Sacramento Valley Groundwater Basin, Colusa Subbasin

- Groundwater Basin Number: 5-021.52
- County: Colusa, Glenn, Tehama, Yolo
- Surface Area: 918,380 acres (1,434 square miles)

Basin Boundaries and Hydrology

The portion of the Sacramento Valley that comprises the Colusa Subbasin is bounded on the east by the Sacramento River, on the west by the Coast Range and foothills, on the south by Cache Creek, and on the north by Stony Creek. Annual precipitation ranges from 17- to 27-inches with higher precipitation occurring to the west.

Hydrogeologic Information

Water-Bearing Formations

The Colusa Subbasin aquifer system is composed of continental deposits of late Tertiary to Quaternary age. Quaternary deposits include Holocene stream channel and basin deposits and Pleistocene Modesto and Riverbank formations. The Tertiary deposits consist of the Pliocene Tehama Formation and the Tuscan Formation. Except where noted, the following information is taken from USBR (1960).

Holocene Stream Channel Deposits. These deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Tehama Formation and Quaternary stream terrace deposits. The thickness varies from 1- to 80-feet (Helley and Harwood 1985). These deposits represent the upper part of the unconfined zone of the aquifer and are moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

Holocene Basin Deposits. These deposits are the result of sediment-laden floodwaters that rose above natural levees of streams and rivers and spread across low-lying areas. They consist primarily of silts and clays and may be locally interbedded with stream channel deposits along the Sacramento River. Thickness of the unit ranges up to 150 feet. These deposits have low permeability and generally yield low quantities of water to wells. The quality of groundwater produced from basin deposits is often poor.

Pleistocene Modesto and Riverbank Formations. Terrace deposits include the Modesto Formation (deposited between 14,000 and 42,000 years ago) and the Riverbank Formation (deposited between 130,000 and 450,000 years ago). The Modesto deposits consist of moderately to highly permeable gravels, sands, and silts. Thickness of the formation ranges from less than 10 feet to nearly 200 feet across the valley floor (Helley and Harwood 1985). The Riverbank deposits are the older terrace deposits that occur at a higher topographic level and consist of poorly to highly pervious pebble and small cobble gravels interlensed with reddish clay, sand, and silt. Thickness of the formation ranges from less than 1 foot to over 200 feet depending on location. The formation yields moderate quantities of water to domestic and shallow irrigation wells and also provides water to deeper irrigation wells that have multiple zones of perforation. Generally, the thickness of the formation limits the water-bearing capabilities.

Pliocene Tehama Formation. The Tehama Formation is the predominant water-bearing unit within the Colusa Subbasin and reaches a thickness of 2,000 feet (Olmsted and Davis 1961). The formation occurs at depths ranging from a few feet to several hundred feet from the surface. The formation consists of moderately compacted silt, clay, and fine silty sand enclosing lenses of sand and gravel; silt and gravel; and cemented conglomerate. Occasional deep sands and thin gravels constitute a poorly to moderately productive, deep, water-bearing zone.

Pliocene Tuscan Formation. The Tuscan Formation occurs in the northern portion of the subbasin at an approximate depth of 400 feet from the surface and may extend to the west to the Greenwood Anticline east of Interstate Highway 5 (DWR 2000). The formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. The formation is described as four separate but lithologically similar units, A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units (Helley and Harwood 1985).

Units A, B, and C are found within the subbasin. 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. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B.

Subareas of the Colusa Subbasin

Stony Creek Fan. The Stony Creek Fan occupies the northern extent of the subbasin and extends from Black Butte Reservoir to the City of Willows, northeast from the City of Willows to the Sacramento River, and north beyond the Tehama County line. The geologic units within the fan area include Holocene alluvial deposits, Pleistocene deposits of the Riverbank and Modesto formations, and Pliocene deposits of the Tehama and Tuscan formations.

Holocene alluvial deposits are observed along Stony Creek to the north and along the Sacramento River to the east. Modesto and Riverbank deposits extend to the east along Stony Creek and south and southeast within several ancestral stream channels (DWR 2000). Older alluviated floodplain and channel deposits reach a thickness of 150 feet at Stony Creek and 110 feet along the Sacramento River.

Thick clays of the upper Tehama Formation underlie the intermediate water-bearing zone of the Stony Creek plain at a depth of 300 feet, rising to a minimum depth of 40 feet on the axis of the Willows anticline. Wells installed 4 miles east of Highway 99W intersect occasional Tehama Formation gravels between 225- and 625-foot depths.

Tuscan Units A, B, and C are believed to extend into the Colusa Subbasin north of the City of Willows. The sediments of the Tuscan Formation interfinger with the sediments of the Tehama Formation in the subsurface (Lydon 1969). The degree of hydraulic conductivity between the Tuscan Formation, the Tehama Formation, and the overlying Stony Creek fan deposits has not been established.

Willows-to-Williams Plain. Basin deposits overlie much of the flat alluvial plains in the area between Willows and Williams. Permeabilities of the near-surface soils are extremely low. Riverbank deposits are observed along the western subbasin boundary north of Maxwell. The interstream areas of the westside creeks contain little gravel and are underlain by a poorly pervious, occasionally alkaline, claypan soil. The Tehama Formation contains little gravel and is not an important water-bearing material in this region.

Arbuckle and Dunnigan Plains. Quaternary surface deposits of alluvium, Modesto and Riverbank formations, and basin deposits in the Arbuckle and Dunnigan plains occur east of Hungry Hollow and Dunnigan hills from Williams to Cache Creek. Basin deposits overlie older alluvial deposits. The region north of Arbuckle is alluviated to depths of 20- to 60-feet with moderately to highly permeable sands and gravels from Sand and Cortina creeks. This zone extends east of Highway 99W and, in the College City area, appears to be Sacramento River channel deposits. The area between Salt and Petroleum creeks is composed of poorly to moderately permeable gravels, clayey sands, and silts. Petroleum and Little Buckeye creeks have deposited a thin, moderately to highly permeable sandy gravel and sandy silts over older stream and terrace alluvium.

The area in the vicinity of Zamora is underlain by a homogeneous section of gravels, sands, and interbedded clays to minimum depths of 450 feet. Water producing members range from 25- to 35- percent of total material penetrated. Well production is high within gravel channels.
A poorly to highly productive water-bearing zone consisting of older alluvial deposits and Tehama deposits on the western and southwestern edges of the Arbuckle Plain ranges in depth from 100- to 300-feet. The zone thickens easterly to depths of 400- to 450-feet.

Tehama deposits coarsen in this area and are an important water-bearing unit. The upper 800- to 900-feet contains 10- to 13-percent fine pebble gravel with a well-sorted, fine to medium sand matrix. This portion of the Tehama Formation is highly pervious, loose, and well bedded. The gravel beds range from 5- to 20-feet in thickness and are well confined within a silt and clayey silt section.

Cache Creek Floodplain. Holocene stream channel deposits are observed along the entire extent of Cache Creek (DWR 2000). The Cache Creek area is alluviated with floodplain deposits which are exposed north of the town of Yolo and extend to Knights Landing. The relative proportion of sand and gravel for the depth interval of 20- to 100-feet is approximately 27 percent.

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

Basin Management

Groundwater management:	Tehama County adopted a groundwater management ordinance in 1994. Glenn County adopted a groundwater management ordinance in 2000. Colusa County adopted a groundwater management ordinance in 1998. Yolo County adopted a groundwater management ordinance in 1996. Reclamation District No. 787 adopted a groundwater management plan in Feb. 1997 and the plan was amended on November 16, 2005.
Water agencies	
Public	Knights Landing WUA, Orland Unit WUA. Cortina Creek FC&WCD, Colusa County FC&WCD, and Yolo County FC&WCD, Artois CSD, Butte City CSD, Hamilton City CSD, NE Willows CSD, Ord CSD, City of Colusa, City of Orland, City of Williams, 4-M WD, Chrome WD, Colusa County WD, Cortina WD, Davis WD, Dunnigan WD, Glenn Valley WD, Glide WD, Holthouse WD, Kanawha WD, La Grande WD,Orland-Artois WD, Princeton WD, Westside WD, and Yolo-Zamora WD, Glenn-Colusa ID, Maxwell ID, Princeton-Cordora-Glenn ID, Provident ID, Maxwell ID, RD 108, RD 478, RD 730, RD 787, RD 1004, RD 2047, Arbuckle PUD, Maxwell PUD
Private	California Water Service Co., Colusa Drain Mutual Water Co., California Water Service Co., Roberts Ditch & Irr. Co. Inc, Willow Creek Mutual Water Co.

Selected References

California Department of Water Resources. 1978. Evaluation of Groundwater Resources: Sacramento Valley. Department of Water Resources in cooperation with the United States Geological Survey. Appendix A. Bulletin 118-6.

California Department of Water Resources. 2000. Geology and Hydrogeology of the Freshwater Bearing Aquifer Systems of the Northern Sacramento Valley, California. In Progress.

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

Lydon. 1969. Geology and Lahars of the Tuscan Formation, Northern California. The Geological Society of America.

Olmsted FH, Davis GH. 1961. Geologic Features and Ground Water Storage Capacity of the Sacramento Valley, California. USGS. Report nr Water Supply Paper 1497.

United States Bureau of Reclamation (USBR), 1960. Tehama-Colusa Service Area Geology and Groundwater Resources Appendix.

Bibliography

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

Berkstressor CF. 1973. Base of Fresh Water in the Sacramento Valley and Sacramento-San Joaquin Delta, California. U.S. Geological Survey in Cooperation with California Department of Water Resources.

Bertoldi G. 1976. Chemical Quality of Ground Water in the Tehama - Colusa Canal Service Area, Sacramento Valley, California. USGS. Water Resources Investigations 76-92.

Bertoldi GT, Johnson RH, Evenson KD. 1991. Groundwater in the Central Valley, California -- A Summary Report. Regional Aquifer System Analysis--Central Valley, California. USGS. Professional Paper 1401-A.

Beyer LA. 1993. Sacramento Basin Province. USGS.

Bryan K. 1923. Geology and Ground-water Resources of Sacramento Valley, California. USGS. 495.

California Department of Pesticide Regulation. 1993. Sampling for Pesticide Residues in California Well Water, 1993 Well Inventory Database. California Environmental Protection Agency.

California Department of Water Resources. 1958. Ground Water Conditions in Central and Northern California 1957-58. California Department of Water Resources. Bulletin 77-58.

California Department of Water Resources. 1960. Northeastern Counties Investigation. California Department of Water Resources. Bulletin 58.

California Department of Water Resources. 1964. Quality of Ground Water in California 1961-62, Part 1: Northern and Central California. California Department of Water Resources. Bulletin 66-62.

California Department of Water Resources. 1966. Precipitation in the Central Valley. Coordinated Statewide Planning Program. California Department of Water Resources, Sacramento District. Office Report.

California Department of Water Resources. 1975. California's Ground Water. California Department of Water Resources. Bulletin 118.

California Department of Water Resources. 1975. Progress Report Sacramento And Redding Basins Groundwater Study. California Department of Water Resources, Northern and Central Districts, in cooperation with the U.S. Geological Survey. Bulletin 118.

California Department of Water Resources. 1976. Progress Report in Ground Water Development Studies, North Sacramento Valley. California Department of Water Resources, Northern District. Memorandum Report.

California Department of Water Resources. 1980. Ground Water Basins in California. California Department of Water Resources. Bulletin 118-80.

California Department of Water Resources. 1987. Progress Report Sacramento and Redding Basins Ground Water Study. California Department of Water Resources, Northern and Central Districts, in cooperation with the U.S. Geological Survey.

California Department of Water Resources. 1990. Colusa Basin Appraisal. California Department of Water Resources. Northern District Memorandum Report.

California Department of Water Resources. 1994. Ground Water Levels in the Sacramento Valley Ground Water Basin, Colusa County. California Department of Water Resources, Northern District.

California Department of Water Resources. 1997. Groundwater Levels in the Sacramento Valley Ground Water Basin, Glenn County. California Department of Water Resources, Northern District.

California Department of Water Resources. 1998. California Water Plan Update. California Department of Water Resources. Bulletin 160-98, Volumes 1 and 2.

California Department of Water Resources. 1964. Groundwater Conditions in Central and Northern California,1961-62. California Department of Water Resources.

Cherven VB, Edmondson WF. 1992. Structural Geology of the Sacramento Basin: Annual Meeting, Pacific Section AAPG, Sacramento, California, April 27, 1992-May 2,1992.

Davisson ML, Criss RE. 1993. Stable Isotope Imaging of a Dynamic Groundwater System in the Southwestern Sacramento Valley. California, USA. Journal of Hydrology 144(1-4): 213-246.

Dickinson WR, Ingersoll RV, Grahm SA. 1979. Paleogene Sediment Dispersal and Paleotectonics in Northern California. Geological Society of America Bulletin 90:1458-1528.

Fogelman RP. 1976. Descriptions and Chemical Analysis for Selected Wells in the Central Sacramento Valley, California. USGS. OF-76-472.

Fogelman RP. 1978. Chemical Quality of Ground Water in the Central Sacramento Valley, California. USGS. Water Resources Investigations 77-133.

Fogelman RP. 1982. Dissolved-solids Concentrations of Groundwater in the Sacramento Valley, California. USGS. HA-645.

Fogelman RP. 1983. Ground Water Quality in the Sacramento Valley, California, Water Types and Potential Nitrate and Boron Problem Areas. USGS. HA-651.

Fogelman RP, Rockwell GL. 1977. Descriptions and Chemical Analysis for Selected Wells in the Eastern Sacramento Valley, California. USGS. OF-77-486.

French J. 1983. Data for Ground-water Test Hole Near Butte City, Central Valley Aquifer Project, California. USGS. USGS 83-697.

Graham SA, Lowe DR, editors. 1993. Advances in Sedimentary Geology of the Great Valley Group, Sacramento Valley, California.

Harwood DS, Helley EJ. 1982. Preliminary Structure Contour Map of the Sacramento Valley, California, Showing Major Late Cenozoic Structural Features and Depth to Basement. USGS.

Harwood DS, Helley EJ. 1987. Late Cenozoic Tectonism of the Sacramento Valley. USGS.

Hull LC. 1984. Geochemistry of Groundwater in the Sacramento Valley, California. Central Valley of California RASA Project. USGS. Professional Paper 1401-B.

Ingersoll RV, Rich EI, Dickerson WR. 1977. Field Guide: Great Valley Sequence, Sacramento Valley.

Jennings CW, Strand RG. 1969. Geologic Atlas of California [Ukiah Sheet]. California Division of Mines and Geology.

Mankinen EA. 1978. Paleomagnetic Evidence for a Late Cretaceous Deformation of the Great Valley Sequence, Sacramento Valley, California. USGS.

Manson MW, California. Division of Mines and Geology. 1990. Landslides and geology along Cache Creek between Clear Lake and Capay Valley, Lake, Colusa, and Yolo Counties, California. Sacramento, California: State of California Resources Agency Dept. of Conservation. 16 p.

McManus D. 1993. Groundwater Resource Evaluation of the West-Side of the Upland Area: Sacramento Valley [M.S.]: California State University, Chico.

Mitten HT. 1972. Estimated Ground-water Pumpage in the Northern Part of the Sacramento Valley, California,1966-69. USGS.

Mitten HT. 1973. Estimated Ground-water Pumpage in the Northern Part of the Sacramento Valley, California, 1970-71. USGS.

Navigant Consulting Inc, United States Bureau of Reclamation, Colusa Basin Drainage District (Calif.). 2000. Colusa Basin Drainage District Integrated Resource Management Program : Programmatic Environmental Impact Statement/Report. Woodland, Calif.: Navigant Consulting Inc. 2 v. p.

Page RW. 1974. Base and Thickness of the Post-Eocene Continental Deposits in the Sacramento Valley, California. U.S. Geological Survey in cooperation with California Department of Water Resources. Water Resources Investigations 45-73.

Page RW. 1986. Geology of the Fresh Groundwater Basin of the Central Valley, California, with Texture Maps and Sections. Regional Aquifer System Analysis. USGS. Professional Paper 1401-C.

Planert M, Williams JS. 1995. Ground Water Atlas of the United States, Segment 1, California, Nevada. USGS. HA-730-B.

Poland JF, Evenson RE. 1966. Hydrogeology and Land Subsidence, Great Central Valley, California, Geology of Northern California. California Division of Mines and Geology. 239-247 p.

Russell RD. 1931. The Tehama Formation of Northern California [Ph.D]: University of California.

Saucedo GJ, Wagner DL. 1992. Geologic Map of the Chico Quadrangle, California. California Division of Mines and Geology.

United States Bureau of Reclamation Mid-Pacific Regional Office. 1981. Stony Gorge and East Park Powerplants, Orland Project - California : An Appraisal Report on Adding Hydroelectric Powerplants at Stony Gorge and East Park Dams. Sacramento, Calif.: United States Bureau of Reclamation Mid-Pacific Regional Office. xi, 55 p.

U.S.Geolgogical Survey. 1981. Water Resources Data for California; Volume 4, Northern Central Valley Basins and the Great Basin from Honey Lake Basin to Oregon State Line. USGS.

Williamson AK, Prudic DE, Swain LA. 1985. Groundwater Flow in the Central Valley, California. USGS. OF-85-345.

Williamson AK, Prudic DE, Swain LA. 1989. Groundwater Flow in the Central Valley, California. Regional Aquifer-System Analysis--Central Valley, California. USGS. Professional Paper 1401-D.

Errata

Updated groundwater management information and added hotlinks to applicable websites. (1/20/06)