Section 2
Water Resource Setting

2.1 Introduction

Butte County encompasses approximately 1,670 square miles in the northern Central Valley, east of the Sacramento River. Butte County borders Tehama County to the north, Plumas County to the east, Yuba and Sutter counties to the south, and Glenn and Colusa counties to the west. Figure 2-1 shows the location of the County.

The majority of Butte County's groundwater resources are located within the Sacramento Valley groundwater basin. The principal groundwater sub-basins (Inventory Units) within the Sacramento Valley basin portion of Butte County are Vina, West Butte, East Butte, and North Yuba. Each Inventory Unit is further divided into Inventory Sub-units, representing areas with common water sources and uses.

2.2 Topography

Elevations within the Sacramento Valley groundwater basin in Butte County increase gently from the southwest to the northeast, with elevations ranging from less than 100 feet above mean sea level (msl) in the southwest to approximately 300 feet above msl in the northeast. Elevations increase to over 7,000 feet in the mountainous eastern area of the county.

2.3 Climate

Butte County has a Mediterranean-like climate with cool, wet winters and hot, dry summers. Temperature varies with elevation within the county; temperatures are warmer in the valley and cooler in the foothill and mountain areas.

Rainfall and winter snowpack in the Sierra Nevada provide Butte County with significant surface water flows and associated groundwater recharge as surface water traverses the county. Typically ninety percent (90%) of the County's average annual precipitation arrives from October through May. Average annual precipitation increases from west to east across Butte County, associated with increasing elevations. Annual average precipitation is approximately 18 inches in the lower elevation areas of the county that overlie the Sacramento Valley groundwater basin. Precipitation increases to more than 75 inches annually in the mountainous eastern area of the county.

2.4 Surface Water Hydrology

Much of the surface water flow in Butte County originates from rainfall and snowmelt in the foothill and mountain areas. Surface water flows in a southwest direction from the higher elevations, through the basin, to the Sacramento River. Surface water flows in the County are extremely variable, both seasonally and annually, in response to the timing and magnitude of precipitation and snowmelt.

Larger surface water bodies bordering or within Butte County include the Sacramento River, the Feather River and Lake Oroville facilities, Big Chico Creek, and Butte Creek. Smaller local streams include Little Chico Creek, Rock Creek, Dry Creek, Little Dry Creek, Clear Creek, Angel Slough, Wyandotte Creek, and Honcut Creek. Figure 2-2 illustrates the location of rivers, streams, water supply, and drainage features in the county.

Groundwater recharge is not well understood but it is likely that surface water bodies contribute to groundwater recharge including water distributed for agricultural production throughout Butte County. Combined surface water delivery to the Western Canal Water District and the Joint Water District Board in the southwest portion of the county was approximately 964,000 acre-feet in 2003 (Butte Basin Water Users Association, 2004).

2.5 Hydrogeology

The Sacramento Valley groundwater basin lies between the Coast Range to the west, the Cascade and Sierra Nevada Ranges to the east and extends from Red Bluff in the North to the Delta in the south, covering 4,900 square miles. It covers parts of Sacramento, Placer, Solano, Yolo, Yuba, Colusa, Tehama, Glenn and Butte Counties, and is the major source of groundwater in Butte County (DWR 2000). As defined by the State DWR, the Sacramento River groundwater basin underlies the Sacramento Valley which is bordered by the Coast Range on the west and the Sierra Nevada Range on the east.

The Sacramento Valley groundwater basin is filled with sediments deposited in marine and terrestrial environments. The older marine sediments usually contain saline or brackish water, and the younger terrestrial sediments contain fresh water. The sediments are deposited on metamorphic and granitic rocks that are exposed at the edges of the valley (DWR 2000).

On a regional scale, the base of freshwater is commonly considered to be defined by a salinity threshold of 3,000 micromhos. Water with a specific conductance of less than 3,000 micromhos per centimeter is considered fresh, and water with a specific conductance that exceeds 3,000 micromhos per centimeter is considered to be saline. The approximate depth at the deepest portion of the aquifer to the base of fresh water within each of the inventory units is:

- Vina Inventory Unit 1,600 feet
- West Butte Inventory Unit 1,500 feet
- East Butte Inventory Unit 1,400 feet
- North Yuba Inventory Unit 600 feet

The principal water bearing units in the Sacramento Valley portion of Butte County are the Tuscan, Laguna, Riverbank and Modesto Formations. The Tuscan and Laguna Formations are the source of water for deeper wells such as irrigation and municipal wells. Ninety percent of the agricultural and municipal wells are completed in the upper 600 feet and 750 feet of the aquifer, respectively. The Riverbank and Modesto Formations are the source of water for shallower wells such as domestic wells. The majority of domestic wells within the county have been completed in the upper 200 feet of the aquifer (DWR 2000). The hydrogeologic analysis of the Northern Sacramento Valley, and extent and properties of the Tuscan Formation, are still exploratory and under evaluation. Section 3 of the *Butte County Water and Inventory Analysis* describes the hydrogeology and geologic setting of the area. Generally speaking, alluvial units tend to pinch out, or become thinner, at the edge of the basins.

The geology of Butte County and surrounding areas is depicted on Figure 2-3. The associated geologic legend is depicted in Figure 2-4. Figures 2-5 and 2-6 illustrate the geology in cross section. The following is a more detailed discussion of Sacramento Valley groundwater basin geologic units and their hydrogeologic properties within Butte County.

Tuscan Formation

The Tuscan Formation consists of four units, Units A through D. Unit A is the oldest deposit and is approximately 250 feet thick. Unit B is approximately 600 feet thick and lies on Unit A. Unit C is 600 feet thick and overlies Unit B (Helley and Harwood 1985). Unit D is not present in Butte County. Units A and B contain the majority of groundwater in the Tuscan Formation. Unit C contains groundwater in the western portion of the valley, and acts as a confining layer above Unit B. The total thickness of the Tuscan Formation is approximately 1,450 feet in Butte County. Figure 2-7 shows the areas where the Tuscan Formation outcrops in Butte County; groundwater recharge is hypothesized to occur in the areas described.

DWR Northern District is studying the confined nature of Tuscan Unit B. The current hypothesis is that Tuscan Unit B is

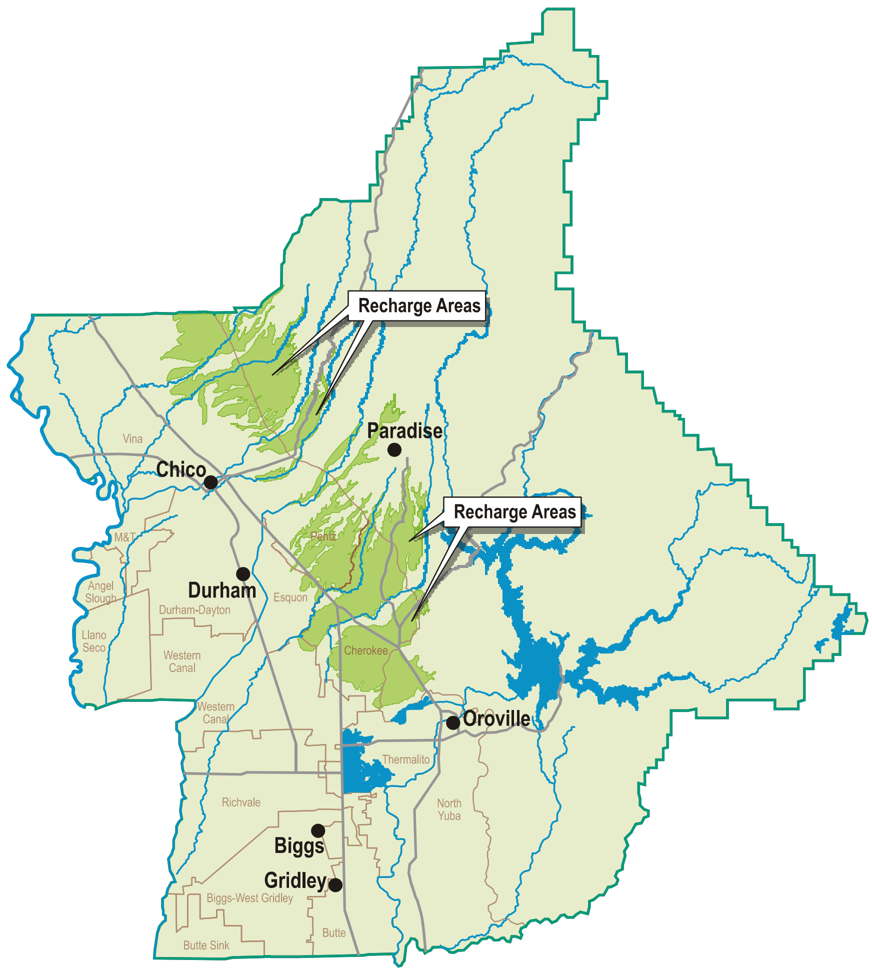


Figure 2-7
Tuscan Formation Recharge Areas

unconfined in the foothills, progressing through semi-confined near the foothills, to fully confined towards the center of the valley.

DWR reported in the *Butte County Groundwater Inventory Analysis* (DWR, 2000) "Pump test results revealed the range of average well yield from a low of 976 gallons per minute (gpm) in the North Yuba Inventory Unit, to a high of 1,395 gpm in the Vina Inventory Unit. Specific capacities for the valley inventory units ranged from a low of 48 gpm per foot in the North Yuba Inventory Unit to a high of 87 gpm per foot in the Vina Inventory Unit. Transmissivity values within the Butte Basin portion of the East and West Butte Inventory Units ranged from 97,000 to 182,000 gallons per day (gpd) per foot. Storativity values ranged from .0003 to .0015. Specific capacity measurements made for wells reported in a previous study provided a range of 45.7 to 104.7 gpm per foot of drawdown".

The *Butte County Water Inventory and Analysis* (DW&RC, 2001) provides more information on the hydrogeology and fresh water bearing units of the groundwater in Butte County. The *Butte County Water Inventory and Analysis* is available for review in local public libraries and also at *www.buttecounty.net/waterandresource*. Reviewers may click on "Reports" and then on "Inventory Analysis." Section 3 of this report describes Butte County's setting and geological features, but the basic reference is DWR Bulletin 118-3.

Laguna Formation
The Laguna Formation is exposed along the eastern edge of the Sacramento Valley, from Oroville south towards Lodi. Thickness estimates range from 180 feet (Helley and Harwood 1985) to 1,000 feet (Olmstead and Davis 1961).

DWR reported in the *Butte County Groundwater Inventory Analysis* (DWR, 2000) "Quantitative water-bearing data for the Laguna is very limited, especially in the Butte County area. Wells completed in the finer-grained sediments of the Laguna Formation yield only moderate quantities of water. Well yield data from the Sacramento-American River area indicate yields as high as 1,000 gpm, with specific capacity values ranging between 24 and 42 gpm per foot of drawdown (Olmsted and Davis 1961). In areas where soft, well-sorted granitic sand dominates, well yields are much higher. Some of the sand aquifers are highly permeable, but the average permeability is low to moderate. In the Gridley area, a sand unit that is stratigraphically equivalent to the Laguna Formation was reported to have a specific capacity of 60 gpm per foot of drawdown (Olmsted and Davis 1961)."

Riverbank Formation
The Riverbank Formation is exposed in the Vina plains and to the west and south of Oroville. The thickness of the Riverbank Formation ranges from 200 feet to 1 foot depending on location (DWR 2000). The water-bearing capabilities of the formation vary depending on the thickness of the formation locally and the concentration of gravels and sands. Lower yields are found in areas with high silt and clay content or where the formation is thin. The formation provides water to domestic and other

shallow wells and to deeper wells with multiple perforated intervals. Groundwater in the Riverbank Formation occurs under unconfined conditions.

Modesto Formation

The Modesto Formation is exposed in the central portion of Butte County, west and south of Chico. The thickness of the Modesto Formation ranges from 200 to 10 feet depending on location (Helley and Harwood 1985). The water-bearing capabilities of the formation vary depending on the thickness of the formation locally and the concentration of gravels and sands. Lower yields are found in areas with high silt and clay content or where the formation is thin. Groundwater in the Modesto Formation occurs under unconfined conditions.

2.5.1 Groundwater Levels

Groundwater levels are monitored in the Sacramento Valley portion of Butte County by DWR and by the DW&RC. DWR reports groundwater levels in feet above mean sea level. Historical monitoring data show that seasonal fluctuation of groundwater levels averages between 5 feet in unconfined aquifers in years of normal precipitation to 20 feet in confined aquifers during times of drought.

Comparison of yearly spring groundwater levels indicates a reduction of groundwater levels during the 1976-77 and 1986-94 droughts, followed by a recovery to pre-drought conditions (DWR 2000). Historical data also indicates a slight decline in groundwater levels from the 1950's to the 1970's, however there has been little change in groundwater levels since the 1970's.

A groundwater elevation contour map for the spring of 1997, prior to the annual period of agricultural use of groundwater, is shown on Figure 2-8. Spring groundwater levels reflect the natural groundwater table's direction of movement in areas unaffected by municipal pumping. Spring groundwater levels vary in elevation from 60 feet above msl in the Butte Sink Inventory Unit, to about 170 feet above msl in the Northeastern part of the Vina Inventory Unit.

Figure 2-9 shows the seasonal change in groundwater levels between the spring and summer during 1997. The contour lines represent lines of equal groundwater elevation change between the spring and summer measurement periods. The figure shows that the seasonal decline in groundwater level ranges from zero, in the southwest portion of the county, to 30 feet in the Durham area. Greater groundwater level decline occurs where groundwater is extracted for agricultural and/or municipal use during the summer months. These areas include the Durham area, the area southeast of Durham (i.e. the Cherokee sub-unit), the area northwest of Chico, the City of Chico, and the area south of Palermo. Historical data indicate that the water level decrease is seasonal and the basin groundwater typically recharges during the winter months (DWR 2000). Though long term historical data shows that well levels seasonally and annually fluctuate, there is no significant difference in the well levels over the long term.

2.5.2 Groundwater Movement

Figure 2-8 illustrates the overall pattern of groundwater movement in Butte County. Spring water level elevation data was utilized. The direction of groundwater movement is illustrated by a series of small arrows perpendicular to the groundwater elevation contours. In general, groundwater flows in a southwesterly direction. The Sacramento River, north of Princeton, is a gaining river, and groundwater flows towards the river. South of Princeton, the Sacramento is a losing river, and the groundwater flows away from the river. Southeast of Princeton water flows into the Butte Sink. Near Butte Creek, a gaining stream, groundwater flows toward the stream.

The groundwater gradient generally reflects the ground surface topography. Along the foothills the gradient is steep, as high as 60 feet per mile. In the center of the valley, west of Biggs and Gridley, the gradient is gentle, as small as 3 feet per mile. The overall gradient in the valley portion of Butte County is approximately 5 feet per mile.

In specific areas, the movement of groundwater varies. There is a groundwater depression under the City of Chico, resulting from municipal pumping for the city's water supply, where groundwater locally flows toward the depression. There is a groundwater mound near the Thermalito Afterbay, associated with recharge from the facility, where groundwater flows outward from the groundwater mound. There is another groundwater mound near Hamilton City; the Stony Creek Fan supplies water for this mound.

In the southeast corner of the East Butte Inventory Unit, groundwater flow converges in the Butte Sink area. Groundwater may act as the source of the wetlands in the Butte Sink area. The Sutter Buttes and Colusa Dome, a subsurface feature west of the Sutter Buttes, impedes groundwater movement to the south in this area. This impediment likely causes the groundwater to move vertically upward, resulting in a shallow groundwater table and the formation of wetlands (DWR 2000).

2.5.3 Groundwater in Storage

Change in groundwater in storage is affected by the rate of groundwater recharge, the rate of groundwater pumping, and climatic conditions. Groundwater levels, which indicate groundwater in storage, change over the course of a year and change from year to year. The groundwater in storage will typically decline throughout summer, when recharge is low and extraction for municipal and irrigation uses is ongoing. Groundwater in storage typically increases during the winter, when extraction decreases and rainfall and associated runoff increase recharge. During periods of drought, groundwater in storage declines and during periods of above average precipitation groundwater in storage increases.

Figure 2-10 shows the annual spring-to-spring change in groundwater in storage for the Sacramento Valley portion of Butte County as calculated by DWR over a twenty-year period from 1980 to 2000. DWR described the calculation of changes in spring-to-spring storage in the *Butte County Groundwater Inventory Analysis* (DWR, 2000). "The annual spring to spring change in groundwater in storage for the Sacramento Valley portion of Butte County was calculated over a twenty-year period from 1980 to 2000. The spring-to-spring change in groundwater storage was calculated using groundwater contour maps developed from spring groundwater level measurements in the upper portion of the aquifer. Digital three-dimensional surfaces were constructed for each groundwater elevation contour map and the volume differences between consecutive spring to spring groundwater elevation surfaces were calculated."

The spring-to-spring graphs start with a baseline of zero for the spring of 1980. Similar to the 1997 water-year, basin-wide groundwater levels during the spring of 1980 closely characterize groundwater conditions associated with a normal water year. At any specific location, the actual changes in groundwater level and the associated groundwater in storage could vary significantly from the average conditions depicted.

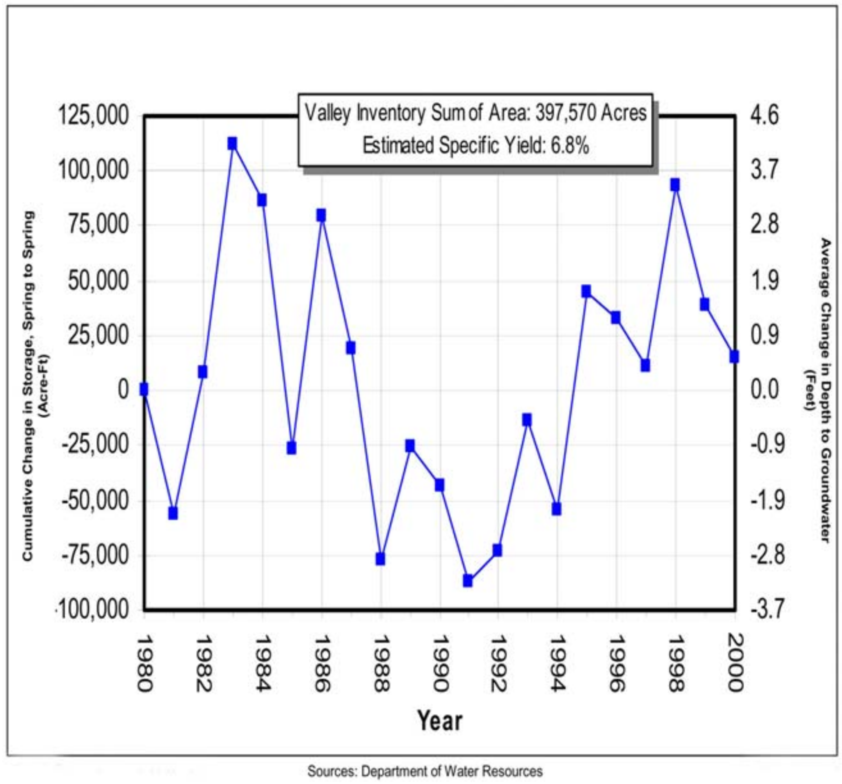


Figure 2-10
Changes in Groundwater Storage

The figure shows that there has not been a significant *net* change in groundwater in storage over the 20-year period. However, there have been significant changes in stored groundwater during periods of drought. The groundwater storage trend indicates that there was slightly more groundwater in storage preceding the 1987 - 1994 drought compared to 1980. Between 1987 and 1988, groundwater storage was reduced by approximately 100,000 acre-feet. The observed lower quantity in groundwater in storage continued until 1995, when the basin recovered relatively rapidly, with an increase of approximately 100,000 acre-feet in groundwater storage between 1994 and 1995.

2.5.4 Groundwater Quality

Groundwater in the Sacramento Valley portion of Butte County is typically of good quality, as evidenced by its low total dissolved solids (TDS) concentrations, which range from 67 parts per million (PPM) to 232 ppm (Newlin 2003). The preferred temperature for drinking water is less than 50˚C, above which there can be plant and/or algae growth. Groundwater temperatures range from 17.6 ˚C to 27 ˚C (Newlin

2003). The Department's recent monitoring indicates that the basin is a high-quality fresh water basin.

The Butte County Department of Health Services and the California Department of Health Services both serve as repositories for groundwater quality data. Municipal water providers submit their water quality data to these agencies, and these agencies make this data available to the public. The U.S. Geologic Survey performs some groundwater quality monitoring in the County, but it does not have a regular program that monitors the same areas every year. More information about water quality monitoring is in Section 3.1.4.2.

2.5.5 Land Subsidence

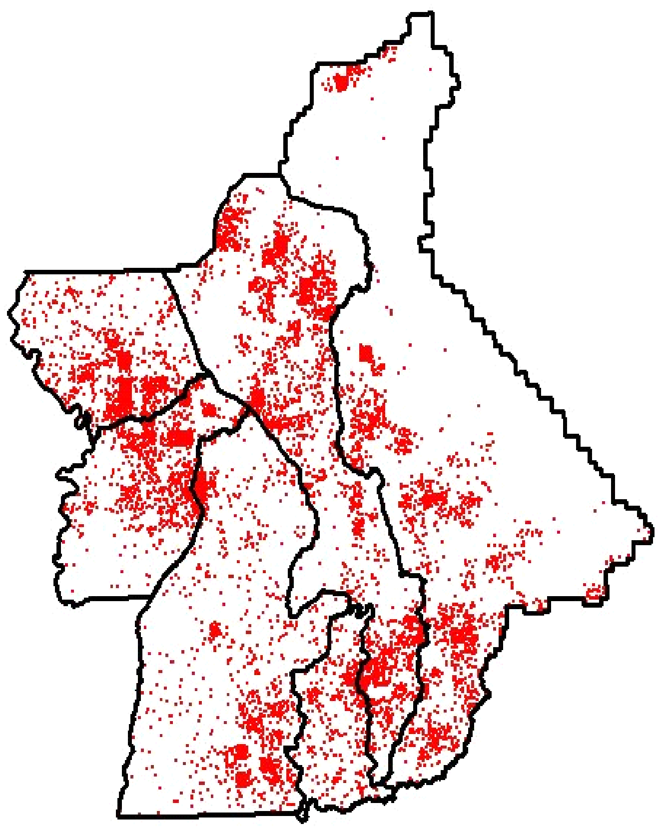
Inelastic land subsidence, for the purpose of the GMP, is the permanent lowering of the ground surface resulting from compaction of geologic materials as a result of groundwater extraction. Permanent compaction is typically observed in fine-grained geologic materials. Land subsidence can damage infrastructure such as canals, wells, and levees. Figure 2-11 shows the extent of groundwater subsidence in the Sacramento Valley.

As indicated on Figure 2-11, no land subsidence has been observed in the Butte County potion of the Sacramento Valley. Areas with historical subsidence are characterized as having thick sequences of fine-grained geologic materials. More information on land subsidence
is in section 3.4.1.3.

2.6 Groundwater Well Infrastructure

Butte County has over 14,000 wells. The Sacramento Valley portion of Butte County has approximately 9,400 wells. The wells are classified by purpose as domestic, irrigation, municipal, monitoring, and other. Figure 2-12 illustrates the densities of all wells throughout the county. Table 2-1 presents the numbers of wells by type, inventory unit, and inventory sub-unit throughout the Sacramento Valley portion of the county.

DWR compiled the well infrastructure information using information contained



Source: DWR Northern District

y (all types)

Figure 2-12
Distribution of Wells in Butte County (all types)

A

in DWR's Well Completion Report database. The accuracy of the well location information varies according to the source of the particular data; most locations are correct to within 1 mile (300 feet for monitoring wells).

The number and type of well included within Table 2-1 below include those wells on file at DWR. Wells on file include those for which a Well Completion Report has been filed, as required under the California Water Code since the late 1940s, and additional well logs on file prior to enactment of the requirement. Well data is accessible for review at DWR's Northern District Planning and Local Assistance Branch Office, or at the following web-site: http://well.water.ca.gov/gw/admin/main_menugw.asp.

Table 2-1
Number of Wells By Inventory Unit and Inventory Sub-Unit

INVENTORY UNIT	INVENTORY SUB-UNIT	Domestic Wells	Irrigation Wells	Municipal Wells	Monitoring Wells	Other Wells	Totals
Vina	Vina	2,096	621	55	138	299	**3,209**
Vina and West Butte	*California Water Service	0	0	66	0	0	**66**
West Butte	Durham/Dayton	1,195	568	40	248	310	2,361
	M&T	18	38	0	2	6	64
	Angel Slough	8	43	0	2	2	55
	Llano Seco	1	16	0	5	10	32
	Western Canal (33%)	15	36	0	0	12	63
	Totals:	1,237	701	40	257	340	**2,575**
East Butte	Pentz	172	39	0	12	20	243
	Esquon	291	108	0	2	26	427
	Cherokee	104	62	0	2	15	183
	Western Canal (67%)	32	76	0	2	17	128
	Richvale	87	72	0	4	21	184
	Thermalito	140	56	0	9	36	241
	Biggs-West Gridley	246	92	4	10	33	385
	Butte	571	183	8	29	115	906
	Butte-Sink	4	11	0	1	4	20
	Totals:	1,647	699	12	71	287	**2,717**
North Yuba	North Yuba	504	178	8	95	81	**866**
Total For Sacramento Valley Portion of Butte County:		**5,484**	**2,199**	**182**	**561**	**1,007**	**9,433**
NOTE: Municipal includes wells classified as Municipal and Public "Other" wells includes industrial wells.							

Source: Department of Water Resources

*Note: For water use projections in the Chico Urban Area the California Water Service utilized data compiled in the Butte County Water Inventory and Analysis (DW&RC, 2001). By statute, private utilities such as California Water Service are not covered by legislation that supports AB 3030. However, California Water Service has actively participated in the development of draft water resource planning documents prepared by Butte County.

2.6.1 Well Depths

Well depth and well use data were collected from Well Completion Reports filed with the DWR. A total of approximately 7,800 of the 9,400 well records from the Sacramento Valley portion of Butte County include depth data for domestic, irrigation, and municipal/industrial wells. Monitoring and "Other" wells are not included in the well depth evaluation. Table 2-2 summarizes this information.

The depths of the 5,484 domestic wells range from 14 to 860 feet, and 50 percent of them are installed to a depth of about 133 feet or less. The depths of the 2,198 irrigation wells range from 28 to 1,050 feet, and 50 percent of them are 321 feet or less in depth. Municipal/industrial well depths range from 36 to 924 feet, and 50 percent of them are installed to a depth of 518 feet or less. DWR's *Butte County Groundwater Inventory Analysis* report (DWR 2000) contains a detailed statistical analysis of the well data.

Table 2-2
Summary of Well Numbers and Depths in Butte County by Region[1]

Inventory Unit	Irrigation		Domestic		Municipal		Total Well Count
	Count	Ave Depth (ft)	Count	Ave Depth (ft)	Count	Ave Depth (ft)	
Vina	621	332	2,096	145	55	530	2,772
West Butte	664	321	1,222	106	40	511	1,926
East Butte	735	320	1,662	134	12	278	2,409
North Yuba	178	288	504	139	9	171	691
Cal Water Area	0	-	0	-	66	603	66
Valley Portion of Butte County	**2,199**	**321**	**5,484**	**133**	**182**	**518**	**7,864**

[1]Limited to information available for irrigation, domestic, and municipal wells.

2.6.2 Well Yields

Selected data on water utility well yields are provided in the DWR's *Butte County Groundwater Inventory Analysis* (DWR 2000). Reported average well yields are similar across the basin, with average rates by sub-basin as follows:

- Vina, West Butte: 1,000 gpm
- East Butte: 980 gpm
- North Yuba: 840 gpm

2.7 Water Demand and Supply

In 2001, the Department completed a detailed countywide assessment of applied water demand and supply. The *Butte County Water Inventory and Analysis* report (CDM 2001) and DWR's companion report, *Butte County Groundwater Inventory Analysis* (DWR 2000) present the methodology and findings. Both reports document the "applied" water demand and supply, that is, the measurable and managed component of the hydrologic cycle used for environmental, agricultural, municipal and industrial, and other purposes.

2.7.1 Water Demand

Butte County residents receive water from both surface water and groundwater sources. Table 2-3 provides a summary of the estimated water demands in the County by sector (agricultural, municipal and industrial, environmental, etc) for normal years. Several points are evident from these water demand estimates:

- The agricultural sector is the largest user of water in the County, with 71% of the total demand. The majority of this agricultural demand is in the valley area.
- The second largest demand component (15 percent) is conveyance loss, which represents the amount of water required to convey supplies to their destination including evaporation, riparian evapotranspiration, percolation to groundwater, and spillage from the system. Some conveyance losses (evaporation and evapotranspiration) are not available to the system for future use, but deep percolation and spillage are available for future use.
- The remaining demand is composed of environmental demands (10%), and urban demands (4%). Environmental demands include water for state and federal wildlife refuges, publicly or privately managed wetland habitat, and agricultural lands flooded for rice straw decomposition or duck habitat. Urban demands include water demands within cities and towns as well as domestic demand within rural areas.
- Increased urban population growth has also contributed to increasing water demand in the valley area.
- The greatest demand is in the East Butte inventory unit (64%), followed by West Butte (18%), Vina (10%), North Yuba (5%), Foothill (2%) and Mountain (1%).

Table 2-3
Normal Year Water Demand (in thousands of acre-feet) (CDM 2001)

Sacramento Valley Region	Agricultural Demand	M&I Demand	Environmental Demand	Conveyance Losses	Total Applied Water
East Butte	629.6	9.5	124	167.6	**930.7**
North Yuba	54	6.7	1.2	5.2	**67.1**
Vina	121.5	19.7	0	2.7	**143.9**
West Butte	201.1	10.3	14	40.2	**265.6**
Valley Region Total	**1006.2**	**46.2**	**139.2**	**215.7**	**1407.3**

2.7.2 Water Supply

Table 2-4 summarizes the estimated water supplies in Butte County for normal years. The supplies are identified by source – either surface or groundwater, and also by surface water system, including local surface water, Feather River water, and deliveries from the State Water Project (SWP) or Central Valley Project (CVP).

Surface-water reuse refers the amount of water that is used more than once after it is diverted from the original surface-water body. Several points are evident from the water supply estimates:

- Relative to the amount of total applied water (i.e. Table 2-3) East Butte and Foothill Inventory Units primarily use surface-water, and the remainder of the county primarily uses groundwater.
- The primary water source within the county is surface water (55%), followed by groundwater (31%) and surface water reuse (14%).
- Supplies are distributed throughout the county in the same pattern as demands, with the most water going to the East Butte inventory unit (64%), followed by West Butte (18%), Vina (10%), North Yuba (5%), Foothill (2%) and Mountain (1%).

Table 2-4

Normal Year Water Supplies (in thousands of acre-feet) (CDM 2001)

Sacramento Valley Region	Local Surface Water	Feather River	SWP	CVP	Ground-water	Surface water reuse	Total Supplies
East Butte	38.3	576.0	0.0	11.2	124.6	180.6	**930.7**
North Yuba	0.0	13.3	0.0	0.0	50.2	3.6	**67.1**
Vina	0.0	0.0	0.0	2.8	138.2	2.9	**143.9**
West Butte	17.7	70.7	0.0	26.6	121.0	29.6	**265.6**
Valley Region Total	**56.0**	**660.0**	**0.0**	**40.6**	**434.0**	**216.7**	**1407.3**

As Table 2-4 shows, the total volume of extracted groundwater in the County is approximately 440 thousand acre-feet (TAF) in normal years. This increases to more than 640 TAF in drought years, primarily due a reduction in surface water from the Feather River (CDM 2001).

Net groundwater extraction is less than total groundwater extraction due to deep percolation of both groundwater and surface water used for irrigation. Deep percolation from applied groundwater and surface water is estimated as approximately 230 TAF during normal years and 240 TAF in drought years. The increase in applied water deep percolation during drought is a direct result of the increased ratio of applied water versus natural water (rainfall) used to produce a crop. In normal years, rainfall provides a higher percentage of the total water required to grow a crop. The hydrogeologic properties of the Sacramento Valley aquifers are still under evaluation. The hydrogeologic character of the aquifers and interaction with streams, confining layers, and recharge is not well understood. Further evaluation is necessary to make any additional statements beyond estimations that have been put forth in this GMP.

2.7.3 Water Demand and Supply Findings

Water demand and supply was calculated in the 2001 *Butte County Water Inventory and Analysis* report (CDM 2001). The total amount of supply called applied water was calculated from the amount of water supplied to domestic, agricultural, environmental, industrial and municipal water users in Butte County. A brief synopsis of those findings follows:

- Under the normal hydrologic scenario, Butte County currently has an adequate surface water and groundwater supply to meet current demands.
- The drought year shows more groundwater pumping and less surface water use than in the normal year. Surface water decreases from 55% of supply in normal years to 41% during a drought, and groundwater increases from 31% to 44%. Surface water reuse stays essentially the same, going from 14% in a normal year to 15% during a drought.
- Dry year shortages are likely to occur primarily in the southwest portion of the county. Shortages are defined by lack of supply, which in most cases is limited by the groundwater infrastructure available.
- The composition of agricultural, municipal and industrial, and environmental demands does not appear to change substantially from the normal year. In a drought year, the majority of the demand is agricultural, at 74%, followed by conveyance losses (11%), environmental demand (10%) and urban demand (5%).
- The portion on the Sacramento Valley aquifer system under Butte County has recovered from the 1988-1994 drought. Long-term trends in groundwater storage indicate the basin groundwater aquifer is not in a state of decline. During normal to wet years, the aquifer system recharges to its maximum storage capacity by the following spring.
- Future increases in demand will be associated with population growth and environmental regulatory requirements, both within and outside of the county.
- A significant amount of water supplied to meet demand remains available for use through deep percolation to groundwater and outflow to other areas.
- Environmental water use constitutes a substantial part of water demand in the county, extending water demand past the typical irrigation season.

Seasonal fluctuations of groundwater wells levels are determined by the amount of use and climatic conditions. Evaluation of the historical data suggests there is not a significant difference in the annual and seasonal elevation fluctuations of groundwater well levels in Butte County.

2.8 Water Demand Forecast

In October 2003, the Department completed a countywide forecast of water demand for the agricultural and urban water use sectors. The *Butte County Agricultural Water Demand Forecast* and the *Butte County Urban Water Demand Forecast* technical memorandums (CDM 2003) present the methodology and findings of the water demand forecasts.

2.8.1 Agricultural Water Demand Forecast

The analysis developed and evaluated five agricultural water demand scenarios using an economic model of agricultural production developed specifically for Butte County. A "Delphi" group of agricultural experts [note: "Delphi" is a statistical term and its methodology involves a group of experts to provide their judgemental forecast of a variable or variables of interest] from Butte County was convened over several meetings to review and provide independent, unbiased evaluation of the approach, assumptions, data, and results. The analysis forecasted demand for five geographic regions within the County. Table 2-5 summarizes the forecast scenarios.

The model produced results for each scenario in each region. Results indicated changes in crop acreage and applied water use (surface water and groundwater). The Study Team observed the following features from the modeling results:

- Agricultural land conversion decreases acreages of low profit per acre crops;
- Crop idling decreases acreages of high water use per acre crops; and
- Water conservation, agricultural land conversion, and crop idling decrease applied water demand.

Table 2-5
Summary of Agricultural Demand Forecast Scenarios

Scenario	Implementation Method	Magnitudes
Land Conversion	Decrease total land in production	Decrease irrigated land 3% in Vina and West Butte Decrease irrigated land 1% in East Butte
Crop Idling	Decrease surface water used for crop production	Decrease surface water delivery 10%
Crop Prices	Increase relative crop prices	Increase rice and orchards price 10%
Water Conservation	Increase crops irrigation efficiency	Set target irrigation efficiencies for each crop
Combination Scenario – Average and Dry Years	Combines land conversion, crop idling, and conservation scenarios	Decrease irrigated land 3% in Vina and West Butte Decrease irrigated land 1% in East Butte Decrease surface water delivery 10% Set target irrigation efficiencies for each crop

NOTE: Land conversion includes both conversions to urban use and conservation easements. Additional water demand following conversion to urban use is addressed in the County's recent Urban Water Demand Forecast document (October 2003). The Butte County Urban Water Demand Foreceast may be viewed at www.buttecounty.net/waterandresource. Click on "Demand Forecast" and link to "Urban Water Demand." This document may also be viewed at local libraries.

Figure 2-13 is an example of forecast results. It summarizes changes to total applied water under the average year combination scenario in all regions. In the East Butte region, total applied water decreases 55,020 acre-feet, or 8.75 percent. Total crop acreage decreases 3,340 acres, or 2.77 percent (not shown). All other regions also experience decreases in applied water and total acreage.

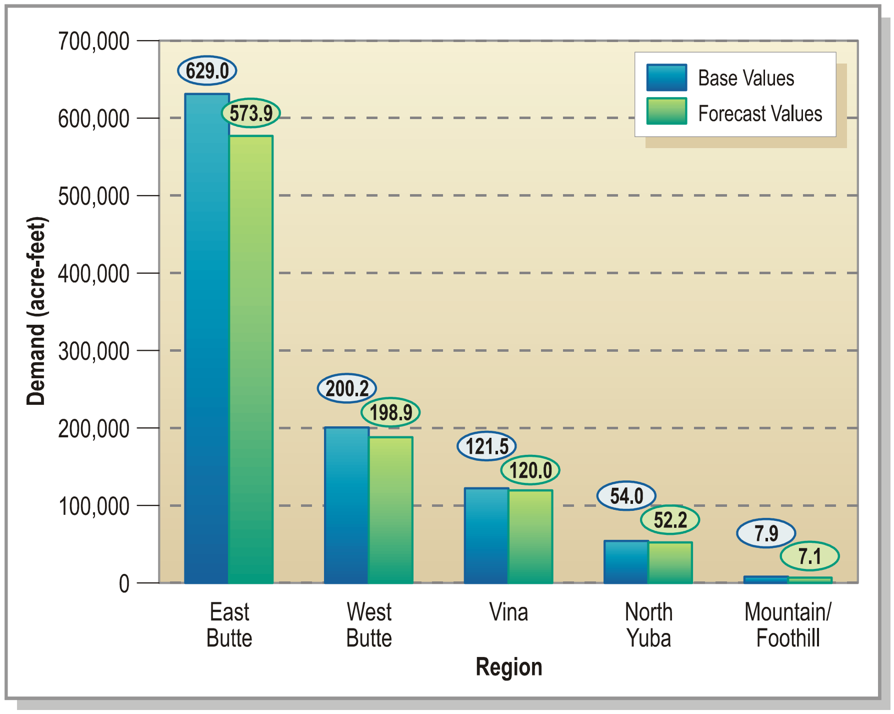


Figure 2-13
Comparison of Total Applied Water
Under Base and Combination (Average Year) Scenarios

The agricultural water demand forecast generated several conclusions important for future water resource planning.

- In general, the analysis indicates that most of the reasonably foreseeable changes evaluated would not result in significant long-term changes in agricultural water demand in Butte County.

  Total applied water demand under the average year combination scenario reduces a minimum of 0.6 percent (1,300 acre-feet) in the West Butte region and a maximum of 8.75 percent (55,020 acre-feet) in the East Butte region. The DW&RC will address agricultural water demand forecasting in the next Water & Inventory Analysis (the proposed 5-year update is 2006). Any new data will be welcomed in that process.

- Crop idling results in the largest decreases to agricultural water demand and provides purveyors with surplus water that could be used by government programs or other water districts.

  Total water demand in the County under the crop idling scenario decreases 63,700 acre-feet (6.3 percent).

- Agricultural land conversion results in a small reduction in irrigated cropland and agricultural water use in the County.

  Total water demand in the County under the agricultural land conversion scenario decreases 9,600 acre-feet (0.9 percent).

- Water conservation would reduce applied water and provide purveyors with surplus water that could be used by government programs or other water districts; however, costs of conservation could be expensive.

  Total water demand in the County under the water conservation scenario decreases 51,800 acre-feet (5.1 percent).

- Relative changes in crop price can have an important effect on agricultural water demand. The analysis presented one plausible case that could increase water demand. However, price forecasting is inexact and has not been attempted in this study. Therefore, results of the price change scenario cannot be viewed as anything more than an example.

- A combination scenario was evaluated that included assumptions of three other scenarios. All three assumptions result in a reduction in agricultural water demand. Although the combination scenario is plausible, readers should consider it a cumulative analysis of potential future conditions.

- The combination scenario was evaluated for both an average year and a dry year condition. The dry year conditions start from the same base level of crop acreage and a higher base level of water use, but the incremental change resulting from the combination scenario is similar to the average conditions.

  Total water demand in the County decreases 60,500 acre-feet (6.0 percent) in an average year and 71,300 acre-feet (6.3 percent) in a dry year under the combination scenario.

2.8.2 Urban Water Demand Forecast

The IWR-MAIN Water Demand Management Suite© was selected to perform the urban water demand forecast, and the selected forecasting method was the *adjusted rate of use* method. This method is consistent with those used by DWR in its statewide planning efforts and is appropriate for the level of data that was available for this analysis.

This analysis forecasted the quantity of water use in several subsectors for the years 2010, 2020, and 2030. Table 2-6 lists the sectors and subsectors for which forecasts were developed.

Table 2-6
Model Sectors and Subsectors

Sector	Subsector
Residential	Single-family
	Multifamily
Nonresidential	Commercial
	Industrial
	Large Landscape

Butte County was divided into six study areas for analysis. Table 2-7 lists the study areas, along with their populations and the purveyors that provide water service to each.

Table 2-7
Forecast Model Study Areas

Study Area	2000 Census Population	Water Purveyor(s)
Biggs	1,799	City of Biggs
Chico	59,444	California Water Service Company, Chico
Gridley	5,450	City of Gridley
Oroville	12,969	California Water Service Company, Oroville
		Oroville Wyandotte Irrigation District
		Thermalito Irrigation District
Paradise	26,451	Paradise Irrigation District
Unincorporated Areas	97,058[1]	Several water purveyors (not listed)
		Private wells
BUTTE COUNTY TOTAL	203,171	Combined private wells and public water purveyors

Estimated as population of incorporated subtracted from population of the entire county.

To calculate water use given subsector, this model multiplied a per unit usage rate by a number of units (people, housing units, or jobs) and by a series of factors that adjust the forecasted quantities to reflect the effect of variables such as income, marginal water price, and weather. DWR public water system statistics provided the basis for the per unit usage rates, which were refined according to information gathered through interviews with water purveyors and planners in the study areas of interest. Figure 2-14 shows the results generated for each study area at the subsector level by the model. Results indicated increases in urban demand over the forecast period.

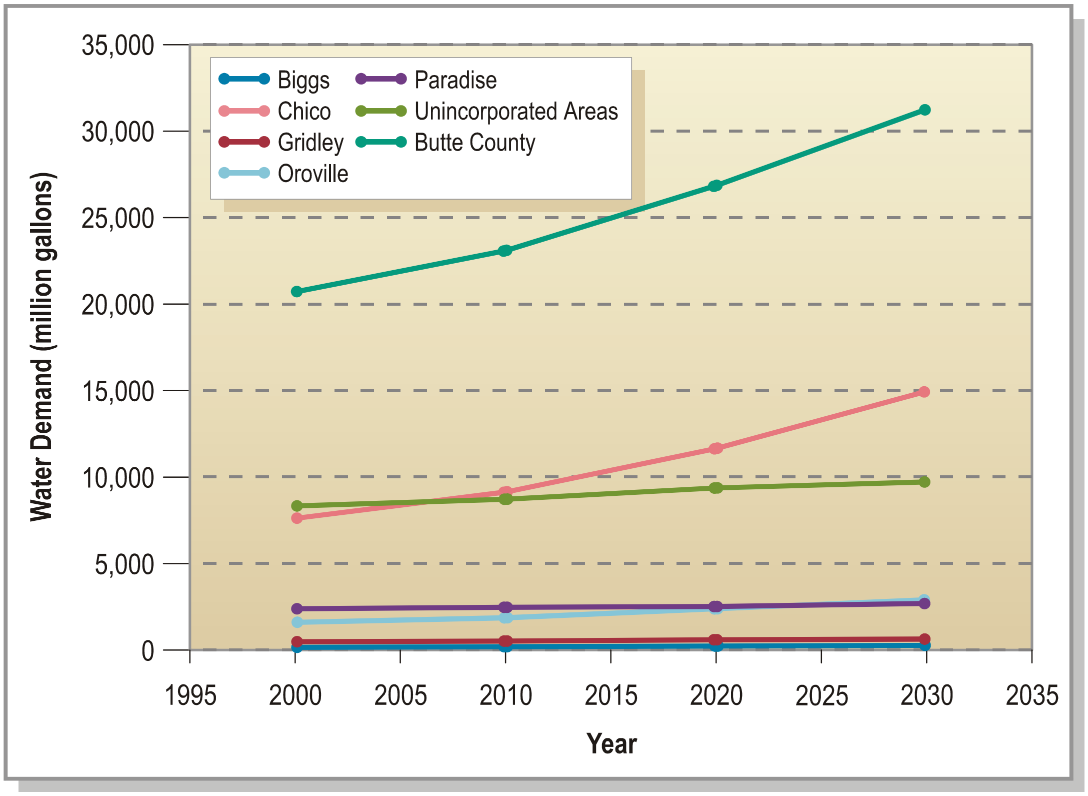


Figure 2-14
Urban Water Demand Forecast Results

Biggs

The demand for Biggs is projected to grow from 186.4 million gallons in 2000 to 269.2 million gallons in 2030, an increase of 44 percent.

Chico

The demand for Chico is projected to grow from 7,616.1 million gallons in 2000 to 14,933.7 million gallons in 2030, an increase of 96 percent.

Gridley

The demand for Gridley is projected to grow from 494.4 million gallons in 2000 to 662.0 million gallons in 2030, an increase of 34 percent.

Oroville

The demand for Oroville is projected to grow from 1,650.4 million gallons in 2000 to 2,927.8 million gallons in 2030, an increase of 77 percent.

Paradise

The demand for Paradise is projected to grow from 2,431.3 million gallons in 2000 to 2,701.2 million gallons in 2030, an increase of 11 percent.

Unincorporated Areas of the County

The demand for the unincorporated areas of the county is projected to grow from 8,322.3 million gallons in 2000 to 9,736.4 million gallons in 2030, an increase of 17 percent.

The Entire County

The demand for the entire county is projected to grow from 20,700.9 million gallons in 2000 to 31,230.3 million gallons in 2030, an increase of 51 percent. The DW&RC will address urban water demand forecasting in the next Water & Inventory Analysis (the proposed 5-year update is in 2006). Any new data will be welcomed in that process.