

Butte County Monitoring Plan for the California Statewide Groundwater Elevation Monitoring (CASGEM) Program

Background

Butte County is proposing to be the monitoring and reporting entity for the geographic area comprising the Vina, East Butte, West Butte and North Yuba subbasins within the boundaries of Butte County. The Butte County CASGEM Monitoring Plan includes information taken directly from the Butte County Inventory and Analysis Report (2005), Butte County Integrated Resource Management Plan (2005) and the Butte County Groundwater Management Plan (2005). These documents can be found at:

<http://www.buttecounty.net/waterandresource>

The Butte County CASGEM Monitoring Plan describes the methodology that provides an adequate coverage of the subbasins to characterize seasonal and long-term trends.

Cooperating Agencies

The Cooperating Agencies for the Butte County CASGEM program include the Biggs-West Gridley Water District, Butte Water District, Richvale Irrigation District, Western Canal Water District, California Water Service Company – Chico and California Water Service Company – Oroville. These Cooperating Agencies have conducted or supported groundwater monitoring efforts in Butte County. These local agencies either have their own AB 3030 Groundwater Management Plans by a local agency (CWC § 10750.2(b)) or are regulated by the Public Utilities Commission (CWC § 10750.7(a)). Butte County Groundwater Management Plan adopted in 2005 covers the North Yuba, East Butte, West Butte, and Vina groundwater sub-basins not otherwise managed under an existing AB 3030 groundwater management plan (CWC § 10750.2(b)) or regulated by the Public Utilities Commission (CWC § 10750.7(a)).

History of Groundwater Monitoring in Butte County

Groundwater level monitoring in Butte County is currently being conducted primarily by a cooperative effort between Butte County and the Department of Water Resource. Historically, the Department of Water Resources has maintained the most comprehensive, long-term groundwater level monitoring grid, with approximately 212 different wells monitored over the last 50 years in the Sacramento Valley portion of Butte County. Within this period of time, the annual size of the monitoring grid has fluctuated from as few as 50 wells, to as many as 180 wells, depending upon the activity of special studies in the area. Until 1989, the majority of these wells were measured semi-annually, during the

spring and fall. Beginning in 1990, the frequency of groundwater level monitoring was increased to monthly, before returning to a semi-annual measurement in 1995. In 1997, the Butte County Department of Water and Resource Conservation, in cooperation with the Department of Water Resources, began to expand the number and frequency of groundwater level monitoring in the valley portion of Butte County. Improvement to the monitoring network has been primarily focused on adding dedicated monitoring wells outfitted with transducers. The Butte County Water Commission's Technical Advisory Committee (TAC) has played an integral part in providing guidance to prioritize areas for additional monitoring wells and to evaluate the data from monitored wells. Multi-completion, dedicated monitoring wells are located and screened to improve the coverage of the basin. The location of monitoring wells is based on the characteristics of the subbasin, properties of the aquifer and other data. For example, in 2007 two new multi-completion observation wells were installed in Butte County, one in the East Butte subbasin and one in the West Butte subbasin. In 2010, multi-completion wells were installed in the Vina subbasin and the West Butte subbasin.

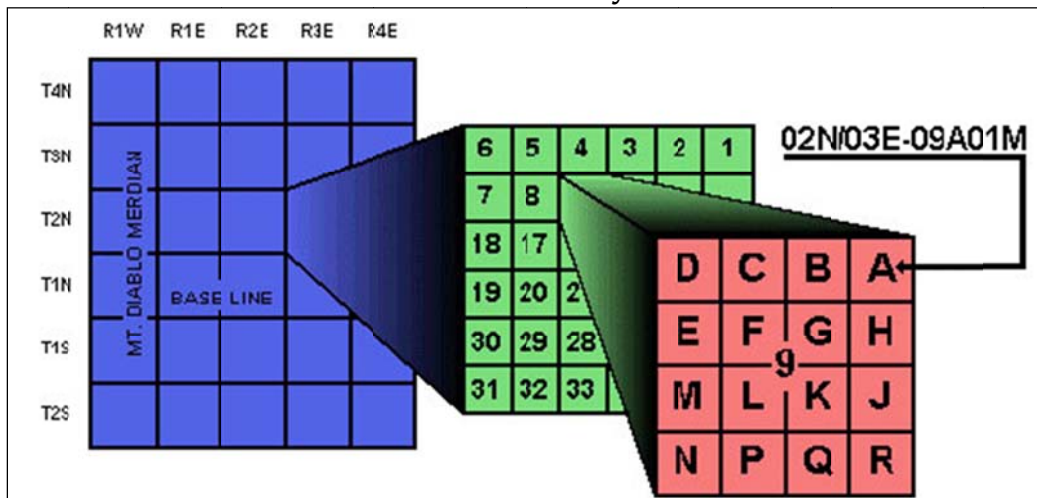
In addition to the groundwater level monitoring conducted by Butte County and the Department of Water Resources, California Water Service Company currently measures monthly groundwater levels in approximately 60 municipal groundwater supply wells in the Chico Urban area. California Water Service wells are typically deep wells that draw from the Tuscan Formation aquifer system. The Cooperating Agencies routinely conduct groundwater elevation monitoring that supplements the monitoring network. The US Bureau of Reclamation and US Geological Survey are not currently measuring groundwater levels in Butte County, but both agencies have monitored wells in the past.

The Monitoring Well Network

Currently there are approximately 111 wells monitored in Butte County. The wells monitored in Butte County consist of a mixture of domestic, irrigation wells and dedicated observation wells. As described in the previous section, the monitoring network developed over a period of time primarily utilizing existing production wells. The installation of dedicated monitoring wells has improved the monitoring network and data analysis. The long term approach is to systematically introduce dedicated multi-completion monitoring wells outfitted with continuous recorders. While the monitoring network continues to increase the number of dedicated monitoring wells, Butte County will continue to rely on data collected from existing wells in the network. Many of these wells provide adequate data taken over a long period of time.

The monitoring network consists of an adequate number of appropriately situated wells to characterize groundwater conditions within each subbasin. The Butte County monitoring wells are shown in Attachment A. The well locations are approximate, but are estimated to be within 500 feet. The monitoring wells are numbered using the State Well Numbering System. The State Well Numbering System identifies each well by its location according to the township, range, section, and tract system. The figure below illustrates how a State Well Number (SWN) is assigned.

State Well Number System Schematic



Selection of Wells for the CASGEM Monitoring Program

The Butte County CASGEM Monitoring Plan will utilize approximately 72 wells from the network for the CASGEM program. The Butte County CASGEM wells include dedicated monitoring wells and the key wells identified in the Annual Groundwater Status Report. The CASGEM wells are adequate to cover all of the subbasins in Butte County. The reliance on dedicated monitoring wells will provide the highest level of data collection to characterize groundwater conditions. To leverage the history of record and provide adequate subbasin coverage, key wells from the Annual Groundwater Status Report are part of the CASGEM program. One of the key wells is a dedicated monitoring well. Butte County has a Basin Management Objective (BMO) program that is structured on data collection and evaluation on a subinventory unit basin within the three subbasins in Butte County. The CASGEM wells are located in 10 of the 16 subinventory units and demonstrate ample geographic coverage within the subbasin. Butte County, in cooperation with DWR, will continue to monitor the remaining wells in the monitoring network. These wells and data will be a secondary tier to the CASGEM monitoring program.

The subbasins covered by the Butte County CASGEM monitoring plan comprise less than 1049 square miles (Vina 196 square miles, West Butte 283 square miles, East Butte 414 square miles and North Yuba 156 square miles). Since there are 111 wells in the monitoring network, the monitoring coverage is over 10 wells per 100 square miles. The primary CASGEM monitoring wells are adequately situated to cover the basin. The number of CASGEM monitoring wells is far above the acceptable range recommended in the Groundwater Elevation Monitoring Guidelines. The 72 wells in the CASGEM monitoring network provide an adequate coverage of the subbasins in Butte County to characterize seasonal and long-term trends.

Table 1: Primary Butte County CASGEM Wells

SWN	Subbasin	BMO Well	Dedicated or Key
17N03E03D01M	North Yuba		K
18N01E35L001M	East Butte		D
18N02E16F01M	East Butte		K
17N03E16N01M	East Butte		K
17N01E17F01M	East Butte		K
17N01E17F02M	East Butte		K
17N01E17F03M	East Butte		K
17N01E24A002M	East Butte	yes	D
17N01E24A003M	East Butte	yes	D
17N01E24A004M	East Butte	yes	D
17N01E24A005M	East Butte	yes	D
17N01E24A006M	East Butte	yes	D
20N02E24C001M	East Butte	yes	D
20N02E24C002M	East Butte	yes	D
20N02E24C003M	East Butte	yes	D
20N03E31M001M	East Butte	yes	D
20N02E09L01M	East Butte		K
21N02E26E003M	East Butte	yes	D
21N02E26E004M	East Butte	yes	D
21N02E26E005M	East Butte	yes	D
21N02E26E006M	East Butte	yes	D
20N02E09G001M	East Butte	yes	D
19N01E35B001M	East Butte	yes	D/K
19N01E35B002M	East Butte	yes	D
19N01E35B003M	East Butte	yes	D
19N02E13Q001M	East Butte	yes	D

19N02E13Q002M	East Butte	yes	D
19N02E13Q003M	East Butte	yes	D
20N03E33L001M	East Butte		D
21N01E08K002M	West Butte		D
21N01E27B001M	West Butte		D
21N01E28F001M	West Butte		D
21N02E30L001M	West Butte		D
21N03E32B001M	East Butte		D
18N03E21G01M	East Butte		K
19N02E07K002M	East Butte		D
19N02E07K003M	East Butte		D
19N02E07K004M	East Butte		D
20N01E35C01M	East Butte		K
20N02E15H001M	East Butte		D
20N02E15H002M	East Butte		D
22N02E30C002M	West Butte		D
22N01E28J005M	Vina		K
22N01E35E001M	West Butte		D
21N02E18C001M	West Butte		D
21N02E18C002M	West Butte		D
21N02E18C003M	West Butte		D
20N02E06Q01M	West Butte		K
20N01E18L01M	West Butte		D/K
20N01E18L02M	West Butte		D/K
20N01E18L03M	West Butte		D/K
21N01W11A001M	West Butte		D
21N01W11A002M	West Butte		D
21N01W11A003M	West Butte		D
22N01E29R01M	West Butte		K
21N01W24B01M	West Butte		D
20N01E02H003M	West Butte		D
23N01W10M001M	Vina	yes	D
23N01W28M002M	Vina	yes	D
23N01W28M003M	Vina	yes	D
23N01W28M004M	Vina	yes	D
23N01W28M005M	Vina	yes	D
23N01W31M001M	Vina	yes	D
23N01W31M002M	Vina	yes	D

23N01W31M003M	Vina	yes	D
23N01W31M004M	Vina	yes	D
23N01W09E01M	Vina		K
22N01W05M001M	Vina		D

Monitoring Schedule

Monitoring wells in Butte County are monitored four times per year as directed by two County Ordinances. Chapter 33-4 of the Butte County Code enacted in 1996 states that groundwater level measurements shall be taken from all designated monitoring wells at least four (4) times per year, during the months of March, July, August, and October. Each district and city within the county are requested to submit copies of all its groundwater monitoring reports to the department as such reports are completed but not later than December 1 of each year. The department shall also encourage individuals to voluntarily provide any available groundwater data. In 2006 Chapter 33A-9 of the Butte County Code was enacted and states that at a minimum, groundwater elevations shall be monitored four (4) times during the year: one measurement prior to the irrigation season in March, two measurements during peak groundwater use in July and August, and one measurement following irrigation season in October. DWR and the Department of Water and Resource Conservation split the monitoring duties, with DWR taking the March and October measurements and the department taking the July and August measurements.

Description of Field Methods

The field methodologies are consistent with the methodologies and procedures described in the Department of Water Resources' Groundwater Elevation Monitoring Guidelines (December 2010). Groundwater elevations are taken by either the steel tape method or by transducers. Approximately 43 of the 111 wells are equipped with data loggers to continuously monitor and record changes in groundwater levels. The remaining wells are measured by hand (i.e., steel tape method) four times per-year, during March, July, August and October. Groundwater levels are reported in feet above mean sea level. The accuracy of the groundwater level measurement is 0.1 feet. The accuracy of the well elevation is dependent on the source of the information. Some of the well elevations have been surveyed, but in the majority of cases the well elevation was estimated from its location on a USGS topographic map. The elevation accuracy is typically considered to be within 1 USGS topographic map contour interval. As a result the accuracy of the elevation should be considered to be between 5 and 20 feet.

Groundwater Reports

Butte County, in cooperation with DWR, evaluates and reports groundwater elevation data. The seasonal and long-term changes in groundwater levels are

determined using water level measurements from wells in the monitoring network. This data are typically depicted on hydrographs, which are graphical plots of the water level measurement history. Prior to 1997, data points for each of the hydrographs in Butte County generally consisted of two measurements per year. Since 1997, four level measurements are recorded each year. The addition of these summer measurements gives the hydrographs the appearance of greater fluctuation. Butte County primarily utilizes spring and fall measurements as a standard point of annual comparison and trend analysis.

Public access to groundwater monitoring data is an important part of Butte County's monitoring program. The DWR Northern District maintains an electronic database of groundwater level measurements for Northern California. The database contains over 100,000 individual groundwater level measurements, some dating back to the early 1930's. Butte County also hosts an online groundwater management tool known as the BMOIC, or Basin Management Objective Information Center. The data generated on either of these websites can be printed in varying formats. The DWR data can be accessed at: <http://wdl.water.ca.gov>. The Butte County site may be viewed from the Departments' main site, or by going directly to <http://gis.buttecounty.net/bmoic3/GIS/Default.asp?loadfile=map.asp&county=>.

For over a decade, Butte County has overseen the publication of an annual Groundwater Status Report. The Groundwater Status Report describes the hydrologic conditions, surface water deliveries, groundwater elevations of key monitoring wells and other factors affecting groundwater conditions in Butte County. In 2006, Butte County's Basin Management Objective program was implemented. The BMO program established quarterly monitoring of key wells, establishment of basin management objectives, evaluation of data and outreach to stakeholders. Butte County has administered these groundwater elevation reporting programs based on subbasins. The key wells were chosen as being representative of groundwater level conditions within each sub-area.

Principal Aquifer Features of the Butte County Basins

Butte County has compiled information and data on the groundwater basin. The data and information provide a scientific foundation to assure that the monitoring program adequately assesses seasonal and long-term trends.

The 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. 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. 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

Groundwater provides about 30 percent of the water supply for urban and agricultural uses in the Sacramento Hydrologic Region, and has been developed in both the alluvial basins and the hard rock uplands and mountains. In general, well yields are good and range from a hundred to several thousand gallons per minute.

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. The Tuscan Formation outcrops on the eastern portion of Butte County and it is presumed that groundwater recharge of the Tuscan Formation occurs in these areas. The current hypothesis is that Tuscan Unit B is 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 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".

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 (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. 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. 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.

The major sources of groundwater recharge in Butte County are percolation of rainfall, infiltration from streams, subsurface inflow, and deep percolation of applied irrigation water in agricultural areas. Of the 3.77 million acre-feet of annual rainfall, less than half is used. Therefore, more than two million acre-feet are available for recharge or discharge via surface and subsurface outflow. Subsurface inflow from higher elevations and percolation of precipitation are the major sources of groundwater recharge in the mountain areas. Some recharge probably occurs adjacent to through-flowing streams in areas of deeper soils or alluvial deposits. Deep percolation of streamflow infiltration and precipitation

are major sources of groundwater recharge in the valley. Most of this recharge occurs on alluvial fans where streams have sustained flow and the soil is highly permeable. In areas with clay soils or buried hardpan layers, high rates of surface runoff and ponding of water indicate locations where infiltration rates are low. Infiltration of surface runoff does occur at the basin margin where Tuscan and fanglomerate rocks are overlain by valley deposits. Deep subsurface inflow occurs in mountainous areas, flowing west to recharge the adjacent valley area.

In general, groundwater flows in a southwesterly direction. Near the Sacramento River, north of Princeton, the river 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. Southwest 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.

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.

The Butte County Groundwater Inventory Analysis reported that 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. At any specific location, the actual changes in groundwater level and the associated groundwater in storage could vary significantly from the average conditions depicted. 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 decrease 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.

Attachment A: Map of the Butte County CASGEM Wells

