	**Fipronil sulfide (µg/L) (62167)**	**Fipronil sulfone (µg/L) (62168)**	**Deisopropylatrazine (µg/L) (04038)**	**Pesticide detections per well**
[LRL]	**[0.013]**	**[0.034]**	**[0.028]**	**[0.0045]**	**[0.032]**	**[0.012]**	**[0.013]**	**[0.024]**	**[0.08]**	
Threshold type[1]	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	
Threshold value	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	
WSAC-17	—	—	—	E0.005	E0.024	—	—	—	—	4
WSAC-18	—	—	—	—	—	—	—	—	—	1
WSAC-20	—	—	E0.006	—	—	—	—	—	—	5
WSAC-23	—	—	—	—	—	—	—	—	—	1
WSAC-27	—	—	—	—	—	—	—	—	—	1
WSAC-28	—	—	E0.005	—	—	—	—	—	—	1
WSAC-29	—	—	E0.005	—	—	—	—	—	—	3
WSAC-31	—	—	—	—	—	—	—	—	—	1
WSAC-32	—	—	E0.006	—	—	—	—	—	—	4
WSAC-34	—	—	E0.007	—	—	—	—	—	—	2
WSAC-35	—	—	E0.006	E0.006	—	—	—	—	—	6
WSAC-36	—	—	—	—	—	—	—	—	—	1
Number of wells with detections	0	0	19	4	3	1	1	1	0	
Detection frequency (percent)			27	6	4	1	1	1		[2]54
Flow-path wells										
ESAC-FP-03	—	—	—	—	—	—	—	—	—	1
ESAC-FP-05	—	—	—	—	—	—	—	—	—	2
ESAC-FP-06	E0.001	E0.01	—	—	—	—	—	—	—	3
ESAC-FP-07	—	—	—	—	—	—	—	—	—	1
WSAC-FP-06	—	—	—	—	—	—	—	—	E0.04	1
WSAC-FP-08	—	—	—	—	—	—	—	—	—	1

Table 6. Pesticides and pesticide degradates detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —Continued

[Results are from the U.S. Geological Survey's (USGS) National Water Quality Laboratory Schedules 2032, 2033, and 2060. Samples from all 108 wells were analyzed, but only wells with detections are listed. Constituents are grouped by primary use of source and within each group are listed in order of decreasing detection frequency in the 71 grid wells. The five-digit number in parentheses below the constituent name is used by the USGS to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA; maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; no., number; RICE, RICE well; RSD5-US, U.S. Environmental Protection Agency risk specific dose at a risk factor of 10^{-5} µg/L (RSD5s are calculated by dividing the 10^{-4} cancer risk concentration established by the USEPA by 10); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected]

	Fungicides		**Degradates**							
GAMA identification no.	***cis*-Propiconazole (µg/L) (79846)**	***trans*-Propiconazole (µg/L) (79847)**	**Deethylatrazine (µg/L) (04040)**	**3,4-Dichloroaniline (µg/L) (61625)**	**Hydroxyatrazine (µg/L) (50355)**	**Desulfinylfipronil (µg/L) (62170)**	**Fipronil sulfide (µg/L) (62167)**	**Fipronil sulfone (µg/L) (62168)**	**Deisopropylatrazine (µg/L) (04038)**	**Pesticide detections per well**
[LRL]	**[0.013]**	**[0.034]**	**[0.028]**	**[0.0045]**	**[0.032]**	**[0.012]**	**[0.013]**	**[0.024]**	**[0.08]**	
Threshold type[1]	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	
Threshold value	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	
					RICE wells					
RICE-01	—	—	—	—	—	—	—	—	—	1
RICE-03	—	—	E0.006	—	—	—	—	—	—	4
RICE-04	—	—	—	—	—	—	—	—	—	1
RICE-06	—	—	—	E0.004	—	—	—	—	—	3
RICE-07	—	—	—	—	—	—	—	—	—	1
RICE-08	—	—	—	—	—	—	—	—	—	1
RICE-09	—	—	—	—	—	—	—	—	—	2
RICE-10	—	—	—	E0.091	—	—	—	—	0.15	4
RICE-11	—	—	E0.006	—	—	—	—	—	—	4
RICE-12	—	—	E0.006	E0.006	—	—	—	—	—	5
RICE-13	—	—	—	—	—	—	—	—	—	1
RICE-14	—	—	—	—	—	—	—	—	—	2
RICE-15	—	—	—	—	—	—	—	—	—	2
RICE-16	—	—	—	—	—	—	—	—	—	1
RICE-17	—	—	—	E0.005	—	—	—	—	—	2
RICE-18	—	—	—	—	—	—	—	—	—	1
RICE-19	—	—	E0.006	—	—	—	—	—	—	3
RICE-20	—	—	—	—	—	—	—	—	—	2
RICE-21	—	—	—	—	—	—	—	—	—	1
RICE-22	—	—	—	—	—	—	—	—	—	2

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[1] Maximum contaminant level thresholds are listed as MCL-US when 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 detection of at least one pesticide in the grid wells. Detections with V remark codes are not included.

Table 7. Constituents of special interest (perchlorate, *N*-nitrosodimethylamine [NDMA], and 1,2,3-trichloropropane [1,2,3-TCP]) detected in samples collected in the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Samples from all 108 wells were analyzed for perchlorate; samples from 45 grid wells and 15 flow-path wells were sampled for NDMA and 1,2,3-TCP; only wells with at least one detection are listed. Analyses done by the Mongomery Watson Harza laboratory. The laboratory entity code for the Montgomery Watson Harza laboratory in the U. S. Geological Survey's National Water Information System (NWIS) is CA-MWHL. CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; MCL-CA, maximum contaminant level (CDPH); MRL, minimum reporting level; no., number; RICE, RICE well; WSAC, West study area of the middle Sacramento Valley study unit; µg/L, micrograms per liter]

GAMA identification no.	**Perchlorate (µg/L)**
Threshold Type	**MCL-CA**
Threshold (µg/L)	**6**
[MRL]	**[0.5]**
Grid wells	
ESAC-03	0.6
ESAC-04	1.4
WSAC-20	0.6
WSAC-24	1.4
Number of wells with detections	4
Detection frequency (percent)	6
RICE wells	
RICE-10	1.3

Table 8. Nutrients and dissolved organic carbon detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed for nutrients; samples from all slow grid wells and all RICE wells were analyzed for dissolved organic carbon. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-US, maximum contaminant level (USEPA); mg/L, milligrams per liter; na, not available; nc, not collected; no., number; RICE, RICE well; USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	Ammonia (mg/L) as nitrogen (00608)	Nitrite plus nitrate (mg/L) as nitrogen (00631)	Nitrite (mg/L) as nitrogen (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-N) (mg/L) (62854)	Orthophosphate (mg/L) as phosphorus (00671)	Dissolved organic carbon (DOC) (mg/L) (00681)
[LRL]	**[0.01]**	**[0.06]**	**[0.002]**	**[0.06]**	**[0.006]**	**[0.33]**
Threshold type[1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**	**na**
Threshold value	[2]**24.7**	**10**	**1**	**na**	**na**	**na**
			Grid wells			
ESAC-03	—	2.46	—	2.50	0.075	nc
ESAC-05	—	6.25	—	6.25	0.168	nc
ESAC-06	—	0.79	—	0.82	0.118	nc
ESAC-10	0.016	0.30	0.005	0.34	0.095	nc
ESAC-11	—	—	—	—	0.100	nc
ESAC-12	—	0.82	—	[3]0.81	0.058	nc
ESAC-15	E0.008	—	—	[4]—	V0.003	nc
ESAC-16	E0.008	0.78	—	[5]0.71	0.092	nc
ESAC-17	0.075	—	—	V0.07	0.167	nc
ESAC-18	E0.006	0.74	—	[5]0.67	0.086	nc
ESAC-19	—	0.50	—	[5]0.45	0.090	nc
ESAC-21	0.117	—	—	V0.16	0.120	nc
ESAC-22	—	*10.4	—	8.81	0.053	nc
ESAC-25	—	0.54	—	0.54	0.112	E0.2
ESAC-26	0.056	—	—	V0.04	0.499	0.5
ESAC-27	E0.008	0.86	—	0.92	0.100	0.8
ESAC-28	—	1.62	—	[3]1.58	0.194	E0.3
ESAC-29	0.095	—	—	V0.12	0.240	nc
ESAC-30	—	0.13	0.011	V0.16	0.256	nc
ESAC-31	E0.006	0.13	E0.001	V0.14	0.101	nc
ESAC-32	—	0.92	—	0.95	0.090	nc
ESAC-34	—	0.89	—	0.91	0.108	nc
ESAC-35	—	0.76	—	0.78	0.066	nc
WSAC-03	—	3.38	—	[3]3.3	0.036	E0.2
WSAC-04	E0.005	—	—	[4]—	0.040	nc
WSAC-06	—	1.03	—	1.10	0.028	nc
WSAC-08	E0.006	3.43	—	[3]3.23	0.031	E0.3
WSAC-10	—	6.49	—	[3]6.35	0.027	nc
WSAC-11	—	2.27	—	[3]2.13	0.065	nc
WSAC-12	0.124	—	—	V0.17	0.200	0.5
WSAC-14	0.011	1.29	0.003	[3]1.26	0.077	nc
WSAC-15	—	*13	—	13.50	0.047	nc

Table 8. Nutrients and dissolved organic carbon detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed for nutrients; samples from all slow grid wells and all RICE wells were analyzed for dissolved organic carbon. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-US, maximum contaminant level (USEPA); mg/L, milligrams per liter; na, not available; nc, not collected; no., number; RICE, RICE well; USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	Ammonia (mg/L) as nitrogen (00608)	Nitrite plus nitrate (mg/L) as nitrogen (00631)	Nitrite (mg/L) as nitrogen (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-N) (mg/L) (62854)	Orthophosphate (mg/L) as phosphorus (00671)	Dissolved organic carbon (DOC) (mg/L) (00681)
[LRL]	**[0.01]**	**[0.06]**	**[0.002]**	**[0.06]**	**[0.006]**	**[0.33]**
Threshold type[1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**	**na**
Threshold value	**[2]24.7**	**10**	**1**	**na**	**na**	**na**
WSAC-17	—	0.73	—	[3]0.72	0.257	nc
WSAC-18	—	0.57	0.003	0.59	0.070	E0.2
WSAC-21	—	6.04	—	[3]5.73	0.081	nc
WSAC-22	E0.008	1.24	—	[3]1.22	0.047	nc
WSAC-25	E0.006	E0.05	—	V0.06	0.101	nc
WSAC-26	E0.005	3.02	—	3.15	0.049	nc
WSAC-28	—	2.54	—	2.64	0.097	nc
WSAC-29	E0.005	1.84	—	1.89	0.043	nc
WSAC-30	E0.005	7.38	—	[3]7.36	0.037	nc
WSAC-31	—	0.77	—	[3]0.75	0.077	nc
WSAC-34	—	9.10	—	[3]8.99	0.032	nc
WSAC-35	—	0.97	—	1.04	0.036	nc
WSAC-36	—	0.45	—	0.51	0.103	nc
Flow-path wells						
ESAC-FP-01	0.320	—	—	V0.33	0.031	nc
ESAC-FP-02	—	2.37	0.010	[3]2.20	0.033	nc
ESAC-FP-03	—	0.33	0.018	V0.35	0.084	nc
ESAC-FP-04	—	0.16	0.002	V0.14	0.056	nc
ESAC-FP-05	—	6.01	E0.002	[3]5.61	0.100	nc
ESAC-FP-06	0.027	—	—	[4]—	0.062	nc
ESAC-FP-07	0.028	—	—	[4]—	0.077	nc
WSAC-FP-01	V0.007	1.32	—	1.42	0.050	nc
WSAC-FP-02	V0.007	0.76	—	0.76	0.038	nc
WSAC-FP-03	V0.009	2.82	E0.001	2.78	0.040	nc
WSAC-FP-04	0.014	—	—	[4]—	0.063	nc
WSAC-FP-05	E0.009	E0.03	E0.002	V0.07	0.064	nc
WSAC-FP-06	—	0.27	0.008	V0.27	0.034	nc
WSAC-FP-07	V0.009	—	—	[4]—	0.055	nc
WSAC-FP-08	—	1.89	—	1.97	0.052	nc

Table 8. Nutrients and dissolved organic carbon detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed for nutrients; samples from all slow grid wells and all RICE wells were analyzed for dissolved organic carbon. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-US, maximum contaminant level (USEPA); mg/L, milligrams per liter; na, not available; nc, not collected; no., number; RICE, RICE well; USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	Ammonia (mg/L) as nitrogen (00608)	Nitrite plus nitrate (mg/L) as nitrogen (00631)	Nitrite (mg/L) as nitrogen (00613)	Total nitrogen (nitrate + nitrite + ammonia + organic-N) (mg/L) (62854)	Orthophosphate (mg/L) as phosphorus (00671)	Dissolved organic carbon (DOC) (mg/L) (00681)
[LRL]	**[0.01]**	**[0.06]**	**[0.002]**	**[0.06]**	**[0.006]**	**[0.33]**
Threshold type[1]	**HAL-US**	**MCL-US**	**MCL-US**	**na**	**na**	**na**
Threshold value	**[2]24.7**	**10**	**1**	**na**	**na**	**na**
RICE wells						
RICE-01	0.517	—	—	0.51	0.109	—
RICE-02	—	0.88	—	0.86	0.149	V0.8
RICE-03	—	1.72	—	1.67	0.057	V0.9
RICE-04	V0.007	0.47	—	0.55	0.093	1.1
RICE-05	V0.013	—	—	V0.13	0.099	2.4
RICE-06	V0.005	0.27	—	V0.32	0.079	1.6
RICE-07	V0.006	0.11	—	V0.11	0.098	1.0
RICE-08	—	1.83	—	1.78	0.082	V0.5
RICE-09	—	E0.04	—	V0.07	0.101	V0.7
RICE-19	V0.008	—	—	V0.06	0.106	1.1
RICE-20	V0.005	3.77	0.005	3.80	0.326	1.4
RICE-10	—	0.36	—	V0.37	0.160	1.0
RICE-11	V0.008	4.93	0.006	4.98	0.058	2.6
RICE-12	V0.01	0.40	0.006	0.47	0.115	1.4
RICE-13	—	3.82	0.026	3.75	0.104	2.3
RICE-14	—	—	—	V0.1	0.051	2.3
RICE-15	—	0.30	—	V0.31	0.097	1.3
RICE-16	V0.007	0.08	0.003	V0.1	0.086	1.2
RICE-17	V0.005	0.88	—	0.99	0.100	2.1
RICE-18	V0.006	0.71	—	0.78	0.076	V0.7
RICE-21	V0.011	0.17	—	V0.21	0.041	V0.8
RICE-22	V0.011	—	—	V0.08	0.048	1.3

[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, but falls within the USGS's National Water Quality Laboratory acceptance criteria of a 10 percent relative percent difference.

[4] Total nitrogen in these samples is less than the sum of the filtered nitrogen analytes and exceeds the USGS's National Water Quality Laboratory acceptance criteria of 10 percent relative difference, but the sum of the filtered nitrogen analytes is less than the LRL for total nitrogen.

[5] Total nitrogen in these samples is less than the sum of the filtered nitrogen analytes and exceeds the USGS's National Water Quality Laboratory acceptance criteria of 10 percent relative difference. Values were verified by the laboratory.

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); mg/L, milligrams per liter; na, not available; no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; —, analyzed but not detected; *, value above threshold level; **, value above upper threshold level]

GAMA identification no.	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Silica (mg/L) (00955)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70301)	Bicarbonate[1] (mg/L as $CaCO_3$)	Carbonate[1] (mg/L as $CaCO_3$)
Threshold type[2]	**na**	**na**	**SMCL-CA**[3]	**MCL-CA**	**na**	**na**	**na**	**na**	**na**	**SMCL-CA**[3]	**SMCL-CA**[3]	**na**	**na**
Threshold (mg/L)	**na**	**na**	**250 (500)**	**2.00**	**na**	**na**	**na**	**na**	**na**	**250 (500)**	**500 (1,000)**	**na**	**na**
[LRL]	**[0.02]**	**[0.02]**	**[0.2]**	**[0.1]**	**[0.002]**	**[0.008]**	**[0.16]**	**[0.04]**	**[0.2]**	**[0.18]**	**[10]**	**[1]**	**[1]**
Grid wells													
ESAC-03	0.06	29.1	21.5	E0.09	0.002	16.4	1.39	34.2	38.1	33.5	274	177	1
ESAC-05	0.11	32.7	7.85	E0.07	0.002	36.8	3.51	63.6	19.1	44.1	353	237	1
ESAC-06	—	18.1	2.26	E0.08	—	12.1	1.75	71.7	7.33	1.5	183	129	—
ESAC-10	0.11	40.6	36.6	0.15	0.036	28.1	1.73	42.7	23.6	13.9	316	255	—
ESAC-11	0.03	13.6	4.62	E0.07	0.019	10.5	3.73	75.7	17.1	2.0	194	135	—
ESAC-12	0.05	23.9	12.9	0.12	E0.001	12.5	1.59	34.9	30	9.5	237	217	1
ESAC-15	0.03	22.4	8.13	E0.07	—	14.4	1.17	60.0	11.9	6.3	195	143	—
ESAC-16	0.08	18.9	36.3	E0.08	—	14.0	3.25	63.7	35.9	10.3	267	163	—
ESAC-17	0.23	55.4	124	0.11	0.079	48.9	5.10	50.3	61.7	22.0	* 552	369	1
ESAC-18	—	17.9	5.12	E0.09	—	11.3	2.38	59.1	10.7	2.6	179	134	—
ESAC-19	E0.01	38.1	9.65	0.24	—	17.8	3.46	69.5	24.7	25.0	306	232	—
ESAC-21	1.71	58.2	** 626	—	1.110	25.0	8.28	36.8	401	—	**1,290	264	1
ESAC-22	0.05	23.0	11.4	—	E0.001	17.4	0.31	60.6	12	21.0	240	99	—
ESAC-25	—	17.2	2.07	E0.09	—	11.3	1.35	67.4	8.43	2.5	177	129	—
ESAC-26	—	8.84	4.12	0.14	0.025	7.85	1.20	47.4	47.7	4.0	212	196	1
ESAC-27	0.14	39.6	19.6	E0.06	0.037	29.0	1.68	50.1	20.6	20.6	312	269	—
ESAC-28	0.02	24.1	5.55	0.14	E0.001	26.4	2.62	61.2	15.2	6.8	259	226	—
ESAC-29	0.07	24.5	15.0	E0.08	0.068	15.6	2.44	37.1	54.8	10.6	297	272	1
ESAC-30	0.16	18.7	58.5	0.11	0.040	21.7	1.67	48.6	36.6	7.3	268	146	1
ESAC-31	0.09	50.1	27.9	E0.08	0.105	32.2	2.49	50.3	49.5	17.4	410	360	1
ESAC-32	E0.02	32.5	4.62	—	—	21.7	1.45	52.1	9.17	12.6	243	212	—
ESAC-34	0.08	50.3	13.5	0.11	0.003	34.4	1.83	62.4	26.9	38.6	397	332	1
ESAC-35	—	28.8	2.60	—	—	19.2	1.55	57.0	10.2	8.4	232	204	—
WSAC-03	—	32.3	7.11	0.10	—	16.2	0.70	28.9	12.8	20.8	207	162	—
WSAC-04	0.03	16.5	5.11	0.18	0.021	15.9	0.56	24.9	34.2	1.2	203	208	2
WSAC-06	0.05	40.5	15.2	0.29	0.003	37.7	0.57	30.3	24.4	24.7	344	335	—
WSAC-08	0.05	67.5	21.4	E0.09	E0.001	19.7	0.84	19.5	17.9	25.8	310	269	—
WSAC-10	0.06	66.5	23.1	E0.08	E0.002	23.8	0.87	21.8	21.8	31.8	329	281	—
WSAC-11	0.28	29.4	87.4	0.21	0.006	29.9	1.05	30.0	51.9	10.5	365	229	1
WSAC-12	0.25	22.8	50.8	0.11	0.125	16.2	1.50	41.3	115	62.3	440	257	1
WSAC-14	0.81	84.5	236	0.42	0.524	70.4	2.12	42.0	259	* 429	** 1,330	393	1
WSAC-15	0.12	48.6	27.1	0.29	0.010	35.6	1.80	26.0	101	49.5	* 584	472	1

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); mg/L, milligrams per liter; na, not available; no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; —, analyzed but not detected; *, value above threshold level; **, value above upper threshold level]

GAMA identification no.	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Silica (mg/L) (00955)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70301)	Bicarbonate[1] (mg/L as $CaCO_3$)	Carbonate[1] (mg/L as $CaCO_3$)
Threshold type[2]	na	na	SMCL-CA[3]	MCL-CA	na	na	na	na	na	SMCL-CA[3]	SMCL-CA[3]	na	na
Threshold (mg/L)	na	na	250 (500)	2.00	na	na	na	na	na	250 (500)	500 (1,000)	na	na
[LRL]	[0.02]	[0.02]	[0.2]	[0.1]	[0.002]	[0.008]	[0.16]	[0.04]	[0.2]	[0.18]	[10]	[1]	[1]
WSAC-17	E0.01	27.3	7.38	0.12	0.008	23.4	1.62	37.6	29.7	20.6	275	248	—
WSAC-18	0.40	50.5	96.4	0.47	0.420	37.6	1.26	28.2	117	110	* 623	388	1
WSAC-21	0.04	27.6	14.0	0.30	0.003	19.8	0.50	29.9	26.9	7.0	257	209	—
WSAC-22	0.16	29.8	34.1	0.20	0.026	24.5	1.05	22.4	39.9	12.0	297	256	1
WSAC-25	0.08	23.0	17.5	0.18	0.013	22.4	2.35	41.5	44.1	8.3	294	268	1
WSAC-26	0.03	33.3	2.80	0.43	—	16.3	0.56	30.0	11.7	3.9	208	192	—
WSAC-28	0.04	43.8	20.1	E0.08	—	22.1	0.69	26.1	10.9	21.0	258	204	—
WSAC-29	0.05	20.9	8.49	0.29	0.008	21.5	0.80	23.3	36.2	11.9	253	242	1
WSAC-30	1.29	79.5	* 358	0.64	—	68.5	0.53	21.4	136	87.0	* 910	248	1
WSAC-31	0.03	18.9	4.23	0.19	E0.002	11.3	0.74	28.2	25	11.1	181	155	1
WSAC-34	0.08	88.9	74.0	E0.09	E0.002	38.5	1.10	23.4	23.4	39.4	486	315	—
WSAC-35	0.02	45.2	16.9	E0.07	0.003	18.9	0.86	22.9	23.6	19.9	277	250	—
WSAC-36	—	24.6	4.41	0.17	0.020	22.5	1.03	30.7	31.7	8.0	256	262	1
Flow-path wells													
ESAC-FP-01	0.31	45.3	124	E0.09	0.026	9.09	1.87	65.1	39	—	331	91	—
ESAC-FP-02	0.03	40.3	13.5	E0.06	E0.002	26.0	1.54	60.2	18.5	11.3	304	246	—
ESAC-FP-03	—	33.0	2.43	E0.05	0.008	23.5	1.34	56.4	10.3	9.2	257	240	—
ESAC-FP-04	—	14.3	1.79	—	E0.002	11.2	2.29	57.7	10.9	2.1	166	130	1
ESAC-FP-05	—	66.1	9.43	E0.08	0.006	41.5	2.75	51.0	22.4	26.5	460	431	1
ESAC-FP-06	0.07	13.5	19.4	E0.09	0.054	3.99	2.88	41.8	51.7	1.4	216	152	6
ESAC-FP-07	0.13	14.6	35.9	E0.09	0.101	4.69	2.73	46.9	68.8	0.3	270	187	3
WSAC-FP-01	E0.02	24.7	2.33	0.33	—	20.5	0.76	31.1	19.9	1.7	217	220	1
WSAC-FP-02	0.04	20.6	11.1	0.15	0.002	16.7	0.75	27.3	21.8	8.9	197	172	1
WSAC-FP-03	0.05	35.4	15.7	0.13	E0.001	24.8	0.75	30.2	16.4	16.7	259	213	1
WSAC-FP-04	0.05	19.9	13.9	0.13	0.032	7.34	1.89	21.3	34.5	0.6	189	174	3
WSAC-FP-05	0.41	28.7	100	0.29	0.227	25.3	2.38	40.4	128	88.4	* 565	302	1
WSAC-FP-06	0.10	16.0	22.4	0.18	0.055	15.8	0.87	21.1	30.4	7.6	202	168	2
WSAC-FP-07	0.07	15.9	15.1	0.12	0.041	7.21	1.56	37.1	41.1	7.2	213	173	2
WSAC-FP-08	0.04	36.9	10.5	0.12	E0.002	18.6	0.73	25.5	18.5	12.6	244	224	1

Table 9. Major and minor ions and total dissolved solids detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); mg/L, milligrams per liter; na, not available; no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; —, analyzed but not detected; *, value above threshold level; **, value above upper threshold level]

GAMA identification no.	Bromide (mg/L) (71870)	Calcium (mg/L) (00915)	Chloride (mg/L) (00940)	Fluoride (mg/L) (00950)	Iodide (mg/L) (71865)	Magnesium (mg/L) (00925)	Potassium (mg/L) (00935)	Silica (mg/L) (00955)	Sodium (mg/L) (00930)	Sulfate (mg/L) (00945)	Total dissolved solids (TDS) (mg/L) (70301)	Bicarbonate[1] (mg/L as $CaCO_3$)	Carbonate[1] (mg/L as $CaCO_3$)
Threshold type[2]	na	na	SMCL-CA[3]	MCL-CA	na	na	na	na	na	SMCL-CA[3]	SMCL-CA[3]	na	na
Threshold (mg/L)	na	na	250 (500)	2.00	na	na	na	na	na	250 (500)	500 (1,000)	na	na
[LRL]	[0.02]	[0.02]	[0.2]	[0.1]	[0.002]	[0.008]	[0.16]	[0.04]	[0.2]	[0.18]	[10]	[1]	[1]
RICE wells													
RICE-01	12.60	814	** 4730	—	nc	447	11.50	24.3	1250	[4]—	** 7,390	135	—
RICE-02	0.05	41.5	8.07	E0.08	nc	36.5	0.87	52.4	33.3	23.3	402	406	1
RICE-03	0.19	67.4	34.4	E0.08	nc	43.9	2.54	58.4	53.3	37.8	* 566	525	1
RICE-04	—	63.3	7.05	0.18	nc	40.2	2.05	57.3	16.9	17.7	404	399	—
RICE-05	0.07	85.1	16.9	0.13	nc	54.7	1.66	70.2	35.5	48.0	* 569	519	—
RICE-06	—	68.7	2.44	0.11	nc	51.9	1.36	67.9	16.1	15.2	456	468	—
RICE-07	0.04	73.0	3.88	0.15	nc	52.4	1.36	52.3	23.1	28.1	488	511	1
RICE-08	0.05	68.2	9.57	E0.1	nc	49.0	1.12	52.4	34.3	36.4	487	459	1
RICE-09	—	22.5	3.05	E0.09	nc	15.1	0.77	39.6	11	5.1	174	155	1
RICE-10	0.03	36.8	3.85	0.24	nc	18.8	0.69	28.5	11.2	7.8	212	204	1
RICE-11	0.10	91.3	26.8	0.18	nc	60.6	0.62	33.4	27.8	49.4	* 562	504	—
RICE-12	0.08	59.9	14.0	0.32	nc	45.6	0.50	30.5	55	20.4	468	482	1
RICE-13	0.10	66.5	26.7	0.12	nc	50.2	0.91	32.7	56.7	37.4	* 539	506	1
RICE-14	0.07	59.5	9.67	0.19	nc	50.9	0.49	28.8	47.7	38.4	478	488	—
RICE-15	0.04	39.2	7.10	0.89	nc	47.7	0.45	21.9	105	79.5	* 566	529	2
RICE-16	0.15	29.2	23.9	1.70	nc	31.9	0.56	17.6	356	* 375	** 1,200	723	2
RICE-17	0.60	92.8	147	1.70	nc	114	0.72	21.5	838	** 2,080	** 3,510	423	2
RICE-18	0.05	59.4	9.18	0.26	nc	38.3	0.81	27.4	72.8	104.0	* 522	416	1
RICE-19	0.04	38.0	3.56	E0.07	nc	25.4	1.23	42.3	27.4	8.5	294	297	1
RICE-20	0.21	47.9	46.9	0.41	nc	64.1	0.85	46.6	81	63.2	* 614	494	1
RICE-21	0.42	77.2	106	0.62	nc	44.3	0.54	19.9	232	* 359	** 1,050	422	1
RICE-22	0.65	73.1	156	0.90	nc	50.0	0.53	16.7	603	** 1,080	** 2,240	505	1

[1] Bicarbonate and carbonate concentrations were calculated from the laboratory alkalinity and pH values (table 4) using the advance speciation method (http://or.water.usgs.gov/alk/methods.html).

[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.

[4] Laboratory reporting level is 4.5 mg/L.

Table 10. Trace elements detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. AL-US, action level (USEPA); CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; nc, not collected; NL-CA, notification level (CDPH); no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in groundwater quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	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]	**[1.6]**	**[0.2]**	**[0.12]**	**[0.2]**	**[8]**	**[0.04]**	**[0.04]**	**[0.04]**	**[0.4]**	**[6]**	**[0.08]**
Threshold type[1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**AL-US**	**SMCL-CA**	**AL-US**
Threshold level	**1000**	**6**	**10**	**1000**	**1000**	**5**	**50**	**na**	**1300**	**300**	**15**
Grid wells											
ESAC-03	—	—	0.83	56	808	—	1.1	0.078	7.6	—	1.37
ESAC-05	—	E0.1	*19.6	104	26	—	4.9	0.084	1.2	—	0.24
ESAC-06	E1.5	—	0.97	15	—	—	1.2	—	3.3	—	2.11
ESAC-10	—	—	5	99	20	—	0.16	—	—	30	0.19
ESAC-11	—	0.87	*70	130	53	—	V0.02	E0.03	—	7	0.19
ESAC-12	4.5	—	4.4	87	107	—	6.0	—	3.2	E4	1.03
ESAC-15	E0.8	—	0.47	16	83	—	6.7	—	E0.21	—	0.14
ESAC-16	E1.1	—	0.78	25	316	—	0.58	—	—	—	0.1
ESAC-17	—	—	*15.9	385	379	—	V0.02	—	—	*355	0.2
ESAC-18	E1.4	—	0.73	21	70	—	0.94	—	—	—	0.09
ESAC-19	E1.1	0.38	9.2	147	96	—	6.9	—	0.72	8	0.43
ESAC-21	E1.5	—	*80.6	461	*1,010	E0.03	V0.04	E0.02	—	221	0.51
ESAC-22	—	—	0.39	19	13	—	1.1	0.07	1.7	—	0.86
ESAC-25	E1.3	—	0.83	13	16	—	0.73	—	0.57	—	0.15
ESAC-26	1.7	E0.11	*23.1	39	237	—	V0.02	—	—	6	0.26
ESAC-27	—	—	6.5	78	37	—	1.1	0.27	1.8	—	1.12
ESAC-28	—	—	*10.1	52	24	—	6.9	—	0.62	—	0.31
ESAC-29	E1.2	—	9.2	141	712	—	V0.03	—	—	295	0.08
ESAC-30	E1	E0.15	*17	38	111	—	V0.03	E0.02	E0.25	E4	E0.15
ESAC-31	E0.8	—	*12	124	140	—	0.12	E0.03	—	19	E0.1
ESAC-32	E1	—	2.6	29	14	—	3.0	—	1.9	E5	0.74
ESAC-34	E1.2	—	5.6	90	E6	—	4.6	—	E0.25	—	0.21
ESAC-35	1.9	—	0.8	23	27	—	4.5	—	E0.25	—	0.1

Table 10. Trace elements detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. AL-US, action level (USEPA); CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; nc, not collected; NL-CA, notification level (CDPH); no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	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]	**[1.6]**	**[0.2]**	**[0.12]**	**[0.2]**	**[8]**	**[0.04]**	**[0.04]**	**[0.04]**	**[0.4]**	**[6]**	**[0.08]**
Threshold type[1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**AL-US**	**SMCL-CA**	**AL-US**
Threshold level	**1000**	**6**	**10**	**1000**	**1000**	**5**	**50**	**na**	**1300**	**300**	**15**
WSAC-03	—	—	0.48	66	16	—	1.2	0.081	0.8	—	0.2
WSAC-04	—	—	3.6	98	33	—	—	0.041	E0.2	43	—
WSAC-06	—	—	0.63	86	87	—	0.72	—	2.6	E3	1.67
WSAC-08	—	—	0.24	103	160	—	1.1	—	0.56	E3	3.43
WSAC-10	—	—	0.36	123	197	—	1.6	—	2	—	0.16
WSAC-11	E1	—	2.6	232	599	—	11.1	—	0.47	—	0.27
WSAC-12	1.8	—	2.2	126	212	—	V0.04	—	E0.28	53	—
WSAC-14	E1.3	—	2.6	29	364	0.04	V0.05	0.09	2	E4	0.62
WSAC-15	E1	—	1.3	295	*2330	—	7.3	0.04	0.47	—	0.08
WSAC-17	E1	E0.17	6.7	48	344	—	0.80	E0.02	1.4	—	0.69
WSAC-18	E1.2	—	1.3	74	447	—	0.07	0.04	E0.24	—	1.37
WSAC-21	E1	—	1.4	198	193	—	8.0	—	E0.26	—	0.1
WSAC-22	E0.8	—	7.9	268	105	—	2.5	—	0.93	14	0.68
WSAC-25	E1	—	4	106	762	—	0.48	—	—	—	0.32
WSAC-26	E1.4	—	1.1	106	11	—	4.3	0.06	0.46	—	0.35
WSAC-28	—	—	0.33	63	36	—	1.3	—	E0.24	—	—
WSAC-29	E1	—	3.1	145	64	—	11.5	—	E0.25	—	0.42
WSAC-30	E0.8	—	0.39	58	339	—	6.0	—	2.7	E5	0.43
WSAC-31	E1.3	—	4.7	61	71	3.54	10.8	—	E0.22	—	0.17
WSAC-34	E0.9	—	0.46	197	—	—	2.7	E0.03	0.47	—	—
WSAC-35	E1.1	—	1.2	117	128	—	2.2	—	0.66	—	0.17
WSAC-36	E1.2	—	4.5	142	117	—	4.3	—	0.47	E4	0.32

Table 10. Trace elements detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. AL-US, action level (USEPA); CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; nc, not collected; NL-CA, notification level (CDPH); no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in groundwater quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	**Aluminum (µg/L) (01106)**	**Antimony (µg/L) (01095)**	**Arsenic (µg/L) (01000)**	**Barium (µg/L) (01005)**	**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]	**[1.6]**	**[0.2]**	**[0.12]**	**[0.2]**	**[8]**	**[0.04]**	**[0.04]**	**[0.04]**	**[0.4]**	**[6]**	**[0.08]**
Threshold type[1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**AL-US**	**SMCL-CA**	**AL-US**
Threshold level	**1000**	**6**	**10**	**1000**	**1000**	**5**	**50**	**na**	**1300**	**300**	**15**
Flow-path wells											
ESAC-FP-01	1.3	—	1.1	73	171	—	V0.02	—	—	106	0.08
ESAC-FP-02	2.1	—	0.71	35	108	—	1.3	0.28	V0.2	65	0.13
ESAC-FP-03	V0.8	—	2.4	47	19	—	1.2	E0.03	—	134	0.11
ESAC-FP-04	V1.7	—	3.2	16	67	—	1.3	—	—	67	—
ESAC-FP-05	2.7	0.23	6.5	116	55	—	5.3	E0.03	—	—	—
ESAC-FP-06	39.4	E0.18	*12.7	17	208	—	0.70	E0.02	—	14	E0.07
ESAC-FP-07	17.2	—	9	35	243	—	0.22	E0.03	—	10	E0.05
WSAC-FP-01	V1.4	—	2.4	128	28	—	16.1	E0.02	—	—	—
WSAC-FP-02	2.2	E0.11	3.3	132	101	—	18.4	—	—	V6	—
WSAC-FP-03	3.7	E0.13	1.6	173	81	—	4.8	E0.02	V0.55	—	—
WSAC-FP-04	11.1	—	5.5	91	80	—	0.16	0.04	—	V6	—
WSAC-FP-05	4.5	—	8.3	42	230	E0.02	—	—	0.35	9	0.8
WSAC-FP-06	3.0	E0.15	4	167	98	—	0.33	—	—	15	—
WSAC-FP-07	4.4	—	*10.6	8	99	—	V0.07	—	—	40	—
WSAC-FP-08	V1.4	—	1.1	99	114	—	4.8	—	—	10	—

Table 10. Trace elements detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. AL-US, action level (USEPA); CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; nc, not collected; NL-CA, notification level (CDPH); no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	Aluminum (µg/L) (01106)	Antimony (µg/L) (01095)	Arsenic (µg/L) (01000)	Barium (µg/L) (01005)	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]	**[1.6]**	**[0.2]**	**[0.12]**	**[0.2]**	**[8]**	**[0.04]**	**[0.04]**	**[0.04]**	**[0.4]**	**[6]**	**[0.08]**
Threshold type[1]	**MCL-CA**	**MCL-US**	**MCL-US**	**MCL-CA**	**NL-CA**	**MCL-US**	**MCL-CA**	**na**	**AL-US**	**SMCL-CA**	**AL-US**
Threshold level	**1000**	**6**	**10**	**1000**	**1000**	**5**	**50**	**na**	**1300**	**300**	**15**
RICE wells											
RICE-01	—[2]	—[2]	4.9	*5,900	*1,260	—[2]	0.42	E0.18	—[2]	*4,610	—[2]
RICE-02	V1.3	E0.11	*10.4	39	55	—	2.4	0.09	—	V3	—
RICE-03	V0.8	E0.14	6.2	188	117	—	2.0	E0.02	V0.31	V5	—
RICE-04	—	—	4.7	154	16	—	1.7	E0.03	V0.54	57	—
RICE-05	—	—	1.4	160	9	E0.02	0.14	0.27	V0.97	28	—
RICE-06	—	—	1.8	85	16	—	0.41	0.04	V0.62	V4	—
RICE-07	V1.0	—	6.2	78	25	—	1.6	E0.02	V0.24	—	—
RICE-08	V1.0	—	6	96	35	—	4.1	—	—	—	—
RICE-09	1.8	E0.18	4.6	26	62	—	V0.07	0.15	V0.28	V6	—
RICE-10	V1.1	E0.16	3.1	87	57	—	0.37	E0.02	V0.32	—	—
RICE-11	V1.1	E0.1	1.6	552	92	E0.02	1.3	0.21	V1.1	V4	—
RICE-12	V1.0	E0.1	3.2	408	223	—	0.08	0.31	—	218	E0.04
RICE-13	V1.2	E0.11	2.3	286	199	—	3.1	0.44	V1.1	—	0.08
RICE-14	V1.2	—	1.1	357	174	—	V0.10	0.39	V0.27	110	—
RICE-15	—	—	1.1	65	551	—	0.77	0.04	V0.48	—	—
RICE-16	V1.3	—	0.57	20	945	—	V0.05	0.13	—	*304	—
RICE-17	E2.4	—	1.6	15	*1,640	0.05	13.1	0.13	V0.83	—	—
RICE-18	2.9	—	1	81	204	—	7.8	0.06	V0.53	—	—
RICE-19	V1.6	E0.11	4.1	61	68	—	V0.08	0.05	V0.69	—	—
RICE-20	V1.4	E0.14	7.5	46	195	0.04	V0.02	0.6	V0.80	—	—
RICE-21	2.2	—	0.38	46	97	—	0.13	0.13	V0.29	155	0.13
RICE-22	—	—	1.9	15	*4,630	—	0.85	1.6	—	166	—

Table 10. Trace elements detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. AL-US, action level (USEPA); CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; nc, not collected; NL-CA, notification level (CDPH); no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	**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)**	**Vanadium (µg/L) (01085)**	**Zinc (µg/L) (01090)**	**Uranium (µg/L) (22703)**
[LRL]	**[0.6]**	**[0.2]**	**[0.4]**	**[0.06]**	**[0.08]**	**[0.4]**	**[0.04]**	**[0.06]**	**[0.1]**	**[0.6]**	**[0.04]**
Threshold type[1]	**na**	**SMCL-CA**	**HAL-US**	**MCL-CA**	**MCL-US**	**HAL-US**	**MCL-US**	**na**	**NL-CA**	**SMCL-CA**	**MCL-US**
Threshold level	**na**	**50**	**40**	**100**	**50**	**4000**	**2**	**na**	**50**	**5000**	**30**
Grid wells											
ESAC-03	14.1	E0.1	0.5	1.19	0.09	254	—	0.35	9.7	3.6	0.37
ESAC-05	E0.4	—	1.8	1.38	0.61	214	—	0.06	28.8	2.8	2.76
ESAC-06	2.1	E0.2	E0.2	0.26	E0.05	112	—	—	28.8	10.7	0.12
ESAC-10	E0.4	*95.1	0.6	0.18	1.0	319	—	E0.05	6.5	1.7	6.07
ESAC-11	20.9	*112	2.0	V0.04	—	138	—	0.27	40.4	V0.42	0.69
ESAC-12	2.8	0.2	2.3	0.13	0.40	290	—	0.11	12.2	4.4	0.45
ESAC-15	—	—	—	V0.07	0.16	145	—	—	17.7	V0.73	0.08
ESAC-16	6.5	E0.1	E0.2	0.14	E0.06	123	—	—	21.1	V0.52	0.23
ESAC-17	0.7	*568	1.8	0.22	—	488	—	0.23	E0.05	3.2	—
ESAC-18	1.6	—	E0.2	0.09	E0.04	116	—	E0.03	19.8	V0.58	0.35
ESAC-19	4.8	—	1.1	0.14	0.6	342	—	0.07	22.7	3.2	1.50
ESAC-21	3.8	*257	16.5	V0.07	—	460	—	0.1	0.11	1.3	—
ESAC-22	0.7	E0.2	—	0.58	0.09	111	—	—	6.8	6.3	0.04
ESAC-25	4.1	—	E0.3	0.12	E0.06	115	—	—	30.6	V1.2	0.07
ESAC-26	1.0	*80.2	4.2	—	—	112	—	0.53	9.6	1.3	0.21
ESAC-27	0.7	*110	0.8	0.57	0.24	258	—	—	8.4	V0.93	2.24
ESAC-28	E0.6	1.3	1.1	0.11	0.12	179	—	0.07	26.2	1.3	1.41
ESAC-29	2.4	*219	E4	0.09	—	276	—	0.23	0.42	12.2	—
ESAC-30	1.7	*99.6	1.4	0.08	0.31	195	—	0.28	35	V0.97	0.39
ESAC-31	1.9	*72.2	2.6	0.13	0.10	388	—	0.08	13.9	V0.92	1.88
ESAC-32	0.7	E0.1	—	0.17	0.16	227	—	—	9.5	4.5	1.09

Table 10. Trace elements detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. AL-US, action level (USEPA); CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; nc, not collected; NL-CA, notification level (CDPH); no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	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)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)	Uranium (µg/L) (22703)
[LRL]	**[0.6]**	**[0.2]**	**[0.4]**	**[0.06]**	**[0.08]**	**[0.4]**	**[0.04]**	**[0.06]**	**[0.1]**	**[0.6]**	**[0.04]**
Threshold type[1]	**na**	**SMCL-CA**	**HAL-US**	**MCL-CA**	**MCL-US**	**HAL-US**	**MCL-US**	**na**	**NL-CA**	**SMCL-CA**	**MCL-US**
Threshold level	**na**	**50**	**40**	**100**	**50**	**4000**	**2**	**na**	**50**	**5000**	**30**
ESAC-34	0.8	—	0.5	0.10	0.36	360	—	E0.03	38.5	137	3.71
ESAC-35	1.3	—	—	—	E0.05	197	—	E0.05	22.4	V0.84	1.05
WSAC-03	3.7	—	1.0	1.32	0.10	368	—	—	3.9	6.6	0.14
WSAC-04	4.4	43.3	1.6	0.59	—	199	—	E0.03	—	V1.2	—
WSAC-06	11.5	—	0.5	0.21	0.08	506	—	—	5.0	62.9	0.40
WSAC-08	3.9	0.2	1.0	0.12	0.09	841	—	—	1.8	10.2	0.54
WSAC-10	6.4	—	E0.7	E0.14	0.09	849	—	—	2.8	13.3	0.78
WSAC-11	21.6	—	—	—	0.50	360	—	—	8.3	V0.51	0.28
WSAC-12	3.8	*106	7.8	V0.05	—	256	—	0.42	0.53	V0.67	0.07
WSAC-14	24.8	*89.8	4.5	0.36	10.8	1570	E0.02	0.08	10.7	8.6	2.57
WSAC-15	37	E0.1	0.5	0.66	1.4	641	—	0.18	5.7	V0.68	2.61
WSAC-17	1.3	0.2	4.0	0.17	0.57	234	—	0.07	18.5	36.4	1.16
WSAC-18	18.6	*84.6	3.7	V0.05	1.2	877	—	E0.05	8.4	V0.37	E0.14
WSAC-21	14.9	E0.1	E0.3	0.08	0.36	276	—	—	5.5	28.1	0.18
WSAC-22	15	36.6	0.6	0.11	0.16	435	—	E0.03	2.6	16.4	0.25
WSAC-25	26.9	1.8	3.5	V0.05	0.31	332	—	0.19	10.8	5.4	0.64
WSAC-26	14.9	—	0.9	V0.07	0.10	254	—	—	3.8	8.9	0.33
WSAC-28	4.1	—	E0.4	0.12	E0.04	428	—	—	2.8	V0.43	0.10
WSAC-29	9.8	3.1	1.0	0.18	0.77	395	—	—	10.8	3.4	0.43
WSAC-30	22	E0.1	1.0	0.30	0.75	1480	—	—	3.7	4.5	1.06
WSAC-31	2.7	—	2.0	V0.03	0.77	226	—	0.06	17.9	V0.53	0.19
WSAC-34	6.9	—	0.7	0.33	0.08	1130	—	—	3.0	2.0	0.79
WSAC-35	5.5	—	0.8	0.11	0.17	619	—	—	3.8	3.3	0.46
WSAC-36	4.6	0.5	3.1	V0.06	0.30	439	—	E0.05	9.4	1.5	0.72

Table 10. Trace elements detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. AL-US, action level (USEPA); CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; nc, not collected; NL-CA, notification level (CDPH); no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	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)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)	Uranium (µg/L) (22703)
[LRL]	**[0.6]**	**[0.2]**	**[0.4]**	**[0.06]**	**[0.08]**	**[0.4]**	**[0.04]**	**[0.06]**	**[0.1]**	**[0.6]**	**[0.04]**
Threshold type[1]	**na**	**SMCL-CA**	**HAL-US**	**MCL-CA**	**MCL-US**	**HAL-US**	**MCL-US**	**na**	**NL-CA**	**SMCL-CA**	**MCL-US**
Threshold level	**na**	**50**	**40**	**100**	**50**	**4000**	**2**	**na**	**50**	**5000**	**30**
Flow-path wells											
ESAC-FP-01	0.6	*184	0.8	V0.05	—	455	—	0.22	E0.05	6.4	—
ESAC-FP-02	—	14.5	0.7	2.2	E0.07	261	—	V0.05	7.5	6.3	0.46
ESAC-FP-03	—	16.8	E0.2	0.31	—	225	—	0.09	23.4	—	0.70
ESAC-FP-04	—	3.5	0.4	0.30	0.12	100	—	0.21	10.0	V0.68	0.09
ESAC-FP-05	1.3	V0.3	0.6	0.57	0.38	534	—	0.31	26.3	—	5.44
ESAC-FP-06	0.7	8.4	4.9	0.47	—	127	—	1.1	2.9	—	0.07
ESAC-FP-07	E0.4	16.4	8.3	0.76	—	96.7	—	0.69	0.7	—	0.05
WSAC-FP-01	12.7	—	0.8	0.31	0.57	439	—	0.03	8.9	—	0.36
WSAC-FP-02	8.5	V0.5	0.8	0.33	0.39	379	—	0.07	10.3	V0.6	0.20
WSAC-FP-03	13.4	V0.8	0.6	0.72	0.11	410	—	0.09	6.4	V1.2	0.12
WSAC-FP-04	16.9	8.4	1.9	1.1	—	635	—	1.4	0.19	—	0.07
WSAC-FP-05	5.6	*60.6	3.9	0.09	E0.06	758	—	0.21	0.82	2.4	0.56
WSAC-FP-06	7.6	7.2	1.1	0.33	0.20	449	—	0.36	8	V1.2	0.07
WSAC-FP-07	4	22.6	2.1	V0.17	—	296	—	0.33	—	—	0.04
WSAC-FP-08	5.5	V0.4	1.3	0.27	0.08	475	—	V0.03	6	V1.4	0.22

Table 10. Trace elements detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey to uniquely identify a specific constituent or property. AL-US, action level (USEPA); CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; HAL-US, Lifetime Health Advisory Level (USEPA); LRL, laboratory reporting level; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); na, not available; nc, not collected; NL-CA, notification level (CDPH); no., number; RICE, RICE well; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	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)	Vanadium (µg/L) (01085)	Zinc (µg/L) (01090)	Uranium (µg/L) (22703)
[LRL]	**[0.6]**	**[0.2]**	**[0.4]**	**[0.06]**	**[0.08]**	**[0.4]**	**[0.04]**	**[0.06]**	**[0.1]**	**[0.6]**	**[0.04]**
Threshold type[1]	**na**	**SMCL-CA**	**HAL-US**	**MCL-CA**	**MCL-US**	**HAL-US**	**MCL-US**	**na**	**NL-CA**	**SMCL-CA**	**MCL-US**
Threshold level	**na**	**50**	**40**	**100**	**50**	**4000**	**2**	**na**	**50**	**5000**	**30**
RICE wells											
RICE-01	E3.3	*3,420	E1.6	1.3	—[2]	*7,880	—[2]	nc	1.1	4.7	—[2]
RICE-02	E0.4	14.2	1.3	0.46	E0.06	354	—	nc	*51.3	V0.48	4.29
RICE-03	1.1	2.6	—	0.38	E0.04	800	—	nc	34.4	V0.56	4.44
RICE-04	0.8	19.9	0.6	0.96	0.09	449	—	nc	25.7	V0.75	3.36
RICE-05	0.7	*75.4	—	1.9	—	618	—	nc	27.1	V1.1	3.52
RICE-06	E0.3	34.1	—	0.86	E0.04	420	—	nc	40.9	V0.75	2.67
RICE-07	—	3.4	E0.4	0.28	—	660	—	nc	*57.4	V0.34	5.19
RICE-08	0.7	V0.2	E0.3	0.22	0.20	666	—	nc	38	V0.52	3.27
RICE-09	1.0	41.9	1.3	0.29	—	179	—	nc	18.4	—	0.34
RICE-10	2.5	7.9	2.5	0.22	E0.05	359	—	nc	10.9	—	0.64
RICE-11	18.3	9.1	0.5	1.6	—	1,340	—	nc	5.8	V1.0	1.13
RICE-12	14.3	*55.2	1.7	0.56	—	1,000	—	nc	2.2	V1.1	1.57
RICE-13	19.9	26.6	0.8	1.1	—	1,010	—	nc	8.4	V0.57	1.48
RICE-14	11.5	*379	1.2	1.3	—	919	—	nc	0.55	V0.99	1.65
RICE-15	23.3	1.3	5.4	0.40	0.43	812	—	nc	5.5	V0.47	4.44
RICE-16	26.1	*434	9.8	V0.20	11	795	—	nc	0.54	V0.53	7.76
RICE-17	31.2	27.5	*46.2	0.61	7.8	1,900	—	nc	8.5	V1.6	10.20
RICE-18	18.9	7.7	0.9	0.28	0.55	772	—	nc	5.2	V0.88	2.04
RICE-19	0.8	6.1	1.2	0.32	—	370	—	nc	24.8	V1.2	1.25
RICE-20	0.9	*216	10.9	1.3	0.32	461	—	nc	29.6	V0.44	4.90
RICE-21	19.7	*156	2.4	0.31	0.45	1200	—	nc	0.42	V0.8	2.38
RICE-22	102	*602	9.6	2.3	E0.77	*4,540	—	nc	E0.74	E4	4.81

[1] Maximum contaminant level thresholds are listed as MCL-US when 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] Laboratory reporting level is four times the LRL stated above.

Table 11. Species of inorganic arsenic, iron, and chromium detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed for iron, arsenic, and chromium; only wells with at least one detection are listed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. Analyses made by the USGS's Trace Metals Laboratory. The laboratory entity code for the USGS's Trace Metals Laboratory in the USGS's National Water Information System (NWIS) is USGSTMCO. CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); MDL, method detection limit; na, not available; no., number; NRP, National Research Program (USGS); NWQL, National Water Quality Laboratory (USGS); RICE, RICE well; RSD, relative standard deviation; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; * , value above threshold level]

GAMA identification no.	Iron(Total)[2] (µg/L) (01046)	Iron(II) (µg/L) (01047)	Inorganic Arsenic(Total)[2] (µg/L) (99033)	Inorganic Arsenic(III) (µg/L) (99034)	Chromium(Total) (µg/L) (01030)	Chromium(VI) (µg/L) (01032)
Threshold type[1]	**SMCL-CA**	**na**	**MCL-US**	**na**	**MCL-CA**	**na**
Threshold (µg/L)	**300**	**na**	**10**	**na**	**50**	**na**
[MDL]	**[2]**	**[2]**	**[0.5]**	**[1]**	**[1]**	**[1]**
			Grid wells			
ESAC-03	—	—	—	—	1	—
ESAC-05	—	—	* 17	—	4	4
ESAC-06	—	—	V3.6	—	—	—
ESAC-10	28	17	4.9	—	—	—
ESAC-11	6	4	[3]* 35	—	—	—
ESAC-12	3	—	3.6	—	6	5
ESAC-15	—	—	V0.7	—	2	—
ESAC-16	—	—	V1.2	—	—	—
ESAC-17	* 359	238	* 14	13	—	—
ESAC-18	—	—	V1.7	—	—	—
ESAC-19	6	—	8.0	—	5	5
ESAC-21	198	57	* 70	70	—	—
ESAC-22	—	—	—	—	1	1
ESAC-25	—	—	V4.3	—	—	—
ESAC-26	6	4	* 19	4	—	—
ESAC-27	—	—	6.2	—	—	—
ESAC-28	—	—	7.8	—	5	4
ESAC-29	* 304	26	8.7	7	—	—
ESAC-30	4	3	* 15	—	—	—
ESAC-31	21	18	* 11	4	—	—
ESAC-32	—	—	2.0	—	2	2
ESAC-34	—	—	5.1	—	4	3
ESAC-35	—	—	V1.7	—	3	2
WSAC-03	—	—	—	—	—	—
WSAC-04	36	23	V5.0	—	—	—
WSAC-06	—	—	V1.5	—	—	—
WSAC-08	2	—	V0.8	—	—	—
WSAC-10	4	—	—	—	1	1
WSAC-11	2	—	1.9	—	9	8
WSAC-12	54	36	1.9	1	—	—
WSAC-14	4	4	2.0	—	—	—

Table 11. Species of inorganic arsenic, iron, and chromium detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed for iron, arsenic, and chromium; only wells with at least one detection are listed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. Analyses made by the USGS's Trace Metals Laboratory. The laboratory entity code for the USGS's Trace Metals Laboratory in the USGS's National Water Information System (NWIS) is USGSTMCO. CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); MDL, method detection limit; na, not available; no., number; NRP, National Research Program (USGS); NWQL, National Water Quality Laboratory (USGS); RICE, RICE well; RSD, relative standard deviation; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	Iron(Total)[2] (µg/L) (01046)	Iron(II) (µg/L) (01047)	Inorganic Arsenic(Total)[2] (µg/L) (99033)	Inorganic Arsenic(III) (µg/L) (99034)	Chromium(Total) (µg/L) (01030)	Chromium(VI) (µg/L) (01032)
Threshold type[1]	**SMCL-CA**	**na**	**MCL-US**	**na**	**MCL-CA**	**na**
Threshold (µg/L)	**300**	**na**	**10**	**na**	**50**	**na**
[MDL]	**[2]**	**[2]**	**[0.5]**	**[1]**	**[1]**	**[1]**
WSAC-15	—	—	1.6	—	6	5
WSAC-17	—	—	5.9	—	—	—
WSAC-18	—	—	1.3	—	—	—
WSAC-21	2	—	1.5	—	6	5
WSAC-22	11	—	6.5	—	2	1
WSAC-25	—	—	[3]2.6	—	—	—
WSAC-26	—	—	V1.8	—	3	2
WSAC-28	—	—	V0.9	—	—	—
WSAC-29	—	—	3.6	—	11	10
WSAC-30	4	—	—	—	7	5
WSAC-31	—	—	4.1	—	9	5
WSAC-34	—	—	V1.0	—	2	2
WSAC-35	—	—	V3.5	—	1	1
WSAC-36	4	3	5.7	—	3	2
Flow-path wells						
ESAC-FP-01	103	82	V1.8	—	—	—
ESAC-FP-02	61	10	V1.4	—	4	2
ESAC-FP-03	130	69	1.8	—	2	—
ESAC-FP-04	62	—	3.5	—	2	1
ESAC-FP-05	—	—	6.0	—	5	4
ESAC-FP-06	12	6	* 12	—	—	—
ESAC-FP-07	8	2	8.0	—	—	—
WSAC-FP-01	—	—	1.5	—	17	17
WSAC-FP-02	5	—	2.7	—	21	19
WSAC-FP-03	3	—	1.1	—	4	3
WSAC-FP-04	6	—	5.4	4	—	—
WSAC-FP-05	10	—	6.9	—	—	—
WSAC-FP-06	13	3	4.3	—	—	—
WSAC-FP-07	39	11	9.3	9	—	—
WSAC-FP-08	6	—	0.7	—	4	4

Table 11. Species of inorganic arsenic, iron, and chromium detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from the 45 slow and intermediate grid wells, 15 flow-path wells, and 22 RICE wells were analyzed for iron, arsenic, and chromium; only wells with at least one detection are listed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. Analyses made by the USGS's Trace Metals Laboratory. The laboratory entity code for the USGS's Trace Metals Laboratory in the USGS's National Water Information System (NWIS) is USGSTMCO. CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); MDL, method detection limit; na, not available; no., number; NRP, National Research Program (USGS); NWQL, National Water Quality Laboratory (USGS); RICE, RICE well; RSD, relative standard deviation; SMCL-CA, secondary maximum contaminant level (CDPH); USEPA, U.S. Environmental Protection Agency; V, analyte detected in sample and an associated blank—thus data are not included in ground-water quality analysis results; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; µg/L, micrograms per liter; —, analyzed but not detected; *, value above threshold level]

GAMA identification no.	Iron(Total)[2] (µg/L) (01046)	Iron(II) (µg/L) (01047)	Inorganic Arsenic(Total)[2] (µg/L) (99033)	Inorganic Arsenic(III) (µg/L) (99034)	Chromium(Total) (µg/L) (01030)	Chromium(VI) (µg/L) (01032)
Threshold type[1]	**SMCL-CA**	**na**	**MCL-US**	**na**	**MCL-CA**	**na**
Threshold (µg/L)	**300**	**na**	**10**	**na**	**50**	**na**
[MDL]	**[2]**	**[2]**	**[0.5]**	**[1]**	**[1]**	**[1]**
RICE wells						
RICE-01	* 4,790	4,720	3.7	4	1	—
RICE-02	3	—	8.8	—	—	—
RICE-03	4	2	[3]4	—	1	1
RICE-04	[3]4	4	4.0	—	1	—
RICE-05	28	28	0.9	—	—	—
RICE-06	4	3	1.5	—	—	—
RICE-07	2	2	5.5	—	1	—
RICE-08	3	3	5.3	—	4	4
RICE-09	3	2	3.8	—	—	—
RICE-10	2	2	2.8	—	—	—
RICE-11	—	—	V2.5	—	—	—
RICE-12	207	126	3.0	—	—	—
RICE-13	—	—	V3.5	—	2	2
RICE-14	112	96	0.7	—	—	—
RICE-15	—	—	V1.5	—	—	—
RICE-16	* 309	250	0.6	—	—	—
RICE-17	2	—	V3.0	—	12	9
RICE-18	—	—	1.1	—	6	5
RICE-19	—	—	3.5	—	—	—
RICE-20	—	—	6.8	—	—	—
RICE-21	140	130	—	—	—	—
RICE-22	[3]6	3	0.7	—	—	—

[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] V codes were applied to ground-water samples for which the concentration measured by the NRP laboratory was greater than the concentration measured by the NWQL preferred method (table 10), and the difference between the results was greater than 20 percent RSD.

[3] Concentration measured by the NRP laboratory was less than the concentration measured by the NWQL preferred method (table 10), and the difference between the results was greater than 20 percent RSD.

Table 12. Stable isotope ratios of water and tritium detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Samples from 70 of the grid wells (WSAC-14 not analyzed), the 15 flow-path wells, and 2 of the RICE wells were analyzed for stable isotopes of water; samples from 70 of the grid wells (WSAC-13 not analyzed), and the 15 flow-path wells were analyzed for tritium. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. The laboratory entity codes for the laboratories in the USGS's National Water Information System (NWIS) listed in the footnotes are shown in parentheses following the laboratory name. CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; MCL-CA, maximum contaminant level (CDPH); nc, sample not collected; no., number; pCi/L, picocuries per liter; RICE, RICE well; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; <, less than]

GAMA identification no.	δ^2H of water[1] (per mil) (82082)	δ^{18}O of water[1] (per mil) (82085)	Tritium[2] (pCi/L) (07000)
Threshold type	**na**	**na**	**MCL-CA**
Threshold	**na**	**na**	**20,000**
	Grid wells		
ESAC-01	–63.1	–8.81	1.9
ESAC-02	–63.4	–8.68	11.5
ESAC-03	–63.4	–8.80	8
ESAC-04	–59.8	–8.19	2.8
ESAC-05	–63.8	–8.88	8
ESAC-06	–59.0	–8.25	1.3
ESAC-07	–56.6	–7.92	4.2
ESAC-08	–78.9	–11.02	9.9
ESAC-09	–56.6	–7.83	3.8
ESAC-10	–48.7	–6.65	2.9
ESAC-11	–60.0	–8.47	<1
ESAC-12	–71.1	–10.11	1
ESAC-13	–80.0	–11.35	3.5
ESAC-14	–57.0	–8.10	2.6
ESAC-15	–67.0	–9.73	1
ESAC-16	–60.0	–8.80	2.9
ESAC-17	–60.8	–8.28	3.5
ESAC-18	–66.1	–9.58	<1
ESAC-19	–56.3	–7.91	<1
ESAC-20	–54.3	–7.78	<1
ESAC-21	–75.2	–10.31	<1
ESAC-22	–53.0	–7.51	12.2
ESAC-23	–72.5	–10.43	10.2
ESAC-24	–57.9	–8.25	<1
ESAC-25	–61.2	–8.72	<1
ESAC-26	–82.2	–11.52	<1
ESAC-27	–55.2	–7.51	9.3
ESAC-28	–67.5	–9.48	7.4
ESAC-29	–59.2	–8.10	2.9
ESAC-30	–83.0	–11.74	<1
ESAC-31	–70.2	–9.41	8.6
ESAC-32	–67.6	–9.47	9.6
ESAC-33	–61.2	–8.70	12.5
ESAC-34	–55.9	–7.37	13.4
ESAC-35	–70.6	–9.88	4.2

Table 12. Stable isotope ratios of water and tritium detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from 70 of the grid wells (WSAC-14 not analyzed), the 15 flow-path wells, and 2 of the RICE wells were analyzed for stable isotopes of water; samples from 70 of the grid wells (WSAC-13 not analyzed), and the 15 flow-path wells were analyzed for tritium. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. The laboratory entity codes for the laboratories in the USGS's National Water Information System (NWIS) listed in the footnotes are shown in parentheses following the laboratory name. CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; MCL-CA, maximum contaminant level (CDPH); nc, sample not collected; no., number; pCi/L, picocuries per liter; RICE, RICE well; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; <, less than]

GAMA identification no.	δ^2H of water[1] (per mil) (82082)	δ^{18}O of water[1] (per mil) (82085)	Tritium[2] (pCi/L) (07000)
Threshold type	**na**	**na**	**MCL-CA**
Threshold	**na**	**na**	**20,000**
WSAC-01	–72.1	–9.98	<1
WSAC-02	–63.0	–8.41	6.4
WSAC-03	–68.1	–9.64	7.4
WSAC-04	–67.4	–9.24	<1
WSAC-05	–65.0	–8.90	7.7
WSAC-06	–66.2	–9.46	8.6
WSAC-07	–66.9	–9.24	13.4
WSAC-08	–62.6	–8.61	11.8
WSAC-09	–63.3	–8.83	6.7
WSAC-10	–63.7	–8.82	7.4
WSAC-11	–59.5	–8.60	<1
WSAC-12	–76.3	–10.35	<1
WSAC-13	–63.9	–8.91	nc
WSAC-14	nc	nc	<1
WSAC-15	–44.7	–5.81	8.3
WSAC-16	–52.1	–6.93	2.6
WSAC-17	–75.9	–10.61	8.6
WSAC-18	–62.2	–8.45	1.6
WSAC-19	–58.7	–8.37	<1
WSAC-20	–44.4	–5.90	4.5
WSAC-21	–59.0	–8.38	1.9
WSAC-22	–59.5	–8.53	5.8
WSAC-23	–60.5	–8.15	7.7
WSAC-24	–59.1	–8.54	1.3
WSAC-25	–51.7	–7.14	<1
WSAC-26	–64.2	–9.08	3.8
WSAC-27	–65.4	–8.84	9.3
WSAC-28	–63.6	–8.75	11.8
WSAC-29	–64.4	–8.87	<1
WSAC-30	–66.9	–9.21	14.7
WSAC-31	–64.8	–9.21	<1
WSAC-32	–74.3	–10.51	8.3
WSAC-33	–62.0	–8.88	<1
WSAC-34	–64.8	–9.04	9.6
WSAC-35	–68.8	–9.37	7.4
WSAC-36	–66.6	–9.26	1.6

Table 12. Stable isotope ratios of water and tritium detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from 70 of the grid wells (WSAC-14 not analyzed), the 15 flow-path wells, and 2 of the RICE wells were analyzed for stable isotopes of water; samples from 70 of the grid wells (WSAC-13 not analyzed), and the 15 flow-path wells were analyzed for tritium. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. Stable isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. The laboratory entity codes for the laboratories in the USGS's National Water Information System (NWIS) listed in the footnotes are shown in parentheses following the laboratory name. CDPH, California Department of Public Health; ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; MCL-CA, maximum contaminant level (CDPH); nc, sample not collected; no., number; pCi/L, picocuries per liter; RICE, RICE well; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; <, less than]

GAMA identification no.	δ^2H of water[1] (per mil) (82082)	$\delta^{18}O$ of water[1] (per mil) (82085)	Tritium[2] (pCi/L) (07000)
Threshold type	**na**	**na**	**MCL-CA**
Threshold	**na**	**na**	**20,000**
	Flow-path wells		
ESAC-FP-01	–53.6	–7.34	<1
ESAC-FP-02	–69.4	–10.06	3.5
ESAC-FP-03	–72.9	–10.11	6.4
ESAC-FP-04	–64.0	–9.14	<1
ESAC-FP-05	–61.7	–8.01	12.8
ESAC-FP-06	–75.5	–10.58	<1
ESAC-FP-07	–80.8	–11.08	<1
WSAC-FP-01	–65.3	–9.13	<1
WSAC-FP-02	–67.7	–9.55	<1
WSAC-FP-03	–63.5	–8.96	9.0
WSAC-FP-04	–66.6	–9.43	1.3
WSAC-FP-05	–71.6	–9.63	<1
WSAC-FP-06	–69.7	–9.66	<1
WSAC-FP-07	–72.9	–10.22	<1
WSAC-FP-08	–69.2	–9.70	12.8
	RICE wells		
RICE-07	–54.1	–6.63	nc
RICE-11	–63.0	–8.47	nc

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

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

Table 13. Nitrogen and oxygen isotopes in nitrate, nitrogen isotopes in nitrogen gas, and carbon-14 activities detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Samples from 42 of the slow and intermediate grid wells (ESAC-35, WSAC-10, and WSAC-11 not analyzed) and the 15 flow-path wells were analyzed for isotopes of nitrate; samples from 43 of the slow and intermediate grid wells (ESAC-35 and WSAC-11 not analyzed) and the 15 flow-path wells were analyzed for carbon-14 activities. Nitrogen and oxygen isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. The laboratoroy entity codes for the laboratories in the USGS's National Water Information System (NWIS) listed in the footnotes are shown in parentheses following the laboratory name. ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; na, not available; nc, sample not collected; no., number; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; —, nitrate not detected, therefore sample was not analyzed for nitrate isotopes]

GAMA identification no.	δ^{18}O of nitrate[1] (per mil) (63041)	δ^{15}N of nitrate[1] (per mil) (82690)	δ^{13}O of dissolved carbonates[2] (per mil) (82081)	[3]Carbon-14 (percent modern) (49933)
Threshold type	**na**	**na**	**na**	**na**
Threshold	**na**	**na**	**na**	**na**
		Grid wells		
ESAC-03	2.76	8.43	–16.37	89
ESAC-05	4.00	6.41	–15.53	98
ESAC-06	2.58	3.92	–17.02	91
ESAC-10	5.28	11.76	–14.19	106
ESAC–11	—	—	–16.57	25
ESAC-12	0.46	4.59	–15.62	62
ESAC-15	—	—	–14.19	95
ESAC-16	1.00	4.38	–17.44	88
ESAC-17	—	—	–14.18	81
ESAC-18	1.39	4.59	–14.84	93
ESAC-19	–0.55	4.55	–15.46	82
ESAC-21	—	—	5.57	11
ESAC-22	3.99	3.52	–18.13	111
ESAC-25	0.01	2.71	–16.03	90
ESAC-26	—	—	–12.79	50
ESAC-27	3.54	9.35	–17.24	93
ESAC-28	2.86	6.38	–15.29	99
ESAC-29	—	—	–15.00	53
ESAC-30	11.21	26.65	–12.86	56
ESAC-31	16.33	24.47	–17.50	82
ESAC-32	6.60	7.46	–19.37	108
ESAC-34	5.64	9.88	–17.47	100
WSAC-03	2.28	4.23	–16.32	103
WSAC-04	—	—	–8.58	34
WSAC-06	3.57	11.54	–16.17	102
WSAC-08	1.02	5.82	–14.29	23
WSAC-10	nc	nc	–14.04	114
WSAC-11	nc	nc	–15.69	66
WSAC-12	—	—	nc	nc
WSAC-14	14.65	25.43	–12.09	40
WSAC-15	3.37	4.53	–15.09	104

Table 13. Nitrogen and oxygen isotopes in nitrate, nitrogen isotopes in nitrogen gas, and carbon-14 activities detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Samples from 42 of the slow and intermediate grid wells (ESAC-35, WSAC-10, and WSAC-11 not analyzed) and the 15 flow-path wells were analyzed for isotopes of nitrate; samples from 43 of the slow and intermediate grid wells (ESAC-35 and WSAC-11 not analyzed) and the 15 flow-path wells were analyzed for carbon-14 activities. Nitrogen and oxygen isotope ratios are reported in the standard delta notation (δ), the ratio of a heavier isotope to more common lighter isotope of that element, relative to a standard reference material. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. The laboratoroy entity codes for the laboratories in the USGS's National Water Information System (NWIS) listed in the footnotes are shown in parentheses following the laboratory name. ESAC, East study area of the middle Sacramento Valley study unit; ESAC-FP, East study area of the middle Sacramento Valley study unit–flow path; na, not available; nc, sample not collected; no., number; WSAC, West study area of the middle Sacramento Valley study unit; WSAC-FP, West study area of the middle Sacramento Valley study unit–flow path; —, nitrate not detected, therefore sample was not analyzed for nitrate isotopes]

GAMA identification no.	δ^{18}O of nitrate[1] (per mil) (63041)	δ^{15}N of nitrate[1] (per mil) (82690)	δ^{13}O of dissolved carbonates[2] (per mil) (82081)	[3]Carbon-14 (percent modern) (49933)
Threshold type	**na**	**na**	**na**	**na**
Threshold	**na**	**na**	**na**	**na**
WSAC-17	5.58	13.78	–15.50	81
WSAC-18	12.82	27.24	–13.10	34
WSAC-21	0.29	1.58	–17.09	88
WSAC-22	0.34	7.46	–15.13	78
WSAC-25	16.81	28.19	–14.14	39
WSAC-26	1.29	2.55	–14.62	74
WSAC-28	0.40	3.67	–13.78	114
WSAC-29	0.06	4.85	–15.03	44
WSAC-30	6.20	10.21	–13.42	84
WSAC-31	–0.20	5.00	–15.56	41
WSAC-34	1.96	5.07	–15.62	114
WSAC-35	2.63	7.86	–14.93	94
WSAC-36	7.25	13.64	–15.42	65
Flow-path wells				
ESAC-FP-01	—	—	–15.25	27
ESAC-FP-02	0.38	8.30	–14.82	100
ESAC-FP-03	11.89	19.89	–17.50	93
ESAC-FP-04	2.17	4.07	–17.45	58
ESAC-FP-05	0.98	5.65	–22.23	100
ESAC-FP-06	—	—	–14.98	9
ESAC-FP-07	—	—	–11.63	5
WSAC-FP-01	0.47	4.18	–13.49	43
WSAC-FP-02	–3.09	2.52	–13.19	23
WSAC-FP-03	0.07	4.49	–17.89	85
WSAC-FP-04	—	—	–14.00	18
WSAC-FP-05	10.56	20.26	–16.50	14
WSAC-FP-06	6.69	9.76	–14.40	15
WSAC-FP-07	—	—	–14.82	15
WSAC-FP-08	3.42	7.43	–15.22	93

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

[2] University of Waterloo (contract laboratory) (CAN-UWIL).

[3] University of Arizona, Accelerator Mass Spectrometry Laboratory (contract laboratory) (AZ-UAMSL).

Table 14. Radioactive constituents detected in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) Program, California, June to September, 2006.

[Samples from the eight slow grid wells were analyzed. The five-digit number in parentheses below the constituent name in the headings is used by the U.S. Geological Survey (USGS) to uniquely identify a specific constituent or property. Analyses by Eberline Analytical Services. The laboratory entity code for Eberline Analytical Services in the USGS's National Water Information System (NWIS) is CA-EBERL. CDPH, California Department of Public Health; E, estimated value; ESAC, East study area of the middle Sacramento Valley study unit; MCL-CA, maximum contaminant level (CDPH); MCL-US, maximum contaminant level (USEPA); no., number; pCi/L, picocuries per liter; USEPA, U.S. Environmental Protection Agency; WSAC, West study area of the middle Sacramento Valley study unit; <, nondetection; L<, nondetection, however, result may be biased low on the basis of matrix-spike results with the potential for a false nondetection; *, value above lower threshold]

GAMA identification no.	Radium-226 (pCi/L) (09511)	Radium-228 (pCi/L) (81366)	Radon-222 (pCi/L) (82303)	Gross alpha radioactivity, 72-hour count (pCi/L) (62636)	Gross alpha radioactivity, 30-day count (pCi/L) (62639)	Gross beta radioactivity, 72-hour count (pCi/L) (62642)	Gross beta radioactivity, 30-day count (pCi/L) (62645)
Threshold type[1]	**MCL-US**[2]	**MCL-US**[2]	**proposed MCL-US**[3]	**MCL-US**	**MCL-US**	**MCL-CA**	**MCL-CA**
Threshold value	**5**	**5**	**300 (4,000)**	**15**	**15**	**50**	**50**
Grid wells							
ESAC-25	E0.02	<0.46	78	<2.2	<2.1	E1.1	E1.6
ESAC-26	E0.03	<0.46	*307	<1.2	<2.5	E1.9	E2.0
ESAC-27	E0.05	<0.51	*972	E1.5	E1.2	E1.6	E1.4
ESAC-28	E0.03	<0.62	*343	E1.1	<2.2	2.7	E3.2
WSAC-03	E0.03	<0.44	*447	E0.6	<3.3	<1.9	<2.8
WSAC-08[4]	E0.03	<0.54	*463	L<2.2	L<2.1	E1.7	<1.7
WSAC-12	0.09	E0.45	*411	<1.7	<2.7	<2.0	E1.0
WSAC-18[4]	E0.05	<0.54	214	L<4.9	L<3.1	E1.2	E1.6

[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 radium-226 and radium-228.

[3] Two MCL-US thresholds have been proposed: 300 pCi/L and 4,000 pCi/L.

[4] Potential to be biased low for gross alpha 72-hour and gross alpha 30-day radioactivity counts because of relatively high concentration of calcium.

Appendix

The appendix discusses methods used to collect and analyze ground-water samples and to report the data for the MSACV study unit. These methods were selected to obtain representative samples of the ground water used for drinking-water supplies in the study and to minimize potential bias of the data. Procedures to analyze and interpret QC data collected as part of the ground-water sampling are also discussed.

Sample Collection and Analysis

Ground-water samples were collected using standard and modified USGS protocols (Koterba and others, 1995), the National Field Manual for the collection of water quality data (U.S. Geological Survey, variously dated) and protocols described by Weiss (1968), Shelton and others (2001), Ball and McClesky (2003a,b), and Wright and others (2005).

Prior to sampling, each well was pumped continuously to purge at least three casing-volumes of water from the well (Wilde and others, 1999). Wells were sampled using Teflon tubing with brass and stainless-steel fittings attached to a sampling point on the well discharge pipe as close to the well as possible. The sampling point was always located upstream of any well-head treatment system or water storage tank. If a chlorinating system was attached to the well, the chlorinator was shut off at least 24 hours prior to purging and sampling the well to clear all chlorine out of the system.

For the *fast* and *intermediate* schedules, samples were collected at the well head using a foot-long length of Teflon tubing. For the *slow* schedule, the samples were collected inside an enclosed chamber located inside a mobile laboratory and connected to the well head by a 10- to 50-ft length of Teflon tubing (Lane and others, 2003).

For intermediate monitoring schedules (flow-path and RICE wells), samples were collected using a portable, 2-in. diameter submersible pump (Grundfos RediFlo2 pump) attached to reels of approximately 300 ft of Teflon tubing. The 10- to 50-ft Teflon tubing used to sample slow schedules was attached to the outflow section of the reels and samples were collected inside an enclosed chamber in a mobile laboratory. Two separate submersible pumps and reels were used to collect samples from monitoring wells in MSACV. All fittings and lengths of tubing were cleaned between samples (Wilde, 2004).

For the field measurements, ground water was pumped through a flow-through chamber fitted with a multiprobe meter that simultaneously measures the water-quality indicators dissolved oxygen, temperature, pH, turbidity, and specific conductance. Field measurements were made in accordance with protocols in the USGS's National Field Manuals (Lewis, 2006; Radtke and others, 2005; Wilde, 2006; Wilde and others, 2006; Wilde and Radtke, 2005). All sensors on the multiprobe meter were calibrated daily. Measurements of temperature, dissolved oxygen, pH, and specific conductance values were recorded at 5-minute intervals for at least 30 minutes, and when these values remained stable for 20 minutes, samples for laboratory analyses were then collected. Field measurements and instrument calibrations were recorded by hand on field record sheets and electronically in PCFF ("Personal Computer Field Forms")-GAMA, a software package designed by the USGS with support from the GAMA program. Analytical service requests were also managed by PCFF-GAMA. Chain of custody documentation forms were completed by hand or electronically. Information from PCFF-GAMA was uploaded directly into NWIS at the end of every week of sample collection.

For analyses requiring filtered water, ground water 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, 2004; Wilde and others, 1999). Prior to sample collection, polyethylene sample bottles were prerinsed twice using dionized water and once with sample water before 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 NWQL.

Temperature-sensitive samples were stored on ice prior to, and during, daily shipping to the various laboratories. The nontemperature-sensitive samples, tritium, noble gases, chromium speciation, and stable isotopes were shipped monthly, whereas VOCs, pesticides and pesticide degradates, constituents of special interest, dissolved organic carbon, radium isotopes, gross alpha and beta radioactivity, and radon-222 samples were shipped daily.

Detailed sampling protocols for individual analyses and groups of analytes are described in Koterba and others (1995) and the USGS's National Field Manuals (Wilde, 2004; Wilde and others, 1999) and in the references for analytical methods listed in table A1; only brief descriptions are given here. VOCs and gasoline oxygenates and degradates, and 1,2,3-TCP samples were collected in 40-mL baked amber glass sample vials that were purged with three vial volumes of sample water before bottom-filling to eliminate atmospheric contamination. Six normal (6 N) hydrochloric acid (HCl) was added as a preservative to the VOC samples, but not to the gasoline oxygenate and degradate samples, or the 1,2,3-TCP samples. Perchlorate samples were collected in 125-mL polyethylene bottles. Tritium samples were collected by bottom-filling two 1-L polyethylene bottles with unfiltered ground water, after first overfilling the bottle with three volumes of water. Stable isotopes of water were collected in 60-mL clear glass bottles filled with unfiltered water, sealed with a conical cap, and secured with electrical tape to prevent leakage and evaporation.

Pesticides and pesticide degradation products, pharmaceutical compounds, and NDMA samples were collected in 1-L baked amber glass bottles. Pesticide and pharmaceutical samples were filtered with a glass-fiber filter during collection, whereas the NDMA samples were filtered at the Montgomery Watson Harza laboratory prior to analysis.

Ground-water samples for major and minor ions, trace elements, alkalinity, and total dissolved solids analyses required filling one 250-mL polyethylene bottle with raw ground water, and one 500-mL and one 250-mL polyethylene bottles with filtered ground water (Wilde, 2004). A Whatman capsule filter was used for filtration. Each 250-mL filtered sample was then preserved with an ampoule of 7.5 N nitric acid. Mercury samples were collected by filtering ground water into a 250-mL glass bottle and preserving with an ampoule of 6 N HCl. Arsenic and iron speciation samples were filtered into 250-mL polyethylene bottles that were covered with tape to prevent light exposure and preserved with 6 N HCl. Nutrient samples were filtered into 125-mL brown polyethylene bottles. Nitrate isotope samples were filtered into 125-mL polyethylene bottles. Radium isotopes and gross alpha and beta radiation samples 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 ground water. These samples had no headspace and were sealed with a conical cap to avoid atmospheric contamination. Samples for alkalinity titrations were collected by filtering ground water into 500-mL polyethylene bottles.

Dissolved organic carbon (DOC), chromium, radon-222, dissolved gases, and microbial constituents were collected from the hose bib at or near the well head, regardless of the sampling schedule (fast, intermediate, or slow). DOC was collected after rinsing the sampling equipment with universal blank water (Wilde, 2004). Using a 50-mL syringe and 0.45-µm disk filter, ground-water samples were filtered into 125-mL baked amber glass bottles and preserved with 4.5 N sulfuric acid. Chromium speciation samples were collected using a 10-mL syringe with an attached 0.45-µm disk filter. After the syringe was thoroughly rinsed and filled with ground water, 4 mL was forced through the disk filter; the next 2 mL of the ground water was then slowly filtered into a small centrifuge vial for analysis of total chromium. Hexavalent chromium, Cr(VI), was then collected by attaching a small cation-exchange column to the syringe filter, and after conditioning the column with 2 mL of sample water, 2 mL was collected in a second centrifuge vial. Both vials were preserved with 10 µL of 7.5 N nitric acid (Ball and McClesky, 2003a,b).

For the collection of radon-222, a stainless steel and Teflon valve assembly was attached to the sampling port at the well head (Wilde, 2004). The valve was partially closed to create back pressure, and a 10-mL sample was taken through a Teflon septum on the value 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 to shield it from light during shipping.

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

Samples for analysis of microbial constituents also were collected at the well head (Bushon, 2003; Myers, 2004). Prior to the collection of samples, the sampling port was sterilized using isopropyl alcohol, and ground water was run through the sampling port for at least three minutes to remove any traces of the sterilizing agent. One sterilized 3-L carboy was filled for coliphage analyses (F-specific and somatic coliphage determinations), and two sterilized 250-mL bottles were filled with ground water for coliform (total coliforms and *Escherichia* coliform) analyses. Total coliforms and *Escherichia* coliform (*E. coli*) plates were prepared using sterilized equipment and reagents (Myers, 2004). Plates were counted under an ultraviolet light, following a 22- to 24-hour incubation time.

Turbidity and alkalinity were measured in the mobile laboratory at the well site. Turbidity was measured in the field with a calibrated turbidity meter. Alkalinity concentrations were measured on filtered samples by Gran's titration method (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 $pK_W = 14$.

Ten laboratories performed chemical and microbial analyses for this study (see table A1), with most of the analyses being performed at NWQL or by laboratories contracted by NWQL. NWQL maintains a rigorous quality-assurance program (Maloney, 2005; Pirkey and Glodt, 1998). Laboratory QC samples, including method blanks, continuing calibration verification standards, standard reference samples, reagent spikes, external certified reference materials, and external blind proficiency samples, are analyzed regularly. Method detection limits are continuously tested and laboratory reporting levels updated accordingly. NWQL maintains National Environmental Laboratory Accreditation Program

(NELAP) and other certifications (http://nwql.usgs.gov/Public/lab_cert.shtml). In addition, the Branch of Quality Systems within the USGS's Office of Water Quality maintains independent oversight of quality assurance at NWQL and laboratories contracted by NWQL. The Branch of Quality Systems also runs a National Field Quality Assurance program that includes annual testing of all USGS field personal for proficiency in making field water-quality measurements (http://bqs.usgs.gov/nfqa/). Results for analyses made at NWQL or by laboratories contracted by NWQL are uploaded directly into NWIS by NWQL.

Data Reporting

Laboratory Reporting Conventions

NWQL uses the LRL as a threshold for reporting analytical results. The LRL is set to minimize the reporting of false negatives (not detecting a compound when it is actually present in a sample) to less than 1 percent (Childress and others, 1999). The LRL is set at two-times the long-term method detection level (LT-MDL). The LT-MDL is derived from the standard deviation of at least 24 MDL determinations made over an extended period of time. LT-MDLs are continually monitored and updated. The method detection limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the concentration is greater than zero (at the MDL, there is less than 1 percent chance of a false positive) (Childress and others, 1999; U.S. Environmental Protection Agency, 2002a). NWQL updates LRL values regularly, and the values listed in this report were in effect during the period analyses were made for ground-water samples from the MSACV study (June to September, 2006).

Detections between the LRL and the LT-MDL are reported as estimated concentrations (designated with an "E" before the value in the tables and text). For information-rich methods, detections below the LT-MDL have high certainty of detection, but the precise concentration is uncertain. Information-rich methods are those that utilize gas chromatography or high-performance liquid chromatography (HPLC) with mass spectrometry detection (VOCs, gasoline oxygenates and degradates, and pesticides and pesticide degradates). For these methods, compounds are identified by presence of characteristic fragmentation patterns in their mass spectra in addition to being quantified by measurement of peak areas at their associated chromatographic retention times. E-coded values also may result from detections outside the range of calibration standards for detections that did not meet all laboratory QC criteria and for samples that were diluted prior to analysis (Childress and others, 1999).

Some compound concentrations in this study are reported using minimum reporting levels (MRLs) 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.

The reporting levels for radiochemical constituents (gross-alpha radioactivity, gross-beta radioactivity, radium-226, and radium-228) are based on a sample-specific minimum detectable concentration (SSMDC), a sample-specific critical value, and the combined standard uncertainty (CSU) (Bennett and others, 2006; U.S. Environmental Protection Agency, 2004). A result above the critical value represents a greater-than-95-percent certainty that the result is greater than zero (significantly different from the instrument's background response to a blank sample), and a result above the SSMDC represents a greater-than-95-percent certainty that the result is greater than the critical value. Using these reporting level elements, three unique cases were possible when screening the raw analytical data, as described in Bennett and others (2006). If the analytical result was less than the critical value (case 1), the analyte was considered not detected, and the concentration was reported as less than the SSMDC. If the analytical result was greater than the critical value, the ratio of the CSU to the analytical result was calculated as a percent (percent relative CSU). For those samples with percent relative CSU greater than 20 percent (case 2), concentrations were reported as estimated values (designated by an "E" preceding the value). For those samples with percent relative CSU less than 20 percent, concentrations were reported unqualified (case 3). For table clarity, only the screened results were reported in table 14; the raw analytical results with their corresponding SSMDCs, critical values, and CSUs, are on file at the USGS California Water Science Center.

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

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

where

^{i}E is the heavier isotope (^{18}C, ^{13}C, or ^{2}H),

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

$R_{reference}$ is the ratio of the abundance of the heavier isotope to the lighter isotope (^{16}O, ^{12}C, or ^{1}H) 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 also written 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 with the ratios observed in the standard reference material.

Constituents on Multiple Analytical Schedules

Eighteen constituents targeted in this study are 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 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 with greater accuracy and precision and lower LRLs for the overlapping constituents is generally preferred. However, the method with higher LRLs may be selected as the preferred method to provide consistency with historical data analyzed by the same method.

Five constituents appear on NWQL Schedules 2020 and 4024, and the preferred method is Schedule 2020 to provide consistency. All samples collected for the GAMA Priority Basin Assessment project are analyzed using Schedule 2020, whereas, only a subset are analyzed using Schedule 4024. Six constituents appear on NWQL Schedules 2032/2033 and 2060, and the preferred method is Schedule 2032/2033 because it has greater precision and accuracy for the six overlapping constituents. For constituents that appear on two NWQL schedules, only the values determined by the preferred method are reported.

The water-quality indicators pH, specific conductance, and alkalinity were measured in the field and at NWQL. The field measurements are the preferred method for all three constituents; however, both are reported because the laboratory alkalinity measurements were made on a greater number of 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 are not normally distributed. The Wilcoxon signed-rank test evaluates the null hypothesis that the median of the paired differences between the two datasets 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 datasets are different.

Specific conductance was measured in both the field and the laboratory for 82 samples, and there was no statistical significance between the two datasets (P = 0.1035). Both laboratory and field pH measurements were made for 80 samples, and the two datasets were systematically different (P = <0.0001). Field pH values were lower by a median of 0.3 pH units. The increase in pH between field and laboratory measurement may be explained by equilibration of the sample with the atmosphere after collection. The partial pressure of CO_2 in ground water is often greater than the atmospheric partial pressure (Appelo and Postma, 2005); thus, CO_2 degasses from the ground water when it is brought in contact with the atmosphere. CO_2 loss results in increased pH. Field and laboratory alkalinities were measured for seven samples, and the two datasets were significantly different (P = 0.0156). Field alkalinity values were lower by a median of 11 mg/L as $CaCO_3$. The differences between the field and laboratory values were greater than 5 percent for all but two samples.

For arsenic, chromium, and iron concentrations, the standard methods used by NWQL are preferred over the research methods used by the USGS National Research Program (NRP) Trace Metal Laboratory (TML) in Boulder, Colorado. The concentrations measured by TML are used only to

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

$$\frac{Fe(III)}{Fe(II)} = \frac{Fe(T) - Fe(II)}{Fe(II)}, \tag{2}$$

where

Fe(T) is the total iron concentration (measured),

Fe(II) is the concentration of ferrous iron (measured), and

Fe(III) is the concentration of ferric iron (calculated).

Quality Assurance

The purpose of quality-assurance is to identify which data best represent environmental conditions and which may have been affected by contamination or bias during sample collection, processing, storage, transportation, or laboratory analysis. Four types of QC tests were used in this study: blank samples were collected to assess contamination; 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 the tables of this report, detections of organic constituents in ground-water samples that may have resulted from contamination were flagged with a “V” remark code, and were not considered detections for calculations of detection frequencies in water-quality assessments. Detections of inorganic constituents in ground-water samples that may have resulted from contamination were flagged with a "V" remark code to indicate that the amount of potential contamination may have been sufficient to change a nondetection into a detection relative to the stated reporting level.

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

Blanks

Blank samples (blanks) were collected using two types of water certified by NWQL to contain less than the LRL or MRL of the analytes investigated in the study. First, inorganic blank water (IBW) was used to collect sample blanks of perchlorate, major ions and trace elements, nutrients, arsenic and iron speciation, and chromium speciation. All other blanks were collected using VOC-free (nitrogen-purged) blank water (VBW). Two types of blanks were collected: source-solution and field blanks. Source-solution blanks were collected to verify that the blank water used for the field blanks was free of analytes. Field and source solution blanks were collected at approximately 10 percent of the wells sampled to determine if equipment or procedures used in the field or laboratory introduced contamination. Field blanks were analyzed for VOCs, gasoline oxygenates and their degradates, pesticides and pesticide degradates, pharmaceuticals, perchlorate, NDMA, 1,2,3-TCP, nutrients, DOC, major and minor ions, trace elements, iron, arsenic, and chromium speciation, and radioactive constituents (table A3). NWQL-certified blank water is not available for tritium or noble gases; thus, source solution and field blanks were not collected for these constituents.

Field blanks were collected by pumping or pouring blank water through the sampling equipment (fittings and tubing) used to collect ground water, then processing and transporting the blank samples using the same protocols for the ground-water samples. The equipment used to collect samples from monitoring wells was significantly different than that used to collect samples from production wells; thus, the field blanks were separated into monitoring well and production well groups for comparison with ground-water data. 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 ground-water samples. Source-solution blanks were not divided into two classes because they were not collected using the field sampling equipment.

If a constituent was detected in field or source-solution blanks, the data for that constituent in ground-water samples were examined for potential contamination. Detections in ground-water samples with concentrations less than the highest concentration measured in a blank plus the LT-MDL were marked with a "V" in the data tables (LRL equals twice the LT-MDL). The highest concentration measured in a blank was assumed to represent the highest potential amount of contamination. Thus, the V remark code flags results that could have changed from a nondetection to a detection relative to the LT-MDL because of contamination. For example, if the LT-MDL for a constituent is 0.10 µg/L, the measured concentration in a ground-water sample with a true concentration of 0.05 µg/L would be reported as a nondetection. But, if the ground-water sample was contaminated with 0.20 µg/L of the constituent, the measured concentration would be reported as 0.25 µg/L, a detection. If the maximum potential amount of contamination is 0.20 µg/L, then ground-water samples with measured concentrations less than 0.30 µg/L may actually have true concentrations less than the LT-MDL.

For organic constituents, results with V codes are not considered to be detections of the constituent when calculating detection frequencies for ground-water quality assessments. For inorganic constituents, results with V codes are considered to have concentrations less than the reported value (including the possibility of the concentration being less than the LT-MDL).

Replicates

Sequential replicate samples were collected to assess variability that may result from the processing and analyses of inorganic and organic constituents. RSD of the measured values was used to express the variability between replicate pairs for each compound (table A4). The RSD is defined as the standard deviation divided by the mean concentration for each replicate pair of samples, multiplied by 100 percent. If one value in a sample pair was reported as a nondetection and the other value was reported as an estimated value below the LRL or MRL, the RSD was set to zero because the values are analytically identical. If one value in a sample pair was reported as a nondetection and the other value was greater than the LRL or MRL, then the nondetection value was set equal to one-quarter of the LRL, and the RSD was calculated (Hamlin and others, 2002). Values of RSD less than 20 percent are considered acceptable in this study. An RSD value of 20 percent corresponds to a relative percent difference (RPD) value of 29 percent. High RSD values for a compound may indicate analytical uncertainty at low concentrations, particularly for concentrations within an order of magnitude of LT-MDL or MDL. Sequential replicate samples were collected at approximately 10 percent of the wells sampled.

Matrix Spikes

Addition of a known concentration of a constituent (“spike”) to a replicate environmental sample enables the laboratory to determine the effect of the matrix, in this case ground water, on the analytical technique used to measure the constituent. The compounds added as 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 performing the analysis. Compounds with low recoveries are of particular concern if environmental concentrations are close to the MCLs; a concentration below an MCL could be above this threshold. Conversely, compounds with high recoveries are of potential concern if the environmental concentrations exceed MCLs; a high recovery could falsely indicate a concentration above the MCL.

Acceptable ranges for matrix-spike recoveries are based on the acceptable ranges established for laboratory “set” spike recoveries. Laboratory set spikes are aliquots of laboratory blank water to which the same spike solution used for the matrix spikes has been added. One set spike is analyzed with each set of samples. Acceptable ranges for set spike recoveries are 70 to 130 percent for NWQL Schedules 2020 and 4024 (VOCs and gasoline additives; Connor and others, 1998; Rose and Sandstrom, 2003; Zaugg and others, 2002), 60 to 120 percent for NWQL Schedules 2032, 2033, and 2060 (pesticides; Sandstrom and others, 2001), and 60 to 130 percent for Schedule 2080 (pharmaceuticals; Kolpin and others, 2002). On the basis of these ranges, we defined 70 to 130 percent as the acceptable range for matrix-spike recoveries for organic compounds in this study.

Laboratory matrix spikes were performed for VOCs, gasoline oxygenate and their degradates, pesticide compounds, pharmaceutical compounds, NDMA, and 1,2,3-TCP because the analytical methods for these constituents are chromatographic methods that may be susceptible to matrix interferences. Replicate samples for matrix-spike additions were collected at approximately 10 percent of the wells sampled, although not all analyte classes were tested for every well (tables A5A–D).

Surrogates

Surrogate compounds are added to environmental samples in the laboratory prior to analysis to evaluate the recovery of similar constituents. Surrogate compounds were added to all ground-water and QC samples that were analyzed for VOCs, gasoline oxygenates and their degradates, pesticide compounds, NDMA, and 1,2,3-TCP (table A6). Most of the surrogate compounds are deuterated analogs of compounds being analyzed. For example, the surrogate toluene-*d*8 used in 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. Only 0.015 percent of hydrogen atoms are deuterium (Firestone and others, 1996); thus, deuterated compounds like toluene-*d*8 do not occur naturally and are not found in environmental samples. Surrogates are used to identify general problems that may arise during sample analysis that could affect the analysis results for all compounds in that sample. Potential problems include matrix interferences (such as high levels of dissolved organic carbon) that produce a positive bias, or incomplete laboratory recovery (possibly attributed to 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 analysis of samples (Connor and others, 1998; Sandstrom and others, 2001).

Quality-Control Sample Results

Detections in Field and Source-Solution Blanks

Field blanks were collected at approximately 10 percent of the sites sampled in MSACV. Table A3 presents a summary of compound detections in field blanks. Field blank results were grouped according to sampling methods (see “Sample Collection and Analysis” section) and analyzed to determine how field blank detections affected environmental data.

Seven source-solution blanks, seven field blanks at production wells, and five field blanks at monitoring wells were collected for analysis of VOCs. Eleven VOC constituents were detected in field blanks collected at production wells or in source-solution blanks (table A3). Only 2 of these 11 VOCs—chloroform and 1,2,4-trimethylbenzene—were detected in ground-water samples collected at production wells. Chloroform was detected in one field blank at a concentration of E0.04 µg/L. Three detections in ground-water samples with concentrations less than 0.05 µg/L (E0.04 µg/L plus one-half of the LRL of 0.02 µg/L) were flagged with a V code (table 5). 1,2,4-trimethlybenzene was detected in one source-solution blank at a concentration of E0.04 µg/L. Four detections in production well samples with concentrations less than 0.07 µg/L (E0.04 µg/L plus one-half the LRL of 0.056 µg/L) were flagged with a V code (table 5). The V-coded results were counted as nondetections for calculation of the detection frequency of chloroform and 1,2,4-trimethylbenzene in the grid wells.

Three VOC constituents were detected in field blanks collected at monitoring wells or in source-solution blanks (table A3), and all three were detected in ground-water samples collected at monitoring wells. 1,2,4-trimethlybenzene was detected in one source-solution blank and one field blank with a maximum concentration of E0.04 µg/L. A single detection in a ground-water sample with a concentration less than 0.07 µg/L (E0.04 µg/L plus one-half the LRL of 0.056 µg/L) was flagged with a V code (table 5). *m-* and *p-Xylene* was detected was detected in two fields with a maximum concentration of E0.07 µg/L. *m-* and *p-Xylene* was detected in one ground-water sample collected from a monitoring well. The concentration of *m- and p-Xylene* detected in the sample was less than 0.10 µg/L (0.07 µg/L plus one-half the LRL of 0.06 µg/L) and was, therefore, flagged with a V code. Toluene was detected in three source solution blanks and three field blanks with a maximum concentration of E0.07 µg/L. Low levels of toluene were detected in source-solution and field blanks in many of the earlier GAMA study units (Bennett and others, 2006; Dawson and others, 2008; Fram and Belitz, 2007; Kulongoski and Belitz, 2007; Kulongoski and others, 2006; Wright and others, 2005). Toluene was detected in one ground-water sample collected from a monitoring well. The concentration of toluene detected in the sample was less than 0.08 µg/L (0.07 µg/L plus one-half the LRL of 0.02 µg/L), and was, therefore, flagged with a V code. Seven field blanks were collected at production wells and four field blanks were collected at monitoring wells for analysis of pesticides and pesticide degradates. Three pesticide compounds were detected in one field blank collected at a production well (table A3), and one of these compounds, bromacil, was detected in ground-water samples collected from production wells. The concentration of bromacil detected in the field blank was E0.11 µg/L. All three detections of bromacil in ground-water samples were less than 0.012 µg/L (0.11 µg/L plus one-half the LRL of 0.018 µg/L), and were, therefore, flagged with a V code (table 6). The V-coded results were counted as nondetections for calculation of the detection frequency of bromacil in the grid wells.

Constituents of special interest (perchlorate, 1,2,3-TCP, and NDMA) and radioactive constituents (radium isotopes and gross alpha and beta radiation) were not detected in any source-solution or field blanks. One field blank was collected at a production well for analysis of radium isotopes and gross alpha and beta radiation. Eleven source-solution blanks, seven field blanks at production wells, and four field blanks at monitoring wells were collected for analysis of perchlorate. Six source solution-blanks, five field blanks at production wells, and one field blank at a monitoring well were collected for analysis of 1,2,3-TCP and NDMA.

DOC was analyzed in one field blank collected at a production well and three field blanks collected at monitoring wells. DOC was detected in all three field blanks collected at monitoring wells, with a maximum concentration of 0.7 mg/L. Six ground-water samples collected at monitoring wells had detections of DOC at concentrations less than 0.9 mg/L (0.7 mg/L plus one-half the LRL of 0.33 mg/L). These six samples were flagged with V codes (table 8), indicating that the concentration of DOC in the samples may be as high as the reported value, but may also be as low as a nondetection relative to the stated detection limit (one-half the LRL).

Nutrients were analyzed in five field blanks collected at production wells and four field blanks collected at monitoring wells. Nitrate and nitrite were not detected in any of the field blanks. Orthophosphate was detected at a concentration of E0.003 mg/L in one field blank collected at a production well, and in two field blanks collected at monitoring wells. One production well sample had an orthophosphate concentration less than 0.006 mg/L (0.003 plus one-half the LRL of 0.006 µg/L); this result was flagged with a V code. Ammonia was detected in two field blanks collected at monitoring wells, with a maximum concentration of E0.007 mg/L. Seventeen ground-water samples collected from monitoring wells had ammonia concentrations less than 0.012 mg/L (E0.007 mg/L plus one-half the LRL of 0.01 mg/L). These results were flagged with V codes, indicating that the ammonia concentration in the samples could be as high as the reported value if no contamination had occurred, but also be as low as a nondetection relative to the LT-MDL of 0.005 mg/L if the maximum potential amount of contamination (0.003 mg/L) had occurred. Total nitrogen was detected in three field blanks collected at production wells, with a maximum concentration of 0.26 mg/L, and in two field blanks collected at monitoring wells with a maximum concentration of 0.45 mg/L. The LRL for total nitrogen is 0.06 mg/L; thus, the threshold concentration for flagging results with V codes was 0.29 mg/L for ground-water samples collected at production wells and 0.48 mg/L for ground-water sampled collected at monitoring wells. Total nitrogen results for the 10 ground-water samples collected from production wells and the 14 collected from monitoring wells with concentrations less than these threshold concentrations were flagged with V codes.

Major ions were analyzed in five field blanks collected at production wells and four collected at monitoring wells. Calcium, chloride, magnesium, and silica were each detected in at least one field blank (table A3). However, for all four ions, the maximum concentration detected in the field blanks plus one-half the LRL was less than the minimum concentrations detected in ground-water samples. Therefore, no data were flagged with V codes.

Trace elements were analyzed in five field blanks collected at production wells and in five field blanks collected at monitoring wells. Maximum concentrations for the three trace elements detected in field blanks collected at production wells were: chromium, 0.04 µg/L; nickel, 0.05 µg/L; and zinc, 1.0 µg/L (table A3). The threshold concentration for flagging results with V codes in table 10 was the maximum concentration of the constituent detected in a field blank plus one-half the LRL for that constituent. Nine detections of chromium with concentrations less than 0.06 µg/L, 10 detections of nickel with concentrations less than 0.08 µg/L, and 16 detections of zinc with concentrations less than 1.3 µg/L in ground-water samples collected from production wells were flagged with V codes, indicating that the concentration in the ground-water sample may be as high as the reported concentration, but also may be as low as a nondetection. In all cases, the results flagged with V codes had concentrations far below health-based or other drinking-water quality thresholds (the MCL-CA for chromium is 50 µg/L; the MCL-CA for nickel is 100 µg/L; and the SMCL-CA for zinc is 5,000 µg/L).

Maximum concentrations for the 11 trace elements detected in at least one field blank collected at a monitoring well were: aluminum, E1 µg/L; barium, E0.9 µg/L; chromium, 0.10 µg/L; copper, 1.80 µg/L; iron, 8 µg/L; manganese, 0.7 µg/L; nickel, 0.20 µg/L; strontium, 0.55 µg/L; tungsten, E0.04 µg/L; vanadium, E0.08 µg/L; and zinc, 2.4 µg/L (table A3). The threshold concentration for flagging results with V codes in table 10 was the maximum concentration of the constituent detected in a field blank plus one-half the LRL for that constituent. Sixteen detections of aluminum, 6 detections of chromium, 18 detections of copper, 7 detections of iron, 5 detections of manganese, 2 detections of nickel, 2 detections of tungsten, and 23 detections of zinc in ground-water samples collected from monitoring wells were flagged with V codes, indicating that the concentration in the ground-water sample may be as high as the reported concentration, but also may be as low as a nondetection. In all cases, the results flagged with V codes had concentrations far below health-based or other drinking-water quality thresholds (table 10). No detections of barium, strontium, or vanadium were flagged with V codes because the maximum concentration detected in the field blanks plus one-half the LRL was less than the minimum concentration detected in ground-water samples.

Arsenic and iron were detected in field blank samples analyzed by the NRP (table A3). Arsenic was detected in two of five field blanks collected at production wells and in two of five field blanks collected at monitoring wells. The maximum concentration of arsenic detected in a field blank analyzed by the NRP laboratory was 4.5 µg/L. Arsenic was not detected in any field blank samples analyzed by NWQL; therefore, the arsenic detected in field blanks analyzed at the NRP laboratory were considered to have originated in the laboratory. Because the arsenic contamination was not related to sampling equipment, there was no basis for assessing NRP arsenic data differently for the two different types of sampling equipment. Because the arsenic concentration data from NWQL Schedule 1948 are preferred over the concentration data from the NRP laboratory, comparisons between the two sets of data were used in conjunction with the detections in the field blanks analyzed at the NRP laboratory to assess the NRP arsenic data. Arsenic concentrations from the NRP were greater than those from NWQL for 27 of the 82 ground-water samples analyzed, and for 19 of the 27, the difference was greater than 20 percent RSD, the criteria for acceptable replicate pairs. The NRP arsenic concentrations were up to 3.5 µg/L greater than the NWQL arsenic concentration in these 19 ground-water samples, a difference that is comparable to the maximum concentration of arsenic detected in the field blanks. Arsenic results from the NRP laboratory for these 19 ground-water samples were flagged with V codes (table 11) to indicate that disagreement between the NWQL and NRP arsenic concentrations may be due to contamination of ground-water samples analyzed at the NRP laboratory. The ratio of arsenic species, $\frac{\mathrm{As(V)}}{\mathrm{As(III)}}$, for these 19 samples may not be representative of the redox conditions in the ground water.

Iron was detected in 2 of 10 field blanks analyzed by the NRP laboratory, with a maximum concentration of 15 µg/L. For eight ground-water samples with iron concentrations greater than 6 µg/L (the NWQL LRL for iron), iron concentrations measured by the NRP laboratory were higher than those measured by NWQL. However, all eight pairs differed by less than 10 percent RSD; thus, none of the NRP iron results were flagged with V codes.

Variability in Replicate Samples

Most of the replicate sample pairs collected during the MSACV study had relative standard deviations (RSDs) of less than 20 percent (table A4). Replicate sample pairs for analytes not detected in any ground-water samples are not reported in table A4. Thirty replicate sample pairs, representing 20 chemical constituents, had RSDs greater than 20 percent; see table A4 for details. However, the replicate sample pairs with high RSDs had very low concentrations. At low concentrations, small deviations in measured values account for large RSDs. Because the variability in measurements occurred at low concentrations, well below regulatory thresholds, this variability was not of QC concern, and no detections were censored as a result of variability in replicate samples.

Matrix Spike Recoveries

Tables A5A–D present a summary of matrix-spike recoveries for the MSACV study. The addition of a spike or known concentration of a constituent to an environmental sample enables the laboratory to determine the effect of the matrix, in this case ground water, on the analytical technique used to measure the constituent. Thirteen environmental samples were spiked with VOCs to calculate matrix-spike recoveries (table A5A). Seventy-one of the 85 VOCs had matrix-spike recoveries in the acceptable range between 70 and 130 percent. Eleven VOCs had at least one-matrix spike recovery greater than 130 percent; however, of these compounds, 6 were not detected in ground-water samples. Seven VOCs had a recoveries below 70 percent; however, of these compounds, 4 were not detected in ground-water samples. The three VOCs that had recoveries less than 70 percent and were detected in ground water included carbon disulfide, 1,2,3,4-tetramethylbenzene, and 1,2,3,5-tetramethylbenzene, with recoveries of 67, 69, and 62 percent, respectively. The four VOCs that had recoveries less than 70 percent, but were not detected in ground water included dichloromethane, 2,2-dichloropropane, styrene, and 1,2,3-trichlorobenzene, with recoveries of 28, 62, 69, and 56 percent, respectively (NOTE: low recoveries may indicate that these compounds may not have been detected if they were present at very low levels).

Twelve environmental samples were spiked with pesticide and pesticide degradate compounds to calculate matrix-spike recoveries, although the number of spiked samples varied depending on laboratory procedures (table A5B). Forty-one of the 136 spike compounds had recoveries in the acceptable range between 70 and 130 percent. Eighteen of the compounds detected in ground-water samples had spike recoveries that exceeded the acceptable range. Twenty-three spike compounds had at least one recovery greater than 130 percent. Ninety-one spike compounds had at least one recovery below 70 percent, with recovery of phosmet being particularly poor. (NOTE: low recoveries may indicate that the compound might not have been detected in some samples if it was present at a very low concentration).

One, 7, and 5 ground-water samples were spiked with perchlorate, 1,2,3-TCP, and NDMA, respectively (table A5C). All spike recoveries were within the acceptable range of 70 to 130 percent.

Two ground-water samples were spiked with radium-226 and radium-228 (table A5D). All spike recoveries were within the acceptable range of 70 to 130 percent with the exception of gross alpha 72-hour and gross alpha 30-day counts for one of the samples. The spiked sample (WSAC-08) that had poor recovery of alpha radioactivity had relatively high concentration of calcium (table 9). Because calcium is known to interfere with alpha counts (Sinojmeri, 1999), this sample and WSAC-18, which had similar major-ion chemistry, were coded as having the potential to be biased low for gross alpha 72-hour and gross alpha 30-day counts.

Surrogate Compound Recoveries

Surrogate compounds were added to environmental samples in the laboratory and analyzed to evaluate the recovery of similar constituents. Table A6 lists each surrogate, the analytical schedule on which it was applied, the number of analyses for blank and nonblank samples, the number of surrogate recoveries below 70 percent, and the number of surrogate recoveries above 130 percent for the blanks and environmental samples. Blanks and environmental samples were considered separately to assess whether the matrices present in ground water affect surrogate recoveries. No systematic differences between surrogate recoveries in blanks and environmental samples were observed. Ninety-one percent of the surrogate recoveries in analyses of VOC and gasoline oxygenate and degradates were in the acceptable range of 70 to 130 percent recovery, as were 96 percent of the surrogate recoveries for pesticides and pesticide degradates, and 89 percent for NDMA and 1,2,3-TCP analyses.

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

[MI agar, supplemented nutrient agar in which coliforms (total and *Escherichia*) produce distinctly different fluorescence under ultraviolet lighting; RSIL, Reston Stable Isotope Laboratory (USGS); UV, ultraviolet; VOCs, volatile organic compounds]

Analyte	Analytical Method	Laboratory and analytical schedule or lab code	Citation(s)
Organic constituents			
VOCs	Purge and trap capillary gas chromatography/mass spectrometry	NWQL, Schedule 2020	Connor and others, 1998
Gasoline oxygenates	Heated purge and trap/gas chromatography/mass spectrometry	NWQL, Schedule 4024	Rose and Sandstrom, 2003
Pesticides	Solid-phase extraction and gas chromatography/mass spectrometry	NWQL, Schedules 2032, 2033, and 2060	Furlong and others, 2001; Lindley and others, 1996; Madsen and others, 2003; Sandstrom and others, 2001; Zaugg and others, 1995
Pharmaceuticals	Solid-phase extraction and HPLC/mass spectrometry	NWQL, Schedule 2080	Kolpin and others, 2002
Constituents of special interest			
Perchlorate	Chromatography and mass spectrometry	Montgomery Watson Harza laboratory[1]	Hautman and others, 1999
N-nitrosodimethylamine (NDMA)	Chromatography and mass spectrometry	Montgomery Watson Harza laboratory[1]	U.S. Environmental Protection Agency, 1996; U.S. Environmental Protection Agency, 1999b
1,2,3-Trichloropropane	Gas chromatography/electron capture detector	Montgomery Watson Harza laboratory[1]	U.S. Environmental Protection Agency, 1995
Inorganic constituents			
Nutrients	Alkaline persulfate digestion, Kjedahl digestion	NWQL, Schedule 2755	Fishman, 1993; Patton and Kryskalla, 2003
Dissolved organic carbon	UV-promoted persulfate oxidation and infrared spectrometry	NWQL, Lab Code 2613	Brenton and Arnett, 1993
Major and minor ions, trace elements and nutrients	Atomic absorption spectrometry, colorimetry, ion-exchange chromatography, inductively-coupled plasma atomic-emission spectrometry and mass spectrometry	NWQL, Schedule 1948	American Public Health Association, 1998; Faires, 1993; Fishman, 1993; Fishman and Friedman, 1989; Garbarino, 1999; Garbarino and Damrau, 2001; Garbarino and others, 2006; McLain, 1993
Chromium, arsenic and iron speciation	Various techniques of ultraviolet visible (UV-VIS) spectrophotometry and atomic-absorbance spectroscopy	USGS Trace Metal Laboratory, Boulder, Colorado[1]	Ball and McCleskey, 2003a,b; McCleskey and others, 2003; Stookey, 1970; To and others, 1998
Stable isotopes			
Stable isotopes of water	Gaseous hydrogen and carbon dioxide-water equilibration and stable-isotope mass spectrometry	USGS Stable Isotope Laboratory, Reston, Virginia, Schedule 1142	Coplen, 1994; Coplen and others, 1991; Epstein and Mayeda, 1953
Nitrogen and oxygen isotopes of nitrate	Denitrifier method and mass spectrometry	USGS Stable Isotope Laboratory, Reston, Virginia, RSIL Lab Code 2900	Révész, K., and Casciotti, K., 2007
Carbon isotopes	Accelerator mass spectrometry	University of Waterloo, Environmental Isotope Lab[1]; University of Arizona Accelerator Mass Spectrometry Lab[1]	Donahue and others, 1990; Jull and others, 2004

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

[MI agar, supplemented nutrient agar in which coliforms (total and *Escherichia*) produce distinctly different fluorescence under ultraviolet lighting; RSIL, Reston Stable Isotope Laboratory (USGS); UV, ultraviolet; VOCs, volatile organic compounds]

Analyte	Analytical Method	Laboratory and analytical schedule or lab code	Citation(s)
		Radioactivity and gases	
Tritium	Electrolytic enrichment-liquid scintillation	USGS Stable Isotope and Tritium Laboratory, Menlo Park, California, Lab Code 1565	Thatcher and others, 1977
Tritium and noble gases	Helium-3 in-growth and mass spectrometry	Lawrence Livermore National Laboratory[1]	Eaton and others, 2004; Moran and others, 2002
Radon-222	Liquid scintillation counting	NWQL, Schedule 1369	American Society for Testing and Materials, 1998; U.S. Environmental Protection Agency, 1999a
Radium 226/228	Alpha activity counting	Eberline Analytical Services, NWQL method 1262	U.S. Environmental Protection Agency, 1980 (USEPA methods 903 and 904)
Gross alpha and beta radioactivity	Alpha and beta activity counting	Eberline Analytical Services, NWQL method 1792	U.S. Environmental Protection Agency, 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[1]	U.S. Environmental Protection Agency, 2001
Total and *Escherichia* coliform	Membrane filter technique with "MI agar"	USGS field measurement	U.S. Environmental Protection Agency, 2002b

[1] The analytes have no schedule or lab code assigned to them.

Table A2. Preferred analytical schedules/methods for constituents appearing on multiple schedules/methods for samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September 2006.

[Preferred analytical schedules are the methods of analysis with the greatest accuracy and precision out of the ones used for the compound in question. MWH, Montgomery Watson Harza laboratory; TML, U.S. Geological Survey's (USGS) Trace Metal Laboratory in Boulder, Colorado; VOC, volatile organic compound]

Constituent	Primary constituent classification	Analytical schedules/method	Preferred analytical schedule/method
Results from preferred method reported			
Acetone	VOC, gasoline degradate	2020, 4024	2020
Diisopropyl ether	VOC, gasoline degradate	2020, 4024	2020
Ethyl *tert*-Butyl ether (ETBE)	VOC, gasoline degradate	2020, 4024	2020
Methyl *tert*-butyl ether (MTBE)	VOC, gasoline degradate	2020, 4024	2020
Methyl *tert*-pentyl ether	VOC, gasoline degradate	2020, 4024	2020
Atrazine	Pesticide	2032/2033, 2060	2032/2033
Carbaryl	Insecticide	2032/2033, 2060	2032/2033
Carbofuran	Herbicide	2032/2033, 2060	2032/2033
Deethlyatrazine	Pesticide degradate	2032/2033, 2060	2032/2033
Metalaxyl	Fungicide	2032/2033, 2060	2032/2033
Tebuthiuron	Pesticide	2032/2033, 2060	2032/2033
Results from both methods reported			
Alkalinity	Water-quality indicator	1948, field	field
Arsenic(Total)	Trace element	1948, TML[1]	1948
Chromium(Total)	Trace element	1948, TML[1]	1948
Iron(Total)	Trace element	1948, TML[1]	1948
pH	Water-quality indicator	1948, field	field
Specific conductance	Water-quality indicator	1948, field	field
1,2,3-Trichloropropane (1,2,3-TCP)	VOC	2020, MWH[1]	MWH[1]

[1] In the USGS's National Water Information System (NWIS), the laboratory entity code for TML is USGSTMCO and for MWH is CA-MWHL.

Table A3. Constituents detected in field blanks collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[E, estimated value; mg/L, milligrams per liter; µg/L, micrograms per liter; —, not detected]

Constituent	Source-solution blanks		Field blanks at production wells		Field blanks at monitoring wells		Number of ground-water data affected
	Number of detections/ analyses	Detected concentrations	Number of detections/ analyses	Detected concentrations	Number of detections/ analyses	Detected concentrations	
Volatile organic compounds (µg/L)							
Acetone	0/7	—	3/7	E3, 6, 11	0/5	—	0
Benzene	0/7	—	1/7	E0.01	0/5	—	0
Dichloromethane	0/7	—	1/7	E0.1	0/5	—	0
2-Butanone (MEK, Methyl ethyl ketone)	0/7	—	2/7	E1.4, 5.9	0/5	—	0
Ethylbenzene	0/7	—	2/7	E0.01, E0.02	0/5	—	0
1,2,4-Trimethylbenzene	1/7	E0.04	0/7	—	1/5	E0.02	6
m- and *p*-Xylene	0/7	—	3/7	E0.04, E0.06, E0.06	2/5	E0.03, E0.07	1
o-Xylene	0/7	—	1/7	E0.03	0/5	—	0
Styrene	0/7	—	3/7	E0.01, E0.02, E0.02	0/5	—	0
Toluene	3/7	E0.01, E0.01, E0.02	3/7	E0.08, 0.10, 0.16	3/5	E0.02, E0.02, E0.07	1
Chloroform	0/7	—	1/7	E0.04	0/5	—	3
Pesticide and pesticide degradates (µg/L)							
Bromacil			1/7	E0.11	0/4	—	3
2,4-D and 2,4-D methyl ester			1/7	0.28	0/4	—	0
Diuron			1/7	0.03	0/4	—	0
Nutrients and dissolved organic carbon (DOC) (mg/L)							
Ammonia (as nitrogen)			0/5	—	2/4	E0.006, E0.007	17
Dissolved organic carbon (DOC)			0/1	—	3/3	E0.2, E0.7, 0.7	6
Orthophosphate (as phosphorus)			1/5	E0.003	2/4	E0.003, E0.003	1
Total nitrogen			3/5	E0.04, E0.04, 0.26	2/4	E0.04, 0.45	24
Major and minor ions (mg/L)							
Calcium			0/5	—	2/4	E0.01, 0.08	0
Chloride			0/5	—	1/4	E0.13	0
Magnesium			1/5	E0.005	2/4	E0.004, 0.039	0
Silica			0/5	—	1/4	E0.03	0
Trace elements (µg/L)							
Aluminum			0/5	—	2/5	E0.9, E1	16
Barium			0/5	—	2/5	E0.8, E0.9	0
Chromium			4/5	E0.03, E0.03, 0.04, 0.04	4/5	0.04, 0.05, 0.08, 0.10	15
Copper			0/5	—	2/5	0.73, 1.80	18
Iron			0/5	—	1/4	8	7
Manganese			0/5	—	1/5	0.7	5
Nickel			1/5	E0.05	4/5	0.08, 0.16, 0.17, 0.20	12
Strontium			0/5	—	2/5	E0.23, 0.55	0
Tungsten			0/5	—	2/2	E0.03, E0.04	2
Vanadium			0/5	—	2/5	E0.08, E0.08	0
Zinc			2/5	E0.3, 1.0	3/5	1.2, 1.6, 2.4	39
Trace element species (µg/L)							
Inorganic arsenic(Total)			2/5	3.3, 4.5	2/5	0.6, 0.7	19
Iron(Total)			1/5	3	1/5	15	0

Table A4. Quality-control summary of replicate samples for constituents collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[The laboratory entity codes for the laboratories in the U.S. Geological Survey's (USGS) National Water Infomation System (NWIS) listed in the footnotes are shown in parentheses following the laboratory name. E, estimated value; mg/L, milligrams per liter; pCi/L, picocuries per liter; RSD, relative standard deviation; TU, tritium unit; µg/L, micrograms per liter; <, less than; —, no value]

Constituent	Number of RSDs greater than 20 percent/number of replicates	Maximum RSD (percent)	Median RSD (percent)	Concentrations for replicates with RSDs greater than zero (environmental, replicate)
Volatile organic compounds, gasoline oxygenates and additives from Schedules 2020 and 4024				
1,2,4-Trimethylbenzene (µg/L)	2/15	40.4	23.6	(E0.07, E0.05), (0.10, 0.18)
Toluene (µg/L)	1/15	47.1	47.1	(E0.02, E0.01)
Chloroform (Trichloromethane) (µg/L)	2/15	28.3	16.5	(E0.08, E0.06), (E0.02, E0.03)
All other VOCs from Schedules 2020 and 4024	0/15	< 20	—	—
Pesticides and pesticide degradates from Schedules 2032, 2033, and 2060				
All pesticides and pesticide degradates from Schedule 2032	0/12	< 20	—	—
All pesticides and pesticide degradates from Schedule 2033	0/2	< 20	—	—
All pesticides and pesticide degradates from Schedule 2060	0/13	< 20	—	—
Pharmaceuticals				
All pharmaceuticals from Schedule 2080	0/9	< 20	—	—
Constituents of special interest[1]				
Perchlorate	0/15	< 20	—	—
1,2,3-Trichloropropane (1,2,3-TCP)	0/7	< 20	—	—
N-Nitrosodimethylamine (NDMA)	0/5	< 20	—	—
Major ions, minor ions, trace elements, and nutrients				
Ammonia (mg/L)	1/11	23.6	23.6	(E0.005, E0.007)
Dissolved organic carbon (DOC) (mg/L)	1/5	26.2	5.2	(1.6, 1.1)
Bromide (mg/L)	2/10	122.6	1.3	(0.03, E0.02), (0.07, 0.005)
Aluminum (µg/L)	1/6	47.1	47.1	(2, E1)
Cadmium (µg/L)	1/8	47.1	47.1	(0.04, E0.02)
Cobalt (µg/L)	4/8	101	18.0	(0.01, 0.06), (0.07, E0.03), (0.06, E0.02), (E0.03, 0.04)
Copper (µg/L)	1/8	32.9	3.4	(E0.28, 0.45)
Iron (µg/L)	2/10	47.1	3.3	(E3, 6), (6, E3)
Lead (µg/L)	1/8	97.9	2.9	(0.10, 0.08)
Nickel (µg/L)	1/8	60.6	1.8	(1.10, 0.44)
Selenium (µg/L)	1/8	20.2	20.2	(0.08, E0.06)
Tungsten (µg/L)	1/8	28.3	28.3	(0.09, 0.06)
Zinc (µg/L)	1/8	41.9	2.2	(E0.51, 0.94)
All other nutrients from Schedule 2755	0/11	< 20	—	—
All other major ions from Schedule 1948	0/10	< 20	—	—
All other trace elements from Schedule 1948	0/8	< 20	—	—

Table A4. Quality-control summary of replicate samples for constituents collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[The laboratory entity codes for the laboratories in the U.S. Geological Survey's (USGS) National Water Infomation System (NWIS) listed in the footnotes are shown in parentheses following the laboratory name. E, estimated value; mg/L, milligrams per liter; pCi/L, picocuries per liter; RSD, relative standard deviation; TU, tritium unit; µg/L, micrograms per liter; <, less than; —, no value]

Constitutent	Number of RSDs greater than 20 percent/number of replicates	Maximum RSD (percent)	Median RSD (percent)	Concentrations for replicates with RSDs greater than zero (environmental, replicate)
		Isotopes and radioactivity		
$\delta^{18}O$ of nitrate[2] (per mil)	1/4	84.8	7.2	(0.01, 0.04)
Tritium[3] (TU)	4/12	141.4	10.9	(0.3, 0), (0.3, 0), (1.3, 1.9), (1.3, 0.7)
Gross-beta radioactivity, 72-hour count[4] (pCi/L)	1/2	39.0	39	(E1.12, E1.97)
Gross-beta radioactivity, 30-day count[4] (pCi/L)	1/2	33.8	21.7	(E1.62, 2.64)
All additional isotopes and radioactivity	0/2	< 20	—	—
		Microbial indicators		
F-specific and somatic coliphage	0/1	< 20	0	—
E. coli, and total coliforms	0/30	< 20	0	—

[1] Analyses performed at Montgomery Watson Harza laboratory, Monrovia, California (CA-MWHL).

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

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

[4] Analyses performed at Eberline Analytical Services, Richmond, California (CA-EBERL).

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) and gasoline oxygenates and their degradates in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetone[1,2]	13	83	122	99
Acrylonitrile	13	93	104	102
tert-Amyl alcohol	2	97	107	102
Benzene[1]	13	91	109	104
Bromobenzene	13	98	115	102
Bromochloromethane[1]	13	83	115	105
Bromodichloromethane	13	91	130	104
Bromoform (Tribromomethane)[1]	13	85	123	98
2-Butanone (MEK, Methyl ethyl ketone)[1]	13	90	112	97
n-Butylbenzene	13	75	108	91
tert-Butyl alcohol (TBA)	2	94	104	99
sec-Butylbenzene	13	83	115	98
tert-Butylbenzene	13	89	126	107
Carbon disulfide[1]	13	67	125	82
Carbon tetrachloride (Tetrachloromethane)[1]	13	87	157	106
Chlorobenzene	13	92	115	102
Chloroethane	13	83	128	106
Chloroform (Trichloromethane)[1]	13	87	130	111
Chloromethane[1]	13	88	128	113
3-Chloro-1-propene	13	99	131	116
2-Chlorotoluene	13	91	109	102
4-Chlorotoluene	13	84	109	98
Dibromochloromethane[1]	13	85	122	101
1,2-Dibromo-3-chloropropane (DBCP)	13	84	113	96
1,2-Dibromoethane (EDB)	13	91	126	104
Dibromomethane	13	83	121	104
1,2-Dichlorobenzene	13	87	111	100
1,3-Dichlorobenzene	13	87	109	102
1,4-Dichlorobenzene	13	91	106	100
trans-1,4-Dichloro-2-butene	13	82	114	96
Dichlorodifluoromethane (CFC-12)	13	70	123	106
1,1-Dichloroethane[1]	13	97	142	112
1,2-Dichloroethane	13	90	132	111
1,1-Dichloroethene (DCE)	13	87	117	104
cis-1,2-Dichloroethene[1]	13	96	117	106
trans-1,2-Dichloroethene[1]	13	94	117	106
Dichloromethane (Methylene chloride)	13	28	128	106
1,2-Dichloropropane	13	94	119	106
1,3-Dichloropropane	13	92	126	106
2,2-Dichloropropane	13	62	124	96
1,1-Dichloropropene	13	93	145	104
cis-1,3-Dichloropropene	13	79	108	97
trans-1,3-Dichloropropene	13	80	116	92
Diethyl ether	13	91	118	102
Diisopropyl ether (DIPE)[2]	13	85	110	102
Ethylbenzene	13	89	115	100
Ethyl *tert*-butyl ether (ETBE)[2]	13	81	119	100
Ethyl methacrylate	13	82	107	96
1-Ethyl-2-methylbenzene (*o*-Ethyl toluene)[1]	13	82	106	94
Hexachlorobutadiene	13	70	108	85
Hexachloroethane	13	86	118	102

Table A5A. Quality-control summary for matrix-spike recoveries of volatile organic compounds (VOCs) and gasoline oxygenates and their degradates in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006. —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)	13	92	112	99
Isopropylbenzene (Cumene)	13	91	119	104
4-Isopropyl-1-methylbenzene[1]	13	81	110	97
Methyl acetate	2	11	112	111
Methyl acrylate	13	95	111	99
Methyl acrylonitrile	13	86	110	104
Methyl bromide (Bromomethane)	13	81	179	111
Methyl *tert*-butyl ether (MTBE)[1,2]	13	86	123	102
Methyl iodide (Iodomethane)	13	75	145	108
Methyl isobutyl ketone (MIBK)	13	85	110	96
Methyl methacrylate	13	73	106	94
Methyl *tert*-pentyl ether (*tert*-Amyl methyl ether, TAME)[2]	13	89	124	100
Naphthalene	13	80	117	96
n-Propylbenzene	13	87	111	98
Styrene	13	69	104	94
1,1,1,2-Tetrachloroethane	13	83	121	102
1,1,2,2-Tetrachloroethane	13	89	116	104
Tetrachloroethene (PCE)[1]	13	91	119	106
Tetrahydrofuran	13	96	112	106
1,2,3,4-Tetramethylbenzene[1]	13	69	126	98
1,2,3,5-Tetramethylbenzene[1]	13	62	135	106
Toluene[1]	13	88	115	104
1,2,3-Trichlorobenzene	13	56	113	106
1,2,4-Trichlorobenzene	13	77	126	99
1,1,1-Trichloroethane (TCA)	13	96	133	106
1,1,2-Trichloroethane	13	84	113	104
Trichloroethene (TCE)[1]	13	91	121	104
Trichlorofluoromethane (CFC-11)[1]	13	96	143	118
1,2,3-Trichloropropane (1,2,3-TCP)	13	89	115	103
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)	13	79	113	98
1,2,3-Trimethylbenzene	13	84	116	105
1,2,4-Trimethylbenzene[1]	13	86	117	102
1,3,5-Trimethylbenzene[1]	13	85	108	100
Vinyl bromide (Bromoethene)	13	96	128	117
Vinyl chloride (Chloroethene)	13	90	128	117
m- and *p*-Xylene[1]	13	86	171	102
o-Xylene	13	82	113	98

[1] Constituents detected in ground-water samples.

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

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Acetochlor[1,2]	11	78	99	87
Acifluorfen	12	42	88	68
Alachlor[2]	11	83	97	91
Aldicarb	12	57	86	59
Aldicarb sulfone	12	28	103	65
Aldicarb sulfoxide	12	68	112	85
Atrazine[1,2,3]	11	87	98	92
Azinphos-methyl[2]	11	63	103	74
Azinphos-methyl oxon[2]	9	29	104	56
Bendiocarb	11	49	93	73
Benfluralin[2]	11	48	62	54
Benomyl	12	45	91	72
Bensulfuron-methyl[1]	12	91	146	108
Bentazon[1]	12	46	202	70
Bromacil[1]	12	51	109	86
Bromoxyni[1]	12	36	62	52
Caffeine	12	55	101	77
Carbaryl[1,2,3]	11	84	108	98
Carbofuran[2,3]	11	74	94	86
Chloramben, methyl ester	12	42	91	81
Chlorimuron-ethyl[1]	12	69	139	108
2-Chloro-2,6-diethylacetanilide[2]	11	80	98	93
2-Chloro-6-ethylamino-4-amino-*s*-triazine (deisopropylatrazine)[1]	12	24	95	76
2-Chloro-4-isopropylamino-6-amino-*s*-triazine (deethylatrazine)[1,2]	11	36	51	44
4-Chloro-2-methylphenol[2]	11	43	74	64
3-(4-Chlorophenyl)-1-methyl urea	12	42	115	76
Chlorpyrifos[1,2]	11	83	100	90
Chlorpyrifos, oxygen analog[2]	11	9	80	29
Clopyralid	12	55	81	69
Cyanazine	2	82	110	96
Cycloate	12	23	83	76
Cyfluthrin[2]	11	31	93	52
λ-Cyhalothrin[2]	11	16	53	37
Cypermethrin[2]	11	34	86	50
DCPA (Dacthal) monoacid	12	61	86	72
DCPA	11	88	104	97
Desulfinylfipronil[1,2]	11	73	97	87
Desulfinylfipronil amide[2]	11	50	108	76
Diazinon[2]	11	78	96	85
Dicamba	12	49	79	57
3,4-Dichloroaniline[1,2]	11	65	89	81
3,5-Dichloroaniline	2	81	95	88
2,4-D and 2,4-D methyl ester, summed on molar basis, reported as 2,4-D[1,4]	12	64	172	79
4-(2,4-Dichlorophenoxy)butyric acid (2,4-DB)	12	53	82	64
Dichlorprop	12	57	90	75
Dichlorvos[2]	11	9	60	30
Dicrotophos[2]	10	20	37	30
Dieldrin[2]	11	76	101	83
2,6-Diethylaniline[2]	11	87	105	96
Dimethoate[2]	11	27	34	29

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Dinoseb[1]	12	54	73	61
Diphenamid	12	42	101	90
Disulfoton	2	60	98	79
Disulfoton sulfone	2	100	118	109
Diuron[1]	12	71	97	88
α-Endosulfan	2	89	114	101
Endosulfan sulfate	2	89	125	107
EPTC	2	92	94	93
Ethion[2]	11	58	80	67
Ethion monoxon[2]	11	66	80	74
Ethoprophos	2	103	108	105
2-Ethyl-6-methylaniline[2]	11	81	108	92
Fenamiphos[2]	11	56	91	77
Fenamiphos sulfone[2]	11	40	172	70
Fenamiphos sulfoxide[2]	10	29	70	44
Fenuron	12	38	99	79
Fipronil[1,2]	11	60	105	81
Fipronil sulfide[1,2]	11	70	97	81
Fipronil sulfone[1,2]	11	52	127	71
Flumetsulam	12	75	158	86
Fluometuron	12	53	103	92
Fonofos[2]	11	77	93	83
Hexazinone[1,2]	11	61	112	77
3-Hydroxy carbofuran	11	52	95	74
2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine (hydroatrazine)[1]	12	13	106	97
Imazaquin	12	50	126	82
Imazethapyr	12	47	99	81
Imidacloprid	12	65	108	80
Isofenphos[2]	11	86	108	91
Linuron	12	65	97	90
Malaoxon[2]	11	67	93	80
Malathion[2]	11	82	103	92
Metalaxyl[2,3]	11	80	98	88
Methidathion[2]	11	71	108	93
Methiocarb	11	47	98	82
Methomyl	12	61	105	79
2-Methyl-4-chlorophenoxyacetic acid (MCPA)[1]	12	61	90	76
4-(2-Methyl-4-chlorophenoxy) butyric acid (MCPB)	12	53	82	65
Methyl paraoxon[2]	11	38	70	48
Methyl parathion[2]	11	57	83	65
Metolachlor[1,2]	11	96	110	102
Metribuzin[2]	11	57	239	70
Metsulfuron methyl[1]	12	55	150	80
Molinate[1,2]	11	87	110	93
Myclobutanil[2]	11	63	93	85
1-Naphthol[2]	11	20	70	30
Neburon	12	73	105	82
Nicosulfuron	12	61	154	96
Norflurazon	12	68	113	89
Oryzalin	12	19	85	76
Oxamyl	11	67	102	81

Table A5B. Quality-control summary for matrix-spike recoveries of pesticides and pesticide degradates in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.—Continued

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Oxyfluorfen	2	58	88	73
Pendimethalin[2]	11	72	91	80
cis-Permethrin[2]	11	41	71	57
Phorate[2]	11	58	84	76
Phorate oxygen analog[2]	11	60	100	80
Phosmet[2]	6	8	8	8
Phosmet oxon[2]	6	47	50	50
Picloram	12	44	111	66
Prometon[2]	11	80	93	85
Prometryn[2]	11	84	104	94
Pronamide[2]	11	76	96	82
Propanil[1,2]	11	73	118	95
Propargite	2	90	137	113
Propham	12	39	99	87
Propiconazole	12	46	122	84
cis-Propiconazole[1,2]	11	84	109	90
trans-Propiconazole[1,2]	11	67	94	86
Propoxur	11	51	97	86
Siduron	12	61	105	93
Simazine[1,2]	11	81	115	94
Sulfometuron-methyl	12	94	141	106
Tebuconazole	2	70	98	84
Tebuthiuron[1,2,3]	11	56	230	101
Tefluthrin	2	53	67	60
Terbacil	12	55	104	87
Terbufos[2]	11	77	131	101
Terbufos oxygen analog sulfone[2]	11	60	101	77
Terbuthylazine[2]	11	85	102	95
Thiobencarb[2]	11	89	116	111
Tribuphos[2]	11	44	68	57
Triclopyr[1]	9	68	86	75
Trifluralin[2]	11	52	72	60

[1] Constituents detected in ground-water samples.

[2] Constituents on Schedules 2032 and 2033; only values from Schedule 2032 are reported because it is the preferred analytical schedule.

[3] Constituents on Schedules 2032 and 2060; only values from Schedule 2032 are reported because it is the preferred analytical schedule.

[4] 2,4-D and 2,4-D methyl ester summed on a molar basis and reported as 2,4-D.

Table A5C. Quality-control summary for matrix-spike recoveries of constituents of special interest in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Acceptable recovery range is between 70 and 130 percent]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Perchlorate[1]	1	99	99	99
1,2,3-Trichloropropane (1,2,3-TCP)	7	88	106	100
N-Nitrosodimethylamine (NDMA)	5	85	106	93

[1] Constituent detected in ground-water samples.

Table A5D. Quality-control summary for matrix-spike recoveries of radioactive constituents in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[Acceptable recovery range is between 70 and 130 percent. hr, hour]

Constituent	Number of spike samples	Minimum recovery (percent)	Maximum recovery (percent)	Median recovery (percent)
Radium-226[1]	2	102	104	103
Radium-228[1]	2	105	117	111
Gross-alpha radioactivity, 72-hr count[1]	2	55	118	86
Gross-alpha radioactivity, 30-day count[1]	2	85	95	90
Gross-beta radioactivity, 72-hr count[1]	2	68	100	84
Gross-beta radioactivity, 30-day count[1]	2	96	98	97

[1] Constituents detected in ground-water samples.

Table A6. Quality-control summary of surrogate recoveries of volatile organic compounds, and gasoline oxygenates and their degradates, pesticides and pesticide degradates, and constituents of special interest in samples collected for the Middle Sacramento Valley Groundwater Ambient Monitoring and Assessment (GAMA) study, California, June to September, 2006.

[The laboratory entity code for the Montgomery Watson Harza laboratory in the U.S. Geological Survey's National Water Information System (NWIS) is CA-MWHL. 1,2,3-TCP, 1,2,3-Trichloropropane; MWH, Montgomery Watson Harza laboratory; NDMA, *N*-nitrosodimethylamine; VOC, volatile organic compound]

Surrogate	Analytical schedule	Constitutent or constituent class analyzed	Number of blank analyses	Median recovery in blanks (percent)	Number of surrogate recoveries below 70 percent in blanks	Number of surrogate recoveries above 130 percent in blanks	Number of environmental sample analyses	Median recovery in environmental samples (percent)	Number of surrogate recoveries below 70 percent in environmental samples	Number of surrogate recoveries above 130 percent in environmental samples
1-Bromo-4-fluorobenzene	2020, 4024	VOC	21	98	1	0	139	97	14	0
1,2-Dichloro-ethane-*d*4	2020, 4024	VOC	21	116	0	1	139	118	0	27
Isobutyl alcohol-*d*6	4024	VOC	1	132	0	1	10	103	0	1
Toluene-*d*8	2020, 4024	VOC	21	100	0	0	139	99	0	0
Diazinon-*d*10	2032, 2033	Pesticide	11	106	0	0	137	95	4	1
α-HCH-*d*6	2032, 2033	Pesticide	11	89	0	0	138	92	0	0
2,4,5-T	2060	Pesticide	11	78	1	0	136	81	2	0
Barban	2060	Pesticide	11	94	1	0	136	89	4	0
Caffeine-^{13}C	2060	Pesticide	11	101	2	0	135	92	15	0
Toluene-*d*8	MWH	Special interest (1,2,3-TCP)	12	98	0	0	63	96	0	0
NDMA-*d*6	MWH	Special interest (NDMA)	12	86	3	0	59	87	13	0