Description of the Region

The Central Coast HR covers approximately 7.22 million acres (11,300 square miles) in central California (Figure 29). This HR includes all of Santa Cruz, Monterey, San Luis Obispo, and Santa Barbara counties, most of San Benito County, and parts of San Mateo, Santa Clara, and Ventura counties. Significant geographic features include the Pajaro, Salinas, Carmel, Santa Maria, Santa Ynez, and Cuyama valleys; the coastal plain of Santa Barbara; and the Coast Range. Major drainages in the region include the Salinas, Cuyama, Santa Ynez, Santa Maria, San Antonio, San Lorenzo, San Benito, Pajaro, Nacimiento, Carmel, and Big Sur Rivers.

Population data from the 2000 Census suggest that about 1.4 million people or about 4 percent of the population of the State live in this HR. Major population centers include Santa Barbara, Santa Maria, San Luis Obispo, Gilroy, Hollister, Morgan Hill, Salinas, and Monterey.

The Central Coast HR has 50 delineated groundwater basins. Within this region, the Gilroy-Hollister Valley and Salinas Valley groundwater basins are divided into four and eight subbasins, respectively. Groundwater basins in this HR underlie about 2.390 million acres (3,740 square miles) or about one-third of the HR.

Groundwater Development

Locally, groundwater is an extremely important source of water supply. Within the region, groundwater accounted for 83 percent of the annual supply used for agricultural and urban purposes in 1995. For an average year, groundwater in the region accounts for about 8.4 percent of the statewide groundwater supply and about 1.3 percent of the total state water supply for agricultural and urban needs. In drought years, groundwater in this region is expected to account for about 7.2 percent of the statewide groundwater supply and about 1.9 percent of the total State water supply for agricultural and urban needs (DWR 1998).

Aquifers are varied and range from large extensive alluvial valleys with thick multilayered aquifers and aquitards to small inland valleys and coastal terraces. Several of the larger basins provide a dependable and drought-resistant water supply to coastal cities and farms.

Conjunctive use of surface water and groundwater is a long-standing practice in the region. Several reservoirs including Hernandez, Twitchell, Lake San Antonio, and Lake Nacimiento are operated primarily for the purpose of groundwater recharge. The concept is to maintain streamflow over a longer period than would occur without surface water storage and thus provide for increased recharge of groundwater. Seawater intrusion is a major problem throughout much of the region. In the Salinas Valley Groundwater Basin, seawater intrusion was first documented in the 1930s and has been observed more than 5 miles inland.

Groundwater Quality

Much of the groundwater in the region is characterized by calcium sulfate to calcium sodium bicarbonate sulfate water types because of marine sedimentary rock in the watersheds. Aquifers intruded by seawater are typically characterized by sodium chloride to calcium chloride, and have chloride concentrations greater than 500 mg/L. In several areas, groundwater exceeds the MCL for nitrate.

Water Quality in Public Supply Wells

From 1994 through 2000, 711 public supply water wells were sampled in 38 of the 60 basins and subbasins in the Central Coast HR. Analyzed samples indicate that 587 wells, or 83 percent, met the state primary MCLs for drinking water. One-hundred-twenty-four wells, or 17 percent, have constituents that exceed one or more MCL. Figure 30 shows the percentages of each contaminant group that exceeded MCLs in the 124 wells.

Groundwater in basins of the San Diego subregion has mainly calcium and sodium cations and bicarbonate and sulfate anions. Local impairments by nitrate, sulfate, and TDS are found. Camp Pendleton Marine Base, in the northwestern part of this subregion, is on the EPA National Priorities List for soil and groundwater contamination by many constituents.

Water Quality in Public Supply Wells

From 1994 through 2000, 2,342 public supply water wells were sampled in 47 of the 73 basins and subbasins in the South Coast HR. Analyzed samples indicate that 1,360 wells, or 58 percent, met the state primary MCLs for drinking water. Nine-hundred-eighty-two wells, or 42 percent, have constituents that exceed one or more MCL. Figure 32 shows the percentages of each contaminant group that exceeded MCLs in the 982 wells.

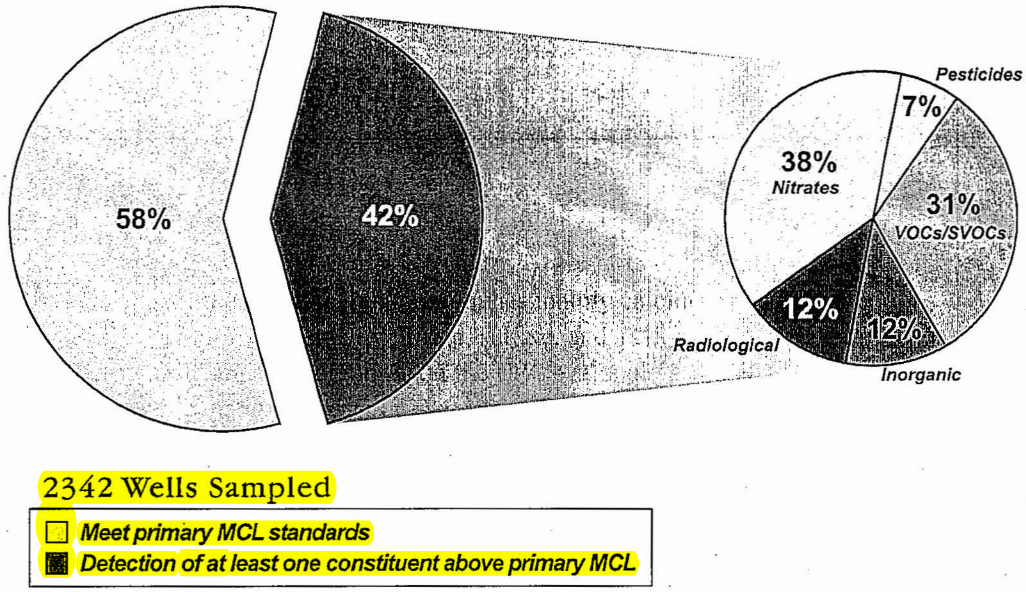

Figure 32 MCL exceedances in public supply wells in the South Coast Hydrologic Region

Table 22 lists the three most frequently occurring contaminants in each of the six contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Changes from Bulletin 118-80

Several modifications from the groundwater basins presented in Bulletin 118-80 are incorporated in this report (Table 23). The Cajalco Valley (8-3), Jamul Valley (9-20), Las Pulgas Valley (9-21), Pine Valley (9-26), and Tecate Valley (9-30) Groundwater Basins have been deleted in this report because they have thin deposits of alluvium and well completion reports indicate that groundwater production is from underlying fractured bedrock. The Conejo Tierra Rejada Volcanic (4-21) is a volcanic aquifer and was not assigned a basin number in this bulletin. This is considered to be groundwater source area as discussed in Chapter 6.

Groundwater Quality

Groundwater quality in the Sacramento River HR is generally excellent. However, there are areas with local groundwater problems. Natural water quality impairments occur at the north end of the Sacramento Valley in the Redding subbasin, and along the margins of the valley and around the Sutter Buttes, where Cretaceous-age marine sedimentary rocks containing brackish to saline water are near the surface. Water from the older underlying sediments mixes with the fresh water in the younger alluvial aquifer and degrades the quality. Wells constructed in these areas typically have high TDS. Other local natural impairments are moderate levels of hydrogen sulfide in groundwater in the volcanic and geothermal areas in the western portion of the region. In the Sierra foothills, there is potential for encountering uranium and radon-bearing rock or sulfide mineral deposits containing heavy metals. Human-induced impairments are generally associated with individual septic system development in shallow unconfined portions of aquifers or in fractured hard rock areas where insufficient soil depths are available to properly leach effluent before it reaches the local groundwater supply.

Water Quality in Public Supply Wells

From 1994 through 2000, 1,356 public supply water wells were sampled in 51 of the 88 basins and subbasins in the Sacramento River HR. Samples analyzed indicate that 1,282 wells, or 95 percent, met the state primary MCLs for drinking water. Seventy-four wells, or 5 percent, have constituents that exceed one or more MCL. Figure 34 shows the percentages of each contaminant group that exceeded MCLs in the 74 wells.

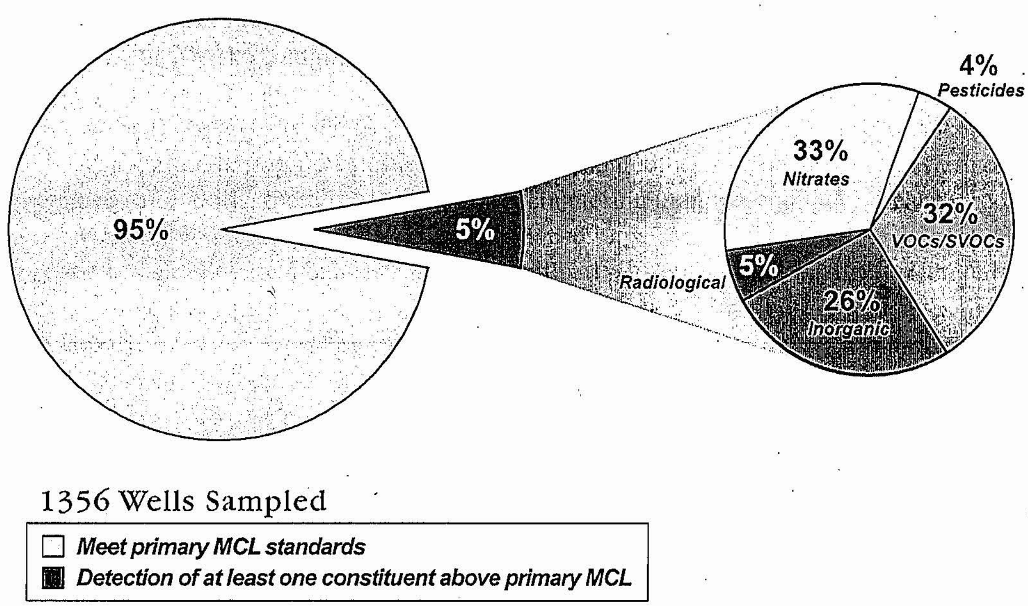

Figure 34 MCL exceedances in public supply wells in the Sacramento River Hydrologic Region

Drinking water standards are most often exceeded for TDS, fluoride, and boron content. The EPA lists 13 sites of contamination in this HR. Of these, three military installations in the Antelope Valley and Mojave River Valley groundwater basins are federal Superfund sites because of VOCs and other hazardous contaminants.

Water Quality in Public Supply Wells

From 1994 through 2000, 605 public supply water wells were sampled in 19 of the 77 basins and subbasins in the South Lahontan HR. Analyzed samples indicate that 506 wells, or 84 percent, met the state primary MCLs for drinking water. Ninety-nine wells, or 16 percent, have constituents that exceed one or more MCL. Figure 42 shows the percentages of each contaminant group that exceeded MCLs in the 99 wells.

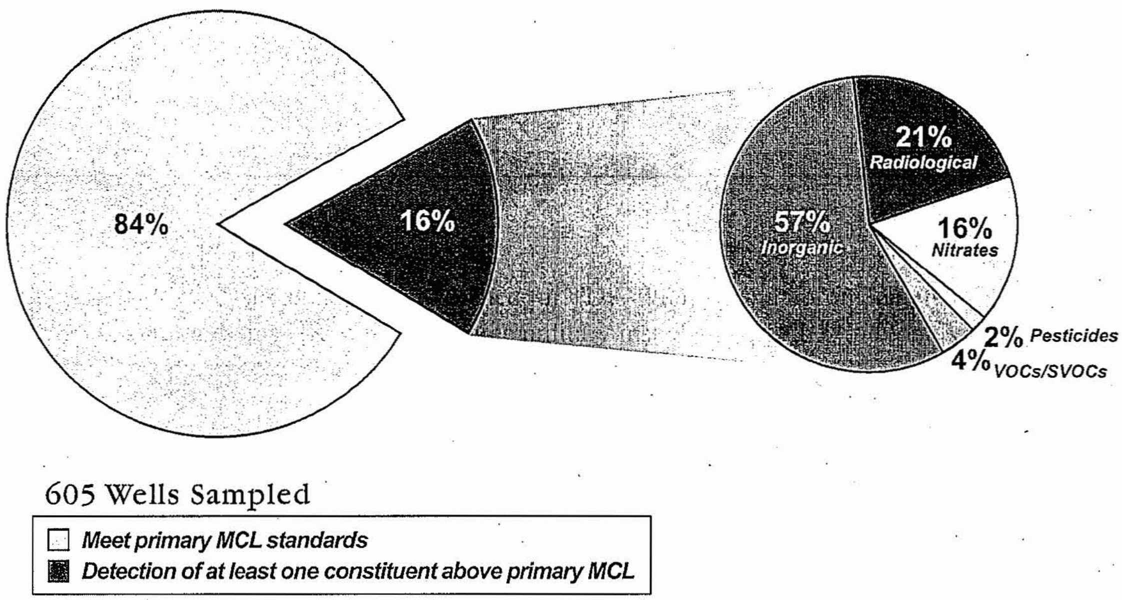

Figure 42 MCL exceedances in public supply wells in the South Lahontan Hydrologic Region

Description of the Region

The Colorado River HR covers approximately 13 million acres (20,000 square miles) in southeastern California. It is bounded on the east by Nevada and Arizona, the south by the Republic of Mexico, the west by the Laguna, San Jacinto, and San Bernardino mountains, and the north by the New York, Providence, Granite, Old Dad, Bristol, Rodman, and Ord Mountain ranges. An average annual precipitation of 5.5 inches and average annual runoff of only 200,000 acre-feet makes this the most arid HR of California (DWR 1994). Surface runoff drains to many closed basins or to the Colorado River.

This HR includes all of Imperial, most of Riverside, much of San Bernardino, and part of San Diego counties (Figure 43). Many of the alluvial valleys in the region are underlain by groundwater aquifers that are the sole source of water for local communities.

About 533,000 people live within the Colorado River HR (DWR, 1998). The largest population centers are Palm Springs, Palm Desert, Indio, Coachella, and El Centro.

Groundwater Development

The earliest groundwater development in California may have been prehistoric water wells dug by the Cahuilla Indians in Coachella Valley of the Colorado River HR. In this report, 64 groundwater basins/subbasins are delineated in this HR. The Deadman Valley, Johnson Valley Area, and Coachella Valley groundwater basins have been divided into subbasins. Groundwater basins underlie about 8.68 million acres or about 26 percent of this HR.

In the Colorado River HR, groundwater provides about 8 percent of the water supply in normal years for agricultural and urban uses (DWR 1998). In most smaller basins, groundwater is found in unconfined alluvial aquifers. In some of the larger basins, particularly near dry lakes, aquifers may be separated by aquitards that create confined groundwater conditions. Depths of basins range from tens or hundreds of feet in smaller basins and along arms of ephemeral rivers to thousands of feet in larger basins. The thickness of aquifers varies from tens to hundreds of feet. Well yields vary in this region depending on aquifer characteristics and well location, size, and use. Some aquifers are capable of yielding thousands of gallons per minute to municipal wells.

Conjunctive use of surface water and groundwater is a long-standing practice in the region. Water is imported from the Colorado River for irrigation in Imperial, Coachella, and Palo Verde Valleys and from groundwater recharge in Coachella Valley. Water imported from Northern California is used to replenish Warren and Joshua Tree groundwater basins. Many agencies have erected systems of barriers to allow more efficient percolation of ephemeral runoff from surrounding mountains. The concept of utilizing groundwater basins in this sparsely populated HR for storing water that would be pumped during drought years is getting much attention.

Groundwater Quality

The chemical character of groundwater in the Colorado River HR is variable. Cation concentration is dominated by sodium with calcium common and magnesium appearing less often. Bicarbonate is usually the dominant anion, although sulfate and chloride waters are also common. In basins with closed drainages, water character often changes from calcium-sodium bicarbonate near the margins to sodium chloride or chloride-sulfate beneath a dry lake. It is not uncommon for concentrations of dissolved constituents to rise dramatically toward a dry lake where saturation of mineral salts is reached. An example of this is found at Bristol Valley Groundwater Basin, where the mineral halite (sodium chloride) is formed and then mined by evaporation of groundwater in trenches in Bristol (dry) Lake. The TDS content of groundwater is high in many of the basins in this region. High fluoride content is common; sulfate content occasionally exceeds drinking water standards; and high nitrate content is common, especially in agricultural areas.

Two of the primary challenges in the Colorado River HR are overdraft in the Coachella Valley and leaking underground storage tanks. The EPA has not yet placed any contamination sites in this HR on the Superfund National Priorities List; however, one site is under consideration because of high pesticide levels.

Water Quality in Public Supply Wells

From 1994 through 2000, 314 public supply water wells were sampled in 23 of the 64 basins and subbasins in the Colorado River HR. Analyzed samples indicate that 270 wells, or 86 percent, met the state primary MCLs for drinking water standards. Forty-four wells, or 14 percent, have constituents that exceed one or more MCL. Figure 44 shows the percentages of each contaminant group that exceeded MCLs in the 44 wells.

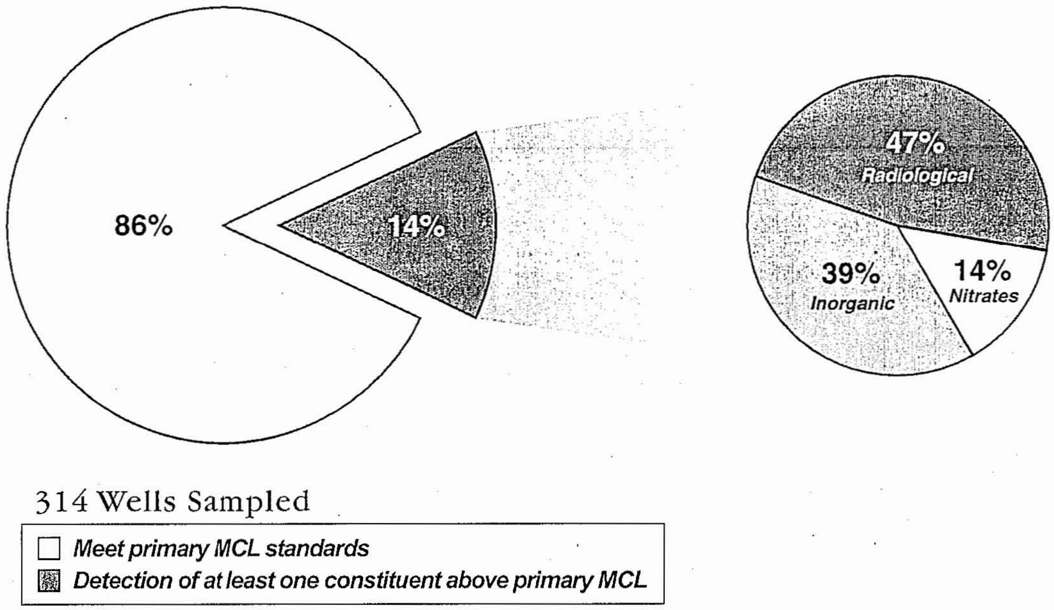

Figure 44 MCL exceedances in public supply wells in the Colorado River Hydrologic Region

Table 39 lists the three most frequently occurring contaminants in each contaminant group and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Table 39 Most frequently occurring contaminants by contaminant group in the Colorado River Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics – Primary	Fluoride – 17		
Inorganics – Secondary	Iron – 38	Manganese – 26	TDS – 5
Radiological	Radium 228 – 3	Combined RA226 + RA228 – 3	Radium 226 – 1
Nitrates	Nitrate (as NO_3) – 6	Nitrate + Nitrite – 1	

evaporation of groundwater in trenches in Bristol (dry) Lake. The TDS content of groundwater is high in many of the basins in this region. High fluoride content is common; sulfate content occasionally exceeds drinking water standards; and high nitrate content is common, especially in agricultural areas.

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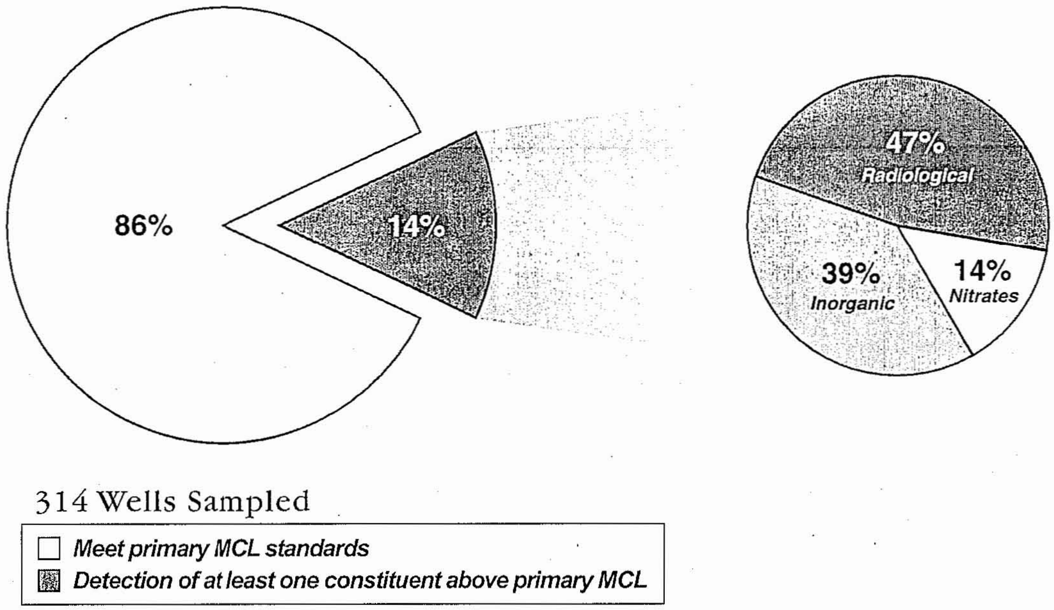

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Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics – Primary	Fluoride – 17		
Inorganics – Secondary	Iron – 38	Manganese – 26	TDS – 5
Radiological	Radium 228 – 3	Combined RA226 + RA228 – 3	Radium 226 – 1
Nitrates	Nitrate (as NO_3) – 6	Nitrate + Nitrite – 1	

Groundwater Quality

Groundwater quality characteristics and specific local impairments vary with regional setting within the North Coast HR. In general, seawater intrusion and nitrates in shallow aquifers are problems in the coastal groundwater basins; high total dissolved solids (TDS) content and general alkalinity are problems in the lake sediments of the Modoc Plateau basins; and iron, boron, and manganese can be problems in the inland basins of Mendocino and Sonoma counties.

Water Quality in Public Supply Wells

From 1994 through 2000, 584 public supply water wells were sampled in 32 of the 63 basins and subbasins in the North Coast HR. Analyzed samples indicate that 553 wells, or 95%, met the state primary Maximum Contaminant Levels (MCL) for drinking water. Thirty-one wells, or 5%, sampled have constituents that exceed one or more MCL. Figure 26 shows the percentage of each contaminant group that exceeded MCLs in the 31 wells.

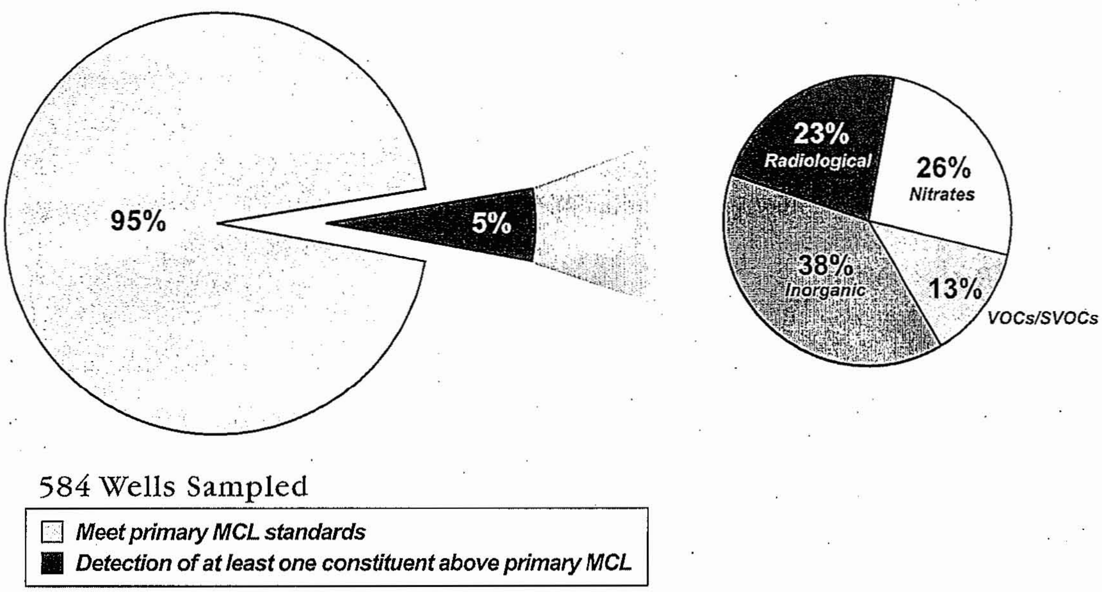

Figure 26 MCL exceedances in public supply wells in the North Coast Hydrologic Region

Table 13 lists the three most frequently occurring individual contaminants in each of the five contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Land subsidence has been a significant problem in the Santa Clara Valley Groundwater Basin in the past. An extensive annual monitoring program has been set up within the basin to evaluate changes in an effort to maintain land subsidence at less than 0.01 feet per year (SCVWD 2001). Additionally, groundwater recharge projects have been implemented in the Santa Clara Valley to ensure that groundwater will continue to be a viable water supply in the future.

Groundwater Quality

In general, groundwater quality throughout most of the region is suitable for most urban and agricultural uses with only local impairments. The primary constituents of concern are high TDS, nitrate, boron, and organic compounds.

The areas of high TDS (and chloride) concentrations are typically found in the region's groundwater basins that are situated close to the San Francisco Bay, such as the northern Santa Clara, southern Sonoma, Petaluma, and Napa valleys. Elevated levels of nitrate have been detected in a large percentage of private wells tested within the Coyote Subbasin and Llagas Subbasin of the Gilroy-Hollister Valley Groundwater Basin (in the Central Coast HR) located to the south of the Santa Clara Valley (SCVWD 2001). The shallow aquifer zone within the Petaluma Valley also shows persistent nitrate contamination. Groundwater with high TDS, iron, and boron levels is present in the Calistoga area of Napa Valley, and elevated boron levels in other parts of Napa Valley make the water unfit for agricultural uses. Releases of fuel hydrocarbons from leaking underground storage tanks and spills/leaks of organic solvents at industrial sites have caused minor to significant groundwater impacts in many basins throughout the region. Methyl tertiary-butyl ether (MTBE) and chlorinated solvent releases to soil and groundwater continue to be problematic. Environmental oversight for many of these sites is performed either by local city and county enforcement agencies, the RWQCB, the Department of Toxic Substances Control, and/or the U.S. Environmental Protection Agency.

Water Quality in Public Supply Wells

From 1994 through 2000, 485 public supply water wells were sampled in 18 of the 33 basins and subbasins in the San Francisco Bay HR. Analyzed samples indicate that 410 wells, or 85 percent, met the state primary MCLs for drinking water standards. Seventy-five wells, or 15 percent, have constituents that exceed one or more MCL. Figure 28 shows the percentages of each contaminant group that exceeded MCLs in the 75 wells.

Table 16 lists the three most frequently occurring contaminants in each contaminant group and the number of wells in the HR that exceeded the MCL for those contaminants.

Conjunctive Use

Since near the beginning of the region's agricultural development, groundwater has been used conjunctively with surface water to meet water needs. Groundwater was and is used when and where surface water is unable to fully meet demands either in time or area. For several decades, this situation was more of an incidental conjunctive use than a formal one. Historical groundwater use has resulted in some land subsidence in the southwest portion of the region.

Groundwater Quality

In general, groundwater quality throughout the region is suitable for most urban and agricultural uses with only local impairments. The primary constituents of concern are TDS, nitrate, boron, chloride, and organic compounds. The Yosemite Valley Groundwater Basin has exceptionally high quality groundwater.

Areas of high TDS content are primarily along the west side of the San Joaquin Valley and in the trough of the valley. The high TDS content of west-side groundwater is due to recharge of streamflow originating from marine sediments in the Coast Range. High TDS content in the trough of the valley is the result of concentration of salts due to evaporation and poor drainage. Nitrates may occur naturally or as a result of disposal of human and animal waste products and fertilizer. Boron and chloride are likely a result of concentration from evaporation near the valley trough. Organic contaminants can be broken into two categories, agricultural and industrial. Agricultural pesticides and herbicides have been detected in groundwater throughout the region, but primarily along the east side of the San Joaquin Valley where soil permeability is higher and depth to groundwater is shallower. The most notable agricultural contaminant is dibromochloropropane (DBCP), a now-banned soil fumigant and known carcinogen once used extensively on grapes and cotton. Industrial organic contaminants include TCE, dichloroethylene (DCE), and other solvents. They are found in groundwater near airports, industrial areas, and landfills.

Water Quality in Public Supply Wells

From 1994 through 2000, 689 public supply water wells were sampled in 10 of the 11 basins and subbasins in the San Joaquin River HR. Samples analyzed indicate that 523 wells, or 76 percent, met the state primary MCLs for drinking water. One-hundred-sixty-six wells, or 24 percent, have constituents that exceed one or more MCL. Figure 36 shows the percentages of each contaminant group that exceeded MCLs in the 166 wells.

Table 28 lists the three most frequently occurring contaminants in each of the six contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Changes from Bulletin 118-80

The subbasins of the San Joaquin Valley, which were delineated as part of the 118-80 update, are given their first numeric designation in this report. Additionally, the Cosumnes Subbasin has been added to the subbasins within the San Joaquin River HR. It is worth noting that the southern portion of the South American Subbasin of the Sacramento Valley Groundwater Basin is also included as part of this HR. The subbasin names and numbers within the region are listed in Table 29.

The cities of Fresno, Bakersfield, and Visalia have groundwater recharge programs to ensure that groundwater will continue to be a viable water supply in the future. Extensive groundwater recharge programs are also in place in the south valley where water districts have recharged several million acre-feet for future use and transfer through water banking programs.

The extensive use of groundwater in the San Joaquin Valley has historically caused subsidence of the land surface primarily along the west side and south end of the valley.

Groundwater Quality

In general, groundwater quality throughout the region is suitable for most urban and agricultural uses with only local impairments. The primary constituents of concern are high TDS, nitrate, arsenic, and organic compounds.

The areas of high TDS content are primarily along the west side of the San Joaquin Valley and in the trough of the valley. High TDS content of west-side water is due to recharge of stream flow originating from marine sediments in the Coast Range. High TDS content in the trough of the valley is the result of concentration of salts because of evaporation and poor drainage. In the central and west-side portions of the valley, where the Corcoran Clay confining layer exists, water quality is generally better beneath the clay than above it. Nitrates may occur naturally or as a result of disposal of human and animal waste products and fertilizer. Areas of high nitrate concentrations are known to exist near the town of Shafter and other isolated areas in the San Joaquin Valley. High levels of arsenic occur locally and appear to be associated with lakebed areas. Elevated arsenic levels have been reported in the Tulare Lake, Kern Lake and Buena Vista Lake bed areas. Organic contaminants can be broken into two categories, agricultural and industrial. Agricultural pesticides and herbicides have been detected throughout the valley, but primarily along the east side where soil permeability is higher and depth to groundwater is shallower. The most notable agricultural contaminant is DBCP, a now-banned soil fumigant and known carcinogen once used extensively on grapes. Industrial organic contaminants include TCE, DCE, and other solvents. They are found in groundwater near airports, industrial areas, and landfills.

Water Quality in Public Supply Wells

From 1994 through 2000, 1,476 public supply water wells were sampled in 14 of the 19 groundwater basins and subbasins in the Tulare Lake HR. Evaluation of analyzed samples shows that 1,049 of the wells, or 71 percent, met the state primary MCLs for drinking water. Four-hundred-twenty-seven wells, or 29 percent, exceeded one or more MCL. Figure 38 shows the percentages of each contaminant group that exceeded MCLs in the 427 wells.

Groundwater Budget (Type B)

Estimates of groundwater extraction are based on surveys conducted by the California Department of Water Resources during 1994 and 1995. Surveys included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 3,000, and 20,000 acre-feet respectively. Deep percolation of applied water is estimated to be 5,700 acre-feet.

Groundwater Quality

Characterization. Groundwater in the basin is characterized as magnesium-sodium bicarbonate and sodium-magnesium bicarbonate type waters. Total dissolved solids concentrations range from 109- to 320-mg/L, averaging 194 mg/L (DWR unpublished data).

Impairments. Localized areas with high iron, manganese, and nitrate occur in the subbasin.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	19	0
Radiological	31	0
Nitrates	20	0
Pesticides	13	0
VOCs and SVOCs	17	0
Inorganics – Secondary	19	1

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

	Well yields (gal/min)	
Irrigation	Range: 0 – 1800	Average: 46 (40 Well Completion Reports)
	Total depths (ft)	
Domestic	Range: 11 – 805	Average: 140 (2239 Well Completion Reports)
Irrigation	Range: 32 – 558	Average: 302 (48 Well Completion Reports)

and subsequent data updates, Bookman-Edmonston/Navigant Consulting provided estimates of several groundwater budget components for an area generally corresponding to the South American Subbasin. The data represent an average budget for the period from 1970 to 1995. Basin inflows include natural and applied water recharge, which total 257,168 af. Subsurface inflow and outflow are not known specifically, but the model indicates that there is a net subsurface outflow of 29,676 af annually. Other groundwater outflows include annual urban extraction of 68,058 af and agricultural extraction of 162,954 af.

Groundwater Quality

Characterization. Groundwater is typically a calcium magnesium bicarbonate or magnesium calcium bicarbonate. Other minor groundwater types include a sodium calcium bicarbonate or calcium sodium bicarbonate in the vicinity of Elk Grove and a magnesium sodium bicarbonate or sodium magnesium bicarbonate near the confluence of the Sacramento and American rivers (Bertoldi and others 1991). TDS ranges from 24 – 581 mg/l and averages 221 mg/l based on 462 records (Montgomery Watson 1993).

Impairments. Montgomery Watson (1997) listed seven sites within the subbasin with significant groundwater contamination. Included in the list are three USEPA Superfind sites – Aerojet, Mather Field, and the Sacramento Army Depot. Other sites are the Kiefer Boulevard Landfill, an abandoned PG&E site on Jiboom Street near Old Sacramento, the Southern Pacific and Union Pacific Rail Yards in downtown Sacramento.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	144	2
Radiological	147	1
Nitrates	170	1
Pesticides	148	0
VOCs and SVOCs	144	8
Inorganics – Secondary	144	46

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Groundwater Storage

Groundwater Storage Capacity. To date, there has been no groundwater storage calculation for the Solano subbasin as it is described by Bulletin 118. The USGS, however, has determined specific yield averages and groundwater storage calculations for some areas within and around the Solano subbasin (Thomasson and others 1960).

Groundwater in Storage. (see above)

Groundwater Budget (Type C)

Currently no groundwater budget has been calculated for the Solano Subbasin.

Groundwater Quality

Characterization. This discussion of groundwater quality is based on USGS Water Supply Investigation Report 84-4244 (Evenson, 1985) except where noted.

Groundwater within the Solano subbasin is considered to be of generally good quality, and useable for both domestic and agricultural purposes. Chemical water types within the basin are variable and classified generally as magnesium bicarbonate in the central and northern areas, sodium bicarbonate in the southern and eastern areas, and calcium magnesium or magnesium calcium bicarbonate around and west of Dixon. Total dissolved solids (TDS) range from between 250 and 500 ppm in the northwest and eastern portion of the basin and are found at levels higher than 500 ppm in the central and southern areas. (Evaluation of data from the Department of Health Services (Department of Health Services, 2000) shows the TDS minimum = 150 ppm, maximum = 880 ppm, average = 427 ppm). In general, most of the water within the subbasin is classified as hard to very hard (see below).

Chloride concentrations are found over 100 ppm in the southern areas, while sulfate concentration is greater than 50 ppm in the southern areas. The maximum contaminant level (MCL) for both chloride and sulfate is 600 ppm.) Boron concentrations are less than 0.75 ppm except in the southern and southeastern basin where concentrations average between 0.75 and 2.0 ppm (more than 1.0 ppm will affect sensitive tree crops).

Iron concentrations increase toward the eastern side of the subbasin, from less than 0.02 ppm to greater than 0.05 ppm (MCL = 0.3 ppm) along the Sacramento River, while manganese concentrations also increase from west to east with concentrations from .01 ppm to over 0.1 ppm (MCL = 0.050 ppm) found north of Rio Vista and east of the Solano-Yolo County line.

Impairments. Overall hardness (as $CaCO_3$) is generally greater than 180 ppm. Approximately one half of drinking water well samples taken between 1970 and 2000 analyzed for overall hardness measured above 200 ppm, but rarely over 400 ppm (Department of Health Services 2000). High concentrations of bicarbonate which cause precipitation of Ca and Mg carbonates is found in the southern portion of the basin.

Arsenic concentrations are typically between 0.02 and 0.05 ppm, with the highest concentrations found along the southeastern margin of the basin. Although this is currently not considered problematic, there could be impacts if the MCL is lowered. The current MCL (as set by the EPA) for arsenic is 0.05 ppm. Also, manganese (a secondary constituent) is found at concentrations above the MCL of 0.05 ppm along the Sacramento River along the eastern portion of the subbasin.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	71	1
Radiological	41	0
Nitrates	96	8
Pesticides	56	3
VOCs and SVOCs	57	1
Inorganics – Secondary	71	17

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

Well yields (gal/min)

Currently there is insufficient data to provide statistics on water well yields.

Total depths (ft) [1]

Domestic	Range: 38 to 1070 ft	Average: 239 ft
Municipal/Irrigation	Range: 62 to 2275 ft	Average: 510 ft

[1]Based on DWR well completion report data from 2001.

Table: 1974 groundwater storage calculations based on Scott (1975):

Groundwater Basin (Scott, 1975)	Area (acres)	1974 Calculated Storage (Scott, 1975)	Estimated % area within Yolo Subbasin[1]	Estimated 1974 Storage within Yolo Subbasin[1]
Cache Creek	45,800	1,528,700	20%	305,740
Upper Cache-Putah	70,300	1,921,000	100%	1,921,000
Plainfield Ridge	8,800	189,400	100%	189,400
Lower Cache-Putah	97,300	2,677,400	95%	2,543,530
Colusa	95,700	2,433,700	0%	0
Yolo Bypass	129,100	4,458,200	25%	1,114,550
Totals	**447,000**	**13,208,400**		**6,074,220**

[1]Represents the portion of each Groundwater Basin (as defined by Scott, 1975) that is contained within the Yolo Subbasin (as defined by the DWR). Percentages were estimated by DWR staff.

Groundwater Budget (Type C)

Currently no groundwater budget has been calculated for the Yolo Subbasin (see comments below).

Groundwater Quality

Groundwater found within the subbasin is characterized as a sodium magnesium, calcium magnesium, or magnesium bicarbonate type. The quality is considered good for both agricultural and municipal uses, even though it is hard to very hard overall (generally over 180 mg/l $CaCO_3$). Selenium and boron are found in higher concentrations locally (Evenson, 1985). Total dissolved solids range from a of 107 ppm to 1300 ppm and average 574 ppm, based on Title 22 data obtained from public supply water well samples (DHS, 2000).

Localized impairments include elevated concentrations of boron (as high as 2 to 4 ppm) in groundwater along Cache Creek and in the Cache Creek Settling Basin area, increased levels of selenium present in the groundwater supplies for the City of Davis, and localized areas of nitrate contamination (YCFCWCD 1992) (Evenson, 1985).

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	61	3
Radiological	53	0
Nitrates	67	1
Pesticides	59	0
VOCs and SVOCs	59	1
Inorganics – Secondary	61	11

Table: 1974 groundwater storage calculations based on Scott (1975):

Groundwater Basin (Scott, 1975)	Area (acres)	1974 Calculated Storage (Scott, 1975)	Estimated % area within Yolo Subbasin[1]	Estimated 1974 Storage within Yolo Subbasin[1]
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Upper Cache-Putah	70,300	1,921,000	100%	1,921,000
Plainfield Ridge	8,800	189,400	100%	189,400
Lower Cache-Putah	97,300	2,677,400	95%	2,543,530
Colusa	95,700	2,433,700	0%	0
Yolo Bypass	129,100	4,458,200	25%	1,114,550
Totals	**447,000**	**13,208,400**		**6,074,220**

[1]Represents the portion of each Groundwater Basin (as defined by Scott, 1975) that is contained within the Yolo Subbasin (as defined by the DWR). Percentages were estimated by DWR staff.

Groundwater Budget (Type C)

Currently no groundwater budget has been calculated for the Yolo Subbasin (see comments below).

Groundwater Quality

Groundwater found within the subbasin is characterized as a sodium magnesium, calcium magnesium, or magnesium bicarbonate type. The quality is considered good for both agricultural and municipal uses, even though it is hard to very hard overall (generally over 180 mg/l $CaCO_3$). Selenium and boron are found in higher concentrations locally (Evenson, 1985). Total dissolved solids range from a of 107 ppm to 1300 ppm and average 574 ppm, based on Title 22 data obtained from public supply water well samples (DHS, 2000).

Localized impairments include elevated concentrations of boron (as high as 2 to 4 ppm) in groundwater along Cache Creek and in the Cache Creek Settling Basin area, increased levels of selenium present in the groundwater supplies for the City of Davis, and localized areas of nitrate contamination (YCFCWCD 1992) (Evenson, 1985).

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	61	3
Radiological	53	0
Nitrates	67	1
Pesticides	59	0
VOCs and SVOCs	59	1
Inorganics – Secondary	61	11

Bear Creek. Bear Creek is the source of waters high in boron, and has an influence on water quality within Cache Creek and on groundwater extracted from Cache Creek deposits within the Capay and Sacramento Valleys (DWR 1961).

Groundwater Level Trends

Groundwater levels within most the Capay Valley Subbasin vary from approximately 10 to 40 feet below ground surface and remain relatively stable, even through dry years. Wells located in the higher elevations along the edge of the valley show a greater variability, and appear to be more impacted by dry years (DWR WDL 2001).

Groundwater Storage

Groundwater Storage for the Capay Valley region was calculated in DWR Bulletin 90 (1961) based on estimated specific yield values for three discrete intervals between the depths of 20 to 200 feet. It was estimated that the Groundwater Storage Capacity of the Capay Valley is approximately 99,800 acre-feet. It can be assumed that the **Groundwater in Storage** for the Capay Valley is roughly equal to the groundwater storage capacity, since water levels tend to remain at relatively shallow depths (see groundwater level trends, above).

Groundwater Budget (Type C)

The DWR Bulletin 90 (1961) provides estimates for the "safe yield of the presently developed water supply" for the Clear Lake-Cache Creek watershed for a six-year period between 1953 and 1959. Specific hydrologic data for the Capay Valley was lacking in this Bulletin, however it was estimated that the average annual safe yield for the Capay Valley over the 6-year study period was 7,300 acre-feet based on the average annual groundwater draft.

Groundwater Quality

Characterization. Groundwater quality within the Capay Valley Subbasin is derived almost exclusively from Cache Creek and its tributaries. Consequently, water quality samples taken from Cache Creek within the Capay Valley reflect the quality of the water within the groundwater basin. Water samples taken from a diversion dam near the lower end of the Capay Valley indicate principally good quality calcium-sodium bicarbonate-type with moderate to very high hardness. Highly mineralized water from Bear Creek and North Fork Cache Creek is a primary source of mineral constituents, especially Boron, in groundwater in the Capay Valley Subbasin (DWR 1961). Total dissolved solids measured in water taken from 6 wells in the Capay Valley ranges from approximately 300 to 500 ppm, and is comparable to that found in water samples taken from Cache Creek (EPA 2001, DWR 1961).

Impairments. Moderate to high levels of boron (1 to over 5 ppm) degrades the quality of water in Cache Creek. Boron levels of over 0.5 ppm are potentially harmful to boron sensitive crops, while levels higher than 2.0 ppm are potentially injurious to crops (DWR 1961).

Resources estimate the thickness to be approximately 500 feet (DWR 2000). Wells completed in the formation yield only moderate quantities of water.

Groundwater Level Trends

As part of a groundwater inventory analysis prepared for Butte County, the portion of the East Butte Subbasin located within Butte County was evaluated for seasonal and long-term changes in groundwater levels for confined and composite portions of the aquifer systems (DWR 2001).

For wells constructed in confined and composite portions of the aquifer, the increased use of groundwater in the northern portion of the subbasin has resulted in wide seasonal fluctuations in groundwater levels. In the northern portion of the subbasin, composite well fluctuations (composite wells are monitoring wells that represent groundwater levels that combine confined and unconfined portions of the aquifer system) average about 15 feet during normal years and 30- to 40- feet during drought years. Annual groundwater fluctuations in the confined and semi-confined aquifer system ranges from 15- to 30- feet during normal years.

In the portion of the subbasin located within the southern part of Butte County, groundwater level fluctuations for composite wells average about 4 feet during normal years and up to 10 feet during drought years. The groundwater fluctuations for wells constructed in the confined and semi-confined aquifer system average 4 feet during normal years and up to 5 feet during drought years.

Recharge Areas

Localized fluctuations in groundwater levels are observed just south of the Thermalito Afterbay due to the recharging of groundwater from this surface water system (DWR 2001).

Groundwater Storage

The storage capacity of the subbasin was estimated based on estimates of specific yield for the Sacramento Valley as developed in DWR (1978). Estimates of specific yield, determined on a regional basis, were used to obtain a weighted specific yield conforming to the subbasin boundary. The estimated specific yield for the East Butte Subbasin is 5.9 percent. The estimated storage capacity to a depth of 200 feet is approximately 3,128,959 acre-feet.

Groundwater Budget (Type B)

Estimates of groundwater extraction are based on surveys conducted by the California Department of Water Resources during 1993 and 1997. Surveys included landuse and sources of water. Estimates of groundwater extraction for agricultural; municipal and industrial; and environmental wetland uses are 104,000, 75,500 and 1,300 acre-feet respectively. Deep percolation of applied water is estimated to be 126,000 acre-feet.

Groundwater Quality

Characterization. Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate waters are the predominant groundwater water types in the subbasin. Magnesium bicarbonate waters occur locally near Biggs-Gridley, south and east to the Feather River. Total dissolved solids range from 122- to 570-mg/L, averaging 235 mg/L (DWR unpublished data).

Impairments. Localized high concentrations of manganese, iron, magnesium, total dissolved solids, conductivity, ASAR, and calcium occur within the subbasin.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	30	1
Radiological	25	0
Nitrates	32	2
Pesticides	16	0
VOCs and SVOCs	19	0
Inorganics – Secondary	30	3

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Production characteristics

Well yields (gal/min)

Irrigation	Range: 0 – 4500	Average: 1839 (37 Well Completion Reports)

Utility pump test records for the East Butte Subbasin show well yields ranging from a low of 65 gpm to a high of 5,459 gpm with an average yield of 1,602 gpm (DWR 2001).

Total depths (ft)

Domestic	Range: 25 – 639	Average: 101 (1477 Well Completion Reports)
Irrigation	Range: 35 – 983	Average: 285 (699 Well Completion Reports)

Active Monitoring Data

Agency	Parameter	Number of wells /measurement frequency
DWR	Groundwater levels	43 wells semi-annually
DWR	Miscellaneous water quality	4 wells biennially
Department of Health Services	Miscellaneous water quality	44

Groundwater Storage

Groundwater Storage Capacity. The storage capacity for the entire Redding Basin is estimated to be 5.5 million acre-feet for 200 feet of saturated thickness over an area of approximately 510 square miles (Pierce 1983). Specific yield data for the Bowman Subbasin aquifer system is not available to estimate storage capacity at the subbasin level.

Groundwater Budget (Type B)

Estimates of groundwater extraction are based on surveys conducted by the California Department of Water Resources during 1994 and 1995. Surveys included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 350 and 9 acre-feet respectively. Deep percolation of applied water is estimated to be 1,500 acre-feet.

Groundwater Quality

Characterization. Groundwater in the subbasin is characterized as magnesium-calcium bicarbonate and calcium-magnesium bicarbonate type waters. Total dissolved solids concentrations range from 70- to 247-mg/L (DWR unpublished data).

Impairments. Groundwater impairments include localized high boron concentrations.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	6	0
Radiological	5	0
Nitrates	6	0
Pesticides	5	0
VOCs and SVOCs	5	0
Inorganics – Secondary	6	1

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

streamflows, and direct infiltration of precipitation are the main sources of recharge into the alluvium (Pierce 1983).

Groundwater Level Trends

Review of the hydrographs for long-term comparison of spring-spring groundwater levels indicates a slight decline in groundwater levels associated with the 1976-77 and 1987-94 droughts, followed by a recovery to pre-drought conditions of the early 1970's and 1980's. Generally, groundwater levels have a seasonal fluctuation of approximately 5- to 10-feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels.

Groundwater Storage

Groundwater Storage Capacity. The storage capacity for the entire Redding Basin is estimated to be 5.5 million acre-feet for 200 feet of saturated thickness over an area of approximately 510 square miles (Pierce 1983). Specific yield data for the Rosewood Subbasin aquifer system is not available to estimate storage capacity at the subbasin level.

Groundwater Budget (Type B)

Estimates of groundwater extraction are based on surveys conducted by the California Department of Water Resources during 1994 and 1995. Surveys included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 680 and 990 acre-feet respectively. Deep percolation of applied water is estimated to be 1,200 acre-feet.

Groundwater Quality

Characterization. Groundwater in the subbasin is characterized as magnesium-calcium bicarbonate and calcium-magnesium bicarbonate type waters. Total dissolved solids concentrations range from 118- to 218-mg/L (DWR unpublished data).

Impairments. No impairments have been identified.

Well Characteristics

	Well yields (gal/min)	
Irrigation	No known data	
	Total depths (ft)	
Domestic	Range: 48 – 398	Average: 181 (447 Well Completion Reports)
Irrigation	Range: 65 – 565	Average: 311 (15 Well Completion Reports)

Groundwater Budget (Type B)

Estimates of groundwater extraction are based on surveys conducted by the California Department of Water Resources during 1994 and 1995. Surveys included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 3,000, and 20,000 acre-feet respectively. Deep percolation of applied water is estimated to be 5,700 acre-feet.

Groundwater Quality

Characterization. Groundwater in the basin is characterized as magnesium-sodium bicarbonate and sodium-magnesium bicarbonate type waters. Total dissolved solids concentrations range from 109- to 320-mg/L, averaging 194 mg/L (DWR unpublished data).

Impairments. Localized areas with high iron, manganese, and nitrate occur in the subbasin.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	19	0
Radiological	31	0
Nitrates	20	0
Pesticides	13	0
VOCs and SVOCs	17	0
Inorganics – Secondary	19	1

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

	Well yields (gal/min)	
Irrigation	Range: 0 – 1800	Average: 46 (40 Well Completion Reports)
	Total depths (ft)	
Domestic	Range: 11 – 805	Average: 140 (2239 Well Completion Reports)
Irrigation	Range: 32 – 558	Average: 302 (48 Well Completion Reports)

Groundwater Budget (Type B)

Estimates of groundwater extraction are based on a survey conducted by the California Department of Water Resources in 1995. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 4,449 and 4,127 acre-feet respectively. Deep percolation from applied water is estimated to be 3,788 acre-feet.

Groundwater Quality

Characterization. Magnesium-sodium bicarbonate is the predominate water type in the subbasin. Sodium bicarbonate and sodium chloride type waters are also found. Total dissolved solids range from 160- to 210-mg/L (DWR unpublished data).

Impairments. High levels of total dissolved salts and chlorides are present in the lower Tehama and Tuscan Formations. Sodium and boron is present at shallow depth where wells draw from the Chico Formation. Locally high concentrations of iron and manganese occur in the basin.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	18	0
Radiological	19	0
Nitrates	17	0
Pesticides	7	0
VOCs and SVOCs	14	0
Inorganics – Secondary	18	7

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

	Well yields (gal/min)	
Irrigation	Range: 30 – 700	Average: 266 (5 Well Completion Reports)
	Total depths (ft)	
Domestic	Range: 18 – 713	Average: 139 (1970 Well Completion Reports)
Irrigation	Range: 32 – 460	Average: 180 (65 Well Completion Reports)

included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 250 and 1,273 acre-feet respectively. Deep percolation of applied water is estimated to be 912 acre-feet.

Groundwater Quality

Characterization. Groundwater in the basin is characterized as bicarbonate type waters with mixed cationic character. Some sodium chloride type waters occur locally. Total dissolved solids concentration is approximately 140 mg/L (DWR unpublished data).

Impairments. High concentrations of total dissolved salts and chlorides are present in underlying marine deposits. Groundwater containing sodium and boron occurs where wells draw from the Chico Formation. Locally high iron and manganese concentrations can occur.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	1	0
Radiological	1	0
Nitrates	1	0
Pesticides	1	0
VOCs and SVOCs	1	0
Inorganics – Secondary	1	0

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

	Well yields (gal/min)	
Irrigation	Range: 8 – 500	Average: 254 (2 Well Completion Reports)
	Total depths (ft)	
Domestic	Range: 40 – 650	Average: 156 (487 Well Completion Reports)
Irrigation	Range: 50 – 700	Average: 265 (8 Well Completion Reports)

Groundwater Quality

Characterization. Groundwater in the subbasin is typed as bicarbonate water with mixed cationic character. The concentration of total dissolved solids is approximately 360 mg/L (DWR unpublished data). There are no known groundwater impairments.

Well Characteristics

	Well yields (gal/min)	
Irrigation	No known data	
	Total depths (ft)	
Domestic	Range: 80 – 884	Average: 189 (18 Well Completion Reports)
Irrigation	Range: 170 – 270	Average: 227 (5 Well Completion Reports)

Active Monitoring Data

Agency	Parameter	Number of wells /measurement frequency
	Groundwater levels	0
	Miscellaneous Water Quality	0

Basin Management

Groundwater management:	Tehama County adopted a countywide AB 3030 groundwater management plan in 1996. Tehama County adopted a groundwater management ordinance in 1994.
Water agencies	
Public	Tehama County Flood Control and Water Conservation District.
Private	

References Cited

Helley EJ, Harwood DS. 1985. Geologic Map of the Late Cenozoic Deposits of the Sacramento Valley and Northern Sierran Foothills, California. Map MF-1790.

Pierce MJ. 1983. Ground Water in the Redding Basin Shasta and Tehama Counties California. Water-Resources Investigations Report 83-4052.

California Department of Water Resources. 1964. Shasta County Investigation. Appendixes E through P. Bulletin 22.

Additional References

Bailey EH. 1966. Geology of Northern California. California Division of Mines and Geology. Bulletin 190.

Groundwater Quality

Characterization. Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. Total dissolved solids (TDS) concentrations range from 120- to 500-mg/L and average 207 mg/L (DWR unpublished data).

Impairments. Impairments include high magnesium, TDS, calcium, ASAR, and phosphorus.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	41	2
Radiological	33	0
Nitrates	41	0
Pesticides	23	0
VOCs and SVOCs	16	0
Inorganics – Secondary	41	4

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

	Well yields (gal/min)	
Municipal/Irrigation	Range: 50 – 1,200	Average: 363 (4 Well Completion Reports)
	Total depths (ft)	
Domestic	Range: 20 – 780	Average: 197 (3293 Well Completion Reports)
Municipal/Irrigation	Range: 22 – 465	Average: 207 (18 Well Completion Reports)

of Stony Creek. This area includes a moderately well-defined, highly productive, shallow water-bearing zone reaching a thickness of 150 feet along Stony Creek and 110 feet along the Sacramento River. Domestic and shallow irrigation wells along the west side of Capay plain and south of the Tehama County line provide moderate-to-high yields from confined groundwater in 10- to 50-foot thicknesses of highly pervious pebble and cobble gravels. In the northwest part of Capay plain, older alluvium of the Riverbank Formation extends from the surface to 150 feet. Wells in this zone have low-to-moderate yields. This zone is underlain by a highly productive confined gravel averaging 40 feet in thickness (USBR 1960).

Groundwater Level Trends

Review of hydrographs for long-term comparison of spring-spring groundwater levels indicates a decline of 5- to 12-feet associated with the 1976-77 and 1987-94 droughts, followed by a recovery to pre-drought conditions of the early 1970's and 1980's. Groundwater level data show seasonal fluctuations of approximately 3- to 15-feet for unconfined wells (5-feet near the Sacramento River), up to 30-feet for semi-confined wells away from the river, 5- to 20-feet for composite wells, and 10- to 30-feet for confined wells. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels.

Groundwater Budget (Type B)

Estimates of groundwater extraction for the Corning Subbasin are based on surveys conducted during the years of 1993, 1994, and 1997. Surveys included landuse and sources of water. Groundwater extraction for agricultural use is estimated to be 152,000 acre-feet. Groundwater extraction for municipal and industrial uses is estimated to be 6,600 acre-feet. Deep percolation of applied water is estimated to be 54,000 acre-feet.

Groundwater Storage

The storage capacity of the subbasin was estimated based on estimates of specific yield for the Sacramento Valley as developed in DWR (1978). Estimates of specific yield, determined on a regional basis, were used to obtain a weighted specific yield conforming to the subbasin boundary. The estimated specific yield for the subbasin is 6.7 percent. The estimated storage capacity to a depth of 200 feet is approximately 2,752,950 acre-feet.

Groundwater Quality

Characterization. Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. The subbasin has localized areas of calcium bicarbonate waters near Stony Creek. Total dissolved solids concentrations range from 130-to 490-mg/L, averaging 286 mg/L (DWR unpublished data).

Impairments. The Corning Subbasin has locally high calcium.

Unit A is the oldest water bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone and siltstone.

Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates in the eastern and northern parts of mapped unit. The formation is approximately 430 feet thick.

Unit C is the primary surficial deposit and consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. The thickness of Unit C exposed in the vicinity of Tuscan Springs and Tuscan Buttes ranges from 165- to 265-feet.

Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The deposit varies in thickness from 30- to 160-feet.

Groundwater Level Trends

Groundwater level monitoring is not conducted in the subbasin.

Groundwater Storage

Groundwater Storage Capacity. No published information was found for groundwater storage in the subbasin.

Groundwater Budget (Type B)

Estimates of groundwater extraction are based on a survey conducted by the California Department of Water Resources 1994. Surveys included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 220 and 120 acre-feet respectively. Deep percolation from applied water is estimated to be 340 acre-feet.

Groundwater Quality

Characterization. Groundwater in the subbasin is characterized as magnesium-calcium bicarbonate. Total dissolved solids (TDS) range from 334- to 360- mg/L (DWR unpublished data).

Impairments. Localized high calcium concentrations occur in the basin.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	1	0
Radiological	1	0
Nitrates	1	0
Pesticides	0	0
VOCs and SVOCs	0	0
Inorganics – Secondary	1	0

Sacramento River banks. The formation consists of fluvial deposits of predominantly silt and clay with gravel and sand interbeds (DWR 1987). The formation is identified within the subbasin at depths ranging from 100- to 150- feet (DWR 1987).

Recharge Areas

Recharge is from inflow from the Sacramento River, Salt Creek, and Antelope Creek. In an investigation conducted by U.S. Bureau of Reclamation, the upper and intermediate aquifer zones (located between the local groundwater elevation and 150 feet in depth) intercept the Sacramento River. Diurnal fluctuations in river stage produce diurnal water level fluctuations in the deeper aquifer zone (Ely 1994).

Restrictive Structures

The Inks Creek fold system is a series of northeast-trending folds north of the Antelope Subbasin. The system isolates the Redding Groundwater Basin from the Sacramento Valley Basin. The fold system is a hydrologic drainage divide and separates the Red Bluff Arch from the Chico Monocline (DWR 1987).

Groundwater Level Trends

Review of hydrographs for long-term comparison of spring-spring groundwater levels indicates a decline of 5- to 10-feet associated with the 1976-77 and 1987-94 droughts, followed by a recovery to pre-drought conditions of the early 1970's and 1980's. Generally, groundwater level data show a seasonal fluctuation of approximate 2- to 15-feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in groundwater levels.

Groundwater Storage

The storage capacity of the subbasin was estimated based on estimates of specific yield for the Sacramento Valley as developed in DWR (1978). Estimates of specific yield, determined on a regional basis, were used to obtain a weighted specific yield conforming to the subbasin boundary. The estimated specific yield for the subbasin is 7.2 percent. The estimated storage capacity to a depth of 200 feet is approximately 269,179 acre-feet.

Groundwater Budget (Type B)

Estimates of groundwater extraction for the Antelope Subbasin are based on a survey conducted by the California Department of Water Resources in 1994. The survey included landuse and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 17,000 and 2,100 acre-feet respectively. Deep percolation of applied water is estimated to be 3,800 acre-feet.

Groundwater Quality

Characterization. Groundwater in the subbasin is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. Total dissolved solids (TDS) range from 119- to 558- mg/L, averaging 280 mg/L (DWR unpublished data).

Impairments. High concentrations of boron, chloride, and TDS are found in groundwater in the vicinity of Salt Creek and Little Salt Creek. Nitrate concentrations of 20- to 45- mg/L have been observed within the west-central portion of the basin (DWR 1987).

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	17	0
Radiological	10	0
Nitrates	17	0
Pesticides	6	0
VOCs and SVOCs	3	0
Inorganics – Secondary	17	3

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

	Well yields (gal/min)	
Municipal/Irrigation	Range: 300 – 800	Average: 575 (4 Well Completion Report)
	Total depths (ft)	
Domestic	Range: 40 - 450	Average: 104 (702 Well Completion Reports)
Municipal/Irrigation	Range: 40 - 600	Average: 176 (92 Well Completion Reports)

Active Monitoring Data

Agency	Parameter	Number of wells /measurement frequency
DWR	Groundwater levels	4 wells semi-annually
DWR	Miscellaneous water quality	5 wells biennially
Department of Health Services	Miscellaneous water quality	22

Groundwater Budget (Type B)

Estimates of groundwater extraction for the Dye Creek Subbasin are based on a survey conducted by the California Department of Water Resources in 1994. The survey included landuse and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 9,300 and 680 acre-feet respectively. Deep percolation of applied water is estimated to be 3,200 acre-feet.

Groundwater Quality

Characterization. Groundwater in Antelope, Dye Creek, Los Molinos, and Vina subbasins is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. Total dissolved solids (TDS) range from 119- to 558-mg/L, averaging 280 mg/L (DWR unpublished data).

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	2	0
Radiological	2	0
Nitrates	2	0
Pesticides	1	0
VOCs and SVOCs	0	0
Inorganics – Secondary	2	0

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

	Well yields (gal/min)	
Municipal/Irrigation	Range: 200 –3300	Average: 890 (5 Well Completion Reports)
	Total depths (ft)	
Domestic	Range: 19 – 220	Average: 94 (432 Well Completion Reports)
Municipal/Irrigation	Range: 55 –597	Average: 188 (56 Well Completion Reports)

Groundwater Quality

Groundwater in Antelope, Dye Creek, Los Molinos, and Vina subbasins is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. Total dissolved solids (TDS) range from 119- to 558-mg/L, averaging 280 mg/L (DWR unpublished data).

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	6	0
Radiological	6	0
Nitrates	6	0
Pesticides	4	0
VOCs and SVOCs	3	0
Inorganics – Secondary	6	0

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Production characteristics

	Well yields (gal/min)	
Municipal/Irrigation		
	Total depths (ft)	
Domestic	Range: 31 – 340	Average: 92 (311 Well Completion Reports)
Irrigation	Range: 27 – 740	Average: 327 (42 Well Completion Reports)

Active Monitoring Data

Agency	Parameter	Number of wells /measurement frequency
DWR	Groundwater levels	3 wells semi-annually
Department of Health Services	Miscellaneous water quality	9

Evaluation of groundwater level data at the northern edge of the California Water Service area (just north of Chico) shows an average seasonal fluctuation in groundwater levels of approximately 10 feet during years of normal precipitation. Long-term comparison of spring to spring groundwater levels shows a decline in levels associated with the above drought periods with recovery to pre-drought conditions of the early 1970's. Further long-term comparison of spring to spring groundwater levels indicates a 10- to 15-foot decline in groundwater levels since the 1950's (DWR 2001).
Areas unaffected by municipal water use reflect the natural groundwater table distribution and direction of movement. Year-round extraction of groundwater for municipal use in the Chico area causes several small groundwater depressions that tend to alter the natural southwesterly movement of groundwater in the area (DWR 2001). In the Chico area, groundwater levels in the unconfined portion of the aquifer system is about 5- to 7-feet during normal precipitation and up to approximately 16 feet during periods of drought. Annual fluctuation in the confined or semi-confined portion of the aquifer system is approximately 15- to 25-feet during normal years and up to approximately 30 feet during periods of drought. Long-term comparison of spring to spring groundwater levels for confined or semi-confined portions of the aquifer system indicates a 10 to 15-foot decline in groundwater levels since the 1950s.

Groundwater Storage

The storage capacity of the subbasin was estimated based on estimates of specific yield for the Sacramento Valley as developed in DWR (1978). Estimates of specific yield, determined on a regional basis, were used to obtain a weighted specific yield conforming to the subbasin boundary. The estimated specific yield for the Vina Subbasin is 5.9 percent. The estimated storage capacity to a depth of 200 feet is approximately 1,468,239 acre-feet.

Groundwater Budget (Type B)

Estimates of groundwater extraction for the Vina Subbasin are based on surveys conducted by the California Department of Water Resources during the years 1993, 1994, and 1997. Surveys included landuse and sources of water. Estimate of groundwater extraction for agricultural use is estimated to be 130,000 acre-feet. Municipal and industrial use is approximately 20,000 acre-feet. Deep percolation of applied water is estimated to be 30,000 acre-feet.

Groundwater Quality

Characterization. Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. Total dissolved solids range from 48- to 543-mg/L, averaging 285 mg/L (DWR unpublished data).

Impairments. Impairments include localized high calcium and high nitrates and total dissolved solids in the Chico area.

Groundwater Level Trends

As early as 1960 groundwater levels showed a well-developed cone of depression beneath the South Yuba basin. Water levels in the center of the cone of depression were just below sea level. Nearly all water levels were well below adjacent river levels on the Bear, Feather, and Yuba Rivers. Groundwater conditions in 1984 reflect a continued reliance on ground water pumping in the South Yuba Basin. Water levels in the center of the South Yuba cone of depression had fallen to 30 feet below sea level. The water level contours adjacent to the Bear and Yuba Rivers indicated a large gradient and seepage from the rivers. By 1990, water levels in the South Yuba Basin cone of depression rose to 10 feet above sea level. The rise in water levels was due to increasing surface water irrigation supplies and reduced groundwater pumping. Current DWR records indicate groundwater levels continue to increase. Bookman-Edmonston Engineering, Inc. (1992)

Groundwater Storage

Groundwater Storage Capacity. An unpublished study by Bookman-Edmonston Engineering, Inc. (1992) estimated groundwater storage in the South Yuba basin. The estimated storage capacity for the South Yuba basin is 1,090,000 acre-feet. This estimate was based on an area of 88,700 acres, which closely corresponds to boundaries used by DWR. The Bookman-Edmonston Engineering, Inc. calculated an average specific yield of 6.9 percent and an assumed thickness of 200 feet.

Groundwater in Storage. There are no published reports, which discuss groundwater in storage.

Groundwater Budget (Type A)

Previous DWR unpublished studies have estimated natural and applied recharge. DWR has also estimated urban and agriculture extractions and subsurface outflow. Basin inflows include natural recharge of 53,700 af, and applied water recharge of 26,000 af. Outflows include urban extraction of 6,000 af, agricultural extraction of 93,400 af, and subsurface outflow of 24,900 af.

Groundwater Quality

Characterization. The generally good water quality characteristics are apparent in the overall salinity of ground water in the study area. In general, total dissolved solids (TDS) concentrations in the study area are below 500 milligrams per liter (mg/l) throughout the entire basin. Bookman-Edmonston Engineering, Inc. (1992). DWR maintains data for 27 water quality wells in the South Yuba Subbasin. Data collected from these wells indicate a TDS range of 141 to 686 mg/l and a median of 224mg/l. The primary water chemistry in the area, mapped by Bertoldi (1991) indicates calcium magnesium bicarbonate or magnesium calcium bicarbonate groundwater. Some magnesium bicarbonate can be found in the northwest portion of the basin.

Impairments. There are no documented impairments to groundwater quality in the subbasin.

Between depths of 100- to 200-feet the proportion is reduced to 24 percent. The percentage of sand and gravel for deposits extending northward from Cache Creek averages 22 percent for the 20- to 200-foot interval. Farther east the proportion increases to 36 percent for the same depth interval (Olmsted and Davis 1961). Tehama deposits are penetrated in the depth interval of 100- to 200-feet.

Groundwater Level Trends

Review of hydrographs for long-term comparison of spring-spring groundwater levels indicates a slight decline in groundwater levels associated with the 1976-77 and 1987-94 droughts, followed by recovery to pre-drought conditions of the early 1970's and 1980's. Some wells increased in levels beyond the pre-drought conditions of the 1970's during the wet season of the early 1980's. Generally, groundwater level data show an average seasonal fluctuation of approximate 5-feet for normal and dry years. Overall there does not appear to be any increasing or decreasing trends in groundwater levels.

Groundwater Storage

The storage capacity of the subbasin was estimated based on estimates of specific yield for the Sacramento Valley as developed in DWR (1978). Estimates of specific yield, determined on a regional basis, were used to obtain a weighted specific yield conforming to the subbasin boundary. The estimated specific yield for the subbasin is 7.1 percent. The estimated storage capacity to a depth of 200 feet is approximately 13,025,887 acre-feet.

Groundwater Budget (Type B)

Estimates of groundwater extraction for the Colusa Subbasin are based on surveys conducted by the California Department of Water Resources during 1993, 1994, and 1999. Surveys included landuse and sources of water. Estimates of groundwater extraction for agricultural, municipal and industrial, and environmental wetland uses are 310,000, 14,000 and 22,000 acre-feet respectively. Deep percolation from applied water is estimated to be 64,000 acre-feet.

Groundwater Quality

Characterization. Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. Calcium bicarbonate waters occur locally from Orland to Artois and near Stony Creek. Mixed character waters for different regions of the subbasin occur as follows: sodium bicarbonate waters from Williams-Colusa south to Grimes; magnesium-sodium bicarbonate or sodium-magnesium bicarbonate waters near Williams-Arbuckle area and locally near Zamora; and magnesium bicarbonate waters locally near Dunnigan. Total dissolved solids (TDS) values range from 120- to 1,220-mg/L, averaging 391 mg/L (DWR unpublished data).

Impairments. High EC, TDS, adjusted sodium absorption ratio (ASAR), nitrate, and manganese impairments occur near Colusa. High TDS and boron occur near Knights Landing. High nitrates occur in Arbuckle, Knights

Landing, and Willows. Localized areas have high manganese, fluoride, magnesium, sodium, iron, ASAR, chloride, TDS, ammonia, and phosphorus.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of wells sampled[2]	Number of wells with a concentration above an MCL[3]
Inorganics – Primary	103	0
Radiological	57	0
Nitrates	109	2
Pesticides	64	0
VOCs and SVOCs	58	0
Inorganics – Secondary	103	18

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

	Well yields (gal/min)	
Municipal/Irrigation	Range 25 – 5,600	Average: 1,967 (109 Well Completion Reports)
	Total depths (ft)	
Domestic	Range: 11 to 870	Average: 155 (2,599 Well Completion Reports)
Municipal/Irrigation	Range 20 to 1340	Average: 368 (1,515 Well Completion Reports)

Active Monitoring Data

Agency	Parameter	Number of wells /measurement frequency
DWR	Groundwater levels	98 wells semi-annually
DWR	Miscellaneous water quality	30 wells biennially
Department of Health Services	Miscellaneous water quality	134

Recharge Areas

DWR, Bulletin 118-6, indicates stream percolation, deep percolation of rainwater, and percolation of irrigation water are the principal sources of groundwater recharge in the Sacramento Valley.

Groundwater Level Trends

Current DWR records indicates groundwater levels have remained relatively constant. DWR hydrographs indicate a shallow-depth water table. Most groundwater levels in Sutter Subbasin tend to be within about 10 feet of ground surface. (DWR, 1992)

Groundwater Storage

Groundwater Storage Capacity. DWR's 1992 California Water Plan estimated a useable storage potential of five million-acre feet for Sutter County. There are no published reports, which specifically discuss the amount of groundwater in storage for the Sutter Subbasin.

Groundwater in Storage. There are no published reports, which specifically discuss the amount of groundwater in storage. A change in storage is discussed in DWR, Bulletin 6, 1952 and Bulletin 118-6, 1978.

Groundwater Quality

Characterization. DWR maintains data for 38 water quality wells in the Sutter Subbasin. Data collected from these wells indicate a TDS range of 133 to 1,660 mg/l. The primary groundwater chemistry in the subbasin is calcium, magnesium, sodium, chloride, sulfate and bicarbonate, which may occur in any combination. Groundwater containing calcium magnesium bicarbonate or magnesium calcium bicarbonate can be found in the northwest portion of the subbasin (Bertoldi, 1991). Recent groundwater quality data collected indicates some wells drilled to various depths contain chemical elements and compounds in amounts that exceed drinking water quality safety and aesthetic standards. (PMC, 1996).

Impairments. Groundwater resources in some portions of the County have naturally occurring levels of minerals, which present some concerns. Groundwater quality is expected to deteriorate unless additional steps are taken to decrease the amounts of contaminants that exist in the ground and are applied to the ground. Steps also must be taken to decrease the ability of wells and other excavations to transmit contaminants from upper regions of the ground to lower regions that provide well water. (PMC, 1996).

Groundwater Budget (Type B)

As part of its water planning process, DWR estimated the following components of the ground water budget for the entire Sutter Subbasin. The calculations are for a 1990 level of development. Estimated inflows include natural recharge at 40,000 acre-feet and applied water recharge at 22,100 acre-feet. There was no artificial recharge. Estimated outflows include urban extraction at 3,900 acre-feet and agricultural extraction at 171,400 acre-feet.

351,000 acre subbasin. This results in an estimated storage capacity of approximately 4.9 million acre-feet.

Groundwater in Storage. There are no known published reports that discuss groundwater in storage.

Groundwater Budget (Type B)

As part of its water planning process, DWR estimated the following components of the groundwater budget. The calculations are for a 1990 level of development. Estimated inflows include natural recharge at 83,800 acre-feet and applied water recharge at 29,800 acre-feet. There was no artificial recharge. Estimated outflows include urban extraction at 109,900 acre-feet and agricultural extraction at 289,100 acre-feet.

Groundwater Quality

Characterization. The chemistry and quality of groundwater has been assessed for the American Basin. Many areas of good quality groundwater exist in the North American subbasin. In some portions of the basin groundwater quality is marginal. The three major groundwater types are: magnesium calcium bicarbonate or calcium magnesium bicarbonate; magnesium sodium bicarbonate or sodium magnesium bicarbonate; and sodium calcium bicarbonate or calcium sodium bicarbonate (DWR 1997).

Comparison of groundwater quality data with applicable water quality standards and guidelines for drinking and irrigation indicate elevated levels of TDS/specific conductance, chloride, sodium, bicarbonate, boron, fluoride, nitrate, iron manganese, and arsenic may be of concern in some locations within the subbasin (DWR 1997).

High TDS levels exist in an area along the Sacramento River extending from Sacramento International Airport northward to the Bear River. The highest levels of TDS are found in an area extending just south of Nicholas to Verona, between Reclamation District 1001 and the Sutter Bypass. Some wells in this area have reported TDS exceeding 1,000 mg/L.

This same area along the Sacramento River extending from Sacramento International Airport northward to the Bear River also contains high levels of chloride, sodium, bicarbonate, manganese, and arsenic. The groundwater in the southern part of the basin is generally characterized as good quality, low in disinfection by-product precursor materials and moderate in mineral content, although some localized contamination issues do exist.

Impairments. There are three sites within the subbasin with significant groundwater contamination issues: the former McClellan AFB, Union Pacific Railroad Rail Yard in Roseville and the Aerojet Superfund Site. Although the Aerojet site lies south of the North American subbasin, a contaminant plume (including TCE and PCE) extends north from Aerojet, under the American River and into the North American subbasin (Montgomery Watson 2000). Other localized areas of contamination exist throughout the basin and are generally smaller in scope and extent of contamination.